SOUTH AFRICAN GUIDE

FOR SELECTION OF APPROPRIATE SANITATION SYSTEMS

J Neethling, R Cottingham, & D Still

WRC Report No. 3049/1/22

SASTEP
South African Sanitation Technology Enterprise Programme

WATER RESEARCH COMMISSION

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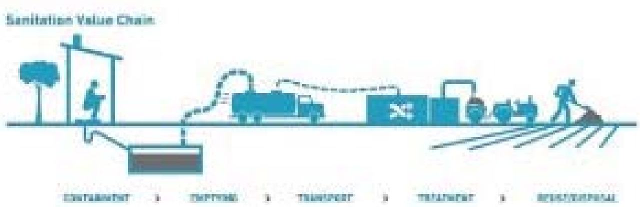

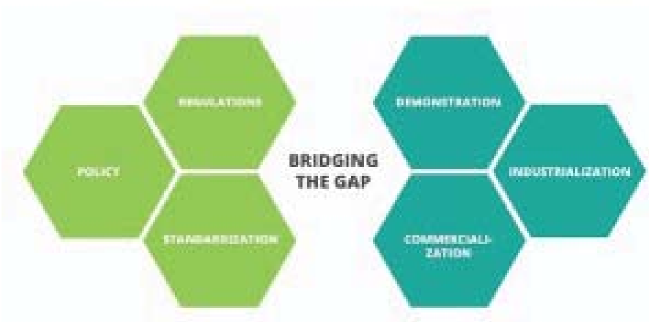

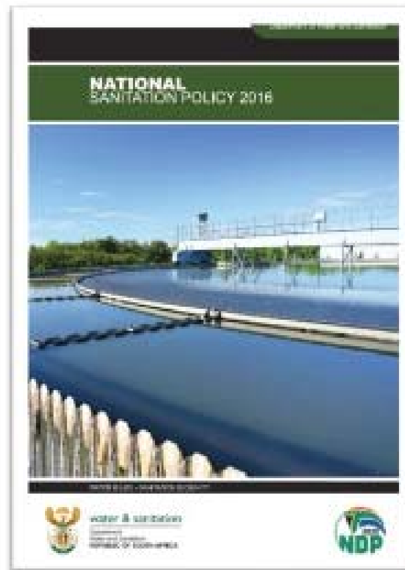

Final Report

by Jeanette Neethling, Ruth Cottingham, and David Still

February 2023

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This is the final report for WRC project no. C2020/21-00665.

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WRC report no. 3049/1/22

ISBN 978-0-6392-0485-7

Table of Contents

List of Tables

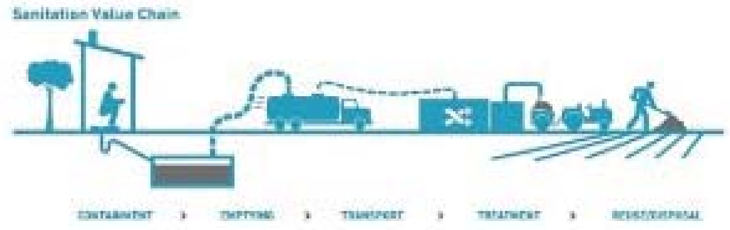
List of Figures

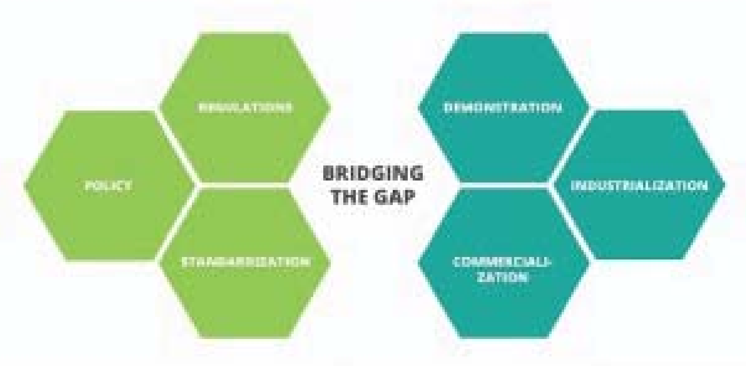
List of Abbreviations

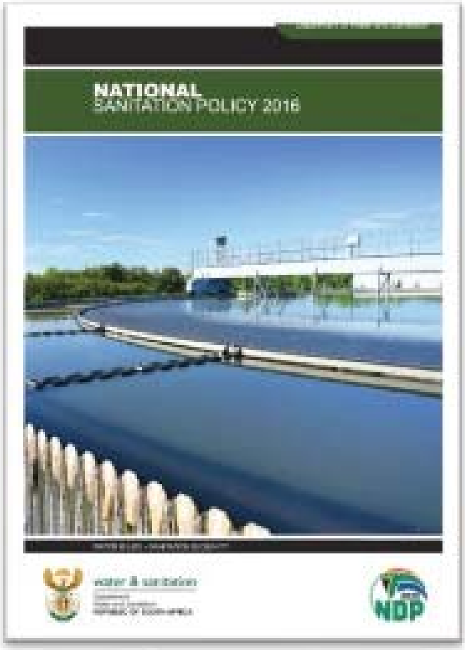
ABR	Anaerobic Baffled Reactor
AD	Anaerobic Digester
AF	Anaerobic Filter
B-BBEE	Broad-Based Black Economic Empowerment
BOQ	Bill of Quantities
CAB	Community Ablution Block
CBS	Container-Based Sanitation
CHDM	Chris Hani District Municipality
CIDB	Construction Industry Development Board
CoCT	City of Cape Town
CSO	Civil Society Organisation
DEWATS	Decentralised Wastewater Treatment Systems
DHS	Department of Human Settlements
DRE	Deep Row Entrenchment
DSA	Direct Sanitation Application
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EAWAG	Swiss Federal Institute of Aquatic Science and Technology
EHP	Emergency Housing Programme
ESU	Engineering Services Unit
EWS	eThekwini Water and Sanitation Unit
FFT	Full Flush Toilet
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plant
FSTU	Faecal Sludge Treatment Unit
HH	Household
ISD	Institutional Social Development
LOS	Level of Service
NSS	Non-sewered sanitation
NSSS	Non-sewered sanitation systems
PFMA	Public Finance Management Act
PFT	Portable Flush Toilet
PID	Partners in Development
RFP	Request for Proposal
SABS	South African Bureau of Standards
SANS	South African National Standard
SASTEP	South African Sanitation Technology Enterprise Programme
SCM	Supply Chain Management
SFD	Shit Flow Diagram
UD	Urine Diverting

UDDT	Urine Diverting Dry Toilet
UISP	Upgrading of Informal Settlements Programme
UKZN	University of KwaZulu-Natal
VIP	Ventilated Improved Pit
WRC	Water Research Commission
WSA	Water Services Authority
WSDP	Water Services Development Plant
WSP	Water Services Provider
WULA	Water Use License
WWTW	Wastewater Treatment Works

CHAPTER 1: INTRODUCTION TO THE GUIDE







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1 Introduction

While South African municipalities struggle to address sanitation service backlogs for low density rural areas, peri-urban and informal settlements, technology developers across the globe are innovating new solutions in sanitation. In South Africa, dry on-site sanitation is utilised in most rural and peri-urban areas while waterborne sanitation is the norm in urban areas (the binary sanitation paradigm). While the drive to extend waterborne sanitation to rural areas is motivated largely by political pressure and user aspirations, widespread implementation of conventional approaches is unsustainable and near impossible in a country with water scarcity, constrained infrastructure, and limited budgets due to the high costs involved. Alternative solutions have been developed in recent years including off-grid and non-sewered sanitation systems (NSSS), with the aim of improving sanitation services without the high capital investment and water usage required for large reticulation services. Sanitation package plants for decentralised waterborne sewage are also continuously developing. The growing suite of options available has the potential to bridge the gap between basic and improved sanitation and allow municipalities to achieve hygiene and sanitation for all.

Innovation in sanitation is hampered by numerous barriers, such as: lack of standardisation and guidance in the selection of appropriate technology/solutions; limited understanding of the systems; unscrupulous service providers who sell substandard or inappropriate solutions; lack of applicable standards; conflicting sanitation policies and regulations; lack of willingness to try or mistrust of new technologies due to past experiences; and lack of clear tender specifications and guidelines with respect to procuring non-traditional sanitation technologies. Without clear guidelines, municipalities are unlikely to pursue any new technologies. Further, many municipalities lack the technical capacity to understand new systems being proposed, which can either lead to inappropriate implementation of solutions or refusal to consider any alternative solutions. Manufacturers of innovative sanitation systems are frequently unable to tender for municipal sanitation contracts because tender specifications are not written with an understanding of these new systems.

In response to the barriers described above, the South African non-sewered sanitation system (NSSS) standard, SANS 30500, was published in 2019. SANS 30500 provides a regulatory basis for implementation of innovative sanitation systems. However, this standard must be aligned with other relevant standards currently used in sanitation decision-making for it to be operationalised. The standard does not override other existing standards, but it must be explained in terms of standards already used by municipalities in their decision making around sanitation. In the absence of capacity to understand and implement the new standard, municipalities will continue in the binary sanitation paradigm, limiting implementation of alternative sanitation solutions. Without implementation at the municipal level, the time, energy, and finances invested in the development of new sanitation solutions in recent years will be wasted and sanitation implementation will continue to be limited by the problems these new sanitation solutions aim to address. Furthermore, an increase in the number of options requires decision makers to grow in their capacity to select appropriate solutions for specific contexts. The landscape becomes more complicated as South Africa moves from a simple “rural = VIP, urban = sewer” binary paradigm to one with multiple options for rural, urban, and peri-urban environments.

Through this project, a suite of tools was produced to improve understanding of innovative sanitation systems to support decision makers who have limited capacity and time. The tools aim to empower municipalities, WSAs, and WSPs to deploy sanitation solutions that are contextually appropriate, including alternative and traditional approaches. While a tool can never replace critical thinking and technical expertise, decision-making tools can help open the possibilities for implementation of alternative sanitation solutions. This will introduce a wider range of technology solutions that can be used in addressing sanitation service delivery challenges, ideally leading to increased access to improved sanitation for more South Africans.

2 Process undertaken to produce the Guide

This Guide was produced primarily through document review and consultations with sanitation sector representatives, including municipal representatives and technology suppliers. The analysis of existing documents and feedback from sanitation professionals led to an analysis of the barriers to the uptake of alternative sanitation systems. **Chapter 2** of this document, ***Understanding the barriers and enabling factors to uptake of alternative sanitation systems*****,** presents the results of this investigation. These are the key findings of the research activities that informed the creation of the guide and tools.

Chapters 3 through 6 of this document present the full suite of tools created through WRC Project C20202021-00665: *Development of Municipal Guidelines for the selection of sanitation package plants, non-sewered sanitation and other alternative sanitation solutions.* The tools were created by the project team, with input from various representatives from the WRC, municipalities, and other sanitation professionals. The sections are listed and described below:

- **Chapter 3: *Selecting sanitation systems*** – A framework for understanding sanitation systems and suggesting key criteria to consider in selection of systems. This chapter accompanies the ***SaniSelect Decision Making Tool,*** a Microsoft Excel tool created to assist decision makers in weighing different technology options along the sanitation value chain, based on the criteria described in Chapter 3.
- **Chapter 4: *Writing a sanitation policy*** – Guidance for municipalities on how to craft a sanitation policy
- **Chapter 5: *Procurement processes for alternative sanitation systems*** – Various approaches to procuring alternative sanitation systems
- **Chapter 6: *Advocating for alternative sanitation systems*** – A simple list of pointers for those advocating for specific alternative sanitation systems or simply for alternative approaches in general

3 Recommendations for disseminating this Guide

This guide aims to provide a common understanding of and language for sanitation systems among South African sanitation professionals, with particular emphasis on building capacity among municipal officials. For this reason, it is important that the guide and conceptual framework are shared with those working in the sanitation sector, including national and provincial water and sanitation departments, municipalities, consultants, and academics. Through this project, the contents of this Guide have been disseminated to a small number of municipalities and national government departments through virtual workshops, but further work must be done. The following section outlines proposed methods and locations for disseminating the guidelines.

3.1 Publishing the Guide

The *South African Guide for Selection of Appropriate Sanitation Systems* emanates from a Water Research Commission (WRC) study and therefore will be published and freely available on the WRC's Knowledge Hub. The version on the Knowledge Hub will be a single document with all sections included. In addition to this combined document, each chapter should be available on its own, as they each address different aspects and could be aimed at different audiences. The Guide should also be made available on the SASTEP and Department of Water and Sanitation (DWS) websites to ensure a wide reach, beyond those who typically search the WRC's Knowledge Hub. Furthermore, the published guidelines can be shared via international platforms, such as SuSanA and the Faecal Sludge Management Alliance.

3.2 Adaptation to a web-based tool

The SaniSelect tool presented in Chapter 3, *Selecting Sanitation Systems*, should be adapted from a Microsoft Excel-based tool to a web-based tool that is easy to access by users and simple to update by custodians of the tool. The begin with, the tool should be integrated into the SASTEP website. If the SASTEP programme comes to an end, maintenance of the tool should become the responsibility of either the WRC or DWS. The architecture of the tool is present in the Excel version, so adaptation to a web version would simply require the input of a programmer/web-developer to create a user-friendly interface and then train a designated team to keep the tool up to date. The team involved in creating the SaniSelect tool should be part of this process as technical consultants.

3.3 Non-sewered sanitation masterclass

The materials provided in this guideline can be adapted to material appropriate for inclusion in a masterclass about non-sewered sanitation. The primary audience of this masterclass will be municipal officials working in the water and sanitation sector. At the end of the masterclass, participants should feel comfortable describing different sanitation systems and what is required along the value chain to achieve sustainable, improved sanitation. They should also be empowered with knowledge to help them evaluate the appropriateness of different solutions based on their specific requirements. The masterclass can be made up of multiple modules, with each module corresponding to one or two chapters of the guidelines. Each module should consist of a presentation by experts in the topic, along with hands-on activities and discussion. A summary of suggested modules is provided in Table 1.

3.4 Training videos: SaniSelect tool

A series of brief training videos should supplement the modules above. These can be used during the training sessions and/or provided as references for afterwards. The videos will focus on the SaniSelect tool, with a single video corresponding to each sheet. These should be under 5 minutes and would simply involve some narration and sharing the content to explain the different parts of the workbook. Suggestions for videos are listed in Table 2.

Table 1: Suggested modules for masterclass on non-sewered sanitation, based on these guide

Number	Module Name	Description	Suggested trainers/parties involved
1	Introduction to the Sanitation Value Chain and the Compendium of Sanitation Systems	Overview of the parts of the Sanitation Value Chain and what is involved in it… introduction to the Compendium of Sanitation Systems and other resources on sanitation.	Sandec/EAWAG, DWS, SASTEP/WRC*
2	Selecting appropriate sanitation systems	Criteria and characteristics to consider, weighing different criteria, and final selection. Introduction to the South African SaniSelect Tool. Understanding the Groundwater Protocol.	DWS, SASTEP/WRC
3	Writing a sanitation policy	South African policy landscape, why create a sanitation policy, how to create it, and how to implement and monitor it	DWS, SALGA, eThekwini or Joburg Water, SASTEP/WRC
4	Procurement of Alternative Sanitation Systems	Barriers to procurement of alternative systems in South Africa – what are the key issues? Various options for procurement processes for alternatives.	DWS, Dept of Treasury, SASTEP/WRC

*SASTEP includes the consultants appointed to create the Guide

Table 2: Suggested training videos to support SaniSelect tool

Number	Video Name	Description
1	Introduction to the Sanitation Value Chain	Overview of the parts of the Sanitation Value Chain and what is involved in it… introduction to the Compendium of Sanitation Systems and other resources on sanitation.
2	How to use the SaniSelect tool	Overview of the first sheet in the workbook, covering the types of cells and how to use them. Plus an overview of the sheets included.
3	Data Entry	Introduction to the *Data Entry* sheet, including what data is required and how to enter it.
4	User Interface	Explanation of how to use the *User Interface* sheet, all the way down to selecting a user interface.
5	On site Coll,Stor,Trmt	Explanation of how to use the *Onsite Collection, Stor, Trmt* sheet, down to selecting an option.
6	Conveyance	Explanation of how to use the *Conveyance* sheet, down to selecting an option(s).
7	Treatment	Explanation of how to use the *Treatment* sheet, down to selecting an option(s).
8	Use and/or disposal	Explanation of how to use the *Use and/or disposal* sheet, down to selecting an option(s).
9	Selected System	Explanation of the *Selected System* summary sheet, which presents the full system selected.

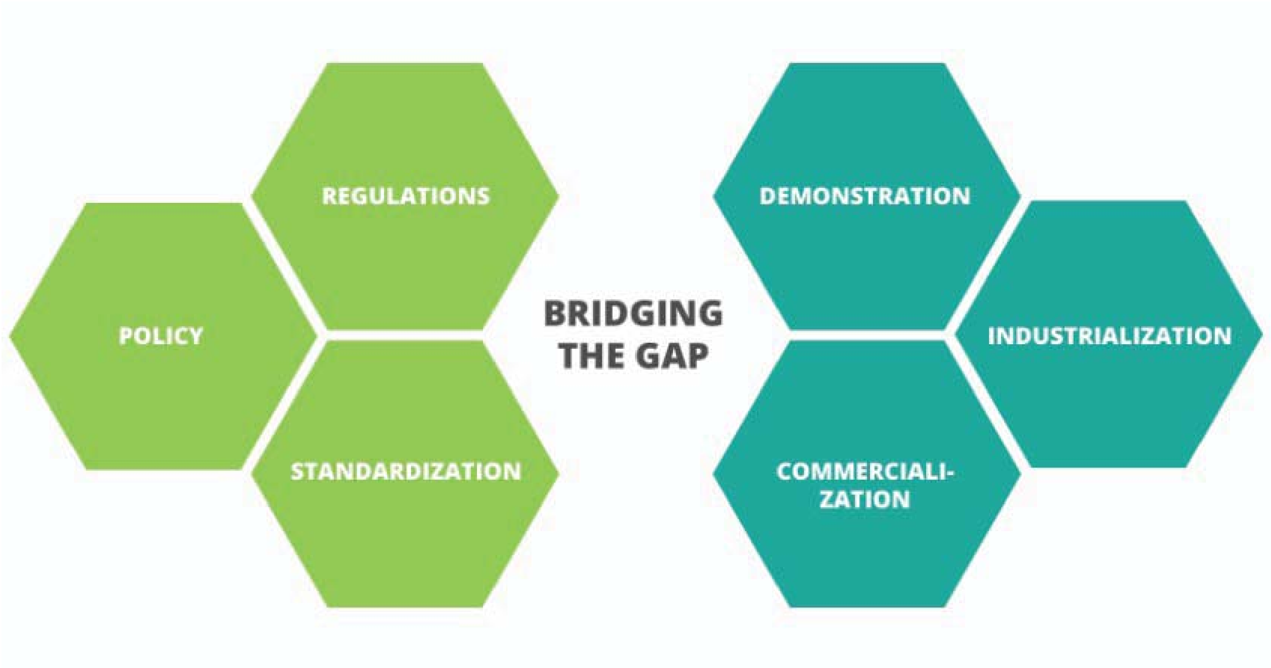
3.5 Seminar for Technology Developers: Advocating for Alternative Sanitation Systems

A brief seminar (ideally webinar to allow for representatives from all over the country) about how to effectively advocate and improve the chances of uptake of your solution and other innovative systems. Emphasis should be place on the reality that more implementation of innovative systems will encourage implementation of innovative systems in general. Therefore, uplifting the sanitation innovation community in general will hopefully lead to benefits for everyone working in the space. This session can be used to encourage less competition and more collaboration through sharing lessons learned. This could also be approached as a single video distributed to technology developers.

Topics to cover:

1. Feedback received from municipalities about why alternatives are difficult to consider
2. Defining your technology in terms of the sanitation value chain functional groups and technologies
3. Tips for advocating for alternatives – what should you include in your advocacy?
4. Overview of technology certification processes and options
    a. Agrément
    b. SANS 30500
    c. SASTEP platform
    d. WRC Advisory Note

CHAPTER 2: UNDERSTANDING THE BARRIERS AND ENABLING FACTORS FOR UPTAKE OF ALTERNATIVE SANITATION SYSTEMS



This chapter presents barriers and enabling factors in the uptake of alternative sanitation systems in the South African context. This includes the following sections:

* **Section 1: Setting the scene**
* **Section 2: Policy and literature review**, considering both South African and international documents related to provision and selection of sanitation systems.
* **Section 3: Case studies of South African Municipalities** compiled through document review and interviews with representatives from a selection of four municipalities, including three large metros and one rural district municipality.
* **Section 4: Case studies of South African technology developers** based on interviews conducted to provide insight into the specific challenges they face in tendering for sanitation projects and generally implementing their solutions in this context.
* **Section 5: Analysis of the tender process for sanitation systems,** based on a review of tender documents to see how challenges faced by both sets of stakeholders above manifest in the language and processes in tenders.

The key findings from all the above activities are then summarised in **Section 6**, with conclusions and recommendations in **Section 7.**

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1 Setting the scene

While South African municipalities struggle to address sanitation service backlogs for low density rural areas, peri-urban and informal settlements, technology developers across the globe are innovating new solutions in sanitation. In South Africa, dry onsite sanitation is utilised in most rural and peri-urban areas while waterborne sanitation is the norm in urban areas (the binary sanitation paradigm). While the drive to extend waterborne sanitation to rural areas is motivated largely by political pressure and user aspirations, widespread implementation is unsustainable and near impossible in a country with water scarcity, constrained infrastructure, and limited budgets due to the high costs involved. Alternative solutions have been developed in recent years including off-grid and non-sewered sanitation systems, with the aim of improving sanitation services without the high capital investment and water usage required for large reticulation services. Sanitation package plants for decentralised waterborne sewage are also continuously developing. These systems have the potential to bridge the gap between basic and improved sanitation and allow municipalities to achieve hygiene and sanitation for all.

Innovation in sanitation is hampered by numerous barriers, such as: lack of standardization and guidance in the selection of appropriate technology/solutions; lack of understanding of the systems; unscrupulous service providers who sell substandard or inappropriate solutions; lack of applicable standards; conflicting sanitation policies and regulations; lack of willingness to try or mistrust of new technologies due to past experiences; and lack of clear tender specifications and guidelines with respect to procuring non-traditional sanitation technologies. Without clear guidelines, municipalities are unlikely to pursue any new technologies. Further, many municipalities lack the technical capacity to understand new systems being proposed, which can either lead to implementation of inappropriate solutions or refusal to consider any alternative solutions. Manufacturers of innovative sanitation systems are frequently unable to tender for municipal sanitation contracts because tender specifications are not written with an understanding of these new systems.

2 Literature and Policy Review

A summary of the literature review conducted for this project is provided below. This provides a picture of the national landscape in terms of policies and standards as well as an overview of sanitation technology design and selection guidelines/tools that have been created.

2.1 South African National Policies

Tissington (2011) analysed the Legislative and Policy framework for basic sanitation in South Africa, highlighting the following key documents: the Constitution (1996); White Paper on Water Supply and Sanitation Policy (1994); National Sanitation Policy (1996); Water Services Act (1997); Housing Act (1997); the Upgrading of Informal Settlements Programme (UISP) and the Emergency Housing Programme (EHP); Municipal Systems Act (2000); White Paper on Basic Household Sanitation (2001); Strategic Framework for Water Services (2003); National Sanitation Strategy (2005); and Free Basic Sanitation Implementation Strategy (2009). Since this policy framework was established, the National Sanitation Policy (2016) was published to address the changing landscape around sanitation and key hurdles that had come up in the previous 20 years of sanitation implementation. In 2018, the Sanitation Master Plan was published by the

National Department of Water and Sanitation to guide the water sector with prioritised actions for development of water resources and delivery of water and sanitation services until 2030.

While the Constitution speaks broadly about human rights, the White Paper (1994) specifically defines adequate sanitation as follows:

> *The immediate priority is to provide sanitation services to all which meet basic health and functional requirements including the protection of the quality of both surface and underground water. Higher levels of service will only be achievable if incomes in poor communities rise substantially. Conventional waterborne sanitation is in most cases not a realistic, viable and achievable minimum service standard in the short term due to its cost. The Ventilated Improved Pit toilet (VIP), if constructed to agreed standards and maintained properly, provides an appropriate and adequate basic level of sanitation service.*
>
> *Adequate basic provision is therefore defined as one well-constructed VIP toilet (in various forms, to agreed standards) per household.* (DWAF, 1994)

The above definition sets the stage for the binary paradigm that has been widely observed across South Africa: flushing systems connected to full sewerage networks being the norm in urban areas and dry, onsite systems being the norm in rural and peri-urban areas. The White Paper defines VIP toilets as the *minimum* level of sanitation service and alludes to conventional waterborne sanitation as the goal in the long-term. However, it does not state that sanitation technologies located somewhere on the spectrum between VIP toilets and full waterborne sanitation are unacceptable. The 2016 National Sanitation Policy acknowledges this dichotomy and aims to address it by highlighting the DWS position on “Appropriate Sanitation Technologies”:

> *Currently, selection of sanitation technologies for an area is largely based on the guidelines for the levels of services in the country, with flush systems being the norm in formal settlements and dry, onsite system being provided in the rural areas of the country. However, experience has shown that these selections of technologies are often not the most appropriate for the area in which they are currently provided. The policy needs to address the issue of appropriate technology and change the preconceived notion of sanitation from either waterborne in urban and dry systems in rural areas to one where the most appropriate technology is provided to an area. Technology choice needs to be based on resource availability within a settlement area.* (DWS, 2016)

The Policy further states that the *definition* of sanitation does not define the *technology* to be used in providing the service. According to the Policy, a “basic sanitation facility” is defined as: “The infrastructure which considers natural (water; land; topography) resource protection, is safe (including for children), reliable, private, socially acceptable, skills and capacity available locally for operation and maintenance, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases by facilitating the appropriate control of disease carrying flies and pests, facilitates hand washing and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner.” (DWS, 2016) The policy also highlights the need to select sanitation solutions that minimise consumption of limited water resources and recognise the value of sanitation by-products. As quoted in the introduction to the Policy:

> *We must introduce new technologies that appreciate that water is a scarce resource and as such provide solutions to dispose of effluent via alternative methods. It's not all about flushing… We must begin by challenging the property development sector through regulation and licensing requirements to invest itself in developing properties less reliant on water for sanitation in order to ensure we introduce the alternative solutions to low, middle and high income areas.*
>
> - The Minister of Water and Sanitation, Ms. Nomvula Mokonyane, National Sanitation Indaba (DWS, 2015, as cited by DWS (2016))

The National Sanitation Policy for South Africa (2016) broadens the range of technologies available for sanitation provision by focusing on *characteristics* of suitable sanitation systems as opposed to *specific technology options* (e.g. flush toilets and VIP toilets). The acceptable basic level of sanitation, as defined by the Policy, is:

- appropriate health and hygiene awareness and behaviour
- the **lowest cost, appropriate** system for disposing of human excreta, household wastewater, **grey-water**, which **considers resource constraints,** is **acceptable and affordable to the users**, **safe** including for children, **hygienic** and easily accessible and which does not have a detrimental impact on the environment;
- a **toilet** and **hand washing** facility;
- enhances a **clean living environment** at the household and community level; and
- the consideration of defecation practices of **small children** and **people with disabilities** and special needs.

The Policy further states a position on research and innovation for sanitation services, in an attempt to support more solutions to the unique situations in South Africa's many settlements. Generally, research and innovation is supported by the policy, with a focus on minimizing resource use and maximizing resource reduction, reuse, recycling, and reclamation (DWS, 2016). This is further emphasised in the *Sanitation Master Plan* (2018), in which one of the key priority areas is research and innovation to address the many challenges facing South Africa, such as water scarcity and inequality.

The Free Basic Sanitation Implementation Strategy provides guidance for decision-making around sanitation technologies by defining the following considerations: community acceptance of the service level and willingness to pay the associated tariff; viability for the WSA and WSP; environmental impact; and technical feasibility (DWAF, 2008).

The above summary highlights the fact that numerous South African Policy documents provide criteria for meeting the minimum sanitation services. While some documents in the past have specifically mentioned VIP toilets and waterborne sanitation as the two main options, there are numerous other options which meet the criteria identified, and the South African sanitation sector, particularly through the National Sanitation Policy (2016) has expressed support for innovative solutions.

2.1.1 Public Procurement Processes

Public procurement is defined as the buying of goods and services by the government from the public sector (Van Der Westhuizen, 2015). Public procurement is governed at the national and provincial levels by the *Public Finance Management Act* (PFMA) and at the local government level by the *Municipal Finance Management Act* (MFMA). While the acts differ considerably in detail, the PFMA shares the same broad objectives as the MFMA, namely: to ensure that revenue, expenditure, assets, and liabilities of all spheres of government are managed efficiently and effectively; to define the responsibilities of people entrusted with financial management; and establish norms and standards, as well as standard processes for financial management. The PFMA requires all government departments to establish a Supply Chain Management (SCM) unit and put SCM processes in place (Van Der Westhuizen, 2015). The MFMA requires that all municipalities have and implement a supply chain management policy to give effect to the MFMA (RSA, 2003). . Supply Chain Management systems are meant to ensure that all goods and services procured by the government are delivered (1) to the right place; (2) in the right quantity; (3) with the right quality; (4) at the right cost; and (5) at the right time (Van Der Westhuizen, 2015).

The scope of public procurement in South Africa is large and consequential, as procurement decisions can promote social and policy objectives by promoting development for previously disadvantaged groups. At the same time, the size of government procurement gives rise to the potential for corruption for personal or political gain. In response to the critical and vulnerable natures of procurement practices the South African Constitution and subsequent policies speak to principles for procurement.

The Constitution requires organs of state to comply with five principles when procuring goods and services: fairness, equity, transparency, competitiveness, and cost-effectiveness. These are reflected both in the PFMA and the MFMA.

Goods and services are generally procured in one of the following manners (Van Der Westhuizen, 2015):

1. External sourcing, where the department purchases goods or services from a supplier
2. Transversal contracts, where goods and service are purchased in large quantities for a number of national, provincial, and/or municipal departments. These contracts are negotiated by National Treasury and involve a competitive bidding process.
3. Public-private partnerships, where joint projects are carried out between government departments and private sector companies. Specific laws regulate these kinds of partnerships.

Processes 1 and 3 may be relevant for procurement of sanitation systems.

2.1.2 External sourcing

There are a number of ways that goods can be externally sourced, and the chosen method is generally defined by the value of the goods or services to be procured. The three methods for procurement via external sourcing include: petty cash (up to R2,000); comparing three quotes (R2,001-R10,000); comparing as many quotes as possible, with a minimum of three (R10,001-R500 000 for national or provincial government and R10,001-R200,000 for local government); and finally, competitive bidding/public tender (>R500,000 for national or provincial government and >R200,000 for local government).

In addition to the above guidance, the *Local Government Municipal Systems Act* (Act No 32 of 2000) makes provision for municipalities to provide basic municipal services either internally or by enlisting the services of an external service provider. Section 78 specifies the steps municipalities must take to procure municipal services from external services. These initial steps centre largely around community consultation. (Van Der Westhuizen, 2015) Following the initial steps, the competitive bidding process would commence.

Public calls for tenders generally meet the minimum constitutional requirements, prevent fraud or favouritism, and ensure that the maximum number of contractors can participate. Receiving several submissions also enables the government to compare prices and select the most cost-effective option. In general, contracts for external sourcing do not exceed three years, as the budgeting framework for government departments only extends for three years. There are provisions for extended contract periods, but a public participation process is required.

Exceptions to the public tender procedures

Bolton (2006) analysed the various exceptions to the requirement for public tenders, including in the case of emergencies or a sole supplier. If municipalities deviate from the public procurement process for either of the reasons above, a detailed record must be kept as to why this was done. Bolton said that single source procurement lends itself to abuse, because the lack of competition gives the contractor no reason to offer competitive pricing. By nature, it can easily end up failing all 5 of the principles described above if not carried out properly. To limit the abuse of this approach, Bolton unpacked possible situations that may warrant the use of single source procurement:

- Intellectual property rights: Where a contractor has exclusive rights to an innovative product, design or manufacturing process for which there is no equivalent, an organ of state may have no option but to contract with them. Failure to do so may prevent the organ of state from having access to the latest technology. For this to be applicable, it is necessary to demonstrate that there are no alternatives. Contractors that have exclusive rights may also license others to manufacture their patented products or use their technical knowledge or manufacturing process, which can give rise to the availability of the protected product from several sources, thus negating this scenario.
- Extension of existing contracts: This applies to unforeseen work that is required but cannot be easily separated from the original contract. For this to be applicable, it is important for legislation to stipulate the time period within which contracts may be awarded to the same contractor.
- Amendments to existing contracts
- A need for proper safeguards: “A claim, for example, that there is only one potential provider for the particular goods or services should be fully justified and supported by detailed and compelling evidence. Organs of state should not, for example, be allowed to award custom-made contracts, that is, contracts that are “tailored to the strengths of a particular supplier”. Such contracts clearly defeat compliance with, in particular, the principles of fairness and competitiveness in section 217(1) of the constitution.

2.1.3 Public-Private Partnerships

A public-private partnership (PPP) is defined as a contract between a public sector institution or municipality and a private entity, in which the private entity assumes considerable financial, technical, and operational risk in the design, financing, building, and operation of a project. Rules regulating PPPs are presented in the PFMA National Treasury Regulations, and PPPs require approval from national or provincial treasury throughout the process.

2.1.4 Communities and public procurement

The International Budget Partnership South Africa has done valuable work around the role of communities and civil society organisations (CSOs) in the monitoring of public procurement. This work points to the need for monitoring of the procurement process and outlines specific ways that communities and CSOs can participate in the public procurement process. Through social audit reports, the work also reveals the experiences of community members being provided basic services, which provides a critical perspective for municipal officials. A selection of reports written by Carlene van der Westhuizen on the topic are listed below:

- *Monitoring Public Procurement in South Africa: A Reference Guide for Civil Society Organizations* (2015)
- *Systemic Challenges Facing the Procurement of Outsourced Basic Services for Informal Settlements in South Africa* (2018)
- *Which procurement information should we publish?* (2018)

2.2 Relevant Standards

2.2.1 National Norms and Standards for Domestic Water and Sanitation Services

The *National Norms and Standards for Domestic Water and Sanitation Services* updates the previous version by considering the complexities and unique challenges faced in different parts of the country (i.e. rural, urban, peri-urban). The Norms and Standards were prepared by the Department of Water and Sanitation to ensure equitable water services provision to households, accounting for availability of water resources, financial challenges, geographical issues, servicing of vulnerable groups, and addressing the backlog (DWS, 2017).

The norms and standards for sanitation services are found in Part 2 of the document and establish the sanitation ladder, which consists of the following service levels:

- No service provision (backlog): People practice open defecation or access an unimproved sanitation facility
- Interim level: Blocking the spread of faecal-oral diseases through proper excreta containment at a fixed point
- Basic level: Remove excreta from the environment through treatment, pathogen reduction, resource recovery, and nutrient reuse
- Full level: Full concern for human health, environment, and sustainability of interconnected systems

The core norms and standards for sanitation services include: hygiene promotion, prevention of pollution, re-use, operation and maintenance, sanitation metering and tariffing, solid waste management, and asset management. Each of these standards is fleshed out in the document with practical advice on how to achieve the given standard.

The document then discusses specific norms for different levels of sanitation service provision. When discussing basic sanitation, the goal is: "People access at least a pleasant, safe, reliable, and well-maintained improved toilet and hand washing facility within their yard" (DWS, 2017). This includes ensuring that sanitation services are never interrupted (e.g. due to unreliable water supply) and ensuring sufficient solid waste and faecal sludge management. With regards to the specific types of sanitation facilities designed, the Norms and Standards says the following (DWS, 2017):

> *The type of sanitation infrastructure or facility adopted and installed shall be an improved facility and depends on the preferences and cultural habits of the intended users, the capacity of the services provider (financial and skills), the existing infrastructure, the availability of water (for flushing and water seals), the soil formation (for groundwater and surface water protection) and the capacity of the applicable wastewater treatment methods.*

2.2.2 SANS 30500

The SANS/ISO 30500 standard, *Non-sewered sanitation systems – Prefabricated integrated treatment units – General safety and performance requirements for design and testing* has been adopted by South Africa to evaluate and measure the viability of non-sewered sanitation technologies. The purpose of the standard is

> *to support the development of stand-alone sanitation systems designed to address basic sanitation needs and promote economic, social, and environmental sustainability through strategies that include minimizing resource consumption (e.g. water, energy) and converting human excreta to safe output.* (ISO, 2018)

The standard includes detailed test methods and performance standards for the testing of all types of non-sewered sanitation systems. Systems are divided into three broad Classes for testing, dependent on the number of front-ends they contain and if they include a biological treatment process. The document applies only to pre-fabricated systems, either manufactured as one package or as a group of pre-fabricated elements that are later joined together. It does not apply to systems that are constructed *in situ*. It must be noted that SANS 30500 does not apply to any system which makes use of a soak pit, leach pit, seepage bed, constructed wetland or similar appropriately designed interface with the environment. It applies to closed systems which produce no effluent, or systems which produce an effluent which meets General Authorisation standards. *SANS 30500 should therefore only be specified where there is a particular valid reason why a soak pit or leach field cannot be used.*

The document specifically does **not** cover the selection of non-sewered sanitation systems, and how to ensure the system is suitable to the context of application. The risk assessment carried out as part of the SANS 30500 assessment process has to be based on a specified intended use (i.e. context of application) for the system, but no guidance is given on how to assess whether a system is suitable for its intended use. Expertise is required to define criteria for evaluating specific a sanitation system. Once criteria are defined for a sanitation system in a specific setting, the SANS 30500 standard can then be used to evaluate if the system meets those criteria.

2.2.3 SANS 10400

SANS 10400 presents the National Building Regulations for South Africa. It is not a handbook on good building practice; rather, it is meant to provide the simplest requirements to ensure that buildings are built in a way that people live and work in a healthy and safe environment (SABS, 2011a). Part P (Drainage) covers waterborne sanitation, and PP10 specifically discusses conservancy tanks, septic tanks, and French drains. Part Q covers dry sanitation systems, specifically chemical and VIP toilets.

SANS 10400-Q:2011 presents requirements for *Non-water-borne means of sanitary disposal.* The standard covers the specific requirements for chemical and VIP toilets, but also makes allowance for other solutions that are either: designed or assessed by a competent sanitation professional (in accordance with Annex B of SANS 10400-P:2010) or the subject of an Agrèment certificate and used in accordance with that certificate. This statement allows for the implementation of innovative solutions that have been properly evaluated, either by a competent person or the Agrèment certification body. Annex B of SANS 10400-P:2010 sets the following requirements for sanitation systems (SABS Standards Division, 2010):

- Provide privacy and protect the user and others from the weather when in use
- Prevent soil, garbage, and other foreign materials from entering the system by the action of rain, wind, or animals
- Not prevent or cause a nuisance or a danger to health as a result of their use and operation
- Withstand all the actions to which they are likely to be subjected to
- Not leak soil water into the surrounding soil, if buried
- Be compatible with the water supply
- Be capable, where required, of carrying the design hydraulic load and drain and discharge into a municipal sewer system, a common drain, or other sewage disposal system, or dispose of effluent in a safe and inoffensive manner
- Not contaminate clean water supplies or ground water to the extent that such contamination poses a health risk
- Be easy to use, clean, and maintain
- Be able to accommodate and dispose of commonly used cleaning materials
- Satisfy nominated parameters, depending upon the nature of the system.

The above list can be used as a starting point for assessing different alternative solutions.

With regards to VIP toilets, the standard states a number of requirements for VIP toilets that can inform decision-makers on whether it is an appropriate technology, namely (SABS, 2011b):

VIP toilets shall:

- Not penetrate the water table
- Only be constructed where the percolation rate measured in accordance with SANS 10400-P does not exceed 50 mm/h and is not less than 2.5 mm/h
- Not be built under or near trees
- Be situated downstream of, or more than 30 m away from, a well or water source
- Be located at least 3 m away from buildings

- Where permanent, be located at least 2.75 m away from the erf boundary to allow access for maintenance

The requirements above highlight that VIP toilets are only appropriate where there is negligible risk of ground- or surface water pollution and where there is sufficient space on the plots to allow for maintenance.

2.2.4 SANS 24521

ISO 24521, *Guidelines for the management of basic onsite domestic wastewater services*, provides guidance for the management of basic onsite domestic wastewater services. The standard has been adopted by SABS and provides valuable technical guidance on technology selection, design, and implementation. Specifically, this standard includes the following (ISO, 2016):

1. Guidelines for the management of basic onsite domestic wastewater services from the operator's perspective, including maintenance techniques, training of personnel and risk considerations;
2. Guidelines for the management of basic onsite domestic wastewater services from the perspective of users;
3. Guidance on the design and construction of basic onsite domestic wastewater systems;
4. Guidance on planning, operation and maintenance, and health and safety issues.

Section 4 of the document covers the main objectives of onsite wastewater services, which can provide some guidance in terms of technology selection. These include:

- Public health and safety
- Occupational health and safety
- Environmental protection
- Sustainable development

The standard also says that solutions should be adapted to local conditions and respond to the actual needs of the community, which emphasises the reality that there is no "one-size-fits-all" solution for sanitation.

After laying out the various considerations for onsite sanitation systems, the standard defines the onsite sanitation chain, namely: user interface, collection, transportation, treatment, and disposal/reuse. Section 5.2 defines technology options to meet each of the needs in the sanitation chain, highlighting the number of options available, with the caveat that these lists are not comprehensive and should not be considered as limiting. Annexure B provides detailed descriptions of each of the technologies identified. It is important to note that the technologies listed are general solutions and that the standard does not make mention of specific suppliers or innovations. (ISO, 2016)

Section 7.2 is titled *Criteria for selecting appropriate basic onsite domestic wastewater technologies*, thus stating a position on how technologies should be selected. According to the standard, "A technological solution is feasible if it meets local demand, if the financial resources are available for its construction and if the financial resources and technical and management skills exist to ensure its proper operation and maintenance." (ISO, 2016) Specific feasibility criteria are defined, and suggestions made on how to assess them:

1. Acceptance by households and local sanitation professionals: can be assessed through surveys

2. Lifespan of the infrastructure: determined by the technology used. The objective is to install the longest lifespan technology that is possible in the context of effectiveness, economic costs, and cultural acceptance. The technology should be durable and locally repairable and be able to handle variations in wastewater/faecal sludge quality and quantity.
3. Efficiency of the technology:
    a. For collection of wastewater and excreta: defined by its ease of use and maintenance and its capacity for pre-treatment
    b. For evacuating wastewater and excreta: defined by its ability to minimise contact between operator and excreta, speed of evacuation, capacity to evacuate all waste (liquid and solid) and capacity to transport material to a treatment plant
    c. For treatment: defined by level of treatment the effluent has received upon leaving the plant
    d. Technology: efficient utilisation of water resources in operation
4. Investment, operating, and maintenance cost
5. Design, construction, operation, and maintenance: refers both to locally available materials and skills to implement the technology (including ongoing operation and maintenance)
6. Accessibility
7. Range: relates to the distance between the sanitation facility being emptied and the disposal or treatment site
8. Surface area: amount of land required for the facilities
9. Water requirements: low or high
10. Availability of energy

Finally, Annexure B provides schematics of basic onsite domestic wastewater systems, highlighting conditions, advantages, and disadvantages of various technology options along the sanitation value chain. This information is useful for decision-makers in understanding how each technology works and being able to compare them side-by-side, similarly to the Compendium of Sanitation Systems by Tilley, Lüthi, Morel, Zurbrügg, & Schertenleib (2014). In the broad scheme, ISO 24521 also contributes to establishing a common language to be used by stakeholders in the sanitation sector.

2.2.5 ISO 31800

ISO 31800, *Faecal sludge treatment units – energy independent, prefabricated, community-scale, resource recovery units – Safety and performance requirements,* was published in 2020 and has not yet been adopted by South Africa. However, with the potential increase of faecal sludge management approaches in South Africa, it is likely that the standard will be adopted by SABS and provide useful guidance for implementation of new solutions. This standard focuses mainly on treatment units serving between 1,000 and 100,000 people, though similar principles can be applied to treatment units designed to serve smaller populations. The document aims "to ensure the performance, safety, and sustainability of community-scale resource recovery faecal sludge treatment units as well as technical robustness and safety in terms of human health and the environment." (ISO, 2020)

The document also aims to promote trust among different stakeholders with the goal of increasing willingness to implement innovative technologies. The document may be used by manufacturers and technology developers to gain consumer confidence in the reliability and safety of treatment units, and stakeholders can use the document as a benchmark to compare performance capabilities of different treatment options. Thus, this standard aims to support the uptake of innovative faecal sludge treatment technologies.

Specifically, the standard covers treatment units that:

a) Primarily treat faecal sludge,
b) Are able to operate in non-sewered and off-grid environments,
c) Are pre-fabricated,
d) Exhibit resource-recovery capability and are capable of being energy neutral or energy net positive.

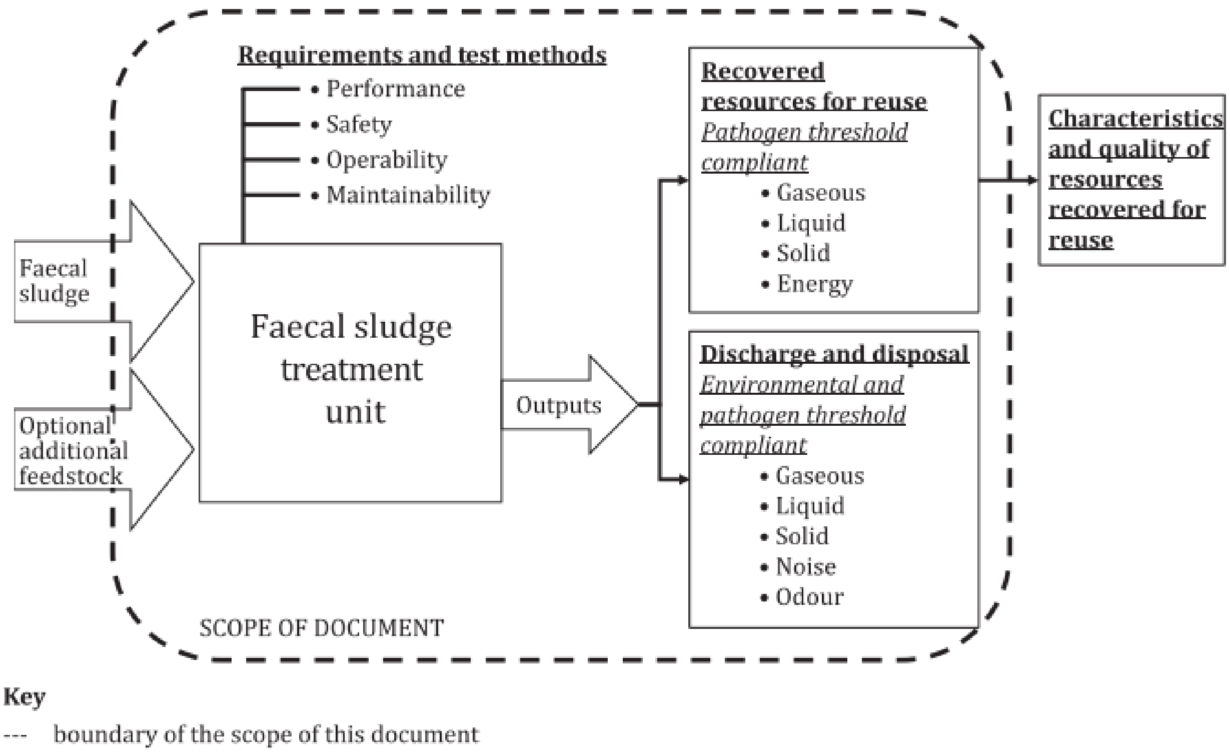


Figure 1: Scope of ISO 31800 (ISO, 2020)

While ISO 31800 does not explicitly cover technology selection, it provides a useful framework for decision-makers to assess the technical performance of faecal sludge treatment plants. Thus, an understanding of the contents of this standard and criteria used to determine the performance of a treatment unit can allow decision-makers to compare various options. Further, proven demonstration of performance at a level that meets the requirements of ISO 31800 can give stakeholders confidence in certain technologies.

2.3 Sanitation technology design guidelines and decision-making tools

Various documents have been prepared in South Africa and internationally that discuss sanitation alternatives and provide some decision-making guidance. A number of these tools are described below, with those emanating out of South Africa presented first, followed by those created elsewhere. These resources were reviewed for what they specifically say about selecting specific technologies for specific purposes. This includes pedestals, waterborne and dry systems, sludge and water end-use and treatment, and urine end-use and treatment. The discussion below provides a brief description of the tools and a summary of specific guidance provided.

2.3.1 South Africa: The Neighbourhood Planning and Design Guide (Red Book)

The Neighbourhood Planning and Design Guide, commonly known as the Red Book, was first produced in 2000 and then updated in 2019 to provide guidance to designers and planners on creating human settlements that are vibrant, safe, integrated, and inclusive (DHS, 2019b). The guide covers all aspects of human settlement design, including sanitation (Section K). The Guide takes designers and planners through the key considerations when selecting and designing sanitation systems, namely (DHS, 2019a):

1. Universal considerations: Regulatory environment, key objectives, development properties, available options
2. Planning considerations: Development characteristics; no. residents; existing features; available options
3. Design considerations: Available guidelines

The guide highlights the requirements for proper sanitation systems as demonstrated in the National Sanitation Policy (DWS, 2016). A sanitation system must meet the following requirements:

1. Sufficient: The water supply and sanitation facility must be continuous and sufficient for personal and domestic uses.
2. Safe: Facilities should be available for use at all times of the day or night, hygienic, safe from collapse, and wastewater or excreta should be safely handled.
3. Acceptable: Culturally appropriate and sensitive to gender, lifestyle, and privacy requirements
4. Physically accessible: Must accommodate the needs of all people, including the physically disabled, children, women, and the elderly.
5. Affordable: Must be available to all, even the poorest, such that sanitation services should not cost more than 5% of household income.

On the selection of a specific technology, the Guide says the following (DHS, 2019a):

> *A range of technology options is available, from dry onsite sanitation to centralised waterborne sanitation and wastewater treatment. The selection of the type of sanitation infrastructure or facility should be participative and based on the context, i.e. the preferences and cultural habits of the intended users, the capacity of the services provider (financial and skills), the existing infrastructure, the availability of water (for flushing and water seals), the soil formation (for groundwater and surface water protection) and the capacity of the applicable wastewater treatment methods. Maintenance, repair and eventual replacement of sanitation facilities need to be taken into account when selecting a sanitation system during the planning and design phases. As far as possible, facilities should be hard wearing, robust, durable and easy to maintain (i.e. without the need for specialist skills or equipment).*

In addition to addressing different contexts, the guide also discusses various types of sanitation systems, namely: household, shared, communal, and public. The guide then differentiates sanitation systems firstly as wet or dry and then by whether containment, transport, treatment, and disposal happen onsite or off-site. As such, the first consideration for technology selection is the availability and reliability of the water supply, as well as the consequences of using water in a sanitation system (DHS, 2019a). Table 3 and Table

4 are taken from the Sanitation chapter of the *Neighbourhood Planning and Design Guide* and present the various options for dry and wet sanitation technologies. The technologies listed encompass general technology options rather than specific manufacturers of these types of system (e.g. considering anaerobic digestion in general rather than specifying one of a number of manufactured products or construction approaches for achieving anaerobic digestion). The options listed in these tables also fall under different *types* of systems (e.g. some front end only solutions and some full treatment systems). This organisation of systems is not very helpful, as some of the options listed could be used together (e.g. low flush toilet connected to an anaerobic digester). The tables seem to communicate a list of options to choose from but does not highlight how different combinations of systems can be created. The Guide does not directly address a process for considering innovative sanitation technologies.

Table 3: Dry sanitation systems (DHS, 2019a)

Option	Containment		Transport		Treatment		Disposal	
	On site	Off site	On site	Off site	On site	Off site	On site	Off site
Ventilated improved single- or double-pit toilets (VIP/VIDP)	X		None		None		Either one	
Urine-diverting dry toilet (UDDT)	X		X		X		X	
Ventilated vault toilet	X			X	X (Solids)	X (Liquids)	Either one	
Continuous composting toilet	X		X		X		X	
Biological / electric toilet	X		X		X		Either one	
Anaerobic digester	X		Either one		X		Either one	
Unimproved pit toilet	These options are not allowed as permanent solutions in residential developments							
Bucket toilet								
Chemical toilet								

Table 4: Sanitation technology options using water (DHS, 2019a)

Option	Containment		Transport		Treatment		Disposal	
	On site	Off site	On site	Off site	On site	Off site	On site	Off site
Waterborne sewerage system	None			X		X		X
Low-flush toilet	Either one		Either one		Either one			X
Pour-flush toilet	X		X		X			X
Water recycling toilet	X		X		X		Either one	
Conservancy tank system	X			X		X		X
Anaerobic reactor	X		X		X		Either one	
Shallow sewer	None			X		X		X
Vacuum system	None			X		X		X
Low-flow on-site sanitation system (LOFLO): Aqua privy	X		Either one		Either one		Either one	
Small-scale septic with leach field system	X		X		X		X	
Pour-flush (use of a bucket to throw water for flushing purpose)	X		X		X		Either one	
Biogas digester	X		X		X		Either one	
Solids-free sewer system/ small bore sewer	X		Both		Both		Both	

Following the presentation of sanitation technology options, the Guide presents Design Guidelines for the various technologies, highlighting various options available for the design of each technology (e.g. construction materials). Section K.4.9 then describes options for upgrading different sanitation systems to better meet the users' needs. This section highlights incremental improvements that can be made to improve the sanitation service overall. When discussing upgrades to VIP toilets, the first point discussed is upgrading from a dry system to one with a water seal (i.e. waterborne system), demonstrating some preference for waterborne systems overall. The Guide then highlights introduction of urine diversion as another upgrade to make to a VIP system, as separating urine from the faeces will decrease odours emanating from the pit.

2.3.2 South Africa: WhichSan Sanitation Decision Support System (2009)

The WhichSan Sanitation Decision Support System was developed as part of a Water Research Commission Study to assist planners and engineers in considering the merits and costs of different sanitation solutions (Branfield & Still, 2009). The tool incorporates an MS Excel-based user interface, a user manual, and factsheets and drawings for the various solutions. The tool allows users to answer various questions about their specific situation, and the results page demonstrates the technical and financial feasibility of various sanitation technologies. The tool covers both sewered and non-sewered sanitation options. This tool, while thorough and useful, has not been continuously updated since 2009. It would be beneficial to revisit this tool and consider how it could be improved and disseminated in South Africa to assist decision makers.

2.3.3 South Africa: Household Sanitation Technology Assessment and Evaluation (2018)

The *Household Sanitation Technology Assessment and Evaluation Protocol* was developed by various sanitation experts, in consultation with stakeholders, to address some gaps in the regulation of the sanitation sector and to provide a framework for evaluating innovative sanitation technologies (WRC, 2018). While many sanitation technologies have been developed in recent years to address the many challenges in the sector, there has been a need for assessing whether these technologies were developed based on sound scientific principles and whether they function as claimed. This protocol, therefore, aimed to support decision-makers in their assessment of new technologies. The protocol's scope is onsite sanitation systems, excluding septic tanks and stand-alone package treatment plants.

The protocol includes the following elements:

1. Desktop assessment: definition of the technology, process design verification
2. Functionality assessment: laboratory analyses based on claims made by the technology developer (e.g. if it "produces a pathogen-free by-product", test for *E. Coli* in the effluent), assessment of process performance
3. Site performance assessment: visual inspection of a technology unit, ideally at an operational unit in the field; structural and mechanical performance
4. Context evaluation: in which contexts is it suitable?

The steps in the protocol are setup with a feedback loop. This allows the assessor to determine whether the technology passes the assessment step and decide whether to proceed with subsequent steps or provide feedback to the technology developer on where to improve the product. While this protocol was envisaged to be incorporated into official technology certification processes in South Africa, it has not been fully taken up. The tool was handed over to DWS, but around the same time, considerable energy was directed to the development of ISO 31800 and ISO 30500 (personal comm., Sudhir Pillay). It is hypothesised that this redirection of attention led to the slow implementation of the WRC assessment criteria that were developed. According to the Department of Water and Sanitation, there are plans to develop a digitised version of the assessment criteria along with a database of technologies that are evaluated by DWS, though this has not yet materialised (personal comm., Iris Mathye). The development of the protocol included an assessment of numerous innovative sanitation technologies developed in South Africa, thus providing a starting-point list of technologies available and their varying levels of readiness.

2.3.4 South Africa: Guideline Document – Package plants for the treatment of domestic wastewater (2009)

This guideline document was developed in 2009 as part of a WRC study on package plants, with the aim of assisting the Department of Water Affairs and Water Services Authorities (WSAs) when authorising and inspecting package plants and to assist package plant supplies and owners to understand their roles and responsibilities (van Niekerk, Seetal, Dama-Fakir, Boyd, & Gaydon, 2009). The guideline follows on a previous WRC study, which evaluated 3 specific package plants and provided more detailed technical background (Gaydon et al., 2007). The guideline document defines a package plant as follows (van Niekerk et al., 2009):

> *A package plant is any onsite, waterborne, domestic wastewater treatment system; whether it consists of one ore many modules; with a total capacity less than 2000 m^3/day. It typically includes equipment largely constructed and packaged off site and brought onsite for installation.*

The purpose of the guideline, as defined in Section 1.3 is

> *to set out minimum requirements for the installation, and operation and maintenance of package plants in South Africa, as well as to provide basic design criteria, so that developers and regulators can ensure the installation of appropriate designs for local climatic conditions; while at the same time achieving effluent compliant with the relevant water quality requirements; and encouraging the reuse of the treated effluent.*

The guideline covers various types of package plants, namely: activated sludge, trickling filter, submerged bio-contactors, rotating bio-contactors, anaerobic systems, pond systems, and constructed wetlands. After defining the various technologies, the document also discusses emerging treatment systems, thus acknowledging the continuous development of new technologies.

The guideline then provides an overview of the regulatory requirements for development, approval, and installation of package plants. In Chapter 4, the guideline provides an overview of minimum requirements for utilising a package plant. These minimum requirements provide a general idea of when package plants are an appropriate solution and which technologies should be considered. Best practices for design and installation of package are then summarised.

Overall, this guideline document provides a useful resource for designers and regulators involved in the implementation of package plants. Thus, the resource will prove useful once a decision-maker has opted for package plan implementation. The technical descriptions of the various types of technologies used in package plants can be used to narrow the options down to a specific set of solutions and manufacturers (i.e. activated sludge vs. anaerobic processes).

2.3.5 South Africa: Sanitation Technology Demonstration Centre at the CSIR

In 2011, the South African Centre for Scientific and Industrial Research (CSIR) established the Sanitation Technology Demonstration Centre in Pretoria, with funding from the Water Research Commission (WRC). The objective of the centre is to provide "practical and visual information on various sanitation technologies in order to bring to light technologies that support sustainable human settlements" (Mema & Sebake, 2010). This site is open to all stakeholders and the general public in order to generate better understanding, appreciation, and acceptance of alternative technologies. All technologies showcased at the centre were selected based on compliance with Department of Water and Sanitation policies.

Since 2011, the demonstration centre has hosted visitors such as ministers of various departments, municipal officials, and sanitation professionals. The centre has played a role in providing a physical demonstration of available technologies that may be able to address the various challenges faced by those visiting. However, without ongoing funding, the Centre will not be properly maintained and may thus provide an unrealistic perspective on technologies (R. Mbhele, personal communication, 6 June 2022). Similarly, updating the demonstration platform with new technologies will require investment, which is a similar challenge faced by the decision-making tools and documents presented previously. The CSIR is currently considering whether the demonstration centre is still relevant and important to the sanitation marker and service providers in order to determine the next steps.

2.3.6 International: Compendium of Sanitation Systems and Technologies (2008)

In 2008 the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) published the *Compendium of Sanitation Systems and Technologies*, which is widely recognized as an international guidance document for the sanitation sector, providing common language to practitioners across the world. The Compendium is a guidance document meant for engineers and planners in low- and middle-income countries (Tilley et al., 2014). The document references other available resources, including the eCompendium, which provides a digital version of the compendium. The compendium describes various technology options across the sanitation value chain and then presents nine system templates, which encompass the most logical combinations of technologies. Overall, the document provides a basis for terminology and an understanding of various system components that is utilised in many other tools and documents.

When discussing selection of the most appropriate system template, the compendium advises designers to attempt to:

1. Minimise redundancy
2. Optimise existing infrastructure
3. Make use of local resources
4. Account for the local enabling environment (especially skills and capacities, socio-cultural acceptance, financial resources, and legal requirements)

2.3.7 International: Sanitation Decision Support Tool

The Sanitation Decision Support Tool is a web-based interface developed by the Akvo Foundation, which assists decision-makers in selecting appropriate sanitation systems. The tool accounts for various site-specific variables such as: water supply, space availability, flood risks, groundwater table depth, terrain, access, soil type, and anal cleansing method to identify suitable and potentially suitable technology options along the sanitation value chain. The simple user interface makes it easy and quick to use to identify options, making it a good tool for decision-makers. However, the tool only allows selection of one simple chain of technologies for one waste stream, thus limiting the opportunities for comparing different options. Furthermore, the further development of the tool is contingent on further funding, which will limit its ability to remain up-to-date as new technologies are developed.

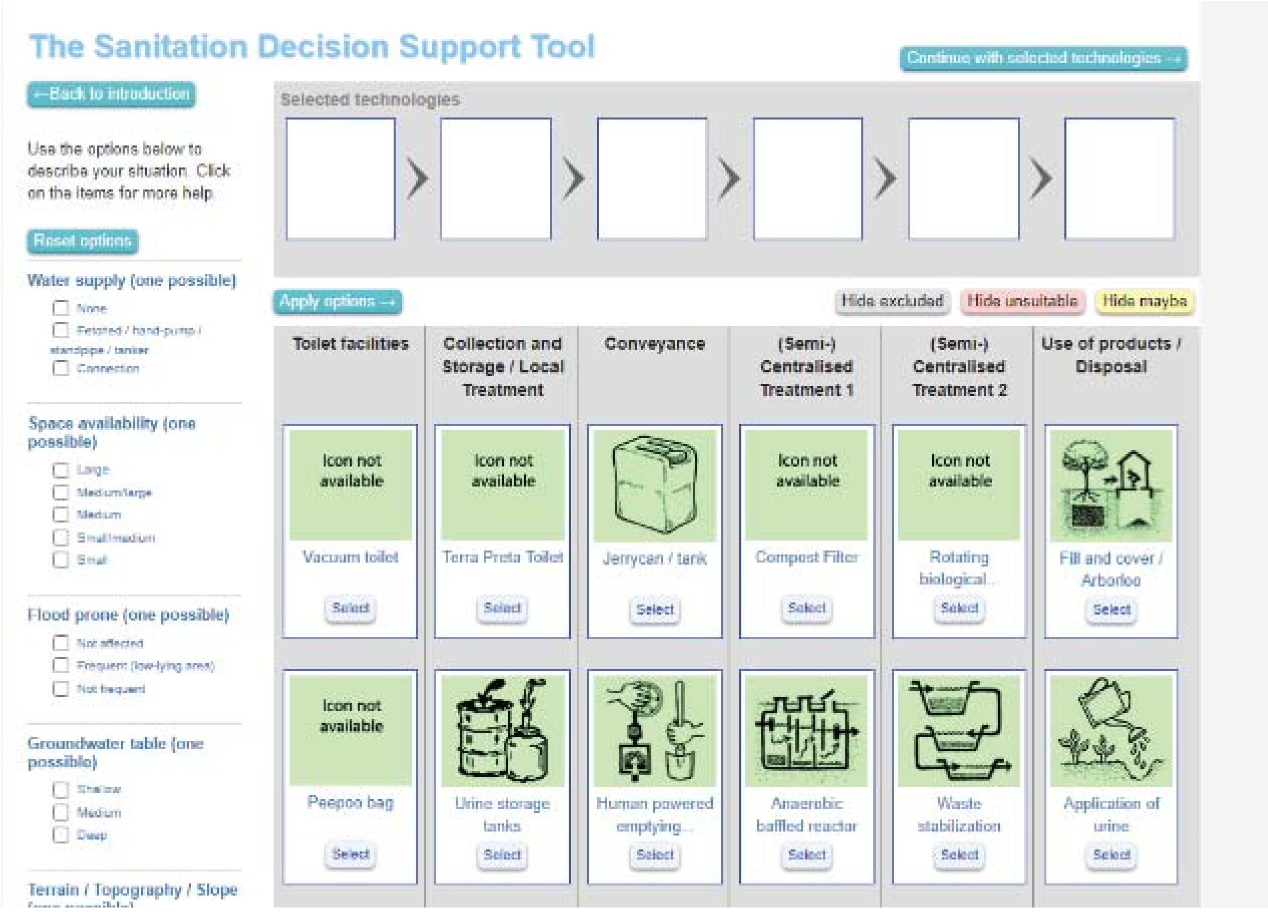


Figure 2: Screenshot of the user interface from Akvo's Sanitation Decision Support Tool

2.4 Other tools reviewed

In addition to the tools described above, useful tools have been created in India, namely, the *Integrated Urban Sanitation Decision Support Tool* (2014) and *A Guide to Decision Making – Technology Options for Urban Sanitation* (2008). For the sake of simplicity, details have not been provided here, but the documents are accessible online.

2.5 Conclusions

The literature review led to a few key findings. For one, South African Sanitation policy demonstrates a desire to incorporate innovative/alternative solutions to address sanitation backlogs and adapt to various constraints (e.g. water shortages). This policy position is clear at the national level and in some larger municipalities. However, the position is relatively broad and therefore difficult to implement in practice. Guidance for sanitation system selection is broad. One the one hand, the broad guidance creates room for alternative technologies. On the other hand, offering only broad guidance on technology selection requires the decision-makers to have a keen understanding of sanitation technologies and why they would or would not meet these broad criteria (e.g. how do I actually know this technology is *safe*?). While efforts are being made to standardise and certify new technologies (e.g. SANS 30500), the current resources used by municipalities do not necessarily create an enabling environment for utilising these technologies, even if they are certified.

There have also been many tools created to support technology selection, and these resources should be drawn on moving forward. Rather than reinventing the wheel, the current project should take existing resources and consider updating them to make room for new solutions and more applicable to the South African context. The work should also consider where there are gaps in the South African sanitation industry's knowledge of various sanitation systems available. For example, documents have been created that provide a common language for sanitation systems. However, has this language been adopted in the South African industry, specifically with government officials? Are practitioners and researchers speaking the same language as decision makers? If not, establishing this common language will be important for ensuring that there is a common understanding of how sanitation systems work in general and specifically. For example, understanding how and why incineration is an option for treatment of faecal sludge will empower decision makers to understand specific technologies that use this approach. This will allow them to do their own informed assessment of a technology based on its method/design.

3 Municipal Case Studies

3.1 City of Johannesburg

As presented during a meeting with Johannesburg Water, the City of Johannesburg has approximately 1,476,466 households, of which 183,000 are within informal settlements (F. Ramatsoele, personal communication, 27 September 2021). Joburg Water is the Water Services Provider for the City of Johannesburg. In informal settlements, Joburg Water primarily provides VIP toilets to each household (Level of Service 1) but also provides chemical toilets or flush communal ablution facilities where required. Joburg Water uses a ratio of 7:1 (households-to-toilets) for chemical toilets and a ratio of 10:1 for communal ablution blocks. Informal settlements that are not recognised by the City of Johannesburg Housing Department are provided with chemical toilets. In addition to providing basic services in informal settlements, the City also has an informal settlement upgrade programme in place.

Joburg Water's experience with sanitation is discussed in detail below.

3.1.1 Updating a sanitation policy

In 2021, City of Johannesburg's Environment and Infrastructure Services Department (EISD) appointed Wits University to assist them in updating their 2003 Sanitation Policy. The new policy addresses the entire sanitation value chain and was only in final draft form at the time of writing this case study. As stated in the policy, "the municipality will use appropriate, certified and accredited toilets and sustainable sanitation systems in the entire sanitation chain." "Certified and accredited toilets" refer to toilets that are licensed by the South African Bureau of Standards (SABS) and endorsed by the City of Johannesburg. This sets the path for the use of new technologies in the City of Johannesburg: SABS approval and endorsement by the City of Johannesburg.

The policy establishes various levels of service (LOS) for sanitation, which are an update from City of Johannesburg's 2018 Water Services and Sanitation Bylaws. The levels of service are defined by technology as well as permanence, shared or private, and location of the toilet system. The various levels of service as defined in the draft policy are shown in Table 5.

For levels of service above nominal sanitation (i.e. short-term, shared, free basic sanitation service), the policy lists at least two options to meet the given LOS, including one for non-sewered areas and one for sewered areas. Furthermore, each LOS generally lists “other sanitation service technologies”, which opens the options to those beyond a binary paradigm. For LOS 2 and 3 (individual yard or household sanitation, respectively), the policy states that decentralised treatment systems are encouraged in areas that are not connected to the sewerage system, and that septic tanks and conservancy tanks are permitted in areas that do not have access to the sewerage system and where geology and space permit. At the policy level, specified technologies are limited to those that are proven and that the City has a large amount of confidence in to implement.

In addition to setting standard levels of service, the policy takes a specific stance on innovation and research, similar to the National Sanitation Policy:

> *The Municipality will promote research and innovation that will promote the implementation of sustainable sanitation solutions. Such solutions should seek to reduce the use of limited resources, promote reuse, recycling and reclamation; and reduce the impact of sanitation services on environmental resources. Platforms that promote collaborative engagement between key stakeholders for innovative sanitation research, should/will be promoted by the Municipality.*
>
> -City of Johannesburg Sanitation Policy Draft (2021)

The City of Johannesburg’s Sanitation Policy provides a good basis and outline for other municipalities aiming to set their sanitation policy. It is specific without being limiting, and it includes a broad view of sanitation beyond just toilets. These principles should be used to guide creation of sanitation policies in municipalities across South Africa. Furthermore, with increasing innovation in the sanitation sector, once sanitation policies are drafted, they should be regularly reviewed (at least every 5 years) to make room for new technologies that have been proven. It is interesting to note that the large municipality appointed an external consultant (Wits University) to draft the new sanitation policy. If a large municipality with technical capacity like the City of Johannesburg requires an external consultant to carry out this task, it can only be assumed that smaller, less-resourced municipalities would require the same, if not more, input from outside consultants.

Table 5: City of Johannesburg sanitation levels of services (Ilemobade, Nathane-Taulela, Dlamini, Roux, & Ngobeni, 2021)

Level of Service	Sanitation option(s)	Description
Nominal sanitation	1. Chemical toilets 2. Other appropriate dry sanitation service technologies	• A short-term, shared, free basic, sanitation service that is provided to communities at a ratio of not more than 10 households to 1 toilet. • Satisfies the minimum standard for basic sanitation services.
LOS 1: Shared sanitation	For areas that are not connected to a sewerage system: 1. Dry toilets (e.g. VIP latrines) For areas that are connected to a sewerage system: 2. Flush (e.g. low-flush, pour flush) toilets 3. Other sanitation service technologies.	• A shared, free basic, sanitation service that is provided to communities at a ratio of not more than 10 households to 1 toilet. • Satisfies the minimum standard for basic sanitation services.
LOS 2: Individual yard sanitation	For areas that are not connected to a sewerage system: 1. Dry toilets (e.g. VIP toilets and composting toilets) For areas that are connected to a sewerage system: 2. Flushing (e.g. low flush, pour flush) toilets 3. Composting toilets 4. Other sanitation service technologies (e.g. UD toilets)	• An enclosed structure located on a property and separate to the structure where the household resides. • Satisfies the minimum standard for basic sanitation services. • Decentralized treatment systems for this LOS is encouraged for areas that are not connected to a sewerage system. • Authorisation for septic tanks and conservancy tanks will be permitted in areas that do not have access to a sewerage system, and for which geology and space permit.
LOS 3: Individual sanitation connected to dwellings	1. Low flush toilets 2. Composting toilets 3. Other sanitation service technologies (e.g. UD toilets) 4. Full waterborne sewer connected to a municipal sewer	• One or more drainage installations per property, within the structure where the household resides. • Satisfies the minimum standard for basic sanitation services. • Decentralized treatment systems for this LOS is encouraged for areas that are not connected to a sewerage system. • Authorisation for septic tanks and conservancy tanks will be permitted in areas that do not have access to a sewerage system, and for which geology and space permit.

3.1.2 Innovation unit

The City of Johannesburg's value for innovation is practically carried out through the Innovation and Technology Unit within Joburg Water, which aims to find solutions to problems and improve and optimise operation. While the specified levels of service above are based only on proven technologies, the innovation unit investigates alternatives. In an interview, the Innovation and Technology Manager described the way in which technologies move from the innovation to implementation phase. These steps are summarised below:

1. **Demonstration platform**: The technology is demonstrated through piloting, as in the current arrangement with the Water Research Commission for testing innovative NSSS. This phase will confirm the *technical* success of the operation. Are treatment objectives achieved? Does the system do what it is supposed to do?
2. **Longer-term assessment of community-related aspects**: This phase would include assessment of the technology and whether it can operate reliably within the community on a long-term basis. This phase would help determine the *appropriateness* of the technology, given the specific challenges faced in different communities (e.g. vulnerability to theft). Overall, the system is assessed in terms of how well it withstands the stresses of regular use.
3. **Financial feasibility**: If the technology is found to be technically suitable and appropriate for the context, a feasibility study would be done looking at the *financial viability*.
4. **Implementation:** If it is found to be financially viable and a worthwhile investment, the technology may be escalated to the Joburg Water leadership where a decision is made on whether the technology should be approved for consideration in future infrastructure planning processes.
5. **Incorporation into supply chain processes**: If the technology is considered suitable for potential future use, consideration is given as to how supply chain processes will apply to its procurement (for example, technologies requiring service contracts would require special consideration).

3.1.3 VIPs/Conservancy tanks and high emptying costs

Joburg Water expressed challenges around the high cost of regular emptying of onsite sanitation systems in informal settlements. As mentioned above, VIP toilets are considered the "Level of Service 1" for households and are implemented at a wide scale. The pits provide 3 m^3 of storage and are emptied at least every 3 months, with some requiring emptying every month. Upon further discussion, it was established that the VIP toilets used in Johannesburg are all **sealed** compartments. By definition, a VIP should consist of a lined pit with *open joints* that allow sludge to decompose over time and liquids to infiltrate into the soil and receive natural treatment. VIP pits have a maximum filling rate of approximately 60 litres per person per year. Thus, a 3-m^3 VIP toilet that serves a family of 5 should only require emptying after 10 years. A conservancy tank, on the other hand, is a sealed container that requires regular emptying. The technology given the name VIP in Johannesburg is closer to a conservancy tank by definition. This experience of providing frequent emptying has led Joburg Water to look more seriously at waterborne options, due to the assumption that the life cycle costs will be significantly lower than emptying every 1-3 months.

> *The VIP can be cheaper in terms of initial capital, but over time, because we need to maintain the desludging that goes with it, it's more costly. The total life cycle cost can prove to be much, much higher compared with waterborne. So the direction we are investing in is to*

> *divert our attention more towards waterborne sanitation or other off grid sanitation technologies especially for informal settlements that are being upgraded under the Upgrading of Informal Settlements (UISP), but have not yet been finalised in terms of the township establishment*.
>
> – Senior Manager for Engineering Services Unit, CAPEX, Johannesburg burg Water

The sealing of VIP pits is due to a conservative interpretation of guidance from the Department of Water and Sanitation on preventing pollution to groundwater from sanitation systems. This rationale was described by a Programme Manager from Joburg Water:

> *Most of the VIPs, the way that they were designed from 2015 onwards, because we have certain sites very close to areas that have underground water or the ones that are using privately-owned areas where they have their own water sources. We prefer to then have a substructure that is either sealed or, in high water table areas, comes together with 350-micron plastic… We also had a discussion with DWS, whereby they did request us that we need to be aware of certain regulations within the water sector. So, we then decided that going forward we would then use a certain substructure and then we would use different sealants within our VIP substructures.*
>
> - Programme Manager in the Project Management Unit, CAPEX, Joburg Water

This situation points to a few key lessons, described below:

Oversimplification of the Department of Water and Sanitation's Groundwater Protocol can lead to oversimplification of sanitation technology selection.

The second edition of the DWS *Groundwater Protocol* ("Protocol") stated that the first version was applied by different agencies with varying levels of skills and understanding, thus resulting in questions as to whether the protocol was effectively protecting groundwater sources and the health of communities (DWAF, 2003). The information was perhaps too complex to be successfully applied. On the other hand, it was clear that the *Protocol* was being used to discount perfectly adequate appropriate technology options for onsite sanitation in favour of costly waterborne sanitation systems that ultimately may pose a more severe threat of pollution and higher financial burden. The updated *Protocol* (2003) therefore outlines a more nuanced approach to determining the vulnerability of groundwater resources. The *Protocol* further outlines special adaptations that can be applied to sanitation systems to reduce contamination (Part 3). In this way, the *Protocol* aims to keep the options open while ensuring that the environment and public health are protected.

The process outlined by the *Protocol* requires a site-specific assessment of groundwater vulnerability, which is not only determined by the depth of the groundwater table, but also soil type, aquifer usage, and other pollutant sources (DWAF, 2003). Among many in the sanitation sector, the *Protocol* has rather been applied more generally to rule out cost-effective, dignified sanitation options in favour of more conservative options with a high O&M burden. While sealed systems may be required in parts of Johannesburg, it is unlikely that this requirement would apply to most areas if the principles of the Groundwater Protocol were correctly applied. This oversimplification has led to widescale implementation of an extremely conservative system and a major financial burden to the city. It has further led to general dissatisfaction with a technology that may be appropriate in certain circumstances.

Improper identification and naming of technologies can lead to confusion and inaccurate assessments.

In this case, assigning VIP as the name of what is really a conservancy tank system creates a confusing understanding of the *processes* that govern the two technologies. While a VIP toilet achieves sustainable operation through the combined processes of decomposition and infiltration, a conservancy tank system is only sustainable if regular emptying and servicing are provided. Each system may be appropriate in specific areas, but misnaming them can confuse their implementation, particularly when sharing lessons learned between colleagues and across municipalities.

In a similar way, the term "pit toilet" has been used when describing "ventilated improved pit toilets (VIPs)". These are not the same, as a VIP provides a pit lining and reinforced concrete slab to improve safety and incorporates a vent pipe to reduce odours. By calling VIPs "pit toilets", an appropriate and safe technology is lumped in with home-built pit toilets that have been constructed by households and institutions as an emergency response to a lack of service provision. This points to the importance of establishing a common language for describing systems as well as an understanding of the processes that govern them.

3.1.4 Package plants guideline

Johannesburg Water approved the *Guideline for the Installation of Privately Owned Package Plants for Domestic Sewage Treatment* ("Guideline") in 2014, which was largely based on the 2009 DWS Guideline Document (van Niekerk et al., 2009) but with more emphasis on the role of the Water Services Provider. The Guideline is aimed at developers, professionals, property owners, and treatment plant suppliers that want approval from Johannesburg for installation of a package treatment plant. This guideline applies to onsite wastewater treatment systems that have a capacity of less than 2,000 m^3/day. The Guideline only permits alternative sanitation systems (e.g. package plants) in areas where waterborne sewer systems are not available, establishing a preference for full waterborne sanitation. Furthermore, in terms of hierarchy of decision-making, package plants are considered a last resort, behind septic tanks and soakaways, extensions to the sewer network, and conservancy tanks.

The Guideline provides guidance on plants intended for water recycling, and this guidance restricts the implementation of innovative non-sewered sanitation systems that aim to treat blackwater to a level appropriate for recycling (e.g. for flushing). The Guideline states that only greywater processing is permitted for the purpose of water recycling, and this is restricted to a single property. These restrictions are likely in place due to the lack of standardisation and regulation of package plants up to this point. However, as more innovative systems are being designed and implemented, regulation of the sector is expected to improve. This restrictive guidance could be updated to include allowance for SANS 30500 certified technologies that meet requirements for recycling water for flushing.

City of Johannesburg is currently working on an updated Guideline document to look at a broader range of issues around sanitation provision. The main gaps in the current Guideline, as identified by Joburg Water are:

1. No list of specific technologies currently available on the market
2. A lack of technology options for informal settlement contexts
3. A lack of clarity on how technologies are evaluated for potential use by Joburg Water. It was noted that there is an issue with a lack of detailed information available for many systems.

This new document will consider the factors involved in selecting different technologies, and a "Green Drop" approach is being proposed to assess package plants. While the 2014 Guideline provided a basis for assessing the *technical* performance and viability of technologies, the current document will need to address the many other factors that influence success, such as vulnerability to theft, robustness, odour control, and sludge disposal, among others. It was noted that Joburg Water has a strong interest in the selection of suitable package plant systems and the target audience for the guideline is not simply private developers looking to select a suitable system.

In general, the Technology and Innovation Manager at Joburg Water expressed a desire to look at the issue of sanitation provision in a more multi-faceted manner than is typically done. They require assistance with weighing their priorities and selecting technologies that are appropriate for specific contexts. Above all, the goal is efficient, sustainable service delivery, and that is the lens through which most aspects are viewed.

3.1.5 Priority for revenue generation

Water services providers must make the business work. Therefore, consistent revenue generation is key. The discussion above about implementation of package plants reflects a general prioritisation for solutions that contribute to revenue generation. This was expressed during an interview with the COO of Joburg Water: "…there is a view that [package plants] might affect the revenues for the various cities." Further to this point, the COO from Joburg Water highlighted that private package plants serving small communities are operated and maintained by the owners of the system. As these are private areas, this limits the provision of services by the City, which reduces the City's revenue. It should be noted that most cities cross-subsidize the cost of wastewater treatment from water sales, which means that any wastewater treatment system which is privately operated should save the city money, even if there is no income to the city for that treatment.

In another discussion with Joburg Water, it was again communicated that the primary way that Joburg Water (and other municipalities) generates revenue is through sale of water and provision of sewerage services. However, as mentioned by the Manager for Technology and Innovation, effluent reuse and sludge beneficiation could also be sources of revenue generation. **For non-sewered sanitation systems, particularly those with high capital costs, to be considered competitively, the potential benefits of effluent reuse and sludge beneficiation would likely need to be emphasised and communicated in terms of revenue.** Furthermore, areas receiving free basic services do not contribute to revenue generation. Therefore, decisions are often made with the primary objective of *reducing costs* of operation as a way of increasing revenue. In this way, solutions with low operating requirements would be prioritised.

3.1.6 Alternative sanitation projects

Joburg Water is considering alternative sanitation technologies to replace VIP toilets and chemical toilets. A pilot was carried out at Diepsloot, testing the Biomite Recycling System, in which flush toilets were installed with a treatment system to treat the water to a suitable level for flushing. The system is powered by solar panels. During the testing, components from the ablution blocks were stolen and the system therefore failed. This issue has become a focus area for testing the robustness of new technologies, particularly when thinking forward to a possible scenario of rolling out multiple decentralised systems in informal settlement contexts.

Joburg Water is currently partnering with the WRC to pilot two additional non-sewered sanitation systems: the Clear Water Recirculation System and the NEWgen System. These systems each consist of a flush system with onsite treatment to allow for water recycling for flushing. Joburg Water plans to test for 9 months before taking these systems to other parts of the city. After the monitoring period, Joburg Water will take ownership of the system and provide cleaners, caretakers, and security. It will be treated as the communal ablution blocks connected to sewer are treated currently. To ensure success, Joburg Water would also have to consider plans for ongoing maintenance of these decentralised treatment systems.

As noted above, the majority of systems currently implemented by Joburg Water are conventional waterborne sanitation, conservancy tanks (referred to by Joburg as VIPs) and chemical toilets. It was noted that the availability of proven alternatives is a significant issue.

Joburg Water's interest in these alternative systems is somewhat informed by ground conditions as there are areas with high groundwater tables as well as dolomitic areas. The other driver for alternatives is the desire to reduce the operating costs associated with frequent emptying of conservancy tanks (VIPs). Johannesburg is also experiencing high population growth, which may also trigger a need for non-sewered sanitation systems in areas beyond the sewered boundary.

3.1.7 Tender process for turnkey sanitation pilot project

Johannesburg Water's Diepsloot pilot sanitation project was initiated in 2012 through an open-ended tender process for a turnkey pilot project. The turnkey approach meant that tenderers were required to provide both design and installation of the system. Thus, those submitting proposals were technology providers who would then subcontract a contractor to install the system if necessary. This differs from typical sanitation tenders, which are generally construction focused. According to the Request for Proposals (RFP), "The project entail[ed] the procurement of turnkey services for the construction of a closed-circuit sewer system."

> *The scope of work entails the construction of one stand alone, full waterborne sewer system complete with ablution blocks to cater for male and female users. The system has to focus on turning human waste into reusable water (for flushing purposes only) through the process of anaerobic water treatment. It will also include the construction of a chamber/s for solids to settle and the anaerobic treatment process to take place, construction of access manholes, provision of pumps, construction of a storage tank, provision of electrical works (solar power may be used) and connections to existing water supply for hand wash basins.*
>
> -Johannesburg Water Request for Proposals 10063

The service provider was given the task of providing detailed drawings for the proposed system. The evaluation of offers was based on the financial offer and preferences, considered separately. The technical proposal was evaluated first and only those that met the minimum requirements were further evaluated. The criteria for technical evaluation included:

1. Availability of key (major) plant and equipment (weighting = 5)
2. Contract programme (weighting = 5)
3. Approach and methodology (weighting = 10)
4. Qualifications of key staff (weighting = 10)
5. Adequacy of key staff for the assignment (weighting = 10)
6. Experience with similar projects (weighting =20)
7. Proposed stand-alone structure in line with specification (weighting = 10)
8. Presentations to evaluators (weighting = 30)

The aim of this request for proposals was to open opportunities for a variety of sanitation technologies that may be able to address their specific challenges, namely: high water table areas, congested areas, rocky areas, and dolomitic areas (Joburg Water, personal comm.). Members of the Engineering Services Unit (ESU) were asked about what types of responses they got to this RFP. Thirteen service providers submitted proposals, and submissions included dry and waterborne sanitation technologies. According to the ESU, some of the submissions did not qualify because they were not considered to be sufficiently established technologies. The representative from the ESU said, “We were looking for technologies that were already existing, that have been tested, or are currently in the testing stage so that we can take them on and see how their performance is.” Thus, even though Joburg Water was interested in piloting new options, it was still important that the technology developer(s) had already done some work to test and prove their technology.

When asked about the turnkey approach and its applicability for future similar projects, the Senior Manager for the ESU highlighted the value of it:

> *I think for me the turnkey arrangement would be more appropriate instead of separating liabilities. Because the person who is providing technology must be responsible in terms of assembling it and also making sure that…it performs well even after construction and so on. So, separating it comes with liability issues where the supplier might end up saying, ‘No, it was because of your contractor who didn’t assemble things in terms of specifications.’ So, a turnkey would be the best way for us.*

While this process was undertaken for a pilot project, Joburg Water has yet to carry out a similar process for widescale implementation of alternative sanitation technologies, and some of the concerns are discussed in the next section.

3.1.8 Procurement concerns

As mentioned above, implementing new technologies at scale requires a process of demonstrating and proving their feasibility. The turnkey pilot process would feed into this process, but the representatives from Joburg Water expressed concern and uncertainty about how to move from the pilot to larger scale implementation, in the event of successful pilots. Most of their concerns centred on ensuring fair procurement processes and not favouring specific technologies. Some excerpts from the discussion with them are provided below:

> *In terms of procurement, we all know, inasmuch as we may all favour a certain technology, but the issue around…going out to tender and specifically targeting a specific supplier, that's where our biggest challenge is. For example, the one [pilot project] in Mofolo. Suppose all the tests and implementing [are] done successfully, but now to go out specifically to target that specific technology, it might be a challenge. That's one thing I've been thinking about. Yes, we've got various pilot studies. How are we going to work around our procurement and avoid branding? And this is…where we expected your input and guidance to assist us as Joburg Water.*
>
> – Senior Manager, Engineering Services Unit

> *When you pilot it in a specific area and it's working well how do you then say to the rest of the market, 'I'm only going with this one because that's the one I piloted.' Because they might come back and say, 'But you never gave us an opportunity to pilot ours.' How do we go to full scale with whichever systems we've piloted? That might be our constraint.*
>
> – COO, Joburg Water

> *What then is the relevance and purpose of all the piloting is if you might go out to tender and attract another supplier as opposed to the one which you prefer out of the 3 which you have piloted.*
>
> -Senior Manager, Engineering Services Unit

In response to these concerns, the researchers asked about whether there was an option to use the sole supplier option for innovative systems. However, it was confirmed by the COO that defining a sole supplier is very difficult, as a sole supplier means that only one supplier manufactures or renders goods and services due to the unique nature of the requirements. In the case of off-grid sanitation systems, there are many different suppliers.

Another individual from Joburg Water suggested that the upcoming ISO 30500 regulations may restrict participation of different suppliers in the sanitation sector.

> *…within our agreement with WRC, they also have an agreement with Bill and Melinda Gates Foundation, and we are trying to follow the ISO 30500 regulations as well. So, part of those challenges we are having is that most of our service providers may not be aware of the ISO 30500. [If] they are with the WRC and are aware of what the Bill and Melinda Gates Foundation are doing, then we might be able to get a bigger pool of suppliers.*
>
> -Project Manager, Project Management Unit

The representatives of Joburg Water highlighted the fact that most suppliers are unaware of ISO/SANS 30500, because the standard is still new worldwide and the infrastructure and processes necessary to implement it in South Africa are still being established. The concerns expressed here emphasise the importance of awareness-raising on the standard once testing capacity has been established and made available. However, it must also be stressed that ISO/SANS 30500 is not intended to be used as a default standard, or used universally, but only at those sites where effluent cannot be disposed of onsite through conventional means such as a soakpit. Thus, testing methods and protocols for systems that do not fully meet ISO/SANS 30500 are also important.

3.1.9 Key lessons from the City of Johannesburg

The key lessons from the City of Johannesburg case study are summarised below:

1. A sanitation policy serves to explicitly lay out a municipality's stance on appropriate sanitation systems for different contexts. It can be written in a way that either encourages or limits innovation.
2. Using correct terminology to describe sanitation systems is important, and sanitation professionals must understand the operating principles of different technologies to avoid blanket rejections of appropriate solutions.
3. There is a need for a more widespread understanding of the nuances of the DWS *Groundwater Protocol*, so that it is applied as written to specific project circumstances.
4. Revenue generation is one of the municipality's primary aims, to ensure that they can keep running. For this same reason, in communities with free basic services, the primary aim is cost reduction. Alternative sanitation solution suppliers should look for ways to incorporate revenue generation or cost reduction to make these solutions more attractive.
5. There is a gap between piloting innovative systems and later procuring them for municipal implementation. Even though the City of Johannesburg is open to innovative solutions, it is uncertain how to procure solutions that are piloted by the City without violating the PFMA.

3.2 eThekwini Municipality

eThekwini Municipality serves a population of 3.8 million, and the eThekwini Water and Sanitation Unit (EWS) is responsible for water and sanitation delivery. The municipality has many different settlement types, including city nodes, suburbs, densely populated informal settlements, and rural settlements. eThekwini developed a Shit Flow Diagram in 2016, which shows that overall, 42% of households are served by onsite sanitation. Faecal sludge from nearly two thirds of those households is contained. This includes households that are served by one of the following: urine diverting toilets, VIPs, septic tanks, or conservancy tanks. Faecal sludge from the balance of those households is not contained, which means the households are served either by unimproved pit latrines or by no system. (L. Zuma, personal communication, 27 September 2021).

Some of the key characteristics and lessons learned from document review and engagements with representatives from eThekwini Water and Sanitation are summarised below.

3.2.1 eThekwini's sanitation policy

eThekwini's Sanitation Policy was published in 2021 and was a step forward from the 2012 *Policies and Practices of the Water and Sanitation Unit*, as it distinctly addressed sanitation. Similarly, the updated Water Policy for eThekwini was published in 2021. The policy separates sanitation provision into the following three categories, defining technology options and processes for each (eThekwini Municipality, 2021):

1. Conventional Sewerage, rated properties
2. Onsite Sewage Disposal, rated properties
3. Free Basic Sanitation

All options for onsite disposal in rated properties require approval from the council, and the options available include septic tanks, conservancy tanks, low volume treatment systems (i.e. package plants), and greywater reuse systems. Free Basic Sanitation is met by household waterborne sanitation, communal ablution blocks, or urine diverting double-vault toilets (UDDTs). Waterborne sanitation is given priority wherever a metered water connection exists. This demarcation simplifies the municipality's planning for sewerage provision or emptying of onsite systems, as each area has a specific type of sanitation system. The policy states that no new VIP toilets may be constructed, but the municipality has a target of emptying existing VIP toilets every 5 years. Community Ablution Blocks are implemented in informal settlements, and these are typically connected to the municipal sewer, or in a few cases are VIPs.

Emptying frequencies for UDDTs and VIPs are prescribed in the policy, specifying every 2 years for UDDTs and every 5 years for VIPs. However, in conversations with a senior engineer at eThekwini, implementing these emptying programmes is more complicated. It takes much longer to get approval for emptying contracts and appointing contractors than it should, which means that the toilets are not emptied as frequently as they are meant to be.

The policy does not cover innovation or research, and the only mention of sanitation alternatives is with regards to package plants for treatment of low volumes (<2 Mℓ/day). This is a significant omission, given the fact that eThekwini Municipality has been engaged for many years in a number of innovative off-grid sanitation pilot projects with international partners. Despite pilot projects carried out in recent years, no new sanitation systems have been implemented at scale in eThekwini since the initial roll out of UDDTs, until recently. Despite the omission of explicit language on innovation in the policy, in practice, eThekwini is regularly implementing innovations. At present, a new DEWATS plant is under construction, and there is also an alternative sanitation project that is currently in the pilot phase and is envisaged to be rolled out at scale (see below).

One aspect to highlight in the policy is that it states that the "policy is to be reviewed annually." Annual review of the policy requires capacity for such review and a prioritisation of this review. It is a high target to reach, but it also ensures that the sanitation policy can remain progressive as new developments are made in the sanitation sector. For example, if the new alternative sanitation pilot project (described below) leads to successful solutions, the policy can be revisited to include the successful solution as an option for free basic sanitation provision.

3.2.2 Supplementary guidelines

The policy also refers to several supplementary guidelines on approval of alternative sanitation systems, which are available on the eThekwini Municipality website: *Guideline for Design and Approval of Onsite (subsurface) Disposal of Domestic Sewage*; *Guideline on Low Volume Treatment Systems*; and *Guidelines for the Submission of Alternative Onsite Waterborne Sanitation Systems*.

The first document provides a guideline for the design and approval of onsite disposal of domestic sewage, including septic tank and soakaway design and the process of approval.

The second document states that the implementation of package plants is to be guided by the Department of Water Affairs/Water Research Commission guideline document, "Package Plants for the Treatment of

Domestic Wastewater" (van Niekerk et al., 2009). Implementation of privately owned package plants also requires a service agreement for providing operational control, monitoring and maintenance over a 5-year period after installation. Finally, the document states that treatment plants discharging to a watercourse prove that the effluent meets the General Limit Values.

Finally, the third supplementary document presents a policy on the submission of alternative water and sanitation related products and systems. The inclusion of this policy creates a starting point for an enabling environment for the uptake of innovative solutions. The first position stated in this policy is that EWS will not undertake product testing on behalf of a private organisation, and if insufficient testing information is available the technology will not be authorised. The policy sets out a process flow diagram for assessing and approving new technologies based on the following aspects (eThekwini Municipality, 2012):

1. Description of product
2. Visual inspection product
3. Compliance with SABS 0400
4. Scientific and/or statistical detail and description of operation
5. Servicing requirements
6. Practicality of use
7. Robustness and materials
8. Construction, installation, specification and requirements

A given technology must satisfy all of the above requirements to be accepted by the municipality. A detailed list of information, data, and support material that technology providers must provide to satisfy the above requirements is included as part of the policy.

Due to the risks associated with new sanitation technologies, this assessment is very thorough. While this may be limiting for some technology developers due to the investments required to adequately test and certify a new technology, the detailed list of requirements gives the municipal official a specific set of requirements to judge a technology by. It also gives the technology developer a clear understanding of what is required for their technology to be accepted. The clear stance taken in this policy demonstrates the Municipality's understanding that new solutions are required and also their desire to ensure that innovation does not put sanitation users at risk.

The inclusion of these supplementary documents highlights the reality that defining policy positions can lead to the need for more documents and guidelines to be drafted to enable municipal officials to comply with the policies. Thus, if a municipality is interested in drafting a policy, they must also know that certain other documents may be required. In some cases, a national guideline document is available (e.g. DWS *Guideline on Package Plant Treatment Systems*), but establishing a municipal guideline is also advantageous for reflecting the specific processes and structures at the municipality.

3.2.3 Lessons from innovative sanitation projects

eThekwini Municipality has been involved in numerous innovative sanitation projects, and some of these are described below.

3.2.4 Urine-Diverting Dry Toilets

Urine-Diverting Dry Toilets (UDDTs) were rolled out in eThekwini from the early 2000s in rural areas. In total, approximately 85,000 have been installed, and they are still being built in communities receiving free basic services. This technology was innovative for its time.

3.2.5 Low Flush Toilets in Social Housing Project

In 2014/2015, pour flush toilets were constructed for a small number of homes as part of a social housing project, but were not at the time replicated on a wider scale because of political problems. As confirmed by Dave Still of PID, pour flush toilets were agreed upon by all stakeholders prior to project commencement as an acceptable solution, but once the project was implemented, political pressure was brought to bear for full waterborne sanitation. From this experience and experiences with successful pour flush projects elsewhere, it can be concluded that where households expect an onsite system like VIP or UD toilets, pour flush toilets are an acceptable option, but where households have some reason to expect full waterborne systems (e.g. proximity to other communities with sewers), they may reject pour flush toilets as an option. Another lesson from this experience for eThekwini was to include cisterns with low-flush toilets, even if they are not connected to the water network (see below).

3.2.6 Innovative Non-Sewered Sanitation Systems

eThekwini has been involved in several test projects on innovative NSS systems, mostly funded by the Bill and Melinda Gates Foundation and the Water Research Commission. In partnership with the University of KwaZulu-Natal (UKZN) and a local engineering firm, eThekwini has been involved in research around the appropriateness of these systems, which has provided eThekwini with some level of international renown. When asked about the potential for implementation of these high-tech systems at scale throughout the municipality, a senior eThekwini engineer said,

> *At the municipality because we're the ones who do maintenance and everything else associated with any system we provide under Free Basic Services… it's the simpler the better. If you have 1000 of the [reinvented toilet] systems, as technical as they are, all over eThekwini, I don't see it being feasible for O&M from a municipality. It is something that could be done with a different model than what we currently have. The O&M of already installed systems is costly for the Municipality.*

In this way, the engineer took the same stance as the policy described above: low-volume treatment systems are reserved for private, rate-paying properties. She then further stated that the Municipality is already struggling with what they have (existing wastewater treatment plants and onsite systems that need emptying) and adding complex treatment systems across the city would be outside of their capacity. This highlighted the primary concern of the municipality around having capacity to maintain the systems that they install.

The engineer was asked about different potential arrangements for maintenance, either through service contracts or capacity building of municipal teams. One issue expressed by another individual from eThekwini Municipality during the consultations was a concern that using a specific technology that requires specific skills to service could potentially lead to the municipality being held to ransom, as the supplier could continue to raise their prices because they know that they are the only ones who can do the job. For this reason, they prefer technologies that are more general and can be serviced by a variety of people with standard plumbing or conventional plant operation experience. As an alternative, the engineer was asked about the potential of the technology supplier being required, in their supply contract, to provide training and operational manuals to individuals at the municipality so that the maintenance could be done in-house. However, she then expressed again that having many small plants scattered across the municipality simply is unfeasible, as they have too little management capacity.

3.2.7 Decentralised Wastewater Treatment Systems (DEWATS)

eThekwini's water and sanitation unit, in partnership with UKZN and BORDA, has been engaged in the testing of Decentralised Wastewater Treatment Systems (DEWATS) since 2009. Since 2009, eThekwini and BORDA have had a signed Memorandum of Agreement (MOA) to explore the feasibility of DEWATS for various applications within the municipality. DEWATS systems can use various treatment processes, but they generally aim to achieve wastewater treatment through low-energy and low-maintenance systems, such as constructed wetlands and anaerobic filters. A DEWATS plant was constructed in Newlands Mashu in eThekwini in 2009 and subsequently served as a demonstration plant and research facility for UKZN students and eThekwini. In addition to the Newlands Mashu plant, there is a DEWATS serving a school and community ablution blocks in Frasers, Tongaat.

Since then, no new DEWATS have been constructed in eThekwini, despite growing interest, even internationally, in the approach. This is largely due to hurdles associated with new technologies being adopted and existing stringent approvals processes.

An engineer who has been involved in the DEWATS development in eThekwini was asked about how new technologies can move from pilot to project scale. Using the DEWATS system as an example of the hurdles that exist for new technologies, the following explanation was provided:

> *I'm tempted to say the willingness of the municipality. But… we've been willing. It's just in some areas the processes are so difficult for innovative work to be absorbed within the municipality. It takes a lot of time, a lot of effort, which probably people won't put in. Or [people] who do put it in will get demoralised after some time. Case in point, the DEWATS. How many years have we been working on the DEWATS? Even now, it's been hanging on by a thread. We have a technology that works and might help us, but it still takes so much time to get it through and get the uptake that is required. Even if it's a working technology and it will help the municipality.*

This reality is current, as eThekwini is currently in the process of implementing a DEWATS system as part of an informal settlement upgrade programme. The engineer spoke about specific barriers faced in this project, citing the challenges with getting a license from Department of Water and Sanitation and appointing a qualified contractor (e.g. BORDA, an international NGO that has long been a champion of the DEWATS concept) to do the design. The Water Use License for the informal settlement upgrade was granted for DEWATS as it was not possible to connect the wastewater to the existing Northern Wastewater Treatment Works. With regards to appointing BORDA as the contractor, this was not possible for numerous reasons, including the facts that they could not be appointed as a sole supplier and the South African branch not being functional at the time and thus being restricted to appointing the main BORDA office, which is based in Germany. However, the fact that eThekwini Municipality has signed MOAs with BORDA in 2011, 2014, 2018, and 2021 enabled BORDA to provide input into the design and implementation of the DEWATS system. BORDA has been subcontracted by the main contractor for design and construction supervision of the DEWATS system.

The situation described above places the informal settlement upgrade at an interesting point in the DEWATS technology testing process. Though it is seen as a temporary solution for the informal settlement upgrade, there are still other potential application areas for DEWATS in communities that cannot connect to a centralised wastewater treatment works. The plant will give eThekwini a test case of the DEWATS system in a real-life setting and scale with a safety net (i.e. discharge to a WWTW). Essentially, it will provide them with an additional, larger scale pilot plant to further test and prove the technology.

3.2.8 Tender for installation of alternative onsite sanitation technologies

A tender was advertised in 2019 for suppliers to install alternative onsite sanitation technologies to replace VIP toilets within eThekwini. The work commenced in June 2021 with a 6-month pilot phase. Demonstration units are being built in public spaces as well as 879 households to showcase the technologies in 5 different wards. Three companies are installing these units, and they all use the same make of low-flush toilet with leach pits (single or double) for disposal. The units have cisterns connected to wall-mounted external 50-litre tanks that users must fill manually. After some months of use, the units will be assessed, and then the municipality will decide whether to replicate these toilets at scale.

This phased approach (pilot and roll-out) is an innovative approach to implementing alternative sanitation solutions and can provide a model for other municipalities. It enables municipalities to see solutions implemented in a few households in their area before committing to large-scale implementation. The process still requires technologies to be somewhat proven and approved (i.e. the criteria above) but does open a municipality up to the greater variety of options. This process does require evaluation capacity at the municipal level to make informed decisions at the end of the piloting phase, and many municipalities do not have this capacity. This requirement, along with the more complex assessment of different technologies, may prove too resource-intensive for the more poorly resourced municipalities.

3.2.9 Difficulties with operations and maintenance / service contracts

eThekwini already faces difficulties with appointing contractors timeously for the scheduled 5-yearly emptying of VIPs and 2-yearly emptying of UDDTs, due to challenges with the procurement process. It is very likely that there will be similar challenges for non-sewered sanitation systems that are designed to be implemented with a service contract. The longer the service contract, the more formidable the procurement obstacles. For example, the 20-year service contract which eThekwini entered into in 2001 for the Durban Water Recycling plant (which treats wastewater and recycles it to industry), required National Treasury approval. This would be very difficult to replicate for multiple small-scale plants.

3.2.10 Key lessons from eThekwini Municipality

The following key conclusions can be drawn from the experiences of eThekwini Municipality with implementation of non-sewered sanitation systems:

1. Certification is important for new technologies, and this process should be accelerated. Further, technology suppliers and decision-makers must be made aware of the certifications that are currently available and those that will be available in the long term (e.g. SANS 30500).
2. Piloting is an important step in technology development. Through their Alternative Sanitation Systems tender, eThekwini has introduced the option of including piloting/testing as part of the implementation process. This staged approach to roll-out of sanitation systems can be applied elsewhere, in order to open municipalities up to more options and provide opportunities for technology alternatives.
3. Cost is a key barrier to the adoption of innovative non-sewered sanitation systems, especially when considering communities that receive free basic services.
4. Maintenance requirements are very important to municipalities. Even a large metro like eThekwini struggles to provide maintenance services. This is even more true for smaller municipalities. While this is partly due to a simple lack of technical capacity or personnel, it is also influenced by the lengthy procurement and planning processes at municipalities.
5. Procurement processes make it difficult to appoint suppliers for service contracts, particularly long-term contracts
6. Policy does not always lead to practice, and the reason for this is often the long, slow processes that take place in the municipal environment. For example, with regards to regular pit emptying in the Sanitation Policy for eThekwini, the process of getting approval for emptying contracts and appointing contractors is too lengthy for them to achieve their aim of emptying VIPs every 5 years and UDs every 2 years. Perhaps this is an area where longer-term service contracts could benefit the municipality (e.g. 3-year ongoing service agreement for UD toilets).
7. Benchmarking within South African Municipalities is important to make sure that they learn from each other and do not repeat mistakes or failures. eThekwini has been at the forefront of sharing experiences with the international community, and this process of sharing should be further developed in the South African context.
8. User and political acceptance are important for considering innovative non-sewered sanitation systems. The user experience provided by the innovative system needs to live up to users' aspirations and expectations for the technology to be successful.

Even demonstrated technologies with proven technical performance can be tough to implement due to the lengthy approval processes required (e.g. Water Use License from DWS). The process could perhaps be simplified by improving awareness around alternative systems, certification, and testing.

3.3 City of Cape Town

Consultation with the City of Cape Town (CoCT) focused on the use of onsite sanitation systems in informal settlements. CoCT has more than 220,000 households in informal settlements. The Informal Settlements Basic Services Branch provides and maintains water and sanitation services in informal settlements, and there are four main types of sanitation technologies offered to these communities. The City of Cape Town refers to the National Norms and Standards for water and sanitation provision and has their own improved standards, which consists of 1 toilet provided for 5 households. (M Mallick, personal communication, 27 September 2021).

Some of the main challenges with providing services to informal settlements include:
- Most facilities are shared between families
- Toilets are frequently dirty
- Toilets are unsafe to access at night, especially for women
- Limited access to water
- Taps too far away from households
- Constant growth of informal settlements, as more people move into the area

3.3.1 Sanitation systems used in City of Cape Town Informal Settlements

The four main sanitation systems used in informal settlements in Cape Town are described in Table 6 below.

Table 6: Four main sanitation systems used in informal settlements in City of Cape Town

Type of sanitation	Frequency Serviced	Method	Approximate no. installed	Approximate no. HHs served
Chemical – shared toilet	3 times per week	Service provider	13,250	66,250
Container – shared toilet	3 times per week	Service provider	8,100	40,500
Portable Flush Toilets (PFTs) – household toilet	3 times per week	Service provider (but cleaning by households)	22,500	22,500
Full flush toilets (FFTs) in ablution blocks	7 days per week	EPWP janitors	14,150	70,750

Portable flush toilets are provided in certain densely populated settlements for single households. There is a seat on top of a small tank, which is serviced three times per week. During servicing, the tank is removed and replaced with a new tank. The full tank is disposed of at the WWTW and then cleaned and disinfected.

Full flush toilets are provided on a 1 toilet per 5 households basis in settlements where a sewer connection is possible. Janitorial services are provided 7 days a week by EPWP workers.

The containerised system consists of a 100-litre container that is dosed with 10 litres of odour-inhibiting chemicals. The full container is removed and replaced with a clean container 3 times per week. The container is emptied, cleaned, and disinfected at the WWTW.

Chemical toilets are provided as a shared facility and are hired from external service providers. Thus, the chemical toilets are different in that they are not city-owned assets. Rather than the container being removed 3 times each week, the toilets are pumped 3 times per week by the external service providers, and the sludge is disposed of at the WWTW. The City of Cape Town is currently looking at phasing this option out, because the servicing cost is much higher than that for the other systems. The high servicing cost is both due to the use of chemicals in the toilets but more so due to the rental fees.

3.3.2 Alternative sanitation systems

The Head of Capital Planning and Implementation for the Water Directorate at the City of Cape Town shared about the Mobisan Toilet, which was piloted in Poek se Bos, funded by a donation by the Dutch Government. The Mobisan Toilet is a dry onsite treatment system that serves 120 households with 14 toilets and 12 urinals. The pilot was initially successful, due to the way that Poek se Bos community took ownership of the system. Additionally, permanent caretakers were appointed to look out for the system, which contributed to the initial success. However, when asked further, the representative shared that eventually, the system was vandalised and metal components from the structure were removed for their scrap value. Thus, while the technology itself may have had potential, the implementation had risks in terms of vandalism and availability of replacement parts. The full Mobisan unit came from overseas and thus it was not simple to source replacement parts in response to vandalism. The pilot ultimately failed and did not lead to replication.

The representative mentioned that other similar dry technologies were also tried in City of Cape Town and had similar outcomes, but he did not elaborate further on the specific technologies or reasoning for communities vandalising the units.

During an interview, the Head of Capital Planning and Implementation did express a desire to open the service offerings and have more flexibility to try new technologies. They are very tied to compliance and tender processes, but they are interested in finding ways to pilot and test alternatives. Specifically, they are looking for water-smart technologies and adapting them for the often-harsh environment of informal settlements.

> *[Because we are a water scarce city] I think there's going to be a push for moving… forward with onsite waterless treatment type technologies, small package plants, etc. How can we go about getting to a point where those type of technologies can be implemented in an informal settlement type environment? We're not there yet. But I think it's something we need to turn our attention to given the fact that we are working our way towards becoming a water-sensitive city that has less reliance on flushing, waterborne sanitation and more into addressing other types of technologies that have been proven to work but also offer benefits to the communities in order to get the acceptance and ownership from them to ensure that the technology is viable and doesn't get vandalised… That's on our horizon.*

3.3.3 Sanitation selection process and challenges

When selecting sanitation systems for informal settlements, the City of Cape Town considers various criteria, such as land ownership, geotechnical conditions, density, and availability of existing services. However, wherever it is feasible, the City of Cape Town prefers installing flush toilets. From the City's perspective, this is preferred because the operational costs for flush toilets are much lower than the alternatives. The City of Cape Town recently developed a Standard Operating Procedure to give guidance in terms of sanitation provision to illegally occupied settlements for emergency relief. The City of Cape Town also developed an Excel-based checklist to help identify appropriate technologies. These resources were not available from the municipality, as they have not yet been approved.

The representative from City of Cape Town mentioned the following challenges with regards to onsite sanitation in informal settlements:

- Water scarcity
- Vandalism of infrastructure leads to failure of the technology
- Communities are very sceptical of onsite treatment and alternative sanitation technologies, refusing to use anything except a flush toilet
- Legislative and environmental compliance requirements may be challenging (e.g. WULA)
- Procurement challenges
- Financial benefits and operational costs must be clearly defined for the city to consider alternatives

When considering procurement processes, the City of Cape Town's Planners work closely with the Supply Chain Management department, and they must work hard to ensure that their tender specifications are specific enough so that they receive quality submissions but not so specific that they exclude potentially suitable suppliers.

3.3.4 Service contracts

With the large number of informal settlements being serviced by sanitation technologies that require at least weekly maintenance, the City of Cape Town has extensive experience in managing service contracts. In a sense, sanitation in informal settlements is seen as an ongoing service rather than a once-off infrastructure intervention. On the one hand, this could be seen as positive, given the fact that many municipalities do not think about any maintenance of sanitation systems. On the other hand, this makes it a costly and complex sanitation system to manage.

Contracts for sanitation in informal settlements are issued on a 3-year basis with one contract for supply of the toilets and another for servicing. Separate contracts are issued for each technology, so for the solutions requiring regular emptying, that includes two for container-based systems, two for portable flush toilets, and one for rental and servicing of chemical toilets: i.e. 5 separate contracts. That in itself represents a large administrative and monitoring burden on the City.

At the same time, the City of Cape Town's service contracts can serve as an example for other municipalities that are not experienced in appointing sanitation service contractors. The service contracts for each of the services are similar in terms of content and standards, and they provide clear guidelines for contractors to ensure the health and safety of workers and the community. The regular use of service contracts in their planning places Cape Town in a unique position to consider new sanitation technologies with high maintenance burdens. Certainly, they are better positioned than municipalities that currently do not even consider emptying of VIP toilets every 10 years.

It should be noted that the City of Cape Town keeps service contracts as general as possible so that they don't exclude all but one supplier. The planners work closely with the Supply Chain Management department, and if a tender specification is seen as too limiting, it is not used. It is possible to keep the service contracts fairly general as the skills required to carry out the servicing and cleaning of the toilets are not specialised and can be offered by multiple contractors. This is something to consider with regards to specialised maintenance or servicing that may be required for new high-tech solutions.

3.3.5 Limits to technology options

Technology options are limited for several reasons, including the precarious location of many informal settlements, the need for temporary solutions, dense areas, and the compliance-driven environment in the city. The approach to sanitation in informal settlements has been standard for at least the past 10 years. Thus, procurement and other processes seem set in stone.

One concrete example is around the purchase of Portable Flush Toilets (PFTs). There is one system that has been in use for over ten years, and that is partly because when they were first implemented, there was no product on the South African market that met the specification. Thus, when they first procured the technology, it was imported from Italy, and the City is now in the routine of purchasing these in bulk annually to meet the needs of the coming financial year. Further cementing the use of this technology, automated wash bays were constructed for the portable flush toilets (PFTs) at the Borcherds Quarry (BQ) Wastewater Treatment Works (WWTW). When asked during an interview about alternative portable flush or similar toilets, the Head of Capital Planning and Implementation stated that the faecal sludge management facility at BQ WWTW is equipped with wash bays designed and sized based on the portable flush toilets that have been in use in the city for over ten years. If they were to select a different supplier with different sized PFTs, they may need to invest more capital to adjust the cleaning process. Thus, even though tender specifications may not limit the specific technologies, operational aspects may. This is one practical example of how upgrading and improving certain processes can impact available technologies.

When it comes to innovative sanitation systems, the Head of Capital Planning and Implementation spoke about one innovative container-based sanitation solution that they had recently considered. However, this technology relied on the continuous supply of a plastic film product used to containerise the waste within the toilet and a purpose-built machine to later separate the organic material from the plastic film. Currently both the film and machine are only available from one service provider, which raises concerns for CoCT about creating a dependence on a sole supplier if they were to adopt this system.

3.3.6 Limits to capacity

One aim of the City of Cape Town is to open their options so that they are not locked into a small number of technologies. Part of this motivation is rooted in the City's goal of becoming a water-sensitive city. During the interview, the Head of Capital Planning and implementation was asked whether increasing sanitation options would also require an increase in capacity. His response revealed the reality that even at a large metro like Cape Town, resources may be too limited to deliver sustainable and sufficient sanitation services:

> *I think it would definitely require capacity, particularly when it comes to the monitoring side of things. That's certainly one of the areas that we always get hammered on when it comes to the auditors. Because we've got close to 60,000 toilets of various types across our informal settlements and how do you monitor that large amount of toilets on a daily basis? We just don't have the warm bodies to be in those informal settlements daily to see that our service providers are working 100% according to the contract specifications or that all toilets are in working order before they are reported by communities as defects…You would need a large component of staff to be able to do that level of monitoring, so it's something we keep getting hammered by the auditors to say that our monitoring is not sufficient to ensure that this is good value for*

> *money…There's not much we can do with the current resources, so definitely resources is a big constraint. But also, it's never easy to motivate for additional budget, especially now with COVID and cutting of costs. It would require some exceptional motivation on behalf of our directors…to source additional funding within the current climate.*

Following the interview with the CoCT representative, it was confirmed that the City had secured additional funding for the creation of additional positions for monitoring services and service providers within informal settlements. The positions are expected to be brought on board within the 2022 calendar year, and represents a positive move towards ensuring effective services and accountable service providers.

3.3.7 Key lessons from the City of Cape Town

The following key conclusions can be drawn from the experiences of the City of Cape Town with implementation of non-sewered sanitation systems:

1. Being locked into a dependency on a sole supplier is a real concern for CoCT in their consideration of future alternative sanitation systems, although they are already effectively in this situation with the supply of PFTs
2. There is political resistance to dry onsite sanitation systems, however innovative they may be.
3. Vandalism is an obstacle to the implementation of shared systems
4. It is very difficult to maintain an adequate level of monitoring on all the toilets in informal settlements.

3.4 Chris Hani District Municipality

The Chris Hani District Municipality (CHDM) is located in the Eastern Cape and provides water and sanitation services to six local municipalities. A majority of the District's residents (63.8%) live in predominantly rural areas. Due to the historical and political context, CHDM is spatially fragmented, with a mix of dispersed rural village settlements, small service towns, and commercial farms. CHDM's approach to onsite sanitation has been informed by its Backlog Eradication Programme, which was initiated in 2010. Between 2009 and 2019, the number of households without hygienic toilets decreased from 108,000 to 53,100, a rate of -6.85% annually. Due to the rural nature of the DM, ventilated improved pit toilets (VIPs) were considered the standard for household sanitation provision. Part way through the backlog elimination programme, the DM was introduced to a new technology and began including it in the programme. Details of this programme are provided below.

3.4.1 Organisation of Engineering Services

The information provided in this case study is based on interviews with two individuals in CHDM, namely: an Institutional and Social Development (ISD) Manager in the Project Management Unit (PMU) and the Manager responsible for Water Services Provision (WSP). Both are within the Engineering Services Unit, which is divided into three divisions, as shown in Figure 3. According to the WSP Manager interviewed, there is currently a chain of command from planning to the PMU to water services and then back to planning.

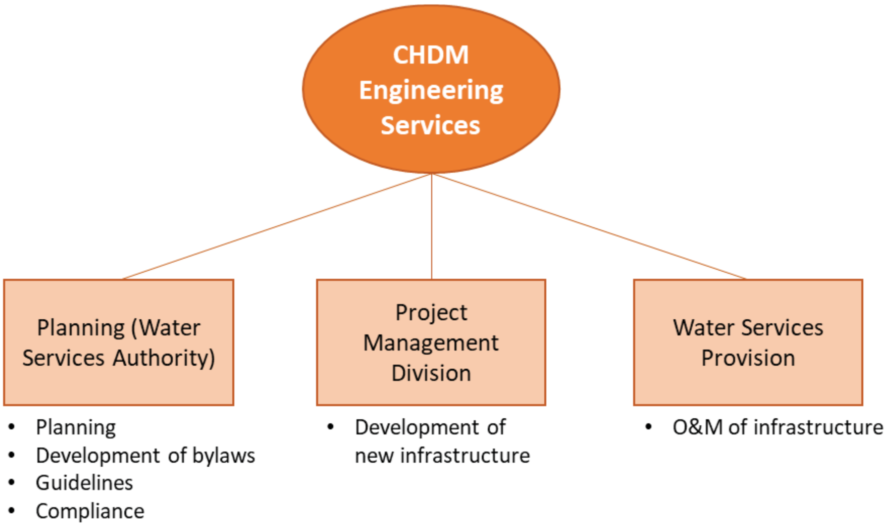


Figure 3: Division of responsibilities in the CHDM Engineering Services Unit

There is currently very little information or feedback shared between the division responsible for O&M (water services provision) and those involved in specifying and selecting sanitation technologies. The WSP Manager shared plans at CHDM to develop a technical appraisal committee, which will be tasked with approving technologies before sanitation tenders are advertised. While the unit currently has a specification committee, their focus is mainly on ensuring compliance with the Municipal Finance Management Act and not on the technical aspects. By including members of the PMU and WSP, the WSP Manager is hopeful that this technical appraisal committee will be able to consider operational aspects more effectively in decision making (i.e. the cost of the asset vs. the cost of operating and maintaining it).

3.4.2 VIPs with movable structures

The Chris Hani District Municipality introduced its backlog elimination programme in 2010. At the time the programme was initiated, the municipality was constrained by limited access to water and sewerage in the rural communities and the desire for a movable structure. The concept behind a movable structure was that once the pit was full, it would be closed, and the structure would be moved to a newly dug pit. To accomplish this, VIPs have been constructed throughout the municipality with prefabricated top structures that can be assembled on site and moved (as opposed to brick structures which would have to be broken down to be moved). This would, in theory, reduce the maintenance burden on the municipality. During an interview, the ISD Manager elaborated on the concept, stating,

> *The VIP with a movable structure… when the pit is full, the household will now have the responsibility to pay for moving it. So, not the municipality. Because the toilet will have been handed over to the owner… it will no longer be the asset of the municipality… so the idea was for the household to take responsibility after the period set for the VIP. Then you can move the structure and put it on another pit.*

However, when the ISD Manager was asked about whether this was happening in communities, she was uncertain. She said that when the concept was first introduced, there was promise of a machine that had been specially designed to move the top structures. However, she had never seen one in use in the municipality.

This situation begs the question: who does an onsite sanitation system belong to once it has been constructed? Is it the asset of the household? If it is the asset of the household, are they then responsible for the ongoing maintenance? In agreement with the ISD Manager, the WSP Manager said that the concept initially was that "onsite sanitation [systems] are treated as assets that are donated to the households," which places the responsibility for ongoing operation on the household. However, he also acknowledged that many people receiving sanitation services from the municipality are indigent and do not have the capacity to pay for maintenance themselves. In those cases, the WSP receives a list of people requiring maintenance services from Ward Councillors or NGOs working in the communities. Despite the original idea of moving the top structures, the WSP Manager indicated that when they maintain VIPs, they empty them using a honeysucker.

No matter the answer to the above questions, it is important for the arrangement to be communicated early and regularly. Households should be made aware early if they are responsible for emptying or moving the toilet, and they should be reminded regularly so that they can plan, budget, and prepare for the day when their toilet becomes unusable. Also, it must be noted that moving a precast toilet not only requires the pit to be dug to specific dimensions, but a concrete foundation collar must also be placed around the top of the pit. Unless that is done correctly, the newly moved top structure has a high probability of collapse. In the interview with the WSP Manager, he indicated that he suspects the cost of emptying is likely lower than the cost of relocating, and the logistics are simpler.

3.4.3 Faecal sludge handling in CHDM

The WSP Manager shared insights into emptying of onsite sanitation systems. As mentioned above, the municipality empties onsite sanitation systems of indigent households in rural areas, along with all onsite systems in urban areas. Emptying is done using a vacuum truck (honeysucker), and sludge is transported to the nearest wastewater treatment works facility.

The WSP Manager was also asked whether they had ever considered deep row entrenchment onsite in rural areas to limit transport costs and prevent overloading treatment plants. He was hesitant about proposing that as an option, saying,

> *It's risky because in terms of the environment, the underground water contamination and all of that, those are the things that you need to consider before taking that decision. And also, [the households] might hesitate for you as government to do that in their yards… they will say you are the uncaring government; you need to relocate it from them. That is something that you need an engagement with the community… it's not something that you can just take a decision and do it.*

3.4.4 Technology selection considerations

The WSP Manager, who also previously served on the PMU, discussed the key aspects that are considered in technology selection, beyond the aspect of a movable structure described in Section 3.4.2 . The primary aspects mentioned were:

1. Cost per unit household
2. Maintainability

3. Ease of construction
4. Job creation and benefits for small and medium enterprises (SMMEs)

3.4.5 Introduction of pour flush toilets

As described during an interview with the Institutional and Social Development Manager, pour flush toilets were introduced to Chris Hani District Municipality around 2015. It was received by the municipality as a solution in between a VIP and full waterborne sanitation and therefore an opportunity to improve sanitation service provision. The solution met the criteria listed in Section 3.4.4 , but also introduced the need for the municipality to consider water availability. Pour flush toilets were added as an additional option for the sanitation backlog programme and were introduced to communities as an alternative. When going to a new ward, both options would be introduced to the community, and they could then decide which one they preferred. While most communities accepted the pour flush, some communities indicated that they did not want it due to water shortages. Even after being educated on using greywater for flushing, these communities insisted on having VIPs because they do not even have sufficient water in the first place.

In addition to pour flush being implemented as part of the sanitation backlog programme, the Water Research Commission also assisted the DM in providing pour flush toilets for a selection of households.

This is an interesting case study of the municipality adopting a new solution while implementing an established programme that was "VIP-biased", as the ISD Manager explained. The fact that pour flush toilets could be constructed as part of an existing VIP implementation programme, demonstrated the effectiveness of introducing *incrementally improved* solutions. The cost of single pit pour flush toilets was not too different to VIP toilets and thus they were able to fit within the existing programme. Furthermore, the rationale described in Section 3.4.2 , where top structures would be moved when pits filled up, was applied to pour flush toilets as well, which meant that additional O&M resources would not be necessary. While this same approach would not work for more sophisticated and expensive systems, it did work in the introduction of a comparable yet improved solution.

3.4.6 Single vs. twin pit pour flush toilets

Pour flush toilets are typically connected to leach pits, which allow for infiltration of water and decomposition of sludge. If a toilet is provided with twin leach pits this allows for a more stabilised sludge at the end of a cycle, because when one pit fills up, it is allowed to "rest" while the other one is in use. During this time, the sludge decomposes, stabilises, and dries out, leaving the household or emptier with a safer material to handle during emptying. However, a majority of pour flush toilets installed in CHDM have single leach pits. This could either be due to the lower cost of implementing a single pit system or simply due to lack of information on the benefits of a twin pit system. The WSP Manager stated that some households have received twin pit systems because environmental conditions prevented a single pit from meeting the minimum volume requirement of 3 cubic metres. When asked about what is meant to happen when single pits fill up, the ISD Manager said that she supposed they would need to be emptied, but "the idea was that the pit would take a long time to be full because of the perforations in the linings."

When considering both capital and long-term maintenance costs, it is likely that twin pit pour flush toilets would prove more advantageous. However, due to the dominance of capital cost considerations in tender evaluation processes, it is unlikely that pour flush with twin pits would be selected over pour flush with single pits or VIP toilets *unless tender specifications were written for twin pit systems*. The WSP Manager expressed support for the idea of advocating for twin pit systems based on his perspective on the O&M requirements.

Another point to consider for existing single pit systems is the opportunity to construct a new pit instead of emptying existing pits immediately, thus converting single pit systems at a later stage into twin pit systems. A cost analysis would need to be done comparing the cost for emptying and disposal of sludge vs. the cost of constructing new pits and connecting the plumbing to them. This would be one approach for the municipality to consider that would extend the life of their pour flush toilets.

3.4.7 Community engagement in sanitation projects

The ISD Manager who was interviewed as part of this project is engaged in community facilitation, and she provided some insight into how communities are included in the implementation of sanitation projects. The District Municipality must work through the relevant local municipalities to gain access and begin working with local ward councillors and committees. Once those gates are opened, the DM can hold community meetings to inform the community about projects. The programme is presented, and a project steering committee is appointed. This generally happens after procurement processes have been carried out. However, in the unique case of pour flush toilets introduced after the start of the programme, these community meetings provided an opportunity for the community to determine which solution worked best for them.

3.4.8 Ethics of piloting

Chris Hani DM was involved in another pilot project of a dry sanitation system with an auger for mechanical advancement of human waste to a chamber. The ISD Manager interviewed simply stated that the technology did not work. “There was an assessment, survey, analysis of the suitability of the technology by the communities. Yes, there are those that started using it, but it proved to be sophisticated.” She emphasised that it would have benefited from dedicated people to make the project work, but the municipality did not have that capacity to dedicate someone to this single project. While the ISD Manager did not share many more details on the pilot, she was asked about what the households had to do after the failed pilot:

> *It's very sad to say that they had to go back to the field that they were using. They didn’t have any type of toilet.*

When selecting a community to pilot the system, the DM saw an opportunity to accomplish service provision in an area with no sanitation. However, this technology had not been demonstrated on a smaller scale in the community, thus putting households involved at risk. The households that were part of this pilot are therefore back on the backlog list. When asked about this approach, the Manager suggested that the units should have been piloted at a few households, but they were demonstrated on a larger scale at about 200 homes.

3.4.9 Need for monitoring and learning

The ISD Manager was asked at the end of her interview about whether there is a need for additional sanitation alternatives in the communities in her DM. She suggested that she would first like to see the current options working properly, sustainably, and appropriately. She pointed to challenges they have experienced in communities located at the base of slopes with pits overflowing with runoff that enters the pits. This causes the toilets to overflow, and points to the need to pay attention to stormwater diversion in the design of onsite systems.

In the realm of wanting to understand the current technologies better, the ISD Manager suggested that post-implementation monitoring is required. This will help point out challenges before they lead to failed sanitation and provide an opportunity for lessons that can inform future projects. She explained that the Project Management Unit, which she works in, is responsible for implementation. After implementation, the Operations and Maintenance (O&M) Unit is in charge. The ISD Manager stated that the O&M Unit must ensure the sustained operation of onsite sanitation systems. This point from the ISD Manager supports the move suggested by the WSP Manager to improve collaboration between the PMU and water services provision divisions of the technical services unit.

3.4.10 Sanitation gaps in CHDM

The WSP Manager provided details on two specific areas where he sees gaps in sanitation provision in CHDM where sanitation alternatives may be required. Firstly, in urban areas, he expressed concern that the existing treatment works are old and do not have capacity to receive additional wastewater from newly sewered communities. There is insufficient space to expand the existing treatment plants, which means that "now, [they] need a technology that is going to use the same space but produce minimum required standards in terms of final effluent." He furthermore pointed to the fact that sewage networks have been designed to serve a specific number of people, and if new developments are being connected, the entire sewerage network would require updating. In addition to the cost of upgrading treatment plants, the upgrading of a sewerage network to support the increasing load will be prohibitive. In light of these challenges, he expressed support for a more decentralised approach to wastewater management in urban areas. He suggested the option of providing package treatment plants for different townships instead of pumping sewage from townships to a central treatment works. Though this may require additional operational capacity, he feels that this approach would lead to greater public trust, which will lead communities to be willing to pay for efficient services.

The other gap he identified was in rural areas, where many urban residents have recently relocated. The demands from residents moving from urban areas present an opportunity something between a VIP, typically implemented in rural areas, and a full waterborne sewerage system. The municipality has a need for alternatives that provide a higher standard than VIPs while acknowledging limited water resources and unreliable electricity supply.

3.4.11 Reaching local government

> *I believe Water Research Commission is busy with [research on these types of innovations]. But those need to be presented in the space of local government, and in municipalities in particular.*

> *So that we engage deeper, we look into all the best technologies with the cost effectiveness. Because as a municipality you don't have money. We are struggling to generate a revenue, but we have technologies that will encourage our communities to pay for the service they get. And also get the high standard of service of the people that are living in the urban areas.*
>
> \- WSP Manager, CHDM

The above comment points to the importance that research and innovation is presented and made accessible to local governments. When asked specifically about who the most important stakeholders are in the local government space, the WSP Manager said that Municipal Managers must be empowered to understand the technical services. While Municipal Managers are often not technical people but rather have qualifications in, e.g. public administration, they are the people who present new ideas to Council. He also emphasised the importance of COGTA and DWS in terms of approving funding for sanitation projects, suggesting that technical understanding is also vital in these departments.

The WSP Manager also discussed that SALGA, DWS, and COGTA are all departments that support local government in water services provision and are therefore good stakeholders to approach when trying to share new information with local government.

3.4.12 Key lessons from Chris Hani District Municipality

1. Though infrastructure provision and ongoing O&M may be allocated to different divisions within a municipality, there should be opportunities for these divisions to share ideas with one another, particularly for those doing O&M to provide input into technology selection. This is an effective way to move beyond the emphasis placed on capital cost, as life cycle costs can be considered before tender specification are written (e.g. twin pit vs. single pit pour flush). There is also a clear case for some overlap between the work done in providing infrastructure and the O&M (e.g. ongoing outreach by the Institutional and Social Development unit to the users of the new infrastructure).
2. Clarity is required in terms of who an onsite sanitation asset belongs to, and this must be communicated with households early on to ensure maintenance is carried out as needed.
3. Introducing sanitation solutions that represent incremental improvements to existing solutions may be a more accessible way to encourage innovation. These solutions provide some benefit without exorbitant costs, making them more accessible for municipalities to improve their service delivery while still meeting existing backlogs at the scale and pace that is required.
4. Sanitation provision is more nuanced than just e.g., urban vs. rural, and municipalities understand this. Municipalities know the specific unique circumstances that their communities are facing, and within these unique circumstances there is a place for sanitation innovation and solutions that can address existing gaps.
5. Research and innovation on sanitation must be shared with the right people to enable the implementation of new solutions. This includes ensuring Municipal Managers have the necessary technical knowledge to advocate for new solutions and using existing channels (e.g. SALGA) to ensure audience with municipalities.

4 South African Technology Developer Case Studies

Three South African technology developers and suppliers were consulted during this research. They represented the following technologies in general:

1. Onsite dehydration toilets
2. Pour and low flush pedestals for onsite or sewered applications
3. Package wastewater treatment plants for general discharge
4. High-tech non-sewered sanitation systems

Discussions with these technology developers revealed various challenges that they face in promoting their innovative solutions in South Africa, particularly to municipalities. Though technology suppliers will generally be biased towards the system(s) they supply, they are also key stakeholders that invest in piloting, certifying, and marketing their solutions to municipalities. The ability of different suppliers will vary based on their size and financial standing, but these efforts are one contributing factor for expanding the market for sanitation alternatives. Many technology suppliers establish relationships with municipalities or consultants to educate them on why their solution should be used. Increasing competition between different technologies can potentially lead to improvements and suppliers holding themselves to higher standards.

A summary of feedback received from each of the technology suppliers is provided below.

4.1 Supplier A: Injection-moulded pedestals for low and pour flush

Along with standard child-friendly VIP pedestals, Supplier A manufactures pour and low flush toilet pedestals which have been used in numerous household and institutional projects across the country. Pour flush toilets have been implemented in South Africa since 2013, with wider scale uptake by municipalities since 2015. Supplier A has had extensive experience piloting their technology across the country and marketing the system to decision makers. They often work alongside construction contractors or suppliers of top structures. Supplier A has furthermore supplied over 100,000 low flush/pour flush units across the African continent. Some of the key findings from the conversation with Supplier A are summarised below.

4.1.1 Supplying but not tendering

Supplier A is an expert in the sanitation market, as they manufacture a variety of sanitation and hygiene components. However, they generally do not tender on municipal sanitation contracts, because most of the tenders are geared towards construction contractors. Though Supplier A does have a construction unit that implements school sanitation projects and other smaller projects, they do not have the capacity to carry out large-scale construction contracts. Furthermore, most tenders require supply of a top structure, which they do not provide. Since Supplier A works with numerous top structure suppliers, if they were to tender on a sanitation project with a specific supplier, they would cause conflict with their other suppliers. Thus, they generally only tender on a sub-contractor basis or supply the pedestals for the contractor that is ultimately selected.

One suggestion from the representative that was interviewed was for separate contracts to be put out for supply of components and construction:

> *That will make more sense, because what happens in most of these areas it becomes a construction-[oriented] tender. There's very little time spent on proper specifications. [It] doesn't matter what kind of toilet goes in… there's very little time spent on doing proper specifications on the actual sanitation (system). They spend more time on the contract for the construction side. [It ends up] that whoever gets awarded…will purely go and look at what is the cheapest thing they can get on the market. Doesn't matter if it's got Agrément certification or anything like that. He'll just go get the cheapest thing he can get because it's more money in his pocket. That is where the biggest problem comes in with current tenders…poor specifications…*

He then elaborated to point out that setting a supply tender separate from the construction tender will ensure that the systems are standardised across a given municipality, whether there is one contractor or ten. This would be helpful in terms of standardising service delivery as well as improving maintenance of systems.

Another element of the construction-focused tenders that the representative from Supplier A pointed out is that when it comes to education post-implementation, many of the contractors have little to no sanitation understanding. They require training from suppliers like Supplier A on how the system is meant to function and what O&M is required. This limits their ability to provide adequate education to the community when it is time for handover of the technology.

This lack of understanding about how systems work can also lead to inappropriate construction techniques. For example, without an understanding that leach pits for pour flush toilets are meant to have open joints so that water can infiltrate into the ground, some contractors may be inclined to close and plaster leach pits, especially if adequate technical guidance is not provided by the municipality. Sealing pits that are meant to be draining means that emptying will be required *much* more frequently than intended, placing a huge maintenance burden on the municipality.

4.1.2 Need for proper specifications

As described above, many sanitation tenders are far more focused on construction methodologies and standards than on sanitation technology specifications, and Supplier A sees an issue with that. They believe it leads to implementation of poor-quality components, which in the long run leads to failure. The interviewee stated that specifications should include requirements for certification, such as Agrément. Acknowledging some of the shortcomings with this certification, the interviewee stated that municipalities should "at least allow for some certifications [in their specifications]. That's a starting point. Currently, they do nothing. It will just say a flushing toilet. So, anything a bit more." He expressed hope that the introduction of the SANS 30500 standard would help with this in some way. However, SANS 30500 is focused on onsite treatment systems and cannot be used for a pedestal in isolation.

4.1.3 Investment in piloting

Supplier A has invested considerable resources in piloting and demonstrating their technology across the country. With about 200 pilots countrywide (almost all of which they have paid for themselves), the representative pointed out the value of being able to take decision-makers to see functional systems in nearby areas. He further stated the value in being able to showcase systems that have been in use for multiple years. He stated that the success rate moving from pilot to implementation is about 15-20 percent, and this is well worth it for them.

The representative of Supplier A regularly mentioned the importance of the personnel at the municipality. At the end of the day, successful pilots or advocacy will only lead to further roll-out if the technical manager at the municipality has bought into the idea and understands the benefits. The representative also mentioned the impact of personnel turnover on establishing new approaches to sanitation provision. While Supplier A may work with one representative during one demonstration, they often find a new person in charge when returning to the same area. This requires constant follow-up and an ongoing commitment by the technology supplier to remain invested in their demonstration projects. While for larger technology suppliers this may be feasible and advantageous, this marketing work would likely be too expensive for smaller technology suppliers.

4.1.4 Incremental acceptance

The representative for Supplier A described the process of uptake of pour flush toilets in a few Eastern Cape municipalities. These municipalities have begun rolling out pour flush toilets as part of their sanitation backlog eradication programme with a primary focus on single pit systems. The representative speculated that the reason for a preference for single pit systems is the comparable price point when compared to the typical alternative, VIP toilets. With only a small amount of additional plumbing required, a contractor can supply a single pit pour flush toilet at a similar price to a VIP, making it very competitive.

Since the initial roll-out of pour flush, there does seem to be some shift in the willingness to pay a bit more for a better or more widely accepted solution. The representative stated that most of the new installations of their systems in these municipalities now include an externally mounted feed tank and cistern, making them low flush systems. Compared to a VIP, these units cost about R1500 more, but the municipality sees the improvement as advantageous, likely due to the wider user acceptance of systems with cisterns. When discussing the various benefits of installing twin pit as opposed to single pit systems, the representative seemed to think this was still a bit out of reach for the municipalities. Perhaps this will change once the single pit systems begin filing up and requiring emptying.

4.2 Supplier B: Dry sanitation system and Innovative NSSS

Supplier B has been manufacturing a dry onsite sanitation in South Africa since 1993, and they are currently involved in local piloting and manufacturing of an off-grid high-tech non-sewered sanitation system (NSSS). The dry sanitation system has been utilised primarily in Limpopo, Mpumalanga, North West, and Free State provinces at households and schools. Thus, the supplier has experience working both with the Department of Basic Education and municipalities. Some key lessons from the conversation with a representative from Supplier B are provided below.

4.2.1 Encouraging new solutions

With many years' experience in marketing an alternative sanitation solution, the representative of Supplier B was able to share about specific hurdles they have had to overcome. Firstly, the representative pointed out that many decision makers are stuck repeating the same projects that have been done in the past, perhaps due to lack of capacity or fear of taking risks on new solutions. He stated,

> *The biggest problem is that… it could be [a lack of capacity]… or it is a 'Let's go with the norms and standards, what our predecessors have done for all the years. And [we] can't get into trouble for that.' So, it's a lot easier to just…grab an old VIP [specification], dust it off, redate it and send it through…We find that that's the norm. VIPs just get rolled out all the time, because the tender and the BOQ [are] so easily and readily available.*

He spoke about the long process of demonstrating an alternative to municipalities, which often requires piloting a small number of units in a community. Supplier B often works with the Ward Councillor to elect a few houses to install their system in and then allow for 6 months to receive feedback on the system. This period allows the users to report on the benefits of the system compared to VIPs. In the event of a successful pilot, the representative expressed that they generally retain those customers. For example, in the North West Province, they have supplied about 6000 units over a period of 5 years, showing steady and ongoing uptake of their system.

He suggested that the decision should be made by the community and the users, not the entity paying for the solution. However, it should be noted that this only works in situation where the alternative being proposed is at a similar price point as the standard option, a VIP.

4.2.2 Moving from one binary to another

The concept of the sanitation binary paradigm speaks to municipalities locking themselves into two solutions for sanitation, typically VIP toilets or full waterborne sanitation. In areas where Supplier B's dry sanitation system has been implemented, it appears that many of these municipalities have adopted a new binary, consisting of this alternative and full waterborne sanitation. The benefits of Supplier B's technology compared to a traditional VIP are generally around the removal of a large pit and reduction in risk to small children along with the use of a sealed containment system, which makes sense in areas with high water tables or dolomitic areas. However, as the supplier correctly stated during the interview, "there's no one size that fits all."

When he spoke of the roll out of this system in Mpumalanga in recent years, he said that he thinks "that specification is really around standardising the systems that go in. When they go into a school…from a maintenance point of view they're going to encounter one of two systems: either waterborne or [Supplier B's system]." Perhaps he is correct in pointing out that limiting the number of different types of systems can make it simpler for those responsible for maintaining the systems. However, it does seem to point to municipalities struggling with making unique decisions for unique situations, considering the site-specific criteria that may warrant this dry system over another. Rather, they see that this new system works in one part of their municipality and then proceed in rolling it out to all households.

4.2.3 Inclusion of a service level agreement

Supplier B includes a servicing programme for 2 years in the price of their dry system. This servicing agreement includes initial inspections of the installation, user education, and servicing on a quarterly basis

(8 times over two years). The quarterly servicing involves inspecting and attending to any system needs, whether that means repairing or replacing parts or emptying dried faecal matter from the system. This leads to positive outcomes for the purchaser of the system and the supplier, who has an opportunity to ensure the initial success and positive perception of the system.

Supplier B accomplishes these service contracts through 29 SMMEs located across the country, which makes it more cost-effective and builds capacity of local contractors. The SMMEs are all trained and accredited and report on their work via a cloud-based reporting platform. At the end of the two-year period, the aim of Supplier B is that some service level agreement would continue to ensure that maintenance remains a priority. This can either be done through direct renewal with Supplier B (which includes the cloud-based reporting platform) or with the SMME directly. For a school, the cost of the service level agreement is R2000 per seat for two years and for a house is R1400 for two years. Despite the relatively low cost for this maintenance, some departments opt to take over the servicing role themselves. The representative from Supplier B mentioned that there is a reluctance to pay for servicing and maintenance. It is also interesting to compare the cost of regularly maintaining this system with the cost of emptying VIP toilets every 5 years. If a VIP toilet costs approximately R2000 to empty, the cost of maintaining a household VIP is *much* lower over a 5-year period compared to the sealed dry sanitation system. However, smaller, more frequent costs may seem more manageable to some decision makers who do not think on a long-term basis.

The representative emphasised that every sanitation system requires maintenance, and it seems some decision-makers do not realize that. He spoke about the need to empty or relocate VIP toilets after they fill up; the need to pay for sewerage for waterborne systems; and the need to empty septic tanks. He also spoke about the innovative NSSS that they are currently testing, which requires a minor service event every 6 months and a major service event likely every 18 months. This needs to be understood at the municipal level and by the users. Furthermore, the responsibilities of different parties need to be made known.

The approach above of providing a service level agreement as part of the cost of the unit may provide a model for other systems that require regular maintenance. It is also a way to get the municipality to consider maintenance requirements from the beginning. However, particularly for technically sophisticated systems, procurement issues may come up with regards to a municipality being locked into agreements with the supplier of a specific technology.

4.2.4 Life cycle costs and water savings

With the innovative NSSS that Supplier B is currently manufacturing, water is treated to a level where it can be recycled for flushing, creating a closed-loop system. The representative highlighted the benefits of this, from reducing water bills to providing an aspirational system in areas where waterborne sanitation would never have been an option. The representative pointed to the reality that the system can be loaded with water of any quality, whether municipal water, surface water, or water from a treatment works. This makes it feasible to implement the system even in places where there is no potable water supply available.

He spoke about a school where they are piloting the system, which has 1200 learners and 32 educators. The theoretical water saving in this installation 130 kilolitres per month, which amounts to a saving of R5,200 per month. Despite the promise of this system, the supplier acknowledged that it would take some time to communicate to decision-makers the benefits that they would be getting by implementing systems like these. It would require shifts in budgets to accommodate systems with higher capital costs, and these shifts will require a deep understanding of the life-cycle costs and potential longer-term benefits.

4.2.5 Certifying alternative systems

Supplier B was asked about what certifications they have and are pursuing with their systems. On the dry sanitation system, the supplier said that they have SABS certification, but this only speaks to the materials that are used and not the success of the onsite treatment process. He mentioned Agrément Certification as an option as well as aspirations for adjusting the dry system so that it could eventually achieve SANS 30500 accreditation. The supplier sees value in the SANS 30500 accreditation if it is fully adopted and implemented in South Africa. In addition, with the dry system, he said that they export the system to numerous other countries and must get local certification for use in those countries. The certification requirements vary from one country to the next, making the process lengthy, complicated, and expensive. Many other countries analyse the outputs for pathogens and metals content to determine whether they are safe for reuse or disposal.

Another complication that Supplier B mentioned was whether SANS 30500 certification could be transferrable from one country to another. The system they are currently manufacturing locally has apparently achieved certification in China, but he is uncertain as to whether this certification would need to be redone with units manufactured in South Africa. It is assumed that the products manufactured locally would require re-certification, and this presents another significant cost, which must be borne by the supplier.

4.3 Supplier C: Package plants and Innovative NSSS

Supplier C has been involved in design, manufacturing, and supply of package treatment plants for water and wastewater throughout South Africa for several years. They are also currently involved in the local commercialisation of a high-tech, non-sewered sanitation system (NSSS). Some key lessons from the interview with a representative from Supplier C are provided below.

4.3.1 Starting with consultants

The representative from Supplier C began by explaining his experience working on recent Green Drop Audits of a number of smaller municipalities, highlighting the general lack of capacity at these municipalities. As a chemical engineer, he noted a lack of skills in water and wastewater treatment, process design, technology selection, and operation of treatment systems. According to the representative, “the consequence of all this is that they rely on consultants. The consultants will do process audits. They will do risk assessments. They will also then define any refurbishment of plants or greenfield projects. So, the whole process is very much in the hands of the consultants.” The consultants generally go for classic, civil-intensive treatment plants rather than considering package plants or other alternatives. This may partly be informed by a lack of knowledge of sanitation alternatives or past negative experiences with alternatives, along with risk-aversion due to consultants being liable for the design. Thus, the representative of Supplier C believes that the work of increasing uptake of sanitation alternatives should begin with consultants.

One aspect of this dynamic to consider is that most consultants are paid based on a percentage of the contract value that they are supervising. Thus, if the same consultant is appointed for both design and construction supervision, there is some motivation for consultants to specify more expensive technologies. While some consultants may look out for the good of the municipalities that they are working with, it is an important dynamic for municipalities to acknowledge, particularly in cases where consultants have a large amount of control over planning and specifications. This emphasises the importance of skills being developed at the municipal level, even if the dynamic of extensive consultant involvement remains common. Municipal decision makers must have some skills to interrogate the proposals and decisions made by consultants.

> *It's not only the small rural municipalities. It's also in the metros [where] we see it as well. Which is a dangerous situation, not only for package selection or alternative tech, but it's also dangerous because the consultants have a bit of a free rein. There's no one to criticise or assess what they're proposing inside the municipalities. So, the municipalities are desperately short of skills. These are skills which relate to water and wastewater process engineering, process selection… They have skills in mechanical, they have skills in civil. But when it comes to chemistry, chemical processes, there's a major shortage there.*

4.3.2 Bound by system design

Supplier C designs and manufactures package treatment plants, which are very cost-competitive when compared to traditional civil works-based treatment systems. Thus, the emphasis on capital cost would seem to favour package treatment plants. However, most tenders are written based on a specific system design that has been defined by the consultant. As stated above, with consultants generally gravitating towards traditional systems, these designs are generally civils-based (i.e. using reinforced concrete). In some tenders, tenderers can provide alternatives if they have also submitted a tender for the specified system. For full treatment systems, a tenderer must provide a full detailed design and bill of quantities for the alternative offer. Aside from being unfeasible in the short time between tender advertising and submission, the process of doing a full detailed design is costly. It represents a huge risk to the supplier who may not receive any benefit from doing the detailed design. As a result, most contractors simply tender on what has been specified.

The representative of Supplier C described the design and build model, which was often the preferred approach in other countries he has worked in. In such a model, the contractors are given a set of constraints and requirements and then design and suggest a solution within those constraints. In this model, consultants are still involved early on with setting the constraints, but the tender process is less prescriptive. This model has not been the preferred approach in South Africa but may have a role as the options for sanitation provision expand. The next stage would be a design-build-operate model, which would place a greater responsibility on the contractor to design and build a system such that operation and maintenance is practical and cost-effective.

4.3.3 Capital cost focused

The representative from Supplier C spoke about the primary emphasis that is given to capital cost, as opposed to life cycle costs:

> *…in South Africa we place a lot of emphasis in the procurement process on capital expenditure. And there's no mention in these…tenders [of] life cycle costs. So, there's no evaluation of maintenance, energy, life cycle costs. It's all based on this 90/10 procurement rule.*

The reality is that all systems require maintenance, and the neglect of life cycle costs is detrimental to the long-term success of sanitation systems. It can also be misleading by guiding decision-makers towards options that are cheaper now but may carry a larger maintenance burden down the line. When asked why he thinks the procurement process is so capital cost focused, the representative said, "I'm not sure. This whole methodology, the municipal procurement framework, I think it was defined… probably 20-25 years ago. Maybe it was just an easier way. I really don't know. I just know it's fact."

4.3.4 Impacts of pilots and previous projects

Consultants and municipalities often have negative perceptions of package treatment plants and often see them as short-term solutions. The representative from Supplier C said that municipalities often see package plants as being difficult to operate since they are designed for smaller flow rates. They are also averse to the decentralised approach because it can require more operators. The representative stated that many package plants have failed, and he believes some of these failures have led to a "black tick against package plants". He then emphasised that one must look at how the plants were designed and acknowledge that many failed package plants were designed on low budgets and without taking into account fundamental design factors.

When asked about the most effective ways to work against the resistance to their systems, the representative advocated for the use of reference plants.

> *There are many contractors out there who build package plants, and successful package plants, not only for municipalities but also for industry…if one has a well-designed and well-defined package plant project, there is absolutely no reason why it should not work. And there are many reference plants around.*

In response to the need to show reference plants, Supplier C provides a detailed list on their website of all plants that they have installed, including the treatment technologies used, capacity of the plants, and location. Having this information easily accessible makes it simpler for potential customers to call the supplier's clients or visit the treatment plants in person.

4.3.5 Service contracts

Like Supplier B, Supplier C generally offers an operations and maintenance contract for two or three years during the proposal stage. The representative said that it is very difficult to get clients to buy-in to the maintenance agreement from the beginning and that "it seems to hinge on when the wheels come off." Most clients say that if the supplier provides a good O&M manual, they should be able to manage. However, particularly when speaking about mining companies, the representative emphasised that wastewater treatment is not their core business. Thus, focus and resources meant for O&M of the system are often diverted to other focus areas. Without ongoing O&M, these plants often become non-compliant, and in areas where the Department of Water and Sanitation officials are strict and competent, the system owner will be in trouble. Only at this stage do they call Supplier C to assist.

Generally, at this point, Supplier C offers various options to the client, including:

1. Technical assistance on a renumeration basis, with support offered approximately once a month
2. Full O&M contract, including a team for day-to-day maintenance and regular specialist involvement

He mentioned one company that has had a full O&M contract with them but has been asking about a hybrid model to save costs. This would entail the company taking care of a day-to-day maintenance and Supplier C still providing some expert technical assistance. The representative from Supplier C said that this may be possible if the operators are well-trained, and a water specialist remains involved on a regular (at least monthly) basis. The representative did not seem concerned about whether package plants could be operated by different water specialist companies, as long as a specialist is involved: "The technology is not so complex that it cannot be done…[by] a water specialist company, even the municipalities if they have the internal skills. There's no reason they can't operate these plants." This comment points to potential for service contracts for package plant treatment systems to be opened to different suppliers and not just the initial supplier or manufacturer of the technology, which is important for fair and competitive procurement processes.

He further emphasised that while some of the above issues may be partly due to capacity, some are simply due to a failure to prioritise maintenance:

> *People just do not do maintenance. That is not package plant related. That is everywhere. There is just no maintenance. It sounds ridiculous. Our [senior] manager travels 800 km's to site [every two weeks]. And sometimes he arrives there …and there are simple things. There's a pump that doesn't run… And everything is out of control. Although the operators know it, they've been trained.*

4.3.6 Making procurement of innovative systems fair

In relation to the innovative NSSS that Supplier C is currently working on, the representative was asked about his views on making the transition from pilot to procurement stage. He said that this has been a concern from the beginning. One approach he mentioned was a franchise model, in which systems not exclusive to one supplier; thus, suppliers other than Supplier C would be able to manufacture and supply the same system, thus opening the tendering process to competition. The representative sees the new system, which recycles treated water for flushing, as an extra tool in their package plant toolkit. Including this new system provides them with a more high-tech option that is applicable to areas with little or no reliable water supply.

4.3.7 Certifying systems

The representative was asked about what certifications (if any) the package plants that they manufacture have and whether these certifications are helpful. He then spoke about a previous initiative that was initiated approximately 10 years ago, called SUPACSA. The concept of the SUPACSA organisation was to bring together the different package plant suppliers in South Africa and form an alliance to promote package plants. There were at least 10 vendors who looked at standards together and developed a strategy for promoting the approach. As part of this, they tried to establish a SUPACSA certification, which was meant to focus on a package plant's ability to meet discharge standards. If plants had this certification, it would provide municipalities and customers with a level of confidence. However, the concept did not move forward, likely due to differences in opinions among the collaborating suppliers.

The representative spoke positively about the concept in that it brought competitors around a table with a common goal: "If the municipalities bought more package plants and they had the SUPACSA label, then they could sell." This experience, though unsuccessful, points to the impact that certification can have on proliferation of innovative systems. If municipalities are better able to evaluate new options based on set standards, they are more likely to buy with confidence. The more alternative systems are implemented, the more open municipalities will be to implementing alternatives, provided that the installations are successful. Standardisation can have the impact of improving success by providing more up-front assessment of new systems. This may address the aversion to package treatment plants that was described above.

5 A look at real procurement processes

Municipal procurement of sanitation solutions has historically been focused on the provision of the established systems of piped sewerage and large wastewater treatment plants in urban areas and ventilated improved pit toilets (VIPs) in rural areas. Both sanitation systems have very different requirements for their delivery in comparison to many of the innovative sanitation solutions that have entered the market more recently, and thus the procurement processes and documentation that have been used in the past are not always relevant to, or supportive of, the adoption of alternative solutions.

This section of the report highlights some of the barriers that current procurement processes and documents present to the selection and adoption of innovative non-sewered sanitation systems, as well as the factors that provide an enabling environment. A number of tender documents have been reviewed to provide some concrete examples.

5.1 Technology choice of an established sanitation system is made pre-tender

Examples of non-sewered sanitation technology options which are found in tender documents include Ventilated Improved Pit (VIP) toilets, Direct Sanitation Application (DSA), Enviroloo, pre-cast concrete toilets and chemical toilets. Municipalities are generally comfortable with the procurement and delivery of certain systems, and it is often easier and less risky to specify a known system rather than a technology which the municipality has no direct experience of. The pre-selection of an established technology, together with the exclusion of alternative tender offers or unsolicited bids, results in fewer opportunities for innovative technologies to be adopted across South Africa. Even where alternative tender offers are allowed, the timeframe for responding to a call for tenders is generally too short to prepare a detailed proposal for an alternative.

5.2 Tender pre-qualification challenges

5.2.1 Construction focus, not technology focus

The implementation of several hundred VIP toilets is essentially a construction project, with no process engineering involved or control/monitoring of system performance. Tenders for the delivery of VIP toilets therefore (rightly) focused on the construction experience and capability of the tendering entity. They have commonly required contractors to have a minimum Construction Industry Development Board (CIDB) grading within the class of Civil Engineering / General Building. This then targeted tenders at contractors with a core business of construction, rather than sanitation technology provision.

> The [redacted] District Municipality seeks professional service providers for the installation of pre-cast concrete VIP toilet units for distribution throughout the [redacted] District. Only tenderers who are registered with the CIDB or are capable of being registered prior to the close of this tender, in a Contractor grading equal to or higher than Grade 6CE/PE or Grade 7CE/GB will be eligible to tender. The contract period is set for 3 years from time of appointment. The scope

Figure 4: Excerpt from VIP tender showing minimum CIDB requirements

The functionality qualification framework for tenders is frequently also written with a bias toward the construction experience of key personnel, rather than the suitability of the technology. An example is shown in Figure 5 below.

Functionality Criteria / Sub Criteria		**Maximum Points Score**
Tenderer's Experience		15
Experience of Key Staff	Contracts Manager	20
	Site agent	15
	Foremen	10
Solution Methodology • Technology proposed; • Suitability for purpose, reliability and related attributes; • Technology must include a whole system as well as a retrofit. • Sound scientific evidence of the performance of the technology. • Suitabilty of materials utilised. • Robustness of materials utilised. • Operation & maintenance management procedures.		40
Maximum possible score for Functionality (M_s)		100

The minimum number of evaluation points for Functionality is **60**. Only those tenderers who achieve the minimum number of Functionality evaluation points (or greater) will be eligible to have their tenders further evaluated.

Figure 5: Example Functionality Criteria from a sanitation tender

In the case of innovative non-sewered sanitation systems, it may be more advisable for tenders to be targeted at the sanitation technology developers/specialists and the suitability of the technology rather than the construction companies, as the decision around the selection of an appropriate system will be guided by both the characteristics of the technology and the competence and stability of the supplier. Appropriate construction experience may well be required for the roll-out of the technology to hundreds of households, but this aspect of delivery could be sub-contracted by the technology developer to a partner with the required CIDB grading, if applicable. **A sanitation technology should not end up excluded from consideration simply because the technology developer does not have major construction experience.**

Even in the case of established technologies, such as VIP toilets, a reliance on construction companies *instead of* sanitation specialists can lead to inappropriate construction due to a lack of understanding of how sanitation systems work. For example, construction contractors may end up constructing sealed and plastered pits for VIP toilets based on common practices in the construction industry. However, this construction method negates the operating principles of VIP toilets, which rely on decomposition of sludge and infiltration of liquid into the soil which leads to the stabilisation of sludge. A lack of understanding that VIP pits should be constructed to be open jointed for this reason, coupled with limited technical direction from municipalities, can lead to a huge maintenance burden on municipalities in the long run.

5.2.2 Local production requirements

Tenders frequently require that the tenderer must have a local presence in South Africa, which is reasonable. They may also stipulate a minimum threshold for local production and content. Various innovative non-sewered sanitation systems developed internationally are starting to enter the South African market. The extent of local manufacture of these systems varies from product to product – for some it is possible to completely localise production quickly, under technology licensing agreements. For other products, it is not financially feasible to localise production until a minimum supply threshold is reached. In these cases, the requirement for a high level of local production can present a barrier to these systems ever entering the South African market.

5.3 Tender specification challenges

5.3.1 No allowance for alternative offers

There is often no allowance made for alternative offers submitted in addition to a Conforming Tender. At times there will be good reasons for this, but the effect is also to narrow the range of technologies and/or implementation models considered for application.

5.3.2 Technology evaluation criteria are too broad

There is little experience currently of implementing innovative non-sewered sanitation technologies at scale. Reasonable performance acceptance criteria (in terms of acceptable effluent quality, level of operation and maintenance required, running costs, etc.) are still being established for these types of systems. The language currently used in tender documents provides very broad criteria (see Figure 6 below). In one sense this can be advantageous, as it widens the net to as many potential technologies as possible. However, it also then requires municipalities to carry out a longer screening and selection process post-tender, which may miss the best solution in the midst of many options being considered.

The solution methodology must respond to the Scope of Work and the details outlined below:

Solution Methodology

- Technology proposed;
- Suitability for purpose, reliability and related attributes;
- Technology must include a whole system as well as a retrofit.
- Sound scientific evidence of the performance of the technology.
- Suitabilty of materials utilised.
- Robustness of materials utilised.
- Operation & maintenance management procedures.

Figure 6: Example of technology evaluation criteria from a tender for alternative sanitation technologies (2019)

Standards such as SANS 30500, *Non-sewered sanitation systems – Prefabricated integrated treatment units – General safety and performance requirements for design and testing,* provide a useful basis for specifying the required performance acceptance criteria for novel NSS technologies.

5.3.3 Tender specifications are too broad and/or unrealistic

Specifications may seem as though they are targeting a 'silver bullet' solution that can be applied successfully in all use contexts (see example below in Figure 7, particularly requirement ii). Many innovative NSS technologies work very well in some contexts but are completely inappropriate for others – for example, an incineration toilet can function very well as a household solution but is likely to fail in a high-urination public toilet use context. The requirement in a tender for a technology to work in all possible contexts can exclude numerous solutions from consideration. In reality, a requirement for a technology to work in all possible contexts SHOULD exclude all solutions, because there really is no 'silver bullet' in sanitation.

The new alternative on-site toilet technology should offer the following:

i) Easy for use in areas with less or no waterborne sanitation;
ii) Technology that can be used in all environments and all areas including rural, peri-rural and or urban;
iii) Technology that requires less maintenance and maintenance user-friendly;
iv) New technology material should be replaceable and made available as and when required;
v) Technology should be odour and insects free at all times;
vi) Technology that is safe to the consumer and the public as a whole;
vii) The technology should be environmental friendly;

Figure 7: Example tender specification criteria for alternative sanitation solutions (2019)

It is advisable for specific performance acceptance criteria to be considered and defined, for inclusion in the tender document. This will aid in the technology selection process and will also ensure that the appointed supplier is held to specific performance standards when the project is implemented. Chapter 9 of the

SASTEP Guideline for *Field Testing and Demonstration of Sanitation Technologies* provides a good guide for setting the performance criteria for NSS technologies.

5.3.4 Tender specifications are too specific

Some tender specifications are so specific that they restrict different suppliers and technologies from tendering, which goes against the principles of competitiveness and cost-effectiveness. As described in Chapter 3, there may be motivations in some instances to specify a single supplier but establishing a sound basis for this is difficult. Tenders that are too specific, favouring a single alternative technology, have potential to restrict innovation and violate the Public Finance Management Act. Based on the strict procurement rules in South Africa, it is surprising that such tenders get approved. However, a lack of capacity and understanding of sanitation systems among supply chain management personnel may contribute to the continued proliferation of specifications like these. Furthermore, when reputable companies see these glaring issues and do not tender and challenge the process, it paves the way for these practices to proliferate

Some tender specifications were reviewed, which would fall under this category of being too specific. This manifests either by mentioning specific suppliers in a specification or writing a detailed functionality specification that is tailored to a specific supplier. Examples are shown below.

	SUPPLY OF TOILETS MATERIALS			
a)	Supply & Delivery of Prefabricated Concrete top structure SUPPLIER 1 or similar approved)	Prov Sum		126
b)	Supply & Delivery of SPECIFIC SUPPLIER 2 substructure	Prov Sum		126
c)	Contractor's charge to allow for handling costs and Profit in respect of subitem (a & b):	%		
	INSTALLATION OF TOILETS SPECIFIC SUPPLIER 2 STRUCTURES)			
PSGA 8.6	Iinstallation of Prefabricated Concrete top structure *Rate to include assembling and commisioning*	No	LIC	126
PSGA 8.6	Provision and installation SPECIFIC SUPPLIER 2 substructure to supplier's specification; model to be supplied by the Supplier *Rate to include assembling and commisioning (incl. related products, user-education)*	No	LIC	126
	Supply, Deliver and apply ABE products	No	LIC	126
PSGA 8.1.3	Concrete			

Figure 8: Tender BOQ with reference to two specific suppliers. Note that with Supplier 1, the BOQ includes the words "or similar approved", but this is not true with products from Supplier 2. This is an issue and limits those that can supply on this contract. (2013)

SPECIFICATION

The product to be delivered must contain the following information to meet the requirements of the municipality:

1. SPECIFIC TECHNOLOGY **Low Flush System**

Materials meet requirements of SANS 10400 (National Building Regulations)

This entails:

1. Precast concrete panel top structure:
   - Floor Area (1600mm x 970mm)
   - Front Height (2047mm)
   - Rear panel wall thickness (150mm)
   - Lockable pressed steel door (2032mm x 800mm)
   - Concrete roof slope (5 degrees)
   - 36 litre PVC water storage tank
   - 1 litre flush PVC Cistern
   - Porcelain seat and PVC seat cover
2. SPECIFIC TECHNOLOGY
3. Sewer Pipes
   - Long Bend SPECIFIC TECHNOLOGY
   - 110mm diameter pipe to soakaway (3m)
   - 50mm diameter vent pipe (2.7m)
4. Soakaway with 40mm Concrete Slab Cover
   - Area (2.05m x 1.27m)
5. Training local labour on how to erect and handle the toilet structure.

Figure 9: Tender specification for a specific, branded low flush toilet technology (2020)

1.1.3 Specifications (Extent of Works)

- The toilet system should be sealed to prevent leakage and possible infiltration of flood and / or groundwater.
- The separation of human liquid and solid waste should occur under gravity within the unit tank.
- An extraction point will have to be provided on the domestic type of toilets, to avoid liquid overload, under high usage applications and wet climatic conditions.
- The forced extraction ventilation system should be well designed to facilitate continuous air flow through the unit, maximising Aerobic, Waste Separation decomposition and evaporation of liquid waste. This airflow through the unit should also maintain a negative pressure to prevent the escape of odours through the ceramic toilet pan. The air flow should be assisted by a ventilation extraction unit positioned on top of the outlet vent pipe, with air being drawn into the container via the inlet vent pipes.
- The design of the system should provide the right environment in terms of sufficient heat, prolonged retention periods in relation to number of users, adequate airflow and oxygen, to dehydrate and decompose the waste efficiently.
- The human waste should be converted via a stimulated bacterial and biological activity into an inoffensive / or stabilised material. The accumulated dried waste that will be periodically removed should be stabilised and safe to handle. The periodic removal must be cost effective and as infrequent as possible.
- The waterless, aerobic toilet system should be of an effective and efficient design, in order to capitalize on air circulation [wind] and heat from the sun to promote aerobic, waste separation of solids and evaporation of liquids. Effectively the system should be fully tested, with an acceptable track record be an environmentally sound zero discharge system, having the following benefits:
  - ✓ Needing no water to operate, conserving water resources
  - ✓ Zero discharge system, with reduced waste volume and cleaning cycles
  - ✓ Preventing pollution and risk to human health, as well as no odours and flies
  - ✓ Minimizing operating cost and the need for reticulation networks
  - ✓ No need to use any chemicals

Figure 10: Tender specification that is written for a specific supplier of a proprietary technology. Later in the installation details, the contact information for a specific company supplying this technology is provided. (2013)

As a general approach, writing a functionality specification may be appropriate for specifying alternative sanitation systems. However, unlike the example in Figure 10, such specifications should be general enough to still allow different technology suppliers of a given sanitation solution (e.g. dehydrating toilets) to tender. An example of how this has been done is shown in section 5.5.

5.3.5 Exclusion of systems that rely on specialist maintenance personnel

The maintenance requirements of traditional flush toilets and VIPs have not relied on the services of specialist technicians. Some of the innovative NSS technologies entering the market are relatively high-tech, and more akin in maintenance requirements to a domestic appliance such as a refrigerator or cell phone. Interventions by specialist maintenance personnel may be a requirement over the lifetime of the product. This is not necessarily a barrier to adoption, provided that the necessary local technical support is in place to support the roll-out of these new products. Some tender specifications exclude systems that require specific technical support, on the grounds that municipalities may be left with un-maintainable systems should a technology provider go out of business, or that they may be held to ransom if the technology is provided by sole supplier. These are valid concerns and need to be addressed if tenders are written to allow the inclusion of high-tech systems.

The guidance on implementation of package plants in eThekwini Municipality requires inclusion of a 2-year service agreement between the supplier of the package plant and the owner. A similar arrangement could be investigated for sanitation systems that require specialist maintenance. Such a commitment could include a set period of support after installation along with a commitment to transfer the skills for maintenance to local/municipal maintenance personnel.

5.3.6 Accounting for systems that rely on service contracts

Some sanitation systems, such as so-called Container Based Sanitation (CBS), rely on frequent servicing of toilets. Chemical toilets are an example of an established system that rely on this arrangement. Other CBS systems rely on service contracts because a reliable waste stream is needed to feed into a beneficiation process. Other sanitation technologies may not require a service contract when installed in a household context, but if installed in a communal situation (e.g. a school) will only be viable if implemented with a service contract. Tender specifications need to ensure that technology suppliers provide clear details of how they envisage their systems operating and if a service contract is part of the model that ensures sustainable operation. The costs associated with such service contracts also need to be clearly stated.

In Cape Town, where container-based systems are common, separate supply and service contracts are generally implemented. The service contracts will for example specify servicing of units three times per week, with delivery of sludge to a wastewater treatment works. These service contracts do not generally rely on specialist servicing and are therefore quite competitive.

One system that is widely used in South Africa and relies on quarterly servicing is the Enviroloo system. The supplier includes a 2-year servicing contract in their price for the toilet, and thus tenders based around this technology specify that contractors must provide for this servicing. This is incorporated into the duration of the contract and as an item in the Bill of Quantities, for example: “Annual Service Maintenance Contract@ R70.00 per. After every service performed, a detailed service report will be sent to the client for perusal and for records. Subjected to Customer Operations and Maintenance Budget." It should be noted that it is not proper for the BOQ to specify the price, except in the case of a provisional sum. The tendering contractors should specify the price.

Incorporating servicing contracts at the time of supply of the new sanitation systems sets the municipality up for ensuring maintenance continues.

5.4 Tender evaluation challenges

The Public Finance Management Act, No. 1 of 1999, was intended to ensure that services and goods are procured by the state in a transparent and fair manner which furthermore ensures that the state receives good value for money. In reality the state procurement system is easily abused and manipulated, as has been shown by the seemingly endless stream of revelations of major procurement abuse brought before the *Judicial Commission of Inquiry into Allegations of State Capture, Corruption and Fraud in the Public Sector including Organs of State* (known generally as the "State Capture Commission" or the "Zondo Commission"), which was set up in 2018 and is still in progress. The Zondo Commission has been hearing evidence of cases involving large sums of money, but it is a reflection of a problem which has come to permeate state procurement in general.

An understanding of how state procurement works is necessary in order to understand how the system is manipulated.

5.4.1 The establishment of Supply Chain Management offices within government organs

State organs used to rely on technical experts, often external consultants, to advise on procurement decisions. However, government bodies now all have Supply Chain Management offices, which have been established to manage and control procurement, ensuring compliance with the PFMA or MFMA and Supply Chain Management policy. The role of external consultants and content experts in procurement decisions has in many cases been minimised or altogether eliminated. This means that tenders are typically evaluated by clerical staff who have little or no expertise regarding the goods or services being procured.

5.4.2 Bid Specification, Bid Evaluation and Bid Adjudication Committees

Prior to advertisement, a state tender must be approved by a Bid Specification Committee. The purpose of the committee is to ensure that the specifications in the tender are appropriate and fair. After the tenders have been submitted, a Bid Evaluation Committee evaluates the tenders, determining which tenders qualify for consideration and which should be disqualified. A tender adjudication report is then sent to the Bid Adjudication Committee, which decides which contractor to appoint. In theory this system should ensure that tenders are fairly drawn up and awarded. In reality the system can be manipulated by for example the inclusion of inappropriate specifications which unfairly exclude certain bidders, or by incompetence or corruption in the process by which tenders are deemed to qualify or not qualify for consideration. For example, in 2016 when eThekwini was evaluating tenders for the emptying of its UDDT toilets, a R70 million contract, the bid evaluation process was repeated three times with different personnel until a certain tender, which was disqualified on the first two rounds of evaluation, was deemed to qualify after all.

5.4.3 Tenders primarily evaluated on B-BBEE level and price, not on functionality, capability, or technology choice

Tenders for procurement of goods and services for organs of state are evaluated on three criteria:

i) Most tenders include a "functionality" section where the tenderers have to demonstrate that they have the experience and competence to provide the services or goods requested. Points are awarded for various criteria and a minimum points threshold is set which must be exceeded if the tender is to qualify for consideration (see Figure 5 for an example). However, the evaluation of functionality can be complex and it is subject to manipulation (see Section 5.4.2 above).

ii) Price

iii) Broad-Based Black Economic Empowerment (B-BBEE) Score. The Preferential Procurement Policy Framework Act (No 5 of 2000) requires all organs of state to apply a formula when evaluating tenders. For tenders up to R50 million in value the formula awards up to 20 points of the tender evaluation score to the B-BBEE score, and 80 points to price. For tenders above R50 million in value 10 points are awarded for B-BBEE score and 90 points for price.

The difference in price between competitive tenders is seldom more than a few percent, which means in effect that most state tenders are awarded to the lowest priced tender submitted by a company with a high B-BBEE rating (typically Level 1 or 2). In many cases tender advertisements state that no tenders will be considered from companies which do not have a stated minimum B-BBEE rating, usually Level 1 or 2.

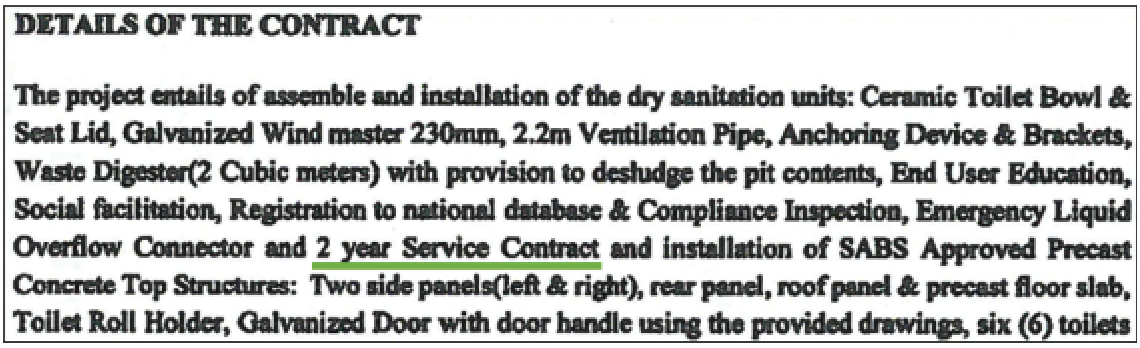
5.4.4 Functionality evaluation does not guarantee an appropriate solution

The purpose of functionality criteria in tender documents is to ensure that only tenders submitted by companies with appropriate experience and expertise are considered. However, the evaluation of how many points to award for the different functionality criteria is a somewhat subjective exercise, and is open to abuse, with competent companies sometimes being disqualified and incompetent companies qualifying. The exclusion of professional experts from tender evaluation processes undoubtedly exacerbates this problem.

5.5 Tender specifications – enabling features

5.5.1 Including a service contract period

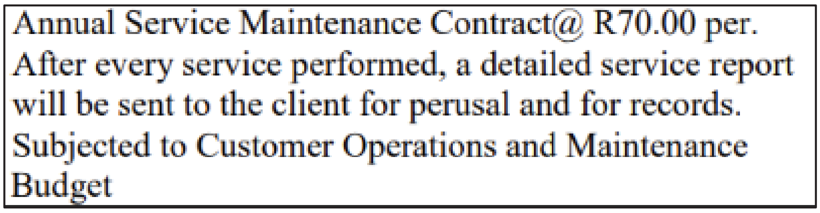
To accommodate sanitation systems with semi-regular servicing required, tenders can include regular servicing over a set period after installation. Including a period of servicing in the price of the system also gives municipal decision makers a realistic view of the operational cost of the system. Examples of this are provided below. One complication with this is that different sanitation systems may require different servicing requirements. Some contractors may be conservative while others will be unrealistic to lower their cost and make them more competitive. Where many alternatives are considered, it would be important for tenderers to submit an operation manual with their application and specify what is included in a service contract (e.g. annual servicing? Quarterly? Monthly?). With this level of detail, the evaluators could determine the value for money.



DETAILS OF THE CONTRACT

The project entails of assemble and installation of the dry sanitation units: Ceramic Toilet Bowl & Seat Lid, Galvanized Wind master 230mm, 2.2m Ventilation Pipe, Anchoring Device & Brackets, Waste Digester(2 Cubic meters) with provision to desludge the pit contents, End User Education, Social facilitation, Registration to national database & Compliance Inspection, Emergency Liquid Overflow Connector and 2 year Service Contract and installation of SABS Approved Precast Concrete Top Structures: Two side panels(left & right), rear panel, roof panel & precast floor slab, Toilet Roll Holder, Galvanized Door with door handle using the provided drawings, six (6) toilets

Figure 11: Details for a contract including a 2-year servicing contract (2021)



Annual Service Maintenance Contract@ R70.00 per. After every service performed, a detailed service report will be sent to the client for perusal and for records. Subjected to Customer Operations and Maintenance Budget

Figure 12: Example BOQ item for annual servicing. Note the BOQ should not specify the price – the tenderer should be the one quoting that. (2014)

5.5.2 Separating tenders

One example of an approach with some potential is splitting sanitation tenders into two: one for supply and installation of a sanitation system and one for the other construction works (e.g. construction of a top structure). This approach works against the limitation of sanitation tenders being construction-centric and thus excluding those who are sanitation experts. This may be applicable in the case of implementation of alternative or innovative technologies. An example of this is presented in Figure 13, in which one tender was released with a specification for an innovative waterless, dehydration toilet. This tender did not include supply and installation of the toilet top structure, which was presumably allowed for in a separate tender document.

This approach does have potential, however, to lead to unforeseen complications and misunderstandings. For example, a similar approach was taken by a district municipality that appointed two contractors for a VIP construction project: one for supply and delivery of precast toilets and one for erection of precast toilets. The approach supposedly opened the erection tender up to local SMMEs, thus providing an employment opportunity for local companies. However, numerous news articles were published in the second half of 2021, which pointed to top structure panels that had been delivered but not erected after some time (Bobelo & Solundwana, 2021). This has led to confusion among community members and allegations of corruption (i.e. people have been paid but the community has not yet benefited from what was paid for). Even if the payment and contract processes have been above board, this procedure of splitting the tenders in two seems to have led to poor coordination between the contractor delivering the supplies and the contractor tasked with erection. These problems only exacerbate community frustration and suspicion. The tender process and payments are now being investigated by the Hawks.

The above example points to the importance of coordinating efforts in the event that tenders are split among separate contractors. This may lead to more complications, but in scenarios where the desired sanitation system requires input from specialists for proper design and installation, these challenges may be worth it.

2. SCOPE OF WORK

The procurement of innovative service providers, for the supply, installation and operation of waterless, dehydration / evaporation toilets within informal settlements. The proposed sanitation technology should exclude the supply and installation of the toilet top structure.

The toilet system should be sealed to prevent leakage and possible infiltration of flood and / or groundwater.

The waterless, dehydration / evaporation toilets should be of an effective and efficient design, in order to capitalize on air circulation (wind) and heat from the sun to promote dehydration of solids and evaporation of liquids. Effectively the system should be fully tested, with an acceptable track record, be an environmentally sound zero discharge system, having the following benefits:

- Needing no water to operate, conserving water resources;
- Zero discharge system, with reduced waste volume and cleaning cycles;
- Preventing pollution and risk to human health, as well as no odours and flies;
- Minimizing operating cost and the need for reticulation networks;
- No need to use any chemicals.

Figure 13: Example Scope of Work which separates supply, installation and operation of the sanitation system from the provision of top structures, thus encouraging sanitation experts to tender. (year unknown)

5.5.3 Specifications that are specific enough without being exclusionary

In contrast to excessively specific specifications that exclude different suppliers from submitting (see section 5.3.4), tenders can be written in a way that ensures competition while also meeting the municipality's requirements. An example is shown in Figure 14, which describes a sanitation system that does not require water, can be used by at least 10 people each day, and has the following characteristics: no water, chemical, or energy input required; non-penetrable by stormwater; and does not pose a risk to groundwater. The specification further requires submission of an operations manual so that evaluators can assess how the system meets these requirements. The specification below ensures that various suppliers of waterless toilets can submit proposals.

APPOINTMENT OF A CONTRACTOR FOR THE SUPPLY, CONSTRUCT, TESTING AND COMMISSIONING OF IMPROVED SANITATION (WATERLESS TOILETS SYSTEMS) IN FARMS
Specific location

Item	Description	Unit	Qty	Rate	Amount
	Improved sanitation (Waterless toilet system) which meets the following specifications:				
	Sub-structure suitable for use of at least 10 people per day with a drying bag or not less than 1.5 cubic meters.	No.	340		
	Appropriate concrete floor slab to cover the pit / sub-structure (if necessary)	No.	340		
	A prefabricated toilet top structure complete with a stainless steel door which opens outwards on a steel pivot hinge and all applicable accessories (toilet bowl, toilet seat with lid, toilet paper hanger).	No.	340		
	Transportation and Delivery to scattered sites in rural areas within the municipality at a radius of 150km Specific location *9, 10 and 11.*	No.	340		
	Contractor Training for assembly and installation	No.	340		
	Consumer Education and Commissioning	No	340		
	Community Liaison Officer	No	4	3 500.0	
Sub-total					

The required toilets system must also adhere or have the specifications as follows;

- *Must use less or no water*
- *Must use less or no chemicals*
- *May use solar or no energy*
- *Easy to implement/Install*
- *A system that is conceals and non - penetrable by stormwater*
- *Minimum Maintenance*
- *Will not pose risk to groundwater and all surrounding environment*

NB: A Manual or brief report indicating how this type of toilet system works and installation procedure must be attached to the tender document.

Figure 14: Example of tender BOQ and specification for waterless toilet system. The specification is broad enough to not exclude waterless toilet system providers while being specific enough to ensure that the municipal gets what they are looking for. (2016)

If the above example were to be used for high-tech waterless toilet systems that dry waste at an accelerated rate, the specification could be adjusted to say, for example: "Must aid in expedited drying of faecal matter either through solar heating, enhanced ventilation, or both."

5.6 Other procurement challenges

State procurement is not well suited to the adoption of new technologies. Those responsible for technology choice tend to be risk-averse and therefore prefer to specify a technology which is known. For this reason the only way a government body will typically consider an innovative technology is if another organisation, such as the Water Research Commission, is covering the cost.

Some of the bigger cities such as eThekwini and Johannesburg do allocate some funds to research and development, and smaller municipalities look to them to test new ideas which they may later choose to adopt.

Some new technologies are not generally available but require "sole-supplier" contracts. For good reasons it requires very strong motivation for such a contract to be approved. However, because in the past sole-supplier contracts have sometimes been awarded corruptly, it is now harder than ever to get this kind of contract approved.

6 Summary of the key issues faced

The obstacles to the introduction of innovative technology are partly related to the making of informed choices (technology selection), and then to giving effect to those choices (technology procurement).

6.1 Selection of non-sewered sanitation systems

a) Limited understanding about sanitation systems and how they are meant to function. This limited understanding can lead to a one-dimensional view of sanitation (e.g. as a toilet seat only), failure of municipal decision makers to evaluate new technologies that are presented to them, and a lack of understanding of the full sanitation value chain that must be considered.
b) Lack of knowledge about systems that are available among municipalities and consultants.
c) Lack of certification and testing of technologies. There is a further need for field testing and demonstration pilots of new technologies, as that will give decision makers more confidence.
d) Many municipalities are looking for a low or NO maintenance solution, but those solutions simply do not exist. It is thus crucial that maintenance requirements are specified early-on to help inform decision-makers and enable them to compare systems. They need sufficient knowledge to be able to determine whether they want to invest more now or later on in the life of the technology.
e) Many municipalities are stuck in the way things have always been done, either due to risk aversion, lack of knowledge, or lack of capacity and time. Changing this requires time and budget to be allocated towards upskilling and training of sanitation personnel.
f) There is limited capacity to consider various options and all relevant factors for each project. Thus, municipalities require support in simple yet effective methods to evaluate alternatives and select appropriate solutions.

6.2 Procurement of non-sewered sanitation systems

a) Specifications must be specific enough to ensure appropriate technologies but not too specific to limit those who can tender and favour a specific supplier.
b) Methods should be explored for receiving alternative offers or pursuing design and build contracts with sanitation experts.
c) Evaluation protocols that look at life cycle costs should be established so that O&M requirements are considered along with capital cost.
d) Methods for incorporating service contracts in supply contracts should be investigated.
e) Options should be explored for separating the sanitation system design and supply portion of the contract from the construction and civil works portion. This will ensure that sanitation systems are designed and implemented by individuals with understanding of how systems should work.
f) It is difficult to move from a successful pilot project to procurement due to the PFMA requirements for tendering. The requirements ensure tendering processes are fair and competitive, but they can also lead to municipalities being unable to implement a system that they know works. This requires tender specifications to be written effectively and requirements to be added, such as a proven piloting track record and certification.
g) All the above require that those writing tender specifications have a deeper understanding of how sanitation systems work and what makes a certain system appropriate in a specific instance. This will enable them to write specifications that cover all of their bases and encourage innovation.

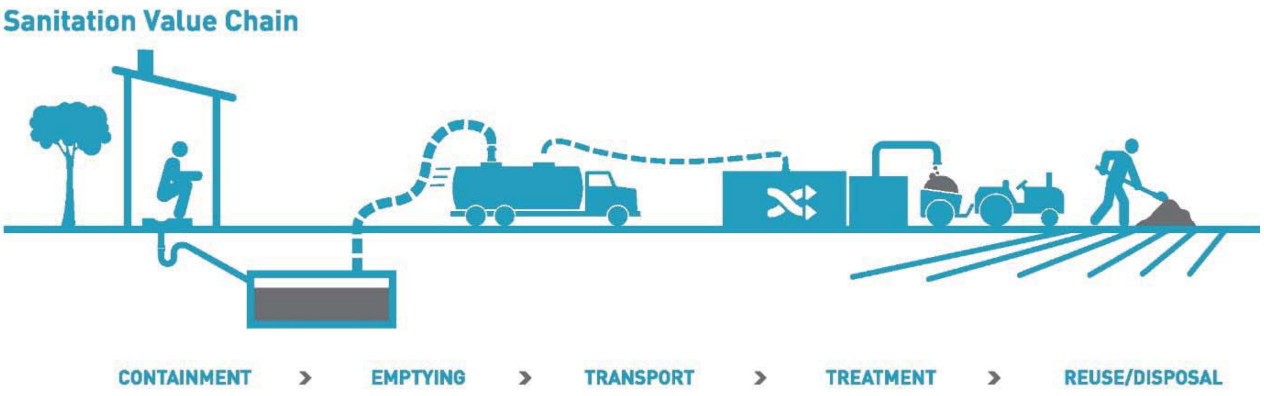
7 Conclusions, next steps

The analysis above has revealed several obstacles and gaps in the uptake of alternative sanitation systems. Many of these are related to understanding, defining, selecting, and procuring alternative sanitation systems. To fill in some of these gaps and specifically to support South African decision makers, this project has led to the creation of the following tools:

1. ***Selecting Sanitation Systems:*** A document setting a framework for understanding what is included in a sanitation system. The aim of this document is to establish a common language among South African decision makers.
2. ***Sani Select decision-support tool***: An MS excel tool that assists with decision-making along the sanitation value chain while considering many different factors
3. ***Writing a sanitation policy****:* A document providing simple guidance for municipalities on writing their own sanitation policy
4. ***Procurement Processes for Alternative Sanitation Systems****:* A document providing guidance on procuring alternative sanitation technologies, with some proposed alternatives to traditional approaches. This also includes some example specifications to assist decision makers.
5. ***Advocating for Alternative Sanitation Systems:*** A document providing high-level tips to technology suppliers and advocates to improve their promotion of alternative sanitation systems, based on feedback from those interviewed during this study.

The above tools are a starting point for supporting municipalities and other decision makers in taking the step towards more sustainable and appropriate sanitation. The tools should be disseminated to decision makers and made readily available for download. A master class can be designed around the above tools, and the class should be accredited so that attendees receive CPD points. One way to improve the effectiveness and sustainability of the training may be to create a series of short videos that can be accessed at any time. They can be used in the master class but also made available online. The short videos would introduce concepts and approaches and provide users of the above tools with reference material that they can revisit after the class. This is the proposed next step to take these materials to the potential users.

CHAPTER 3: SELECTING SANITATION SYSTEMS



This chapter is intended to support water and sanitation officials in municipalities to understand and select appropriate sanitation systems for their context. Specifically, this chapter:

* **Presents a framework for understanding sanitation systems** as a series of components along the sanitation value chain,
* **Defines numerous technology options** and approaches along the value chain
* **Presents criteria** that should be considered when selecting a sanitation system.
* **Introduces the *SaniSelect Decision Making Tool***, including information on how to use the Microsoft Excel tool to support decision making.

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1 The Context: Sanitation in South Africa

Since the beginning of South Africa's democracy in 1994, there has been a vision to pursue equality through improved service delivery, with varying levels of success. One pivotal aspect of service delivery is sanitation provision, which ensures that people can perform their basic bodily functions without experiencing risks to their health or the environment. The pressure to address serious sanitation backlogs, along with increasing pressure because of water stress and other environmental factors (e.g. high water tables), has led to two realities:

1. Creation of a "binary paradigm", in which dry sanitation systems (e.g. VIP toilets) are used in rural and peri-urban areas and full waterborne sanitation systems connected to wastewater treatment plants (WWTPs) are used in urban areas. The binary paradigm makes it simple for decision-makers to select technologies, but it also limits innovation. Furthermore, the limited options have often led to user dissatisfaction.
2. Increasing innovation in the sanitation sector, with individuals and organisations in South Africa and beyond coming up with new solutions to the challenges faced.

The binary paradigm at the municipal level in South African municipalities means that innovative products have struggled to find their place in the market. Therefore, these innovative products are often relegated only to the donor-funded, research-based projects, rather than large-scale municipal implementation. While new solutions are not appropriate everywhere, and there is certainly no "one-size-fits-all" solution for sanitation backlogs, some circumstances warrant an innovative or alternative solution.

1.1 Defining sanitation systems

This section presents different categories of sanitation systems that might be applied in different scenarios and situations. The definitions are presented in Figure 15, and examples of each category are presented in Figure 16. The diagram begins by defining a **Sanitation System** broadly as the *facilities and services for managing human waste along the sanitation value chain. This includes containment, storage, and treatment onsite or conveyance and treatment elsewhere, with eventual safe end-use or disposal.* This definition is derived from the World Health Organisation's definitions of sanitation and sanitation systems. The use of the term "products" in the definitions below is based on the 2014 EAWAG Sanitation Systems *Compendium* and is defined as "input and output materials, including those generated by humans, those required for technical functionality, and those generated through storage or treatment processes." In the definitions in Figure 15, products are either referred to generally as products or more specifically, either by stating a specific product (e.g. excreta, effluent) or the general category (input or output of a process).

The definitions presented here refer to the handling of the PRIMARY output from the various systems. For example, the primary output of dry systems is excreta or faecal sludge, and the primary output from waterborne and wet systems is a liquid stream (wastewater). The definitions relate to the fate of the primary output. In the case of dry systems, this is the solid stream (excreta/faecal sludge), and for waterborne systems, this is the liquid stream (wastewater/effluent). The systems may have additional outputs (e.g. sludge from on-site wet systems or source-separated urine), but handling of those would be defined separately.

The first level of differentiating **Sanitation Systems** is as **Off-Site Sanitation** or **On-Site Sanitation.** These terms are widely used in the sanitation field. **Off-Site Sanitation** systems are by nature waterborne systems, as sewers are used to convey wastewater to a treatment site. These systems can either be **Centralised** systems, implemented at an extensive scale, or **Decentralised** systems, implemented at a local level (i.e. ward-scale or smaller). In the South African context, "ward-scale" implies less than approximately 3 000 homes.

On-Site Sanitation is generally accomplished either through **Dry Systems** or **Wet Systems. Dry Systems** do not use water to function. Products from a dry sanitation system may go through one of the following systems:

1. **On-Site Treatment**: Products are fully treated to a level at which they can be safely reused on the site where they are generated.
2. **Storage to Direct Disposal/Reuse**: the dry sanitation system contains excreta on site for some time, leading to partially treated/stabilized faecal sludge that is disposed of or reused without further treatment. Disposal or reuse may happen on the site where the products are generated or at a nearby location.
3. **Storage to Community-Level Treatment**: Similar to **Storage to Direct Disposal/Reuse**, except that the faecal sludge is emptied and conveyed to a nearby treatment facility, which may be constructed in situ or be prefabricated.
4. **Sealed Containment**: Excreta is collected in sealed containers, which must be collected or emptied on a frequent basis and delivered to a treatment facility.

Wet Systems use water to function, and the primary product (i.e. wastewater) from these systems may go through one of the following systems:

1. **On-Site Treatment:** Products from a flush toilet(s) are treated directly on the site where they are generated, producing an effluent that can either be discharged to the environment or recycled safely.
2. **On-Site Storage to On-Site Effluent Disposal:** Products from a flush toilet(s) are contained on site, and the partially-treated effluent is disposed of on the site where it was generated through some kind of percolation system. Faecal sludge may be disposed of or treated off-site or on-site (see options for **On-Site Dry Sanitation**).
3. **Sealed Containment:** Products from a flush toilet(s) are contained on site in a sealed container (i.e. conservancy tank) and must be emptied regularly and delivered to a treatment facility.

While the definitions above are simple to apply when considering single plots (e.g. a single household or communal toilet block) or on a neighbourhood scale, the definitions become unclear when considering waterborne treatment systems installed in housing or commercial developments. These developments may include multiple households, with the products treated in a single system, which seems to indicate decentralised off-site sanitation. However, if the development land has a single landowner, this system may be considered an on-site sanitation system. However, the classification of this type of system as on-site or off-site will not necessarily influence the design of the technology(s).

A Sanitation System provides the facilities and services for managing human waste from the toilet to containment, storage, and treatment onsite; or conveyance and treatment elsewhere to eventual safe end-use or disposal (WHO)

Off-Site Sanitation *uses a sewer network to convey wastewater from the toilet to treatment elsewhere. Off-site sanitation may be an option where a piped water supply is available to the property*

Centralised
*A system in which excreta and wastewater are collected and conveyed via an extensive **sewer network to one or more large scale wastewater treatment plants***

Centralised Treatment
systems are constructed in situ (civil-based construction) and receive sewage via an extensive sewer network. Inputs are untreated human waste and wastewater outputs are treated products.

Decentralised
*A **local-level system** where excreta and wastewater are collected and conveyed via a sewer network to a **nearby (ward-scale or smaller) treatment facility**. Ward-scale is under approx. 3000 homes.*

Decentralised Treatment
systems may treat up to 2 000 m^3/day. They are constructed in situ (civil-based construction) or prefabricated. Outputs include effluent, sludge, and sometimes biogas. The effluent is treated to a level suitable for discharge to the environment or reuse.

On-Site Sanitation *is a system in which excreta and wastewater are collected and stored or treated near where they are generated e.g. within the plot.*

Dry Systems
Products from a dry system are contained or treated on-site before further treatment or disposal.

On-Site Treatment
Products from the dry toilet are directly treated to a level where they can be safely disposed or reused.

Storage to Direct Disposal or Reuse
Faecal sludge/partially treated excreta is removed for direct disposal or reused without further treatment. This takes place on-site OR at a nearby location.

Storage to Community-Level Treatment
Faecal sludge from a group of containment systems is treated in a nearby treatment facility.

Sealed Containment
Excreta is collected in sealed containers. The containers are either transported (Container-Based Sanitation) or emptied on a frequent basis, and the waste is delivered to a treatment facility.

Wet Systems
Products from a wet system (cistern or pour flush) are either contained or treated where they are generated before treatment and disposal or reuse.

On-Site Treatment
Products from toilet(s) are treated where they are generated. The treatment goal is recycling or safe discharge to the environment.

On-Site Storage to Effluent Disposal
Products from flush toilets are contained on-site, and partially treated. The effluent is disposed of onsite using a soil-percolation system (or into an off-site sewer). Faecal sludge is removed and may be disposed, or treated off-site or on-site (see On-Site Dry Treatment).

Sealed Containment
Products from flush toilets are contained on-site in a sealed tank. The contents are emptied regularly and delivered to a treatment facility.

Blue are water-based systems and **green are dry systems**

Figure 15: Definitions of sanitation system categories

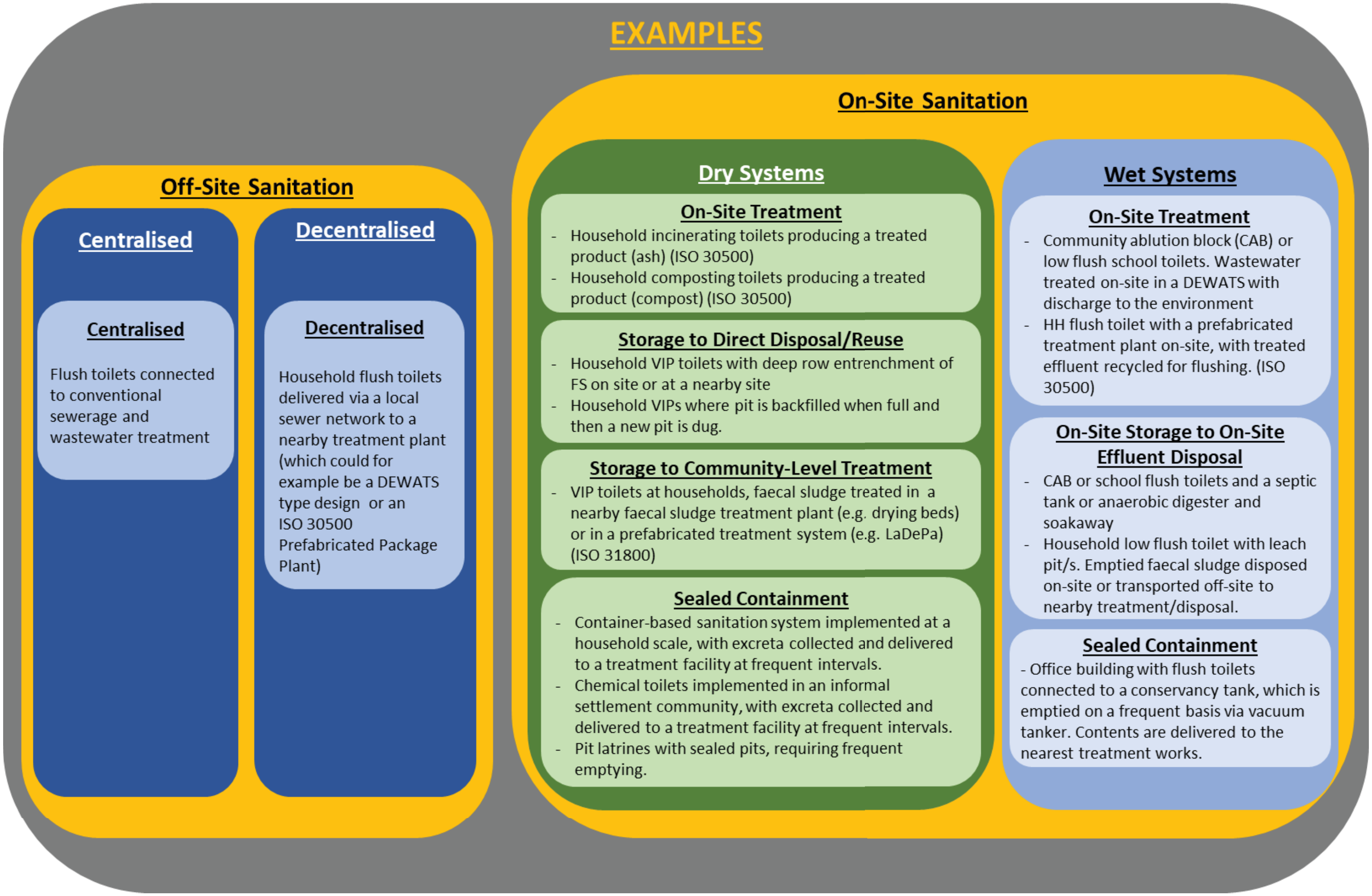


Figure 16: Examples of sanitation systems in each category

1.1.1 Relevance of ISO/SANS Standards

ISO/SANS 30500

ISO/SANS 30500 sets standards for a specific subset of Non-Sewered Sanitation Systems (NSSS), which are defined in the standard as:

A prefabricated integrated treatment unit, comprising frontend (toilet facility) and backend (treatment facility) components that

> *a) collects, conveys, and fully treats the specific input within the system, to allow for safe reuse or disposal of the generated solid, liquid, and gaseous output, and*
>
> *b) is not connected to a networked sewer or networked drainage systems.*

Prefabricated means manufactured in a factory or workshop and transported to the location of installation. To meet ISO/SANS 30500, these prefabricated treatment systems must meet certain effluent standards, based on whether the effluent will be discharged to the environment or recycled for non-potable use, e.g. for flushing toilets. Non-Sewered Sanitation Systems may be entirely off-grid, i.e. no electrical or water connection needed, but it is not necessary for compliance with the standard. These systems may also be connected to one or multiple user interfaces.

By this definition, ISO/SANS 30500 systems can fit under **Decentralised Off-Site Sanitation Systems** or **Dry** or **Wet** systems with **On-Site Treatment** for, depending on the application. A prefabricated NSS (SANS 30500) treatment system might be connected to a decentralised sewer network, providing decentralised treatment for a single community, or it may be connected to a single household or communal toilet block for treatment on site.

ISO 31800

ISO 31800 provides a standard for Faecal sludge Treatment Units, which are by definition *energy independent, prefabricated, community-scale, resource recovery units*. Based on this definition, Faecal Sludge Treatment Units that comply with ISO 31800 could be used to treat products from **On-Site Dry Systems.** Specifically, these systems fit would under **Storage to Community-Level Treatment** systems or **Sealed Containment** systems, depending on the nature of on-site containment (i.e. extended storage or sealed containment).

1.2 Why shift focus from centralised sanitation?

Large sewer networks connected to centralised wastewater treatment plants (WWTPs) are unsustainable and inappropriate for many of the communities across South Africa. At the most basic level, these systems require large amounts of water to operate, but South Africa is a water scarce country. Furthermore, these systems are infrastructure-intensive, requiring sewer networks that connect neighbourhoods to the central treatment facility. While it is possible to connect settlements to existing networks to save on costs, many circumstances exist in South Africa where land becomes inhabited *before* the internal sewer network can be established, further complicating the construction process. When discussing informal settlements, it is also important to note that many of these settlements are in areas that are inappropriate for sewers due to the topography. Some are located on extremely steep slopes with hills separating them and the existing WWTP. Implementation of a sewered network and connection to the WWTP will be even more infrastructure-intensive, requiring pump stations. Finally, many of South Africa's WWTPs are already performing poorly, routinely failing to pass Green Drop tests[1], and would be further burdened by increased influent loads. This does not even account for the many losses within poorly maintained sewerage systems which contributes to environmental pollution and public health concerns. There is a case for investment in decentralised and on-site systems to address this gap and avoid overburdening existing treatment plants.

Thus, there is a large and growing need for non-sewered or decentralised sanitation systems to provide sanitation in new settlements, existing settlements without sanitation provision, and even in existing settlements that have access to sanitation. This must be balanced with user demands and preferences to ensure proper use of facilities. It is unfair to say that people do not prefer on-site treatment systems if their only experience with on-site treatment is a negative one. It is therefore imperative to understand how sanitation systems are *meant* to function and to put necessary maintenance systems in place to ensure that they function as they are supposed to.

1.3 The sanitation value chain

The sanitation value chain is a systems approach to sanitation provision, which focuses on containment, emptying, transport, treatment, and reuse and/or disposal, as shown in Figure 17. Every sanitation system can be conceptualised using the sanitation value chain, though some may lack technologies at a given step. For example, a fully waterborne sewered system does not include containment onsite or emptying, but waste is "transported" via sewers to centralised treatment facilities. In another example, precast VIP latrines common to the south African rural landscape operate on the concept that once the pit is full, the entire precast structure will be moved above a new pit. The faecal sludge is therefore left in the pit. Thus, the value chain of this system consists only of containment and disposal. In any case, each of the five aspects of the sanitation value chain should be considered when planning systems.

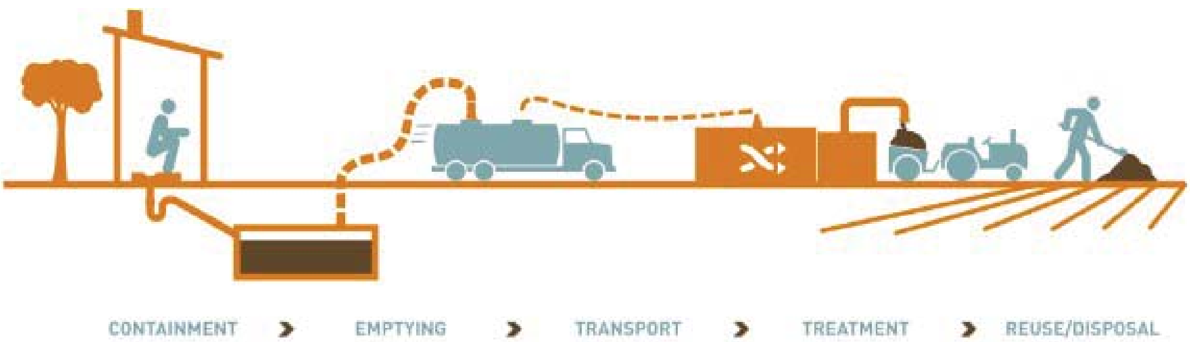


Figure 17: The Sanitation Value Chain (Bill & Melinda Gates Foundation, 2015)

[1] Data from the DWS IRIS database shows that with up to 36% of plants being monitored nationally, compliance in terms of microbiological (35% monitoring), chemical (36% monitoring), physical (33% monitoring), and operational (4% monitoring) characteristics is 65.9%, 80.9%, 87.1%, and 26.3%, respectively. The low monitoring percentages is worrying in itself, along with the low performance, particularly in terms of microbial characteristics.

2 Purpose of this Chapter

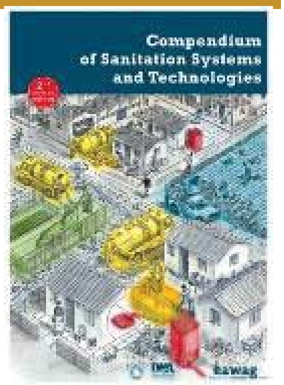
This chapter aims to support decision-makers in planning for an appropriate sanitation system. The document presents a **framework for conceptualising sanitation systems** to shift the focus from toilets only to an entire system. This framework will establish a common language among sanitation professionals and support the selection and procurement of sanitation alternatives. The document then presents **key criteria** to consider when selecting a system and then assesses various technologies along the sanitation value chain for their appropriateness based on those criteria. Thus, based on basic information about the project area and community and the project's key constraints and priorities, one could select several appropriate options for implementation.

This document and tool do **NOT** select technologies on behalf of the user. While the tool does provide scores, these are based on weightings set by the user, and the final decision of technology choice is carried out by the user.

This document and tool do **NOT** provide any design or detailed costing assistance. Once a set of solutions are laid out in a sanitation chain, a detailed design phase would begin, which would include planning, construction details, and detailed costing. Thus, the document and tool may help decision-makers understand their proposed system better, but they cannot replace competent personnel for the design and implementation of the solution.

3 Compendium of Sanitation Systems and Technologies

A key reference document for selection of sanitation systems is the *Compendium of Sanitation Systems and Technologies (2nd Edition, 2014)* and the companion *eCompendium* which were produced by the Swiss Federal Institute of Aquatic Science and Technology, commonly known as EAWAG. These resources are freely available at www.sandec.ch/compendium. The *Compendium* goes into more detail than this document, which simply provides an overview and basis for understanding systems in South Africa. Users of this document should consult the *Compendium* as well.



HOW IS THIS DOCUMENT RELATED TO THE *COMPENDIUM*?
Many of the definitions and terms presented in this document are taken directly from the *Compendium of Sanitation Systems and Technologies*. This document updates and contextualizes some of the information to make it applicable to South Africa. The project team has noted wherever technologies or information have been added or amended.

A * denotes information or items that have been added or amended. Details that are amended are companied by a footnote.

4 Defining terms

Sanitation is not achieved only through toilets. To define the challenges with sanitation provision and envision solutions, a common language covering the entire sanitation process is needed. This section and the terms defined are mostly taken from the *Compendium of Sanitation Systems and Technologies* (Tilley et al., 2014).

A **sanitation system** is made up of **products**, **functional groups**, and **technologies.**

4.1 Products

Products are input and output materials, including those generated by humans, those required for technology functionality, and those generated through storage or treatment processes. The *Compendium* provides definitions for each product, as follows (Tilley et al., 2014)[2]:

> **Anal cleansing water** is water used to cleanse oneself after defecating and/or urinating; it is generated by those who use water, rather than dry material, for anal cleansing.
>
> **Biogas** is a mixture of gases released during anaerobic digestion, which includes methane (50-75%), carbon dioxide (25-50%) and other gases, such as nitrogen, hydrogen sulphide, and water vapour. Biogas can be collected and used as a fuel or simply flared*[3].
>
> **Biomass** refers to plants or animals cultivated using water and/or nutrients from a sanitation system. The term biomass may include fish, insects, vegetables, fruit, forage, or other beneficial crops that can be used for food, feed, fibre, or fuel production.
>
> **Blackwater** includes urine, faeces, flushwater, and cleansing materials (e.g. toilet paper, newspaper) produced by a combined flushing toilet system.
>
> **Brownwater** includes faeces, flushwater, and cleansing materials and is produced by urine diverting flush toilets.
>
> **Compost** is decomposed organic matter produced through controlled aerobic degradation. Compost can be used as a soil conditioner and has a variable nutrient content. Excreta or sludge should be composted long enough under thermophilic conditions (55 to 60°C) to be sanitised enough for safe agricultural use.
>
> **Concentrated urine nutrients**[4] are the by-product of various treatment processes for source-separated urine. These processes produce some form of concentrated nutrients/salts that are typically used for agriculture (e.g. struvite, $MgPO_4$) or even in building (e.g. urea biobricks). The

[2] The definitions provided here have been truncated for simplicity. Longer definitions are provided in *The Compendium.*

[3] This document added "or simply flared" to the description of biogas.

[4] This product has been added to this list and is not part of the 2014 EAWAG *Compendium*

specific concentrated product is determined by the specific urine treatment technologies employed.

Dried Faeces are faeces that have been dehydrated until they are dry and crumbly. Dried faeces are produced by storing faeces in a dry environment with adequate ventilation, high temperatures, and/or absorbent materials. Though dried faeces are not necessarily sanitised after the drying process, they are high in organic matter.

Dry cleansing materials are solid materials used to cleanse oneself after defecating and/or urinating (e.g. paper, leaves, corncobs, rags, or stones). Depending on the sanitation system, these materials may be collected and separately disposed of or put into the system.

Effluent is the general term for a liquid that leaves a technology, typically after blackwater or sludge have undergone solids separation or some other type of treatment. Depending on the type of treatment, effluent may be completely sanitised or may require further treatment before it can be used or disposed of.

Excreta is a mixture of urine and faeces that is not mixed with flushwater. Excreta is small in volume but concentrated in nutrients and pathogens. Excreta consistency will vary depending on the quality of faeces.

Faeces refers to (semi-solid) excrement that is not mixed with urine or water. Depending on diet, people produce approximately 50 litres per year of faecal matter. Fresh faeces contain about 80% water. Of total nutrients excreted by humans, faeces contain about 12% of N, 39% of P, 26% of K, and have 10^7 to 10^9 faecal coliforms per 100 mℓ.

Flushwater is the water discharged into the user interface to transport the content and/or clean it. Freshwater, rainwater, recycled greywater, or any combination of the three can be used as a flushwater source.

Greywater is the total volume of water generated from washing food, clothes, and dishware, as well as from bathing, but not from toilets. It may contain traces of excreta (e.g. from washing diapers) and, therefore, also pathogens. Greywater accounts for approximately 65% of wastewater produced in households with flush toilets.

Organics refers to biodegradable plant material (organic waste) that must be added to some technologies in order for them to function properly (e.g. composting chambers). Organic degradable material can include, but is not limited to, leaves, grass, and market waste. Though other products contain organic matter, this compendium uses the term organics to refer to undigested plant material.

Pit humus is the term used to describe the nutrient-rich, hygienically improved, humic material that is generated in double-pit systems through dewatering and degradation. The degradation processes in double pit systems can be aerobic and anaerobic in nature, depending on the technology and operating conditions. The main difference between pit humus and compost is that the degradation processes are passive and not subjected to a controlled oxygen supply, C:N ratio, humidity, and temperature. Therefore, the rate of pathogen reduction is generally slower and the quality of the product, including its nutrient and organic matter content, can vary considerably.

Pre-treatment products are materials separated from blackwater, brownwater, greywater, or sludge in preliminary treatment units, such as screens, grease traps, or grit chambers. Fats, oil, grease, and various solids (e.g. sand, trash) can impair transport and/or treatment efficiency through clogging and wear. Therefore, early removal of these substances is crucial for the durability of certain sanitation systems.

Sludge is a mixture of solids and liquids, containing mostly excreta and water, in combination with sand, grit, metals, trash and/or various chemical compounds. Faecal sludge is generated from onsite sanitation systems, while wastewater sludge is a product of the wastewater treatment process in sewer-based systems.

Stored urine is urine that has been hydrolysed naturally over time (i.e. urea has been converted by enzymes into ammonia and bicarbonate). Stored urine has a pH of approximately 9. Most pathogens cannot survive at this pH. After 6 months of storage, the risk of pathogen transmission is considerably reduced.

Stormwater is the general term for the rainfall runoff collected from roofs, roads, and other services before flowing to low-lying land. It is the portion of rainfall that does not infiltrate into the soil.

Treated sludge[5] is a general term for sludge emanating from onsite or sewered sanitation systems that has been treated in some way. The level of treatment of the sludge will be determined by the desired end use, but in general, treated sludge is, at a minimum, able to be safely disposed of. It has been stabilised and disinfected to some extent.

Urine is the liquid produced by the body to rid itself of urea and other waste products. In this context, the urine product refers to pure urine that is not mixed with faeces or water. depending on diet, urine collected from one person in one year (approximately 300 to 500 litres) contains 2 to 4 kg of nitrogen. With the exception of some rare cases, urine is sterile when it leaves the body.

4.2 Functional groups

Functional groups are groupings of technologies that have similar functions. There are five different functional groups from which technologies can be chosen to build a system.

User Interface (U) describes the type of toilet, pedestal, pan or urinal with which the user comes into contact; it is the way by which the user accesses the sanitation system. In many cases, the choice of user interface will depend on the availability of water. Note that greywater and stormwater do not originate at the user interface but may be treated along with the products that originate from it.

[5] This product has been added to the list and is not included in the 2014 EAWAG *Compendium.*

Collection and storage/treatment (S) describes the ways of collecting, storing, and sometimes treating the products generated at the **user interface.** The technologies under the S category often provide passive treatment (e.g. requiring no energy input) as a function of storage. Thus, products that are 'treated' by these technologies often require subsequent treatment before **use and/or disposal**. However, there are also innovative systems that do produce products that are safe for disposal or reuse.*[6]

Conveyance (C) describes the transport of products from one functional group to another. Although products may need to be transferred in various ways between functional groups, the longest, and most important gap is between **user interface** or **collection and storage/treatment** and **(semi-) centralised treatment**. Therefore, for the sake of simplicity, conveyance only describes the technologies used to transport products between these functional groups.

(Semi-) Centralised Treatment (T)[7] refers to treatment approaches that are generally appropriate for large user groups (i.e. neighbourhood to city level applications). The operation, maintenance, and energy requirements of approaches within this functional group are generally higher than for smaller-scale technologies at the **S** level. The options provided under this functional group represent general approaches to treatment of liquid streams (e.g. blackwater, greywater, urine) and solid streams (e.g. sludge). Specific technologies are not addressed in this document, as a design professional is required to define specific treatment steps required.

Use and/or disposal (D) refers to the methods by which products are ultimately returned to the environment, either as useful resources or reduced-risk materials. Furthermore, products can also be cycled back into a system.

4.3 Technologies

Technologies are the specific infrastructure, methods or services designed to contain and transform products, or to transport products to another functional group. The guide contained in this section, which is generally adapted from EAWAG's 2014 *Compendium of Sanitation Systems and Technologies,* defines over 60 technologies covering the functional groups described above. Apart from the technologies that appear in the *Compendium*, some additional technologies have been added based on the technologies that are available in South Africa as well as new innovations that are becoming available. These additions to the EAWAG *Compendium* have been indicated by an asterisk *. Technology lists for treatment and use/disposal have been edited extensively for this document, as it was determined to be more appropriate to cover "approaches" rather than specific technologies, as this is not a design guide. Furthermore, some descriptions and information have been edited, and these are explained in footnotes where necessary.

[6] This document adds the qualification that some innovative systems produce products that are safe for disposal or reuse. This addition is a result of advancements in sanitation technology development.

[7] In this document, treatment is addressed through different approaches, rather than specific technologies (as is done in the 2014 EAWAG *Compendium*). This is not a design guideline, and therefore it is simply here to provide an understanding of the broad options available (e.g. centralised vs. decentralised approaches).

When discussing technologies below, it should be noted that these do not refer to specific suppliers or manufacturers. If a specific technology is selected, the decision maker would need to go one step further to learn about suppliers of that technology. For common technologies in the South African context, there may be numerous suppliers. For innovative technologies, fewer suppliers may currently be available. Ideally, a database of technology suppliers should be kept and maintained by a central, objective agency (e.g. the Water Research Commission or the Department of Water and Sanitation). This database is outside the scope of this project. For the sake of decision-making, it is valuable to understand *how* technologies work. This framework is helpful for building a generic sanitation system before going a step further to define the specific supplier or manufacturer. In this way, there is potential to write specifications that speak to a generic technology or approach, thus avoiding some of the concerns with favouring one supplier over another.

The technologies/approaches in each functional group are described below in terms of a general description and advantages and disadvantages. The advantages and disadvantages have been reworded to reflect specific experiences from South Africa with different technologies. Further information including design considerations, appropriateness, health aspects, and operation & maintenance, can be found in the *Compendium of Sanitation Systems and Technologies.*

4.3.1 User interface (adapted from the EAWAG 2014 Compendium)

No.	Name	Description	Advantages	Disadvantages
U.1	Dry toilet	A dry toilet pedestal receives human waste and wiping material. Without a flushing mechanism, waste falls directly below the pedestal. 	1. Does not require a constant source of water 2. Can be built and repaired with locally available materials 3. No moving parts, therefore less vulnerable to breakages 4. Low capital and operating costs	1. No odour barrier provided in the pedestal 2. Lower user acceptance where communities expect flush toilets 3. Often used as solid waste receptacles 4. Pit/storage system must be located directly below pedestal, which can be a source of fear among communities
U.2	Urine diverting dry toilet (UDDT)	A urine diverting dry toilet pedestal incorporates a mechanism for separating urine from faeces and wiping material. The solid waste drops directly below the pedestal, and the urine is diverted to a separate compartment or soakaway. 	1. Does not require a constant source of water 2. No moving parts, therefore less vulnerable to breakages 3. Reduced odour expected due to the separation of urine 4. If working properly, sludge likely to be drier and easier to handle if the pit has to be emptied 5. Potential for reuse of urine, but only likely to happen if a service provider collects it from households	1. More expensive than a dry toilet with no urine diversion 2. Lower user acceptance where communities expect flush toilets 3. Often used as solid waste receptacles 4. Requires separate solutions for two waste streams 5. Risk of faecal contamination in the urine separation compartment, depending on the design of the pedestal 6. Current designs (which split the toilet bowl in two with a vertical divider) require thought by the user to position themselves correctly on the toilet seat so that urine and faeces go to the right places. 7. Urine section of bowl frequently becomes clogged with solid waste 8. Pit/storage system must be located directly below pedestal, which can be a source of fear among communities

No.	Name	Description	Advantages	Disadvantages
U.3	Flush urinal*[8]	A urinal handles only urine. Though typically installed in public restrooms for males, innovations are being made to design urinals that are appropriate for use by females who squat over the urinal. Flush urinals incorporate a water seal to limit odours. 	1. Automatically separates urine at the source, without faecal cross-contamination – more options for beneficial reuse of urine 2. Saves space in public restrooms and therefore increase number of people who can be served 3. Regularly cleaned through flushing of the urinal – reduces odours and makes user experience better	1. Requires water to operate 2. Requires separate piping for urine 3. Urinals in public toilet settings may be used to dispose of greywater and can easily become clogged with solid waste
U.4	Pour flush toilet	A pour flush toilet incorporates a P-trap with a water seal. The toilet is flushed manually by pouring water down the toilet. 	1. Water seal greatly reduces odours in the toilet cubicle 2. Lack of a cistern means reduced risk of constant leaking 3. Can be used when water supply is cut 4. Can be flushed with greywater or other alternative water resources 5. Use of water to move waste allows flexibility in the location of on-site storage 6. Pits/onsite storage can be off-set from the toilet pedestal, reducing fears of children falling in 7. Far less trash deposited in the pedestal due to reduced size of opening	1. Requires water for flushing 2. Requires users to manually flush the toilet 3. Manual flushing can lead to varying amounts of water being used 4. Cannot be used when NO water is available (municipal or alternative) at the site 5. Blockages may occur, though it should be noted that certain designs are less vulnerable to blockages and have been shown to be able to handle both toilet paper and newspaper without experiencing blockages 6. Higher capital cost compared to dry sanitation options

[8] In *The Compendium*, U.3 is "Urinal", but for this guide, it has been changed to "Flush Urinal", to allow for separate evaluation of waterless urinals (U.12). The two approaches have different applications, and a variety of waterless urinals are at different stages of development

No.	Name	Description	Advantages	Disadvantages
U.5	Cistern flush toilet[9]	A cistern flush toilet incorporates a water seal and includes a cistern with float valve that is opened when the user turns a handle, pushes a button, or other mechanism. The cistern stores water for flushing, and once a flushing event occurs, it is refilled with water. Due to the water scarcity in South Africa, it is recommended that only low flush toilets are utilised in new sanitation projects. 	1. Water seal greatly reduces odours in the toilet cubicle. 2. Cistern with flush mechanism ensures consistent flush volumes and is convenient for users. 3. Can be flushed with greywater or other alternative water resources 4. Can be manually flushed if necessary when water supply connected to cistern is intermittent 5. Use of water to move waste allows flexibility in the location of on-site storage 6. Pits/onsite storage can be off-set from the toilet pedestal, reducing fears of children falling in 7. Far less trash deposited in the pedestal due to reduced size of opening 8. Aspirational for most users – will be acceptable to and welcomed by to vast majority of users	1. Requires water for flushing 2. Incorporation of a cistern increases the potential for constant leakages 3. Incorporation of flushing mechanism introduces a point of potential breakages 4. Cannot be used when there is NO water available (municipal or alternative) at the site 5. Blockages may occur, though it should be noted that certain design changes are less vulnerable to blockages and have been shown to be able to handle both toilet paper and newspaper without experiencing blockages 6. Higher capital cost when compared to pour flush toilets 7. Much higher operation and maintenance costs than dry sanitation systems, particularly in public use settings – constant leaks can cause huge water bills, and more mechanical parts that can go wrong

[9] For the purposes of this guide, U.5 is assumed to be a low flush toilet with a cistern. This is due to the water scarcity in South Africa and the wide availability of different low flush options. A low flush toilet generally requires 5 or less litres of water to flush, while a full flush toilet requires anywhere from 9 to 16 litres of water.

No.	Name	Description	Advantages	Disadvantages
U.6	Urine diverting flush toilet (UDFT)	A urine diverting flush toilet operates in the same way as U.5 but incorporates a urine diversion mechanism. 	1. Water seal reduces odours in the toilet cubicle. 2. Cistern with flush mechanism ensures consistent flush volumes and is convenient for users. 3. Can be flushed with greywater or other alternative water resources 4. Can be manually flushed when water supply connected to cistern is intermittent 5. Use of water to move waste allows flexibility in the location of on-site storage 6. Pits/onsite storage can be off-set from the toilet pedestal, reducing fears of children falling in 7. Far less trash deposited in the pedestal due to reduced size of opening 8. Aspirational for most users. 9. No behavioural change required when using latest designs of urine diversion flush toilet (toilet bowl looks normal) 10. Opportunity for treatment and reuse of the source-separated urine for agriculture purposes (probably only if urine is collected and treated from multiple households). In the case of decentralised and centralised WWT, urine diversion leads to lower levels of nitrogen and other nutrients entering the WWTW, thus reducing the treatment burden.	1. Requires water for flushing 2. Incorporation of a cistern increases the potential for constant leakages 3. Incorporation of flushing mechanism introduces a point of potential breakages 4. Cannot be used when there is NO water available (municipal or alternative) at the site 5. Blockages may occur, though it should be noted that certain design changes are less vulnerable to blockages and have been shown to be able to handle both toilet paper and newspaper without experiencing blockages 6. Higher capital cost when compared to pour flush toilets 7. Potential for faecal cross-contamination in the urine stream, depending on the urine separation design 8. Requires separate storage/treatment approaches for the two separate waste streams

No.	Name	Description	Advantages	Disadvantages
U.7*[10]	Dry toilet with mechanical advancement	A dry toilet pedestal can incorporate a mechanism for advancing the faeces, as a way of separating the user from their waste. This may take many forms; a few examples are an auger which must be turned by the user; a "door" which is opened when in use and closed after use; or a plastic film which is opened to receive human waste and then closed again. 	1. Does not require water for flushing 2. Reduced odour due to mechanical advancement 3. Users normally cannot see excreta after advancement (design-dependent) 4. Will not be used as waste receptacles as frequently if there is a smaller opening 5. In certain setups, the pit/storage can be located offset from the user, which can lessen fears related to dry pit systems.	1. Slightly more expensive than a dry toilet without mechanical advancement 2. Vulnerable to breakages and due to moving parts 3. Breakages can lead to emergency situation (e.g. build-up of faecal material in the pedestal) 4. Dependent on well-trained users to ensure effective operation 5. Downstream treatment can be negatively impacted on if excess water is added to the system (e.g. when cleaning the toilet) – makes it less easy for users to clean the toilet

[10] U.7 is not included in the EAWAG *Compendium* (2014). It has been added to this guide due to several innovative systems that are becoming available.

No.	Name	Description	Advantages	Disadvantages
U.8*[11]	Urine diverting dry toilet with mechanical advancement	A urine diverting dry toilet with mechanical advancement is like U.7 but incorporates urine diversion as well. 	1. Does not require water for flushing 2. Reduced odour due to mechanical advancement 3. Odour is likely further reduced due to urine diversion 4. Users cannot see excreta after flushing 5. Will not be used as waste receptacles as frequently if there is a smaller opening 6. Opportunity for treatment and reuse of the source-separated urine for agriculture purposes (probably only if urine is collected and treated from multiple households). In the case of decentralised and centralised WWT, urine diversion will lead to lower levels of nitrogen and other nutrients entering the WWTW, thus reducing the treatment burden	1. Slightly more expensive than other dry toilet options 2. Requires separate solutions for the separated urine and the solid waste 3. Risk of faecal contamination in the urine separation compartment, depending on the design of the pedestal. 4. Vulnerable to breakages due to moving parts 5. Breakages can lead to emergency situation (e.g. build up of faecal material in the pedestal) 6. Dependent on well-trained users to ensure effective operation 7. Downstream treatment can be negatively impacted on if excess water is added to the system (e.g. when cleaning the toilet) – makes it less easy for users to clean the toilet 8. Certain designs of urine diversion pedestal may require the user to think about how they position themselves on the toilet to ensure urine faeces go to the right places; may be very difficult for small children to avoid defecating into the urine diversion section. The most recent design of urine diversion pedestal avoid this issue.

[11] U.8 is not included in the EAWAG *Compendium* (2014)

No.	Name	Description	Advantages	Disadvantages
U.9*[12]	**Urine diverting pour flush toilet**	The urine diverting pour flush toilet operates on the same principle as U.4 but incorporates a urine diversion mechanism. Flush water, faeces, and wiping material are separated from urine at the pedestal interface. 	1. Water seal greatly reduces odours in the toilet cubicle 2. Lack of a cistern means that the risk of constant leakage from the system is greatly reduced 3. Can be used when water supply is cut 4. Can easily be flushed with greywater or other alternative water resources 5. Use of water to move waste allows flexibility in the location of on-site storage 6. Pits/onsite storage can be off-set from the toilet pedestal, reducing fears of children falling in 7. Far less trash deposited in the pedestal due to reduced size of opening 8. Opportunity for treatment and reuse of the source-separated urine for agriculture purposes. In the case of decentralised and centralised WWT, urine diversion will lead to lower levels of nitrogen and other elements entering the WWTW, thus reducing the treatment burden.	1. Requires water for flushing 2. Requires users to manually flush the toilet 3. Manual flushing can lead to varying amounts of water being used 4. Cannot be used when NO water is available (municipal or alternative) at the site 5. Blockages may occur, though it should be noted that certain designs are less vulnerable to blockages and have been shown to be able to handle both toilet paper and newspaper without experiencing blockages 6. Potential for cross-contamination in the urine stream, depending on the urine separation design 7. Requires separate storage/treatment approaches for the two separate waste streams 8. Higher capital cost compared to dry sanitation options

[12] U.9 was not included in the EAWAG *Compendium* (2014). While urine diverting flush toilets (U.6) are included in the *Compendium*, the inclusion of U.9 allows for pour flush versions (i.e. without a cistern). This is important, because the decision to use pour flush or cistern flush systems is influenced by many factors.

No.	Name	Description	Advantages	Disadvantages
U.10* [13]	**Leak-free cistern flush toilet**	Leak-free cisterns have been in development by a few companies to address the challenge with constant leakages in cistern flush toilets. These cisterns will work with different low-flush pedestals and use different innovative methods to limit or eliminate the opportunity for leakages. 	1. Water seal greatly reduces odours in the toilet cubicle. 2. Cistern with flush mechanism ensures consistent flush volumes and is convenient for users. 3. Can be flushed with greywater or other alternative water resources 4. Can be manually flushed if necessary, when water supply connected to cistern is intermittent 5. Use of water to move waste allows flexibility in the location of on-site storage 6. Pits/onsite storage can be off-set from the toilet pedestal, reducing fears of children falling in 7. Far less trash deposited in the pedestal due to reduced size of opening 8. Aspirational for most users 9. Limits the constant leakage associated with cistern-flush toilets, thus reducing overall water usage greatly	1. Requires water for flushing 2. Not yet widely tested and used 3. Incorporation of flushing mechanism introduces a point of potential breakages 4. Cannot be used when there is NO water available (municipal or alternative) at the site 5. Blockages may occur, though it should be noted that certain design changes are less vulnerable to blockages and have been shown to be able to handle both toilet paper and newspaper without experiencing blockages 6. Higher capital cost when compared to all other flush systems, but this could be offset by value of water savings due to reduced leaks

[13] U.10 is not included in the EAWAG *Compendium* (2014). This is a relatively new innovation, and there are a few suppliers in South Africa currently working on solutions. This technology has potential to overcome the main drawback of cistern flush toilets when compared to pour flush toilets, i.e. constant leakage and wastage. Thus, it has been included here as an innovative solution that may be feasible in the near future, pending further technical development and commercialisation.

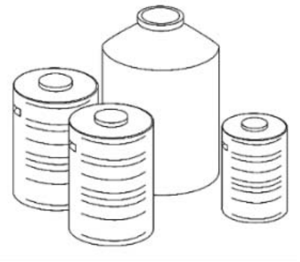
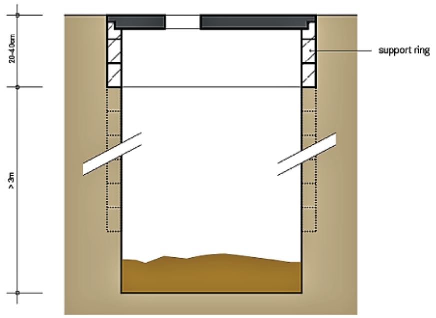
No.	Name	Description	Advantages	Disadvantages
U.11* [14]	Leak-free cistern flush toilet with urine diversion	This user interface will operate in the same way as U.10 but incorporate a pedestal with a urine diversion mechanism. 	1. Water seal greatly reduces odours in the toilet cubicle. 2. Cistern with flush mechanism ensures consistent flush volumes and is convenient for users. 3. Can be flushed with greywater or other alternative water resources 4. Can be manually flushed if necessary, when water supply connected to cistern is intermittent 5. Use of water to move waste allows flexibility in the location of on-site storage 6. Pits/onsite storage can be off-set from the toilet pedestal, reducing fears of children falling in 7. Far less trash deposited in the pedestal due to reduced size of opening 8. Aspirational for most users 9. Limits the constant leakage associated with cistern-flush toilets, thus reducing overall water usage greatly 10. Opportunity for treatment and reuse of the source-separated urine for agriculture purposes. In the case of decentralised and centralised WWT, urine diversion will lead to lower levels of nitrogen and other elements entering the WWTW, thus reducing the treatment burden.	1. Requires water for flushing 2. Not yet widely tested and used 3. Incorporation of flushing mechanism introduces a point of potential breakages 4. Cannot be used when there is NO water available (municipal or alternative) at the site 5. Blockages may occur, though it should be noted that certain design changes are less vulnerable to blockages and have been shown to be able to handle both toilet paper and newspaper without experiencing blockages 6. Higher capital cost when compared to all other flush systems 7. Potential for cross-contamination in the urine stream, depending on the urine separation design 8. Requires separate storage/treatment approaches for the two separate waste streams

[14] U.11 is not included in the EAWAG *Compendium* (2014).

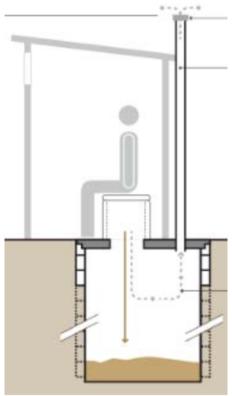
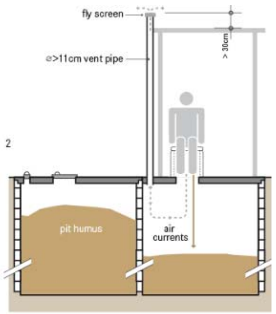
No.	Name	Description	Advantages	Disadvantages
U.12*[15]	Waterless urinal	A waterless urinal operates in the same way as U.3, but it does not use water for flushing. Alternatively, a waterless urinal incorporates an alternate seal (e.g. floating liquid or a valve) to minimise odours. 	1. Automatically separates urine at the source 2. Saves space in public restrooms, therefore increasing number of people that can be served 3. Male and unisex versions available 4. Does not require water to operate	1. Requires separate piping for urine 2. Lack of water for flushing may lead to build-up of urine and odours, also increased risk of precipitation (solids built-up) in pipework

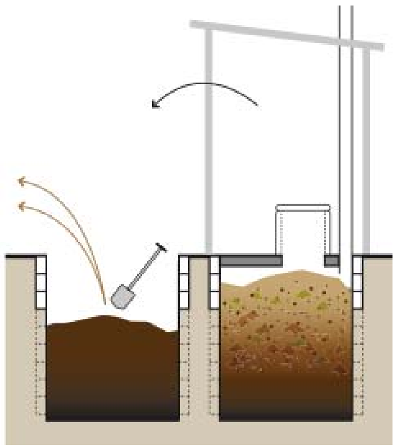
[15] U.12 is not included in the EAWAG *Compendium* (2014), which includes urinals broadly (U.3), but does not distinguish between waterless urinals and those requiring water. For this document, the two solutions have been split, because various criteria will influence whether one or the other is selected.

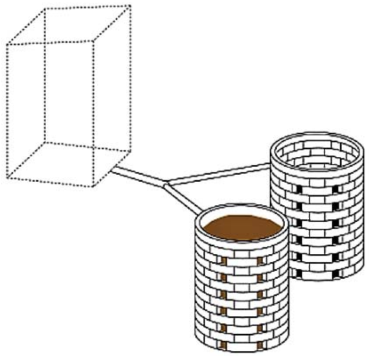
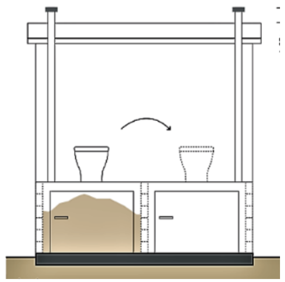
4.3.2 Onsite collection and storage/treatment (adapted from the EAWAG 2014 Compendium)

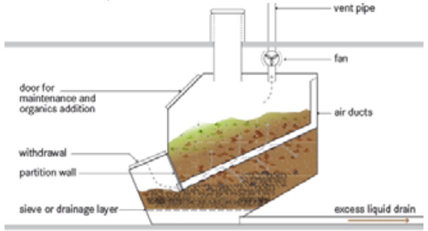
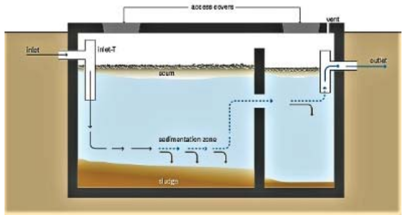
No	Name	Description	Advantages	Disadvantages
S.1	**Urine storage tank/ container**	A urine storage container stores urine collected from urine diverting systems and urinals on site. From the storage container, urine is either applied as a fertiliser or transported off site for treatment. 	1. Simple technology 2. Can be built with locally available materials or tanks 3. Stored urine can be used in agriculture – but this has not occurred widely in South Africa on a household scale 4. Small land requirement 5. Low operating costs if emptied by household	1. Exposure to odours when opening tank 2. Capital costs may be high depending on the size of the tank 3. Tank may need to be partially or fully buried to achieve adequate pipe falls 4. May require frequent emptying (depending on the size of the tank) 5. Household may not want to handle urine – may require a service provider to collect urine from multiple households
S.2 [16]	**Single pit**	A single pit is a commonly used storage technology throughout South Africa, particularly older and homebuilt dry toilets. The pit should be lined (e.g. with bricks) to prevent collapse. In general, single pits without ventilation are not considered adequate for minimum sanitation service. 	1. Simple technology 2. Can be built with locally available materials and labour 3. Small land area required	1. Flies and odours normally noticeable 2. Limited BOD and pathogen reduction in the pit 3. Not appropriate where there is a high groundwater table or where soil is sandy 4. Due to instability and untreated nature of sludge, emptying can be hazardous, and sludge requires further treatment after removal 5. Users can see excreta through the toilet 6. Small children may feel unsafe using these toilets as the opening to the pit can be large, particularly if no child seat is available 7. Solid waste frequently disposed of to the pit, making pits fill faster and limiting the treatment/reuse opportunities for the sludge if the pit has to be emptied

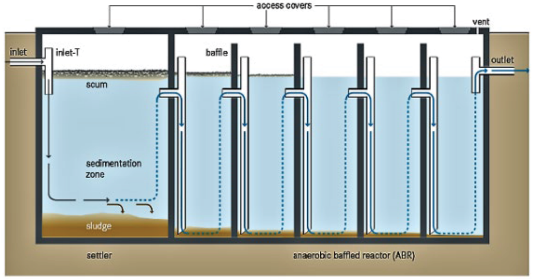
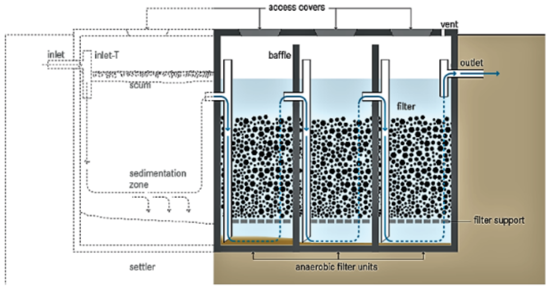
[16] This technology has been listed here, but it is not acceptable in the South African context, as it is below the minimum standard for sanitation.

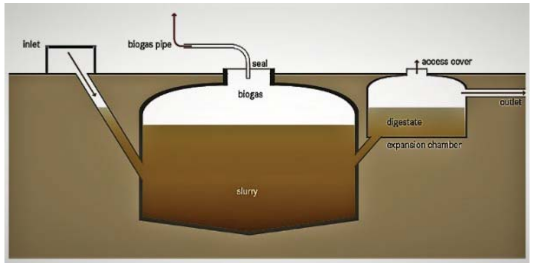
No	Name	Description	Advantages	Disadvantages
S.3	**Single ventilated improved pit**	A single ventilated improved pit (VIP) is the most implemented onsite sanitation system in South Africa. It consists of a lined pit (e.g. with bricks) which is not sealed, allowing urine and water to percolate through the soil. The pit is equipped with a ventilation pipe to reduce odours and flies. 	1. Significant reduction in odours and flies 2. Can be built with locally available materials and labour 3. Low capital cost compared to alternatives 4. Small land area required 5. Established and proven design	1. Limited BOD and pathogen reduction in the pit 2. Must be emptied or abandoned when full 3. Not appropriate where there is a high groundwater table or where soil is sandy 4. Due to instability of sludge, emptying can be hazardous, and sludge requires further treatment after removal 5. Users can see excreta through the toilet 6. Small children may feel unsafe using these toilets as the opening to the pit can be large, particularly if no child seat is available 7. Solid waste frequently disposed of to the pit, making pits fill faster and limiting the treatment/ reuse opportunities for the sludge if the pit must be emptied
S.4	**Double ventilated improved pit**	A double ventilated improved pit (DVIP) has a similar construction as a single VIP, but the provision of two pits allows them to be used continuously. While one pit is in use, the contents of the other pit are decomposing, which leads to a pit humus material that is more stabilised and safer to remove. 	1. Longer life span than a single VIP 2. Removal of pit humus is easier than faecal sludge and can safely be done using shovels, if the pits have been used properly 3. Significant reduction in pathogens during the resting phase 4. Potential for use of removed pit humus as a soil conditioner 5. Flies and odours greatly reduced compared to non-ventilated pits	1. Humus can only be removed manually 2. Higher capital costs than a single VIP, but operational costs may be reduced 3. Not appropriate where there is a high groundwater table or where soil is sandy 4. Requires moving the pedestal and/or superstructure when the pit fills up and covering holes that are not in use 5. Users can see excreta through the toilet 6. Small children may feel unsafe using these toilets as the opening to the pit can be large, particularly if no child seat is available 7. Solid waste frequently disposed of to the pit, making pits fill faster and limiting the treatment/ reuse opportunities for the sludge if the pit must be emptied

No	Name	Description	Advantages	Disadvantages
S.5	Fossa alterna	Fossa alterna is also a ventilated two-pit system like a DVIP, but it differs in that the rotational cycles are short and aim specifically to produce a soil conditioner by-product. This is accomplished by digging shallow pits (maximum 1.5 m) and adding organic material (e.g. soil, ash, leaves) after every defecation event. The organic material speeds up the decomposition process, leading to shorter cycles (e.g. 1 year) compared to the DVIP. 	1. Long life span 2. Removal of pit humus is easier than faecal sludge and can be done safely using shovels 3. Significant reduction in pathogens 4. Smaller excavation required compared to DVIP 5. Generates a nutrient-rich humus which can be used as a soil conditioner 6. Flies and odours are greatly reduced compared to non-ventilated pits 7. Can be built with locally available materials and labour	1. Humus can only be removed manually 2. Higher capital costs than a single VIP, but operational costs may be reduced 3. Not appropriate where there is a high groundwater table or where soil is sandy 4. Requires moving the pedestal and/or superstructure when the pit fills up and covering holes that are not in use 5. Requires constant source of organic material and user behaviour change to function 6. Addition of solid waste can eliminate end use opportunities 7. Users must limit excess water disposed of to the pit for proper decomposition of the waste 8. Individual households may not wish to empty their own pits or use the product – may require a service provider

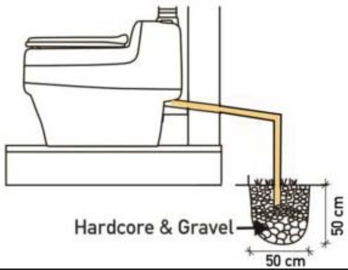
No	Name	Description	Advantages	Disadvantages
S.6	Twin pits for pour or low flush	Twin pits for pour flush consist of two alternating pits that are permeable to allow infiltration of liquids. Only one pit is in use at a time, and when that pit fills up, the pipework is adjusted to direct flow to the other pit. The first pit then rests until the second it is full, at which point the pit humus is removed. 	1. Long life span 2. Excavation of humus is simpler than faecal sludge 3. Even if faecal sludge is emptied early, it is easier to remove than sludge from a VIP due to the incorporation of water and the lack of trash (removal with vacuum pump possible) 4. Significant reduction in pathogens 5. Potential for use of pit humus as a soil conditioner 6. Odours and flies are significantly reduced due to incorporation of a water seal 7. Pit location is flexible	1. Removal of pit humus/faecal sludge is required, but the lack of trash makes this simpler than with dry systems (pump can be used) 2. Requires switching of pipework to accommodate both pits 3. Not appropriate where there is a high groundwater table or where soil is sandy 4. Requires sufficient space for infiltration of liquids 5. Requires water for operation
S.7	Dehydration vault	Dehydration vaults are used to collect, store, and dehydrate faeces and dry anal cleansing material. They are sealed and ventilated to encourage dehydration and are typically used with urine diverting dry toilets, which limits moisture entering the vault. They are also typically used in pairs, which allows one vault to fill up while the other one rests. Organic cover material should be added to improve drying. 	1. Long life span (virtually unlimited if maintained) 2. Significant reduction in pathogens 3. Potential use of dried faeces as a soil conditioner 4. Odour and fly problems kept to a minimum if maintained properly 5. Can be built with locally available materials and labour 6. Appropriate in rocky or flood-prone areas or those with high groundwater tables due to the sealed vault 7. Low capital costs and no excavation required	1. Requires training and user acceptance to ensure proper use 2. Requires constant source of cover material 3. Removal of dried faeces is required, but this can be done quite simply – however many households may not wish to do this themselves 4. Pedestal must be moved and/or holes covered to ensure alternating operation between the vaults

No	Name	Description	Advantages	Disadvantages
S.8	Composting chamber	A composting chamber is a sealed system, consisting of a reactor (storage chamber), a ventilation unit, a leachate collection system, and an access door. Composting is an aerobic process, which leads to the decomposition of excreta by microorganisms, and it is assisted by the addition of organic material (e.g. organics, food waste, bulking material) and ventilation.  	1. Significant reduction in pathogens 2. Compost can be used as a soil conditioner 3. No issues with odour and flies if operated properly 4. Opportunity for co-management of organic waste 5. Long service life 6. Low operating cost (if self-emptied) 7. The container is sealed, making it an appropriate option in flood prone areas or those with high groundwater tables	1. Requires trained user or service personnel for maintenance 2. Compost may require further treatment, especially if not operated at optimal conditions in terms of temperature, organic matter, aeration via regular mixing 3. Leachate requires treatment and/or safe disposal 4. Requires expert design and construction 5. May require specialised parts and electricity (depending on the supplier) 6. Requires constant source of organic material 7. Manual removal of compost is required every 2-10 years (or more frequently in some cases) 8. Must avoid excess water being disposed of down the toilet
S.9	Septic tank	A septic tank is a water-tight chamber with at least two compartments, which allow for settling and anaerobic processes to reduce solids and organics. A septic tank can be constructed with brick/blockwork or prefabricated with fibreglass, PVC, or plastic. Settled solids are removed periodically from the tank, and liquid effluent flows to further treatment. 	1. Simple, robust, and common technology 2. No electrical energy required 3. Low operating costs 4. Long service life 5. Small land area required for septic tank, especially when built underground (but note frequently used with soakaway for effluent which requires further land area)	1. Low reduction in pathogens, solids and organics 2. Regular desludging required 3. Effluent and sludge both require further treatment (or land area for soakaway for effluent) and/or safe disposal

No	Name	Description	Advantages	Disadvantages
S.10	Anaerobic baffled reactor	An Anaerobic Baffled Reactor (ABR) is essentially an improved septic tank with a series of baffles under which wastewater is forced to flow. The baffles lead to increased contact time between the active biomass and wastewater, leading to improved treatment. 	1. Less vulnerable to organic and hydraulic shock loads than a conventional septic tank 2. No electrical energy required 3. Low operating costs 4. Long service life 5. High BOD reduction 6. Low sludge production 7. Moderate land area required (can be built underground)	1. Expert design and construction required 2. Low reduction of pathogens and nutrients 3. Sludge and effluent require further treatment and/or safe disposal 4. Periodic emptying of sludge in all chambers is required
S.11	Anaerobic filter	An Anaerobic Filter (AF) is a fixed-bed biological reactor with one or more filtration chambers in series. Wastewater flows through the filter, which traps particles and degrades organic matter. 	1. No electrical energy required 2. Low operating cost 3. Long service life 4. High reduction in BOD and solids 5. Low sludge production 6. Moderate area requirement (can be built underground)	1. Expert design and construction required 2. Low reduction of pathogens and nutrients 3. Sludge and effluent require further treatment and/or safe disposal 4. Risk of clogging, depending on pre- and primary treatment 5. Removing and cleaning clogged filter media is cumbersome 6. High capital cost compared to alternatives

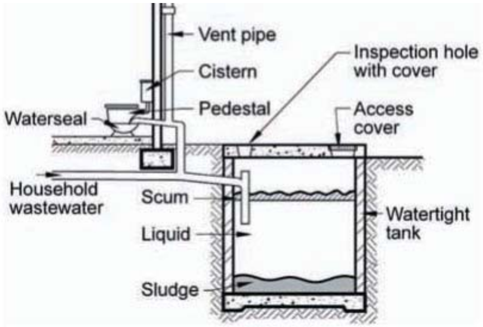
No	Name	Description	Advantages	Disadvantages
S.12	**Anaerobic digester**	An Anaerobic Digester (AD) is an anaerobic treatment technology that produces a digested slurry (digestate) that can be used as a fertiliser and biogas that can be use for energy. An AD must be airtight and be domed at the top to accommodate the biogas produced. They can be constructed with bricks or prefabricated. 	1. Renewable energy generation 2. Small land area required 3. No electrical energy required 4. Long service life 5. Low operating costs	1. Expert design and skilled construction required 2. Incomplete pathogen removal – digestate requires further treatment 3. Limited gas production below 15°C (highly climate dependent) 4. Limited gas production if blackwater is the only input (organic-rich materials should be added, such as animal manure or food waste) 5. Emptying required every 5-10 years
S.13*[17]	**Single pit for pour flush**	A single pit for pour flush consists of one pit that is permeable to allow infiltration of liquids. A single pit system may cost less up-front, but it will require more frequent emptying and further treatment after emptying, when compared to the twin-pit system. 	1. Reduced trash in the sludge due to flush system 2. Flexibility of location due to the use of water to transport waste (can be offset from the toilet structure) 3. Odours and flies are significantly reduced due to incorporation of a water seal 4. Lower capital cost compared to twin pit system	1. Faecal sludge must be removed regularly to allow continuous operation (higher operational cost than twin pit system) 2. Faecal sludge to be removed will be fairly unstable compared to that removed from twin pit systems 3. Not appropriate where there is a high groundwater table or where soil is sandy 4. Requires water for operation

[17] S.13 is not included in the EAWAG *Compendium* (2014), but it has been included here as this is a relatively common technology used in South Africa.

No	Name	Description	Advantages	Disadvantages
S.14*[18]	Incineration vault	An incineration vault includes a fuel source that is used to burn (incinerate) excreta. The incineration process converts excreta to a pathogen-free ash product, which can be disposed of or used as a soil enhancement. 	1. No water required 2. Production of a pathogen-free output 3. Potential use of ash by-product in agriculture (phosphorus and potassium rich) 4. Simple, single unit treatment process for all waste 5. Most designs have a self-cleaning bowl system (e.g. paper bowl liners)	1. Energy source required 2. High operating and capital costs 3. Air pollution control required for exhaust gases 4. Dependent on user behaviour for proper functioning (e.g. mechanical advancement) 5. Slightly more effort than a flush toilet – e.g. bowl liner to be inserted before each use 6. User required to periodically empty the ash tray
S.15*[19]	Soakaway for Urine	Source-separated urine can alternatively be sent directly to a soakaway, which is a covered, porous chamber that allows urine to slowly soak into the ground. A soakaway is typically filled with some media (e.g. gravel), which creates voids for infiltration. 	1. Simple, safe, robust option for disposal of source-separated urine 2. Reduces contact between humans and urine	1. No reuse of nutrients in urine 2. Potential for clogging 3. Not appropriate in flood-prone areas or those with high water tables

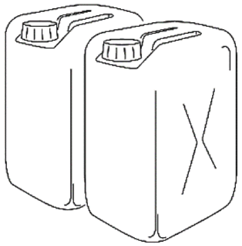
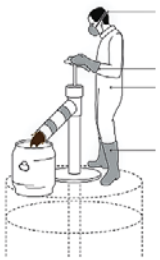
[18] S.14 is not included in the EAWAG *Compendium* (2014), likely because there were few proven options on the market at the time. However, advancements have been made since 2014, and incineration vaults are becoming more available and currently undergoing evaluation in the South African context.

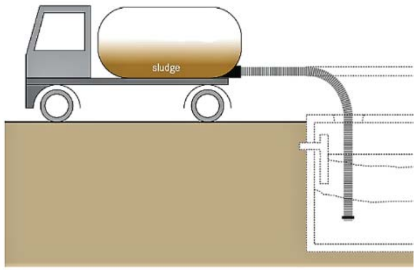
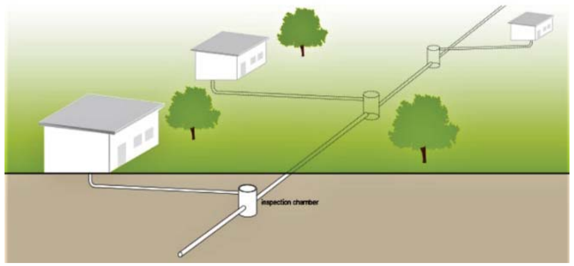
[19] S.15 is not included in the EAWAG *Compendium* (2014).

No	Name	Description	Advantages	Disadvantages
S.16*[20]	Sludge storage container	Container-based solutions utilise a storage container for human excreta, which is emptied on a regular basis. Sludge storage containers are typically used with dry sanitation technologies and have a capacity up to 50 litres. 	1. Appropriate in a variety of settings due to the sealed container and limited space requirements 2. Regularly removed waste provides a constant input of high nutrient, high energy sludge for beneficiation/treatment systems 3. Opportunity for job creation/local enterprise around servicing	1. Require regular emptying (once a week to up to 3 times per week), thus rely on a service plan 2. Material is not treated within system – requires off-site treatment or disposal
S.17*[21]	Conservancy Tank	A conservancy tank is a water-tight chamber which stores blackwater and/or greywater until emptying is required. A conservancy tank can be constructed with brick/blockwork or prefabricated with fibreglass, PVC, or plastic. A conservancy tank must be emptied frequently, as there is no overflow. While conservancy tanks are typically at least 1000 litres in volume, in this guide, any completely sealed containment system that exceeds 50 litres and is not specifically for source-separated urine is considered a conservancy tank. Furthermore, though conservancy tanks are typically used with waterborne sanitation systems only, S.17 includes any sealed containment for dry sanitation systems that does not provide any on-site treatment (e.g. drying or composting) and exceeds 50 litres.	1. Simple, robust, and common technology 2. No electrical energy required 3. Sealed containment makes it appropriate in areas with high risk of groundwater contamination 4. Able to handle greywater in addition to blackwater  	1. Low reduction in pathogens, solids and organics 2. Very regular emptying required (approximately once every 1 or 2 months) 3. Expensive to maintain 4. Emptied material is not treated and requires a reliable treatment or safe disposal method

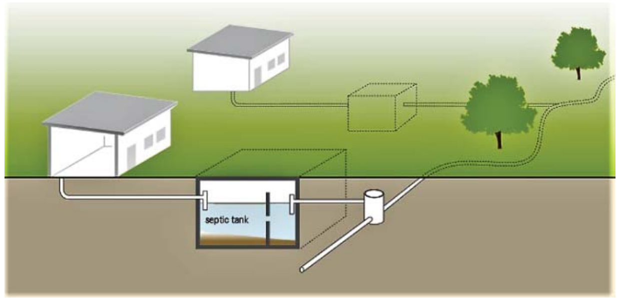
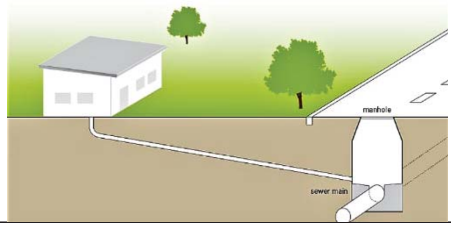
[20] S.16 is not included in the EAWAG *Compendium* (2014), but with the growth of container-based sanitation solutions and the wide-scale implementation of chemical and container toilets in South Africa, it is appropriate to include it in this guide.
[21] S.17 is not included in the 2014 EAWAG *Compendium*, but it has been included here as it is a relatively common technology employed in South Africa in areas that are at risk of groundwater contamination and/or out of reach of the municipal sewer network.

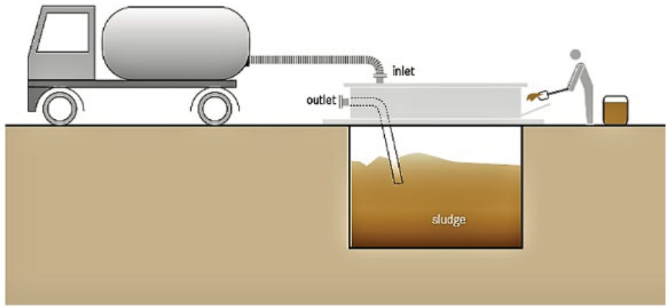
4.3.3 Conveyance (adapted from the EAWAG 2014 Compendium)

No	Name	Description	Advantages	Disadvantages
C.1	Jerrycan/ Tank	Jerrycans are light, plastic containers that are readily available and can be carried by one person. When sealed, they can be used to safely store or transport urine. 	1. Jerrycans are widely available and robust 2. Very low capital and operating costs 3. Potential for local job creation and income generation 4. Easy to clean and reusable 5. Low risk of pathogen transmission	1. Heavy to carry 2. Spills may happen 3. Mild to strong odour when filling and emptying jerrycans (depending on storage conditions)
C.2	Human-Powered emptying and transport	Human-powered emptying and transport refers to the different ways by which people can manually empty and/or transport sludge and solid products generated in onsite sanitation facilities. Human-powered emptying of pits, vaults and tanks can be done in one of two ways: 1) using buckets and shovels, or 2) using a portable, manually operated pump specially designed for sludge (e.g. the Gulper, the Rammer, the MDHP or the MAPET)  	1. Potential for local job creation and income generation 2. Simple hand pumps can be built and repaired with locally available materials 3. Low capital costs; variable operating costs depending on transport distance 4. Provides services to areas/communities without sewers	1. Spills can happen which could pose potential health risks and generate offensive smells 2. Time consuming: emptying pits out can take several hours/days depending on their size 3. Garbage in pits may block pipe (for manual pumps) 4. Some devices may require specialized repair (welding) 5. Requires a vehicle (e.g. Bakkie) if sludge is to be transported offsite

No	Name	Description	Advantages	Disadvantages
C.3*[22]	**Motorized Emptying and Transport (Honeysucker)**	Motorized emptying and transport refers to a vehicle equipped with a motorized pump and a storage tank for emptying and transporting faecal sludge and urine. Humans are required to operate the pump and manoeuvre the hose, but sludge is not manually lifted or transported. 	1. Fast, hygienic and generally effective sludge removal 2. Efficient transport possible with large vacuum trucks 3. Potential for local job creation and income generation 4. Provides an essential service to unsewered areas	1. Cannot pump thick, dried sludge (must be thinned with water or manually removed) 2. Garbage in pits may block hose 3. Cannot completely empty deep pits due to limited suction lift 4. Very high capital costs; variable operating costs depending on use 5. Hiring a vacuum truck may be unaffordable for poor households 6. Not all parts and materials may be locally available 7. May have difficulties with access
C.4	**Simplified Sewer**	A simplified sewer describes a sewerage network that is constructed using smaller diameter pipes laid at a shallower depth and at a flatter gradient than Conventional Sewers (C.6). The simplified sewer allows for a more flexible design at lower costs. 	1. Can be laid at a shallower depth and flatter gradient than conventional sewers 2. Lower capital costs than conventional sewers; low operating costs 3. Can be extended as a community grows 4. Greywater can be managed concurrently 5. Does not require onsite primary treatment units 6. Simpler to adapt in densely populated settlements than conventional gravity sewers.	1. Requires repairs and removals of blockages more frequently than a conventional gravity sewer 2. Requires expert design and construction 3. Leakages pose a risk of wastewater exfiltration and groundwater infiltration and are difficult to identify

[22] In the EAWAG *Compendium* (2014), C.3 refers both to vacuum tanks and alternative motorised emptying tools (e.g. the Pitvaq). However, in this guide, vacuum trucks have been allocated to C.3 and a separate technology (C.8) has been included which covers hybrid mechanised/human-powered emptying systems. The inclusion of a separate item is because these tools have been designed to specifically fill serve communities that vacuum trucks cannot serve. Thus, selection of the appropriate emptying and conveyance technique relies heavily on site specific characteristics and the financial implications.

No	Name	Description	Advantages	Disadvantages
C.5	Solids-Free Sewer	A solids-free sewer is a network of small-diameter pipes that transports pre-treated and solids-free wastewater (such as septic tank effluent). It can be installed at a shallow depth and does not require a minimum wastewater flow or slope to function.  	1. Does not require a minimum gradient or flow velocity 2. Can be used where water supply is limited 3. Lower capital costs than conventional gravity sewers; low operating costs 4. Can be extended as a community grows 5. Greywater can be managed concurrently 6. Simpler to adapt in densely populated settlements than conventional gravity sewers.	1. Space for interceptors (for solids removal) is required 2. Interceptors require regular desludging to prevent clogging – will likely need to be managed by a service provider 3. Requires training and acceptance to be used correctly 4. Requires repairs and removals of blockages more frequently than a conventional gravity sewer 5. Requires expert design and construction 6. Leakages pose a risk of wastewater exfiltration and groundwater infiltration and are difficult to identify
C.6	Conventional Gravity Sewer	Conventional gravity sewers are large networks of underground pipes that convey blackwater, greywater and, in many cases, stormwater from individual households to a (Semi-) Centralized Treatment facility, using gravity (and pumps when necessary). The conventional gravity sewer system is designed with many branches. Typically, the network is subdivided into primary (main sewer lines along main roads), secondary and tertiary networks (networks at the neighbourhood and household level).  	1. Less maintenance compared to Simplified and Solids-Free Sewers 2. Greywater and possibly stormwater can be managed concurrently 3. Can handle grit and other solids, as well as large volumes of flow	1. Very high capital costs; high operation and maintenance costs 2. A minimum velocity must be maintained to prevent the deposition of solids in the sewer 3. Requires deep excavations 4. Difficult and costly to extend as a community changes and grows 5. Difficult/impossible to implement in pre-existing densely built communities 6. Requires expert design, construction and maintenance 7. Leakages pose a risk of wastewater exfiltration and groundwater infiltration and are difficult to identify

No	Name	Description	Advantages	Disadvantages
C.7	Transfer Station (Underground Holding Tank)	Transfer stations or underground holding tanks act as intermediate dumping points for faecal sludge when it cannot be easily transported to a (semi-) centralized treatment facility. A motorised emptying tool is required to empty transfer stations when they are full. Operators of Human-Powered or small-scale Motorized Sludge Emptying Equipment (see C.2 and C.3) discharge the sludge at a local transfer station rather than illegally dumping it or travelling to discharge it at a remote treatment or disposal site. When the transfer station is full, a vacuum truck empties the contents and takes the sludge to a suitable treatment facility. Municipalities or sewerage authorities may charge for permits to dump at the transfer station to offset the costs of operating and maintaining the facility. 	1. Makes sludge transport to the treatment plant more efficient, especially where small-scale service providers with slow vehicles are involved 2. May reduce the illegal dumping of faecal sludge 3. Costs can be offset with access permits 4. Potential for local job creation and income generation	1. Requires expert design and construction 2. Can lead to odours if not properly maintained 3. May be difficult to find suitable sites for transfer stations within communities due to competition for space, traffic issues and odours / spills generated at transfer station

No	Name	Description	Advantages	Disadvantages
C.8*[23]	Hybrid Human-Powered/ Motorised Emptying and Transport	Hybrid emptying systems have been designed to provide the power of motorised emptying with the flexibility of human-powered emptying. They provide pumping in some form while also being able to access difficult-to-reach areas. Often, sludge is removed by the pumping device and then transported in a bakkie, trailer, or tuk tuk to the disposal/treatment/transfer site. 	1. Fast, hygienic and generally effective sludge removal 2. Ability to access densely populated areas which large vacuum trucks cannot 3. Potential for local job creation and income generation 4. Provides an essential service to unsewered areas	1. Cannot pump thick, dried sludge (must be thinned with water or manually removed) 2. Garbage in pits may block hose 3. Cannot completely empty deep pits due to limited suction lift 4. High capital costs compared to human-powered emptying 5. Hiring motorised emptying teams may be inaccessible to poor households 6. Not all parts and materials may be locally available 7. Requires a separate vehicle for transport of sludge offsite

4.3.4 Treatment

This section provides an overview of treatment approaches. While the 2014 EAWAG *Compendium* lists specific treatment technologies, this document presents different approaches to treatment of sewage and faecal sludge. This guide is not meant to serve as a *design* guide. Thus, instead of guiding users through specific technologies, the approaches presented below are different ways that treatment can be handled, and each approach has its own advantages and disadvantages. Once an approach is selected, a competent individual must be consulted to design the system in detail. Approaches T.1 through T.4 are those for treating primarily blackwater (i.e. sewage), though most can also accommodate greywater and some can accommodate industrial effluent. Approaches T.5 through T.7 are those for

[23] C.18 is not included in the EAWAG *Compendium* (2014). A number of innovative tools are at different stages in the technology development process, but they generally all seek to meet the needs of emptying difficult-to-reach systems.

treating faecal sludge from onsite sanitation systems, and approach T.8 encompasses treatment plants for nutrient recovery from source-separated urine. While T.1 and T.5 represent centralised approaches (i.e. city-scale), the remainder of approaches are decentralised. Though this may require some strategic thinking around the operation and maintenance of these systems, especially given that many South African municipalities struggle to maintain the few wastewater treatment plants that they do have. However, decentralisation provides an opportunity for job creation and upskilling in the sanitation sector as well as less risk of environmental pollution from dysfunctional sewers or illegal discharge of faecal sludge. WRC Report No. TT 651/15 titled *Wastewater Treatment Technologies – A Basic Guide* provides useful information on specific treatment technologies that may be employed in the approaches listed below. This document should be consulted once an approach is selected, as it provides guidance on a number of technical options that are currently available to achieve treatment objectives.

No.	Name	Description	Notes about applicability	Standards/guidelines
T.1	Conventional Centralised Wastewater Treatment Works	Conventional wastewater treatment works (WWTWs) in the South African context generally consist of preliminary treatment (e.g. screening), primary treatment (e.g. clarifiers for settling), secondary treatment (e.g. activated sludge), and tertiary treatment (e.g. nutrient removal and disinfection). The design of conventional WWTWs is influenced by numerous constraints, such as influent characteristics and expected fluctuations, available space, and electricity availability. Processes in conventional WWT often require electricity, and installation of these systems is typically civil-intensive. These systems are generally applied on a city-wide scale, such that all city sewers contribute to the treatment plant's influent. 	Generally, new treatment works will not be built unless a large previously non-sewered area gets connected to a sewer network. If the existing treatment works has capacity for additional flow, newly-sewered areas may be able to be connected. While it is a common practice to discharge sludge from on-site sanitation systems at WWTW headworks, this practice is not advised unless the system is specifically designed to handle such flows. Sludge from onsite systems, especially dry sanitation systems, is much more concentrated than blackwater discharged in sewers.	South African National Water Act (General Authorisation Limits) *Wastewater treatment technologies: A basic guide* (WRC)

No.	Name	Description	Notes about applicability	Standards/guidelines
T.2	**Decentralised Wastewater Treatment Systems (DEWATS)**	DEWATS is an approach to wastewater treatment for flows of domestic and/or industrial wastewater between 1 m^3 and 1000 m^3 per day. To achieve treatment, DEWATS typically incorporate primary treatment (e.g. sedimentation ponds, septic tanks), secondary treatment (e.g. anaerobic baffled reactors, anaerobic filters), secondary aerobic treatment (e.g. horizontal gravel filters), and post-treatment (e.g. aerobic polishing ponds). DEWATS treatment systems are designed with the following principles in mind: reliability, longevity, tolerance towards inflow fluctuation, cost efficiency and, most importantly, low control and maintenance requirements (Ulrich et al., 2010). These systems are typically implemented on a neighbourhood scale, rather than a citywide scale. 	DEWATS systems generally aim to operate on gravity, which eliminates reliance on pumps and therefore, electricity. Thus, DEWATS systems usually require a site that has some downhill slope, otherwise extensive earthworks may be required. DEWATS systems can either be implemented as "package treatment systems", fabricated off-site and installed on the prepared site, or as civil-based works, constructed with traditional building materials. Regardless, the approach to treatment is based on low-energy, low-cost technologies. A municipality opting for DEWATS as an approach will end up with a larger number of treatment plants compared to one using a centralised approach. This will call for a different approach to plant operation and maintenance (e.g. teams assigned to multiple plants), but with DEWATS systems, the low-operation design will make this more manageable.	South African National Water Act (General Authorisation Limits) *Decentralised Wastewater Treatment Systems (DEWATS) and Sanitation in Developing Countries: A Practical Guide* (BORDA, WEDC)

No.	Name	Description	Notes about applicability	Standards/guidelines
T.3	Package Wastewater Treatment Plants	A package treatment plant is an onsite, waterborne, domestic wastewater treatment system with a total capacity less than 2,000 m^3/day (van Niekerk et al., 2009). They are typically constructed and packaged off-site and brought onsite for installation. For the purposes of this list, this option encompasses traditional package plants using one of the following as their primary treatment process: activated sludge, trickling filter, submerged bio-contactor, or rotating bio-contactor. In addition to these primary treatment processes, most package treatment plants incorporate pre- and post-treatment to ensure discharge at General Authorisation limits. For the purposes of this document, T.3 includes all prefabricated treatment units that are not "closed-loop" systems for one or more of the following reasons: require a connection to electrical mains, require connection to a sewer, discharge effluent to a watercourse or to a soakaway/leach field. 	Package treatment plants can accomplish most of what traditional wastewater treatment systems can accomplish, up to a certain influent flow. The primary benefit of implementing a package treatment plant instead of a civils-based treatment works is the short time spent on site. Aside from basic civil works (e.g. concrete slabs) and the installation process on site, all fabrication takes place off site. Commissioning is quick, because the testing of all unit processes in the package plant is done off site. Implementation of a package plant may also require less engineering costs, as most companies that fabricate package plants have ready-engineered solutions that only require minor customisation before fabrication. A municipality opting for package plants as an approach will end up with a larger number of treatment plants compared to one using a centralised approach. This will call for a different approach to plant operation and maintenance (e.g. teams assigned to multiple plants). Furthermore, package treatment plants require trained operators and may require specialist intervention on a periodic basis. Most package plant suppliers have this expertise and/or are willing to transfer that expertise to appointed individuals.	SANS 30500 South African National Water Act (General Authorisation Limit) *Guideline document: Package Plants for the Treatment of Domestic Wastewater*

No.	Name	Description	Notes about applicability	Standards/guidelines
T.4	**Off-Grid Package Wastewater Treatment Plants**	Off-grid package wastewater treatment plants are like those above except, for the purposes of this document, they are characteristically "closed loop". This means that any energy requirement is met by the system itself, either through solar power, treatment by-product, or other renewable energy source. It further means that treated effluent is recycled within the system for flushing, and thus the toilet system does not require a connection to an external water supply. Finally, any solid by-products produced by the system are in a form that is safe to reuse or dispose of. 	The applicability of off-grid package plants are similar to package plants (T.3) in that they essentially provide a "plug-and-play" solution. These systems also have the potential to open opportunities for implementation of flush toilets where there is a low or unreliable water supply. The incorporation of off-grid energy supply also makes these systems less vulnerable to power cuts. They can be connected to a decentralised sewer network at a neighbourhood scale or to a single toilet block (e.g. school or community ablution block). A municipality opting for off-grid package plants as an approach will end up with a larger number of treatment plants compared to one using a centralised approach. This will call for a different approach to plant operation and maintenance (e.g. teams assigned to multiple plants). Furthermore, off-grid package treatment plants require trained operators and may require specialist intervention on a periodic basis. Most off-grid package plant suppliers have this expertise and/or are willing to transfer that expertise to appointed individuals.	SANS 30500 South African National Water Act (General Authorisation Limit) *Guideline document: Package Plants for the Treatment of Domestic Wastewater*

No.	Name	Description	Notes about applicability	Standards/guidelines
T.5	**Co-treatment of faecal sludge in conventional WWTWs**	This approach involves discharging faecal sludge from onsite sanitation systems (e.g. septic tanks and VIP latrines) into a conventional wastewater treatment plant. Faecal sludge is either discharged into the sewer network or directly at the headworks of the treatment works. While this approach is not recommended for many reasons, there are some limited options available for co-treatment of FS with blackwater in conventional WWTWs, provided that the amount of FS added is strictly controlled to maintain the correct balance of organic matter. There is potential for co-treatment of FS with the sludge produced from WWTW (biosolids) in, e.g. drying beds or lagoons. 	This is only applicable if discharge of FS into the WWTW can be strictly controlled and if the quantities of FS being discharged are relatively small. There may be potential to use land already demarcated for WWT (i.e. existing WWT facilities or land within the WWTWs) to co-treat faecal sludge and biosolids (sludge from the WWT process). This approach may make the authorisation process simpler. However, delivering faecal sludge from scattered onsite sanitation systems to a centralised treatment plant comes with a large cost of transporting faecal sludge.	*South African National Water Act (General Authorisation Limits)* *Faecal Sludge Management: Systems Approach for Implementation and Operation (Chapter 9: Co-treatment of Faecal sludge in Municipal Wastewater Treatment Plants)* (Strande et al.)

No.	Name	Description	Notes about applicability	Standards/guidelines
T.6	Designated faecal sludge treatment plants	A designated faecal sludge treatment plant (FSTP) is designed specifically to treat faecal sludge from onsite sanitation systems. These plants typically consist of a combination of processes to achieve solid/liquid separation (e.g. settling tanks), dewatering (e.g. unplanted drying beds), and stabilisation (e.g. co-composting). The number and types of treatment technologies used will be determined by factors, such as land availability, faecal sludge quality (e.g. trash contents), and desired end use of products (e.g. soil conditioner or fuel). For the purposes of this document, treatment processes that fall under this solution are those that are constructed *in situ* (i.e. civil-based work). 	FSTPs are typically implemented on a neighbourhood scale, making them a decentralised approach. The reason for this is that the cost of transporting large volumes of faecal sludge can be prohibitive. Thus, the best approach to ensuring that faecal sludge is delivered to FSTPs, instead of discharged into the environment, is to locate FSTPs close to the sources of faecal sludge. Thus, though operation of FSTPs may relatively simple, not requiring specialist involvement, the operation and maintenance approach must be rethought (e.g. requiring operators for multiple plants instead of just one). With the need for more operators, there is also an opportunity for more job creation.	*South African National Water Act (General Authorisation Limits)* *Faecal Sludge Management: Systems Approach for Implementation and Operation* (Strande et al.) *Faecal Sludge and Septage Treatment* (Kevin Tayler)

No.	Name	Description	Notes about applicability	Standards/guidelines
T.7	**Self-contained faecal sludge treatment units**	Self-contained Faecal Sludge Treatment Units (FSTUs) are energy-independent, community scale resource recovery units. A variety of standalone treatment units exist, and a new standard, ISO 31800, has recently been developed. This standard applies to units that treat primarily faecal sludge, are able to operate in non-sewered and off-grid environments, are prefabricated, and exhibit resource recovery capability. These FSTUs vary based on their treatment methods and recovered resources. 	Overall, selection of an ISO 31800 compliant FSTU would be informed by a desire to recover resources from faecal sludge in a space- and energy-efficient manner. They provide a safe method for dealing with faecal sludge on a community scale. Like prefabricated package sewage treatment plants, FSTUs require very little time onsite for installation, as most of the work is done offsite to fabricate the unit. The use of FSTUs is considered a decentralised approach. Thus, the operation and maintenance approach must be rethought (e.g. requiring operators for multiple plants instead of just one). With the need for more operators, there is also an opportunity for more job creation.	*South African National Water Act (General Authorisation Limits)* *ISO 31800* *Faecal Sludge Management: Systems Approach for Implementation and Operation* (Strande et al.) *Faecal Sludge and Septage Treatment* (Kevin Tayler)

No.	Name	Description	Notes about applicability	Standards/guidelines
T.8	**Treatment of urine for recovery of nutrients**	Various technologies have been piloted for recovering nutrients from source-separated urine. Urine contains nutrients that are valuable for agricultural use, but transport of large volumes of urine can lead to excessive costs. Thus, these treatment systems aim to extract the nutrient value from urine while reducing the volume. Examples of this include recovery of struvite ($MgPO_4$), nitrified effluent, and urea. The processes vary and all of them are at different stages of development.  	This approach is most applicable in instances where resource recovery from urine is desired on a community level. Single households can simply reuse urine in their own garden, but when considering community-scale reuse, the cost of transporting large volumes of urine is prohibitive. Thus, these nutrient recovery treatment units aim to concentrate the nutrients in urine so that the cost of transportation is much lower. The systems also provide a safer way of dealing with source-separated urine from many individuals, as most treatment processes include some form of pathogen inactivation. These units generally require energy and/or chemical input, which can lead to the operating costs outweighing the income potential from saleable products. However, if there is considerable demand for the product(s), it can be financially feasible (e.g. Aurin fertiliser by EAWAG in Switzerland).	

Effluent requirements for General Authorisation vs. SANS 30500

In South Africa, **all treatment systems** that discharge to the environment must, at a minimum, meet the General Discharge Limit (GA) as set out in the National Water Act. In certain circumstances, the Department of Water and Sanitation may specify that the treatment system must meet the Special Limit if the receiving catchment is considered "sensitive". SANS 30500 compliant systems must meet the effluent requirements set out in the SANS 30500 standard. Limits in SANS 30500 depend on whether the system is considered Category A (for unrestricted urban use, e.g. toilet flushing) or Category B (for discharge to the environment). For SANS 30500 systems to be considered compliant, they must meet the limit which is most stringent between GA and SANS 30500. A summary of all constituents specified in each of the standards is presented in Table 7.

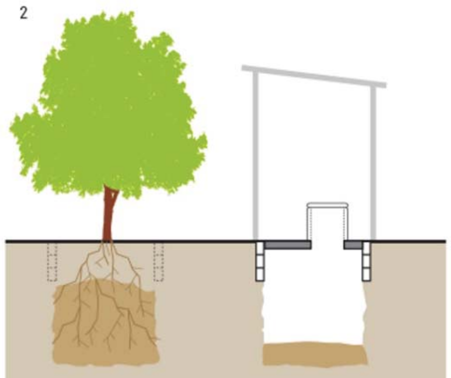
Table 7: Comparison of effluent limits for South Africa General Authorisation and SANS 30500

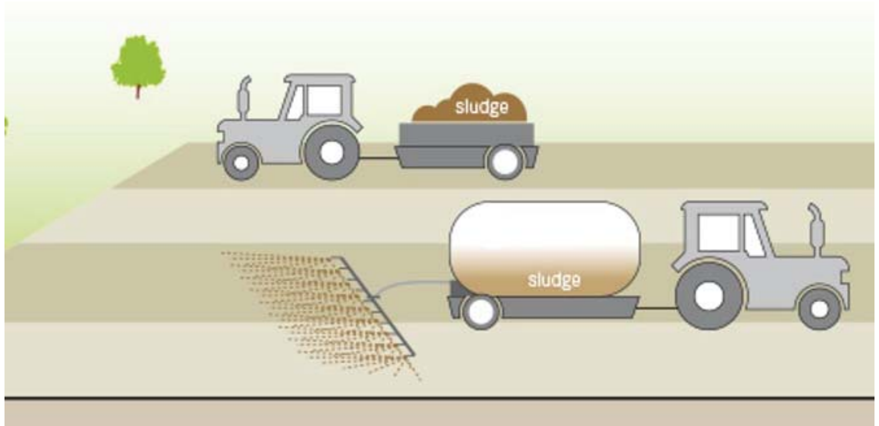
Constituent	Unit	South Africa General Authorisation	SANS 30500	
			Category A (unrestricted urban use)	Category B (discharge to env.)
Faecal coliforms	per 100 mℓ	1000	N/A	
Human enteric pathogens	per ℓ	N/A	100	
Human enteric viruses	per ℓ	N/A	10	
Human enteric helminths	per ℓ	N/A	<1	
Human enteric protozoa	per ℓ	N/A	<1	
pH		5.5-9.5	6.0-9.0	
COD	mg/ℓ	75	50	150
Total nitrogen	% reduction	N/A	70	
Ammonia	mg-N/ℓ	3	N/A	
Nitrate/nitrite	mg-N/ℓ	15	N/A	
Chlorine as free chlorine	mg/ℓ	0.25	N/A	
Suspended solids	mg/ℓ	25	10	30
Electrical conductivity	mS/m	70 above intake up to 150	N/A	
Total phosphorus	% reduction	N/A	80	
Ortho-phosphate	mg-P/ℓ	10	N/A	
Fluoride	mg/ℓ	1	N/A	
Soap, oil, or grease	mg/ℓ	2.5	N/A	
Dissolved Arsenic	mg/ℓ	0.02	N/A	
Dissolved Cadmium	mg/ℓ	0.005	N/A	
Dissolved Chromium (VI)	mg/ℓ	0.05	N/A	
Dissolved Copper	mg/ℓ	0.01	N/A	
Dissolved Cyanide	mg/ℓ	0.02	N/A	
Dissolved Iron	mg/ℓ	0.3	N/A	
Dissolved Lead	mg/ℓ	0.01	N/A	
Dissolved Manganese	mg/ℓ	0.1	N/A	
Mercury and its components	mg/ℓ	0.005	N/A	
Dissolved Selenium	mg/ℓ	0.02	N/A	
Dissolved Zinc	mg/ℓ	0.1	N/A	
Boron	mg/ℓ	1	N/A	

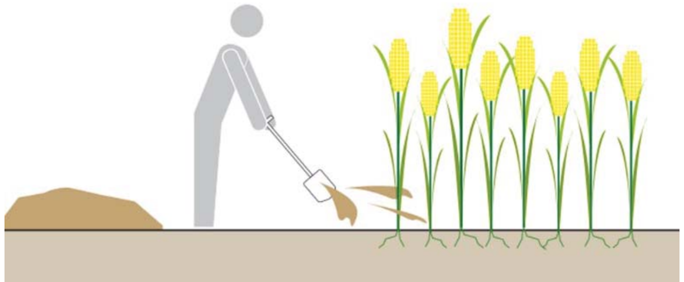
NOTE: Items with "N/A" indicate limits not specified in the given standard

4.3.5 Use or disposal

This section provides an overview of use or disposal options. While the 2014 EAWAG *Compendium* lists more specific technologies, this document presents different general options available for use and disposal of treatment by-products. By selecting a desired use or disposal option, the design of the treatment system can be done to produce products that can be used or disposed as desired. For example, the treatment system designed to produce a soil conditioner by-product will be different from a system to produce a fuel by-product. Thus, the numbering of options in the list below do not match the numbering in the EAWAG Compendium, though many options are common to both documents. Options D.1 through D.7 below present options for solid by-products (e.g. sludge or treated sludge by-products); options D.8 through D.12 present options for effluent; options D.13 and D.14 present options for urine reuse; and options D.15 and D.16 present options for biogas (product of anaerobic digestion). While some treatment processes may produce biogas that can be used as a fuel source (option D.5), options D.15 and D.16 refer to use of biogas produced during anaerobic digestion in the collection, storage, and treatment phase. The options presented here are intentionally general and broad, given that

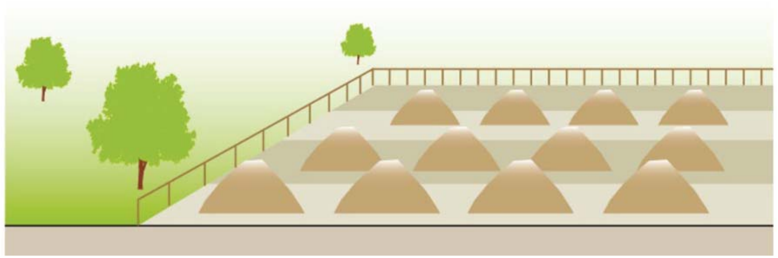
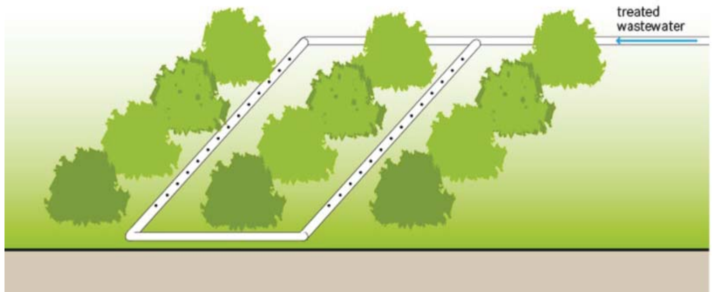
No.	Name	Description	Advantages	Disadvantages
D.1	Fill and cover/Arborloo	To decommission a pit, it can simply be filled with soil and covered. Although there is no benefit, the full pit poses no immediate health risk and the contents will degrade naturally over time. Alternatively, the Arborloo is a shallow pit that is filled with excreta and soil/ash and then covered with soil; a tree planted on top of the nutrient-rich pit will grow vigorously. 	1. Simple technique for all users 2. Low costs 3. Low risk of pathogen transmission 4. Tree planting has food and perhaps income benefits	1. New pit must be dug; old pit cannot be reused

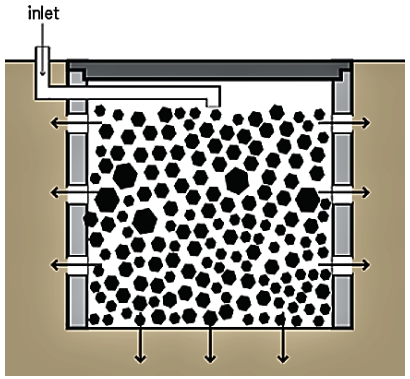
No.	Name	Description	Advantages	Disadvantages
D.2	Surface application of treated sludge	Sludge that has been treated (e.g. removed from a Planted Drying Bed) can be used in agriculture, home gardening, forestry, sod and turf growing, landscaping, parks, golf courses, mine reclamation, as a dump cover, or for erosion control. Although sludge has lower nutrient levels than commercial fertilizers (for nitrogen, phosphorus and potassium, respectively), it can replace an important part of the fertilizer need. Additionally, treated sludge has been found to have properties superior to those of fertilizers, such as bulking and water retention properties, and the slow, steady release of nutrients. Solids are spread on the ground surface using conventional manure spreaders, tank trucks or specially designed vehicles. Liquid sludge can be sprayed onto or injected into the ground. 	1. Can reduce the use of chemical fertilisers and improve water holding capacity of soil 2. Can accelerate reforestation 3. Can reduce erosion 4. Low costs	1. Odours may be noticeable, depending on prior treatment 2. May require special spreading equipment 3. May pose public health risks, depending on its quality and application 4. Micropollutants may accumulate in the soil and contaminate groundwater 5. Social acceptance may be low in some areas

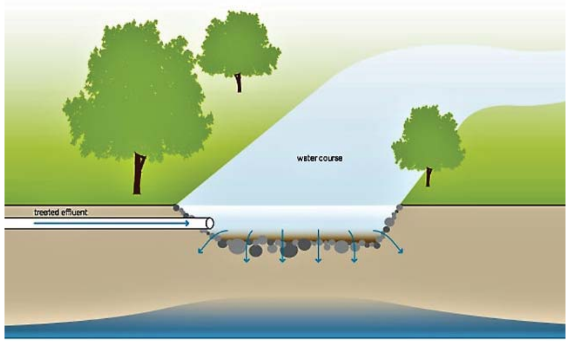
No.	Name	Description	Advantages	Disadvantages
D.3	Deep row entrenchment	Deep row entrenchment is the burial of sludge from a variety of sources (e.g. WWTP or VIP latrine) in trenches, ideally in areas where crops are grown. Buried sludge is covered by soil (approximately 300 mm). Deep Row Entrenchment (DRE) can be done on a household basis, a decentralised community basis, or on a commercial basis.  	1. Simple, low-cost option 2. Buried sludge adds carbon and nutrients to the soil and can increase water holding capacity (can reduce reliance on commercial fertiliser) 3. Improvements in crop yield can be observed, allowing a simple way to recycle sludge 4. Can contribute to food security, especially if fruit trees are planted at the household level. 5. Low risk of harm to the environment, especially compared to surface application	1. Digging trenches can be costly, particularly on a commercial basis.
D.4	Land application of compost or other soil conditioner	Compost and pit humus can be beneficially used to improve the quality of soil. They add nutrients and organics and improve the soil's ability to store air and water. They can be mixed into the soil before crops are planted, used to start seedlings or indoor plants, or simply mixed into an existing compost. 	1. Can improve structure and water holding capacity of soil 2. May encourage income generation 3. Low risk of pathogen transmission 4. Low costs	1. May require a year or more of maturation 2. Pathogens may exist in a dormant stage (cysts and oocysts) which may be come infectious if moisture is added, but risk of infection is low if material is properly handled 3. Social acceptance may be low in some areas

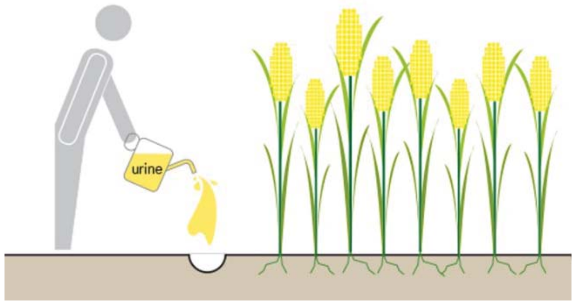
No.	Name	Description	Advantages	Disadvantages
D.5	Fuel (e.g. biogas, briquettes)	Sludge can be treated to produce various fuel products that can be used to supply electricity or fuel for cooking or heating. Products may include biogas produced during anaerobic digestion or briquettes produces through pyrolysis of faecal sludge. Recycling of faecal sludge for fuel production can reduce deforestation where wood is used for cooking, and it can reduce reliance on grid electricity. Recycling faecal sludge for electricity production can contribute to the energy independence of some treatment systems. Furthermore, use of treated faecal sludge as a source of heat can also improve treatment efficiency (e.g. raising temperatures of anaerobic digesters). 	1. Product is small, space-efficient, and energy dense. 2. Products can offset the need for fuel for cooking, heating, and/or electricity.	1. Use of the products will require additional infrastructure depending on the application. 2. Energy output from treated sludge is often not equivalent to demand (e.g. biogas from a digester can be used for cooking, but a single household digester will not meet all of the needs of that household).

No.	Name	Description	Advantages	Disadvantages
D.6	Landfill application	Disposal of sludge in landfills is common with sludge produced at WWTPs but may also be used for faecal sludge. However, for sludge to be disposed of in a landfill, it requires treatment as it is considered a hazardous substance. The same is true of pre-treatment products (e.g. trash) that have been removed during treatment. These are contaminated with sludge and therefore also considered hazardous, requiring some treatment prior to landfill disposal. This option is not recommended for sludge, as it does not realize the potential benefits of sludge and contributes to climate change, as landfills are source of greenhouse gas emissions. It furthermore requires the payment of gate fees at landfills and the transport of sludge to landfills, many of which are at or near capacity. 	1. In some cases, the only option due to limited funds for capital expenditure on treatment systems. 2. May prevent unmitigated disposal.	1. Expensive, due to gate fees and transport requirements 2. Treatment required to reduce hazardous nature of sludge or pre-treatment products (i.e. trash/detritus).

No.	Name	Description	Advantages	Disadvantages
D.7	Surface disposal and storage	Surface disposal refers to the stockpiling of sludge, faeces or other materials that cannot be used elsewhere. Once the material has been taken to a surface disposal site, it is not used later. Storage refers to temporary stockpiling. It can be done when there is no immediate need for the material and a future use is anticipated, or when further pathogen reduction and drying is desired before application. 	1. May prevent unmitigated disposal 2. Storage may render the product more hygienic 3. Can use vacant or abandoned land 4. Little operation skills or maintenance required 5. Low capital and operating costs	1. Requires a large land area 2. Potential leaching of nutrients and contaminants into groundwater 3. Surface disposal hampers the beneficial use of a resource
D.8	Irrigation	Wastewater of varying quality can be used in agriculture to reduce dependence on freshwater. Only water that has had secondary treatment (i.e. physical and biological treatment) should be used to limit the risk of crop contamination and health risks to workers. This is typically done with drip irrigation to minimise evaporation losses, but it can also be done through surface application. 	1. Reduces depletion of groundwater and improves the availability of drinking water 2. Reduces fertiliser needs 3. Potential for local job creation and income generation 4. Low risk of pathogen transmission if water is properly treated 5. Low capital and operating costs depending on the design	1. May require expert design and installation 2. Not all parts and materials may be locally available 3. Drip irrigation is sensitive to clogging (i.e. water must be free from suspended solids) 4. Risk of soil salinisation if the soil is prone to the accumulation of salts 5. Social acceptance may be low in some areas

No.	Name	Description	Advantages	Disadvantages
D.9	Soakaway	A soakaway is a covered, porous chamber that allows water to slowly soak into the ground. A soakaway is typically filled with some media (e.g. gravel), which creates voids for infiltration. A soakaway is an appropriate solution to receive wastewater (greywater or blackwater after primary treatment). A soakaway should be used in soils with good absorptive properties (i.e. not clay, hard packed or rocky soils). 	1. Simple, robust option 2. Can be built and repaired with locally available materials 3. Small land area required 4. Low capital and operating costs	1. Primary treatment required to prevent clogging 2. May negatively affect soil and groundwater properties
D.10	Pond	Effluent can be discharged to a pond, where it will receive further treatment and can provide a habitat for fish and/or floating plants. Any remaining nutrients in the effluent will be used up by the fish and/or plants, and the fish and/or plants can provide a useful by-product. 	1. Can provide a cheap, locally available protein source 2. Water hyacinth grows rapidly and is attractive 3. Potential for local job creation and income generation 4. Relatively low capital costs; operating costs should be offset by production revenue 5. Can be built and maintained with locally available materials	1. Requires abundance of fresh water 2. Requires a large land (pond) area 3. May require expert design and installation 4. Fish may pose a health risk if improperly prepared or cooked 5. Some plants can become invasive species if released into natural environments 6. Social acceptance may be low in some areas 7. Requires maintenance

No.	Name	Description	Advantages	Disadvantages
D.11	Water disposal/ Groundwater recharge	Treated effluent and/or stormwater can be directly discharged into receiving water bodies (such as rivers, lakes, etc.) or into the ground to recharge aquifers. The receiving water body should be analysed to ensure that disposal of the water will not negatively impact the receiving water. 	1. May provide a "drought-proof" water supply (from groundwater) 2. May increase productivity of water bodies by maintaining constant levels	1. Discharge of nutrients and micropollutants may affect natural water bodies and/or drinking water 2. Introduction of pollutants may have long-term impacts 3. May negatively affect soil and groundwater properties
D.12	Recycling for non-consumption (e.g. flushing toilets, washing)	Effluent treated to a suitable level can be recycled for non-potable use. Water recycling in areas where human contact is likely (e.g. flushing toilets) must be treated sufficiently to reduce risks to humans and must be treated to a higher degree than water to be reused for agriculture. This use/disposal option may be costly to achieve, but it can make it feasible for waterborne systems to be used in areas with no reliable water connection (e.g. extremely rural areas). 	1. Reduces the burden of waterborne sanitation systems on limited water resources. 2. Enables use of waterborne systems in locations typically viewed as inappropriate for waterborne sanitation in terms of water availability.	1. Requires regular monitoring of effluent to ensure that recycled water does not pose a risk to users. 2. Can be costly, as water is generally pumped to elevated tanks to be reused for flushing. 3. Pumping to elevated tanks will require electricity. 4. Treatment systems often require electricity to achieve suitable treated effluent standard

No.	Name	Description	Advantages	Disadvantages
D.13	Application of stored urine	Stored urine is a concentrated source of nutrients that can be applied as liquid fertiliser in agriculture, replacing some or all chemical fertilisers. Guidance is provided by the WHO on how to safely apply stored urine. The generally accepted guidance is that urine stored for 1 month is safe for agricultural application at the household level. Urine to be used on food crops should be stored for at least 6 months. 	1. May encourage income generation 2. Reduces dependence on costly chemical fertilisers 3. Low risk of pathogen transmission 4. Low costs	1. Liquid urine is heavy and difficult to transport 2. Smell may be offensive 3. Labour intensive 4. Risk of soil salinisation if the soil is prone to the accumulation of salts 5. Social acceptance may be low in some areas
D.14	Application of concentrated urine nutrients	Products from urine treatment systems include concentrated fertilizers, such as struvite ($MgPO_4$) or concentrated nitrogen fertiliser solution. These products can be applied as fertiliser to various crops. Due to the treatment processes, these products are considered free from pathogens and can be used at agronomic rates for various plants, including timber, food crops, or ornamentals. 	1. Safe, concentrated nutrient source to off-set reliance on non-renewable fertilisers. 2. Low-volume product can be cheaply transported. 3. Potential for products to be registered as fertiliser products and sold in the South African market.	1. Products are relatively expensive to produce. 2. Some products may not be readily available to plants (e.g. struvite). Organic matter from recycled sludge can improve the availability of nutrients.

No.	Name	Description	Advantages	Disadvantages
D.15	Building materials	Building materials may be produced from both sludge and source-separated urine streams. Processes to achieve this have not yet been widely demonstrated, but some are currently being researched. Treatment processes to produce building materials can be investigated if demand is large.  	1. Utilises potential of recycled sludge and/or urine. 2. Provides a renewable building material to replace common non-renewable materials (e.g. concrete blocks).	1. Not yet proven or widely demonstrated. 2. Production of materials likely requires chemical addition and/or energy/labour intensive processes. 3. Certification required to become an official, approved building material.
D.16	Biogas combustion	In principle, biogas can be used like other fuel gas. When produced in household-level biogas reactors, it is most suitable for cooking. Additionally, electricity generation is a valuable option when the biogas is produced in large anaerobic digesters.  	1. Free source of energy 2. Reduction of indoor air pollution and deforestation (if firewood or coal were previously used) 3. Little operation skills or maintenance required	1. May not fulfil total energy requirements 2. Cannot replace all types of energy 3. Cannot be easily stored (low energy density per volume) and, thus, needs to be continuously used

No.	Name	Description		Advantages	Disadvantages
D.17	Biogas flaring to atmosphere	If biogas is produced in the system but no infrastructure is available for using it as a fuel source, it may be flared. Burning biogas off ensures that methane and volatile organic compounds are converted to carbon dioxide, reducing the environmental impact of released biogas. This practice is common in WWTWs where there is little appetite for use of biogas produced in anaerobic digesters.		1. Limited infrastructure required compared to reusing biogas for fuel. 2. Flaring of biogas limits the environmental impact of the biogas being released to the atmosphere.	1. Releases some carbon dioxide to the atmosphere. 2. Does not utilise potential of biogas produced during treatment.

4.3.6 Combined systems

Combined systems combine multiple functional groups in one unit (e.g. a user interface connected to an onsite treatment system). These systems are described below. In addition, many sanitation systems will require consideration of more than one technology or approach in each functional group to handle the many different products along the value chain. For example, a flush toilet connected to a septic tank produces effluent that is typically discharged to a soakaway as well as faecal sludge, which must be emptied and disposed of or treated.

4.3.7 User interface/Onsite treatment combinations

Some solutions package a specific user interface with an onsite treatment technology. In these systems, the decision-maker will be bound to a user interface and treatment/containment system supplied by a single supplier. This approach is common with innovative systems, such as incinerating toilets and dehydrating systems. All technologies available should be defined in terms of which functional group(s) they incorporate, and in the case of combined systems, this will simply include more than one.

5 Criteria for selecting sanitation systems

Criteria for selecting sanitation systems include project-specific and technology-specific characteristics. Criteria are further defined based on their influence on decision-making, as described below:

1. **Compatibility criteria** are defined by technology compatibility. Certain technologies are only compatible with specific other technologies or inputs. Thus, in the process of selecting technologies along the sanitation value chain, compatibility of technologies or input products will influence whether or not a specific technology is an option.
2. **Gate selection criteria** are also criteria that will restrict the options available based on specific project characteristics. Under certain circumstances, some technologies will be inappropriate for use. These are the gate selection criteria which reduce the available options.
3. **Rating criteria** are generally technology-specific characteristics that will influence their appropriateness for a given project. In general, the importance of different rating criteria will vary based on the project's specific needs. For example, in one project, capital cost may be highly important, whereas in other projects, space limitations may be the defining characteristic.

Important project-specific and technology-specific characteristics to consider during technology selection are presented below, though these are not necessarily the *only* characteristics that may be considered important during decision-making.

5.1 Project-specific characteristics

This section presents a selection of key project-specific characteristics that should be considered when selecting a sanitation system. Defining the project and site is an important first step in selecting a set of appropriate technologies, because each project and site is different.

5.1.1 Vision for sanitation

Sanitation decision-making has historically been defined by project constraints, without consideration of possibilities. Particularly with the Sustainable Development Goals, the global view of sanitation has evolved to become an avenue for other development goals in addition to being itself a goal. For example, beneficiation in sanitation has potential to contribute to food security. Construction, operation, and maintenance of sanitation systems also has potential to create jobs, addressing unemployment. These and other opportunities are important to consider and can influence how other criteria are prioritised in decision making. Thus, decision-makers should set their vision for sanitation (or for a sanitation project) from the beginning.

5.1.2 Project type

Project type refers to whether the project aims to provide user interfaces at the household or community level. The project type will influence the most appropriate technologies, as some technologies are more vulnerable in communal settings than others. Household settings are easier to manage, as there is generally a small number of users using the toilet daily. As such, it is easier to manage behaviour of the users, whereas in a public setting, the sheer number of users, and lack of individual responsibility for the facility, makes it difficult to manage behaviour. Thus, certain user interfaces will be more susceptible to failure in a public or communal setting.

U S **Project type** is most relevant when selecting an appropriate **user interface** and may also be relevant to selecting onsite **collection, storage, and treatment.**

5.1.3 Water availability

Water availability is important both in terms of the *type* of water source and the *quantity* available. These factors will determine whether a waterborne system is feasible. In general, where water supply is limited or unreliable, waterborne systems are not advised due to the high chance of failure. However, it should be noted that certain treatment processes or package plants make it possible to recycle water for flushing. Though these systems may require extensive investment to achieve the required level of treatment, they do make it possible to implement waterborne systems in areas with limited water availability, as most of the water is recycled.

The types of water sources for households include:

- No connection: No water available or water is fetched far away from the settlement
- On-site groundwater extraction: Water extracted from boreholes or wells
- Water tanker: Water supplied by trucks
- Communal standpipes: Pipe water connection for public use
- Yard tap: Single tap provided in each plot
- Yard tank: Water tank installed in the household yard that can be filled either by a water tanker or by a trickle feed arrangement.
- Roof tank: Water tank installed on the roof of the house supplied via a trickle feed arrangement
- Household connection: Metered connection into the house.

The types of water sources for communal projects include:
- No connection: no water available or fetched far away from the settlement
- Communal standpipe located within 50 metres of the site
- Yard tap located on site
- Reliable water connection at the site

Available quantity of water is defined by the following levels:
- Very low (<10 litres per capita per day)
- Low (10-25 litres per capita per day)
- Medium (25-60 litres per capita per day)
- Medium high (60-100 litres per capita per day)
- High (>100 litres per capita per day)

U The **type of water source** available influences the reliability and convenience of the water supply and will influence the selection of an appropriate **user interface** as the starting point for defining the system as dry or waterborne, unless a water-recycling system is being considered.

U The **quantity of water** available per person per day will influence the selection of an appropriate **user interface**.

5.1.4 Groundwater Vulnerability Class

Groundwater vulnerability is determined based on the *Protocol to Manage the Potential Groundwater Contamination from On Site Sanitation* from the Department of Water and Sanitation (2003). The protocol outlines a process in detail for determining the risk of groundwater pollution from sanitation systems. The version published in 2003 was the second version, with the aim to balance three needs: (a) to avoid being overly conservative in any recommendations of sanitation infrastructure; (b) to provide a tool that requires relatively low resources in terms of expertise and finances for investigation and use of the tool; and (c) to provide an assurance of safety for protection of both human health and the groundwater resources. It was written in response to an assessment of the original document, which found that the original protocol was not always applied effectively and that it was also used to discount perfectly adequate appropriate technology options in favour of costly waterborne infrastructure, which "ultimately may pose significantly higher threats of pollution and a greater financial burden on the municipality."

The overall approach for assessing groundwater contamination risks is based on a risk assessment approach, rather than a black-and-white approach. It is based on assessing the vulnerability of the underground water resources and the contamination load from the particular sanitation system. The risk of contaminating groundwater at the zone of the sanitation systems is then weighed with the strategic value of the aquifer related to current and/or future use of water from the aquifer. In this way, the protocol takes a much more nuanced approach to assessing groundwater contamination risk than typical rhetoric around the topic seems to take. The document further provides guidance for adaptations that can be made to sanitation systems to reduce the risk of groundwater contamination.

The protocol defines five aquifer vulnerability classes, which are determined both by the **soil type**, which influences the movement of pollutants through the ground, and **depth to groundwater table**. By considering these factors, one can determine the vulnerability of the groundwater and thus weigh different sanitation options. The five vulnerability classes defined in Table A of the *Protocol* are:

1. Extreme (usually highly fractured rock and/or high groundwater table): high risk and short distance (<) 2 m to water table
2. High (usually gravely or fractured rock and/or high water table): high risk and medium distance to water table (2-5 m)
3. Medium (usually fine sand, deep loam soils with semi-solid rock and average water table): Low risk and medium to long distances to water table (>10 m)
4. Low (usually clay or loam soils with semi-solid rock and deep water table): Minimal and low risk and long to very long distance to water table (>20 m)
5. Negligible (usually dense clay and/or solid impervious rock with deep water table): Minimal risk with confining layers

The **soil type** and **depth to groundwater table** will determine the **Groundwater Vulnerability Class**.

S D The **Groundwater Vulnerability Class** mostly influences selection of on-site **collection and storage/treatment** and final **end use or disposal**.

5.1.5 Percolation rate

Percolation refers to the downward migration of water in the unsaturated zone. The percolation rate refers to the speed at which water moves through soil and can influence the processes of water draining from onsite sanitation systems, particularly those receiving effluent. The test for determining percolation rate in soil can be found in PP28 of SANS 104000, and the results can be used to determine the suitability of different onsite containment and disposal options as well as sizing effluent disposal systems, such as soakaways (PP10.7 of SANS 10400).

S D The **percolation rate** in the soil will impact the selection of an appropriate onsite **collection and storage/treatment**. It will also influence the selection of a **use and disposal** solution for liquid products.

5.1.6 Terrain

The terrain of the site refers to the slope. While the slope over a project area may vary, it is important to consider both the typical and maximum slope within the project area, as the terrain will influence access to the site.

C Specifically, the **terrain** will influence the selection of **conveyance** systems, as it is not appropriate to plan for emptying via vacuum truck or installation of standard sewer networks in areas with a slope exceeding 25°.

5.1.7 Housing density

Housing density impacts technology selection due to the fact that sewerage systems are only appropriate in medium to high-density areas, while onsite sanitation systems can pose a problem in high density areas, both due to space limitations and potential saturation of soil with pathogenic bacteria and increased risk of environmental pollution.

S C

Once a user interface has been selected, **housing density** will determine which onsite **collection and storage/treatment** options are feasible. If onsite collection and storage/treatment is not desired in dense settlements, **conveyance** via sewers might be feasible.

5.1.8 Mean plot size

Mean plot size determines the amount of space available for a sanitation system. In particular, mean plot size will determine the amount of space available for onsite collection, storage, and treatment.

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Knowing the **mean plot size** will help decision makers determine how important the space requirements are when selecting an onsite **collection and storage/treatment** option.

5.1.9 Flood-prone area

Whether or not the area is prone to flooding will determine which onsite collection, storage, or treatment technologies are appropriate. In areas prone to flooding, unsealed containment systems can potentially overflow with water, leading to contamination of the environment.

S

Whether or not the area is **flood-prone** will influence the appropriateness of onsite **collection and storage/treatment** options.

5.1.10 Access to area

The accessibility of the area determines whether mechanical emptying with a vacuum tanker is feasible in the case of onsite systems. There are options available for conveyance of products from inaccessible areas.

C

The level of **access to the area** will influence the appropriateness of technologies for **conveyance** of products.

5.1.11 Existing sewer and WWTP availability

Existing sewer and wastewater treatment plant (WWTP) availability is determined both by the distance to existing sewerage network and the capacity of the existing WWTP. If the project is located too far from an existing sewerage network, the cost per home served of installing a sewer connection may be prohibitive. If the existing WWTP is already at capacity with no plans for upgrading, it is unfeasible and irresponsible to connect additional sanitation systems. Thus, for full waterborne sewerage and connection to an existing WWTP to be feasible, the project location must be located close enough to an existing sewer that goes to a WWTP with capacity. If full waterborne sewerage is desired, the decision makers can consider either upgrading the existing WWTP or pursuing decentralised treatment options, such as package treatment plants or DEWATS.

C **Existing sewer and WWTP availability** will influence the appropriateness of **conveyance** technologies, particularly sewers that connect to existing networks.

5.1.12 Anal cleansing method

Anal cleansing is done using water, toilet paper, or hard paper (e.g. newspaper, especially in low income areas). Dry sanitation systems are generally robust whether toilet or hard paper are used, but dry containment, storage, and treatment systems that rely on drying for treatment may be harmed by the addition of anal cleansing water. On the other hand, all flushing systems can easily handle water or toilet paper used for anal cleansing. Most full-flush systems are robust when hard paper is used for wiping, but some low flush systems may struggle. Past research (Still & Louton, 2012) has shown that while the use of newspaper will require extra water to flush (e.g. a double flush), it generally does not block low flush systems. Thus, while this criterion is not absolutely critical to the success or failure of different user interfaces, it is useful to note when considering flush systems.

U **Anal cleansing method** may influence the appropriateness of different **user interface** options.

5.1.13 Preference of users

The preference of users in the community is important to the success of any sanitation project, particularly when it comes to onsite sanitation systems. If users of the sanitation technology have had some say in the selection, they are more likely to use and take ownership of the systems. This ownership can take the form of caring for the infrastructure, keeping it clean, and replacing broken parts. This sense of ownership may also lead to benefits down the line, once the system requires larger maintenance (e.g. pit emptying). User preference is assessed in different ways but is often determined during initial community consultation meetings. It is difficult to capture the desires of all members of the community, which is why investigating options for allowing individual users to select a technology may be a beneficial exercise. The technology selection process must also consider whether users will be contributing to the capital cost of the system or indeed purchasing it outright. There must also be clarity on whether users will be paying for and/or actually carrying out operation and maintenance activities (particularly on the storage and treatment portions of the systems), and what willingness exists to pay for / do this.

U S C T D

The **preference of users** will mostly influence the selection of a **user interface**, as this is the aspect of a sanitation system that users mostly interact with. However, it is also advised that the users are consulted during the design and selection of all aspects of the sanitation system. Thus, it should be considered at all parts of the sanitation system, including **collection and storage/treatment**, **conveyance**, **treatment**, and **reuse and/or disposal.**

5.2 Technology-specific characteristics

Different technology options can be defined in terms of key criteria. While capital cost has often been treated as the main (and sometimes only) factor to consider, numerous other characteristics should be considered. The following sections present additional aspects to consider. While this is by no means an exhaustive list, it does provide a good starting point for a well-rounded view of technology options.

In the following sections, each characteristic is defined and its relevance to different functional groups is discussed. Then, the technologies in the relevant functional groups are rated according to the given characteristic. In general, 3 stars are allocated to the best performing technologies, and 0 or 1 stars are allocated to the worst performing technologies. The ratings are generally based on the comparison of the alternatives rather than being based on absolute terms. Further information on what the ratings mean is provided in each section.

5.2.1 Water demand

U

Water demand of **user interfaces** will influence technology selection, particularly where water is scarce or unreliable.

Water demand is relevant to user interfaces. Dry systems require no water, while flush systems require varying amounts of water depending on the pedestal design and functionality. While there are differences in flush water required between low flush and full flush systems (2-3 litres vs. 9-18 litres), there is also a great different in water consumption when comparing cistern flush and pour flush systems. Pour flush systems have no water connection or cistern and are therefore free from the constant leakages that are often common in cistern flush systems with worn parts. Particularly where water is scarce and/or unreliable, it is vital to consider the water required to operate the user interface. While many flush systems can be flushed with grey or other water, it is important to consider the consequences of a failed system in the case of no water availability.

Table 8 shows recommended ratings of different user interfaces in terms of water demand. It is advised that low flush toilets are used primarily where flush systems are desired, due to the severe water scarcity in South Africa. **If the table below included full flush systems, they would receive a score of zero.** The ratings in Table 8 are defined as follows:

- *** = no water required to operate
- ** = some water required (2-5 litres) but no cistern → no constant leakage
- * = some water required (2-5 litres) and cistern included → chance for constant leakages and high water demand

Table 8: Ratings for user interfaces in terms of water demand (NOTE: Medium means a small amount of water is required, and full means a larger amount of water is required)

USER INTERFACE	U.1	U.2	U.3	U.4	U.5	U.6	U.7	U.8	U.9	U.10	U.11	U.12
	Dry toilet	Urine diverting dry toilet	Flush urinal	Pour flush toilet	Cistern low-flush toilet	Urine diverting low flush toilet	Dry toilet with mechanical advancement	Urine diverting dry toilet with mechanical advancement	Urine diverting pour flush toilet	Leak-free cistern flush toilet	Leak-free cistern flush toilet with urine	Waterless urinal
Score	***	***	**	**	*	*	***	***	**	**	**	***

5.2.2 Capital cost

Capital cost is typically considered one of the most important factors in technology selection. While it is not the only factor to consider (long-term operating and maintenance costs should be part of the equation, but seldom are), the reality is that available finances will absolutely influence the options that are available to municipalities. Particularly in the context of sanitation backlogs, municipalities are conscious of targeting the largest number of households in their backlog with the funds that are available. The ratings shown below are based on comparative costs between options used in similar FSM trains (e.g. septic tanks vs. leach pits and not septic tanks vs. composting chamber).

U S C T D

Capital cost of technology options in all parts of the sanitation value chain will influence decision making for **user interface**; **collection and storage/treatment**; **conveyance**; **treatment**; and **use or disposal**.

The ratings presented in the following tables are based on general assumptions. The options will have varying costs based many factors, such as specific system design elements, the supplier, and the location of the project. However, the ratings do provide some idea of the comparative costs of different options.

Table 9: Ratings for user interfaces in terms of capital and construction cost

USER INTERFACE	U.1	U.2	U.3	U.4	U.5	U.6	U.7	U.8	U.9	U.10	U.11	U.12
	Dry toilet	Urine diverting dry toilet	Flush urinal	Pour flush toilet	Cistern flush toilet	Urine diverting flush toilet	Dry toilet with mechanical advancement	Urine diverting dry toilet with mechanical advancement	Urine diverting pour flush toilet	Leak-free cistern flush toilet	Leak-free cistern flush toilet with urine diversion	Waterless urinal
Capital	***	***	**	**	*+	*	**	**	**	-	-	**
Const-ruction	***	***	***	***	**	**	***	***	***	**	**	***

Table 10: Ratings for onsite collection and storage/treatment in terms of capital and construction cost

COLLECTION, STORAGE, TREATMENT	S.1	S.2	S.3	S.4	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16
	Urine storage tank/container	Single pit	Single ventilated improved pit	Double ventilated improved pit	Fossa alterna	Twin pits for pour or low flush	Dehydration vault	Composting chamber	Septic tank	Anaerobic baffled reactor	Anaerobic filter	Anaerobic digester	Single pit for pour flush	Incineration vault	Soakaway for Urine	Sludge storage container
Score	***	***	***	**	**	**	**	**	*	-	-	-	***	-	***	***

Table 11: Ratings for conveyance in terms of capital cost

CONVEYANCE	C.1	C.2	C.3	C.4	C.5	C.6	C.7	C.8
	Jerrycan/ Tank	Human-Powered emptying and transport	Motorized Emptying and Transport (Honeysucker)	Simplified Sewer	Solids-Free Sewer	Conventional Gravity Sewer	Transfer Station (Underground Holding Tank)	Alternative Motorized Emptying and Transport
Score	***	**	*	**	**	*	**+	**
*Scores are as follows: *** = Low (<R10,000); ** = Medium (R10,000-R50,000); * = High (>R50,000)*								

Table 12: Ratings for treatment in terms of capital and construction cost

	Liquid treatment				*Sludge treatment*			*Urine*
TREATMENT	**T.1**	**T.2**	**T.3**	**T.4**	**T.5**	**T.6**	**T.7**	**T.8**
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Score	**	**	**	*	***	**	*	*
*Scores are as follows: *** = Low or uses existing infrastructure; ** = Moderate cost; * = High-cost solution*								

Table 13: Ratings for use or disposal in terms of capital and construction cost

	Sludge options							*Effluent/liquid options*					*Urine options*		*Sludge /urine*	*Biogas options*	
USE AND/OR DISPOSAL	**D.1**	**D.2**	**D.3**	**D.4**	**D.5**	**D.6**	**D.7**	**D.8**	**D.9**	**D.10**	**D.11**	**D.12**	**D.13**	**D.14**	**D.15**	**D.16**	**D.17**
	Fill and cover/Arborloo	Surface application of treated sludge	Deep row entrenchment	Land application of compost or other soil conditioner	Fuel	Landfill disposal	Surface disposal and storage	Irrigation	Soakaway	Pond	Water disposal/ Groundwater recharge	Recycling for non-consumption	Application of stored urine	Application of concentrated urine nutrients	Building materials	Biogas combustion for fuel	Biogas flaring to atmosphere
Score	***	***	*	***	**	**	**	*+	**	*	**	*	***	***	*	**	**

5.2.3 Operation and maintenance requirements

Operation and maintenance requirements add to the life cycle cost of a technology and should be considered from the beginning. The true cost of a technology is not just the cost to procure and install it. Sanitation technologies, like any other technology, require regular maintenance. The extent and cost of this maintenance varies from one technology to the next, depending, among others, on the complexity of the system, the presence of wearing parts, and the requirement of inputs (e.g. chemicals or water). This factor must not be forgotten when selecting technologies, as some technologies may have higher initial costs but overall lower O&M requirements.

U S T D

Operation and maintenance requirements will influence decision making for **user interface**; **collection and storage/treatment**; **treatment**; and **use or disposal**.

Table 14: Ratings for user interfaces in terms of O&M requirements

USER INTERFACE	U.1	U.2	U.3	U.4	U.5	U.6	U.7	U.8	U.9	U.10	U.11	U.12
	Dry toilet	Urine diverting dry toilet	Flush urinal	Pour flush toilet	Cistern flush toilet	Urine diverting flush toilet	Dry toilet with mechanical advancement	Urine diverting dry toilet with mechanical advancement	Urine diverting pour flush toilet	Leak-free cistern flush toilet	Leak-free cistern flush toilet with urine diversion	Waterless urinal
Score	***	***	**	**	*	*	**	**	**	**	**	***

Table 15: Ratings for onsite collection and storage/treatment in terms of O&M requirements

COLLECTION, STORAGE/ TREATMENT	S.1	S.2	S.3	S.4	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16
	Urine storage tank/container	Single pit	Single ventilated improved pit	Double ventilated improved pit	Fossa alterna	Twin pits for pour or low flush	Dehydration vault	Composting chamber	Septic tank	Anaerobic baffled reactor	Anaerobic filter	Anaerobic digester	Single pit for pour flush	Incineration vault	Soakaway for Urine	Sludge storage container
Score	-	**	**	**	***	***	**	*	***	***	***	**+	**	*	***	-
Ratings	*- = Extensive (at least weekly maintenance required)* ** = Average (regular maintenance required (1 to 4 times a year))* *** = Moderate (difficult desludging required every 5-10 years (e.g. with excessive trash in sludge)* **** = Limited (desludging required every 5-10 years)*															

Table 16: Ratings for treatment approaches in terms of O&M requirements

TREATMENT	*Liquid treatment*				*Sludge treatment*			*Urine*
	T.1	T.2	T.3	T.4	T.5	T.6	T.7	T.8
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Score	*	***	*	*	***	**	*	*
Ratings	**** = Limited O&M required* *** = Semi-regular manual labour required* ** = Electricity and/or chemical inputs required and/or specialised replacement parts required; specialist maintenance required*							

Table 17: Ratings for use or disposal in terms of operation and maintenance requirements

USE AND/OR DISPOSAL	*Sludge options*							*Effluent/liquid options*					*Urine options*		*Sludge/ urine*	*Biogas options*	
	D.1	**D.2**	**D.3**	**D.4**	**D.5**	**D.6**	**D.7**	**D.8**	**D.9**	**D.10**	**D.11**	**D.12**	**D.13**	**D.14**	**D.15**	**D.16**	**D.17**
	Fill and cover/Arborloo	Surface application of treated sludge	Deep row entrenchment	Land application of compost or other soil conditioner	Fuel	Landfill disposal	Surface disposal and storage	Irrigation	Soakaway	Pond	Water disposal/ Groundwater recharge	Recycling for non-consumption	Application of stored urine	Application of concentrated urine nutrients	Building materials	Biogas combustion for fuel	Biogas flaring to atmosphere
Score	***	**	**	***	***	*	**	*	***	*	***	*	**	***	***	*	**
Ratings	*** = Little/no O&M required ** = Semi-regular O&M required * = Regular O&M and supervision required*																

5.2.4 Ease of construction and local job creation

Ease of construction relates to whether specialist input is required for construction or installation of a specific technology and therefore to the potential for local job creation. In many sanitation projects, employment for the local community is an important element, both to municipalities and to the community. This aspect may apply to all parts of the sanitation value chain, but for the purposes of this document, it is evaluated in terms of user interface and treatment.

U T **Ease of construction/potential for local job creation** could be considered when selecting a user interface and treatment system.

Table 18: Ratings for user interfaces in terms of ease of construction

USER INTERFACE	U.1	U.2	U.3	U.4	U.5	U.6	U.7	U.8	U.9	U.10	U.11	U.12
	Dry toilet	Urine diverting dry toilet	Flush urinal	Pour flush toilet	Cistern flush toilet	Urine diverting flush toilet	Dry toilet with mechanical advancement	Urine diverting dry toilet with mechanical advancement	Urine diverting pour flush toilet	Leak-free cistern flush toilet	Leak-free cistern flush toilet with urine diversion	Waterless urinal
Score	***	***	**	***	**	**	**	**	***	**	**	***
Ratings	**** = No specialist involvement required (i.e. can be done by a construction contractor) ** = Some specialist involvement may be required (e.g. plumber) * = Specialist involvement definitely required (e.g. plumber)*											

Table 19: Ratings for treatment approaches in terms of potential for local job creation

TREATMENT	*Liquid treatment*				*Sludge treatment*			*Urine*
	T.1	T.2	T.3	T.4	T.5	T.6	T.7	T.8
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Score	***	***	**	**	*	***	**	**
Ratings	**** = Extensive, civil-based construction ** = Some, during site preparation (pre-fabricated solutions) * = None*							

5.2.5 Installation time

Installation timeframe may be important where timelines are constrained. Solutions with a shorter timeframe between appointment and commissioning are generally prefabricated solutions (i.e. most of the assembly is done off-site), which require a small amount of "on-site" time for installation. Prefabricated solutions also are generally pre-engineered, meaning that they require limited time for design, whereas civil-based treatment works generally require extensive design time to create a site-specific design. These solutions have the benefit of being less vulnerable to delays due to weather and/or conflict in the recipient community. However, these solutions also may have less opportunity for local job creation, as most of the assembly is done off-site by skilled personnel. While this may be relevant to many parts of the sanitation value chain, it has the largest impact on the treatment step, which is generally the most construction-intensive step.

T

Installation time is relevant when considering **treatment** options, particularly when comparing pre-fabricated solutions with civil-intensive construction systems.

Table 20: Ratings for treatment approaches in terms of installation time required

TREATMENT	*Liquid treatment*				*Sludge treatment*			*Urine*
	T.1	T.2	T.3	T.4	T.5	T.6	T.7	T.8
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Score	*	*	**	**	***	*	**	**
Ratings	**** = None (uses existing infrastructure)* *** = Minimal time required (prefabricated solutions)* ** = Long timeframe (civil-based works)*							

5.2.6 Odour control

User interfaces are the main aspect that users interact with, which define the user experience. Often, odour is one of the primary points that influences the user experience. When considering odour control provided by user interfaces, waterborne systems typically utilise a water seal in a P-trap and some dry systems utilise a mechanical advancement system that is meant to separate the user from their waste. The success of both odour control methods is contingent on proper operation of the system. in addition, dry systems that divert urine from faeces offer some level of odour control, as the addition of urine to faeces can lead to more odorous sludge. User interfaces can be weighed based on the level of odour control they provide.

U

Odour control should be considered in selection of **user interfaces.**

Table 21: Ratings for user interfaces in terms of odour control provision

USER INTERFACE	U.1	U.2	U.3	U.4	U.5	U.6	U.7	U.8	U.9	U.10	U.11	U.12
	Dry toilet	Urine diverting dry toilet	Flush urinal	Pour flush toilet	Cistern flush toilet	Urine diverting flush toilet	Dry toilet with mechanical advancement	Urine diverting dry toilet with mechanical advancement	Urine diverting pour flush toilet	Leak-free cistern flush toilet	Leak-free cistern flush toilet with urine diversion	Waterless urinal
Score	*	**	***	***	***	***	**	**	***	***	***	**
*=no odour control; ** = some odour control; ***=no odour expected												

5.2.7 Simplicity of operation

Similarly, simplicity of operation relates to the level of skill required to operate a technology or carry out a given service. In some South African municipalities, manual emptying of pit latrines makes contracts available to low-skill, low-resourced contractors, while technology-intensive methods may restrict certain contractors. Where this is advantageous, the simplicity of operation may be an important factor.

C **Simplicity of operation**, in this model, is considered when selecting **conveyance** options.

Table 22: Ratings for conveyance in terms of simplicity of operation

CONVEYANCE	C.1	C.2	C.3	C.4	C.5	C.6	C.7	C.8
	Jerrycan/ Tank	Human-Powered emptying and transport	Motorized Emptying and Transport (Honeysucker)	Simplified Sewer	Solids-Free Sewer	Conventional Gravity Sewer	Transfer Station (Underground Holding Tank)	Alternative Motorized Emptying and Transport
Score	***	***	*	**	**	**	*	**
Ratings	*** = No special skills needed ** = Some special skills needed * = Only trained operators							

5.2.8 Operation efficiency and hygiene

C

Operation efficiency and hygiene is relevant when selecting **conveyance** options, since emptying onsite sanitation systems can lead to health risks for sanitation workers. To limit the health impacts of emptying on sanitation workers and the community, it may be wise to select conveyance/emptying technologies that limit contact with excreta. Improved efficiency may also be advantageous in terms of the cost of conveyance and emptying techniques.

Conveyance options are scored in Table 23 based on operation efficiency and hygiene, based on the ratings described in the table.

Table 23: Ratings of conveyance in terms of efficiency and hygiene

CONVEYANCE	C.1	C.2	C.3	C.4	C.5	C.6	C.7	C.8
	Jerrycan/ Tank	Human-Powered emptying and transport	Motorized Emptying and Transport (Honeysucker)	Simplified Sewer	Solids-Free Sewer	Conventional Gravity Sewer	Transfer Station (Underground Holding Tank)	Alternative Motorized Emptying and Transport
Score	**	*	**	***	***	***	**	**
Ratings	*** = Very efficient, limited contact with sludge ** = Efficient, some contact with sludge * = Relatively inefficient, extensive contact with sludge probable							

5.2.9 Reuse potential

Certain technologies along the sanitation value chain can enable reuse opportunities of resources. Some technologies transform human waste and/or flush water into recyclable materials, and others enable that transformation.

U S T D

Reuse potential may influence decisions around **user interface**; **onsite collection and storage/treatment**; **treatment**; and **use/disposal**. This is described in more detail below.

User interface

The first way that a user interface can enable resource reuse is by separating urine and faeces, which provides an opportunity early-on for reuse of urine in agriculture. Urine contains a large proportion of the nutrient value of human waste and has generally a lower pathogen load than faeces (in the majority of cases urine is sterile when it exists the body). Thus, separating it at the user interface keeps the nutrient source out of contact with faeces, thus potentially reducing the treatment requirements for reuse. User interfaces can also encourage reuse of products by discouraging disposal of solid waste with human waste. Onsite sanitation systems are often used as solid waste disposal options for communities with little or no solid waste management services. However, solid waste can make resource recovery and treatment processes very costly due to the labour required to remove solid waste before treatment. Solutions with a restricted diameter, such as flush toilets with a P-trap, discourage solid waste disposal and thus, sludge from these types of systems generally have lower trash content. Excessive trash content also greatly reduces efficiency and hygienic operation of emptying processes for onsite sanitation systems, and this should also be considered.

Table 24: Ratings of user interfaces in terms of resource reuse potential

USER INTERFACE	**U.1**	**U.2**	**U.3**	**U.4**	**U.5**	**U.6**	**U.7**	**U.8**	**U.9**	**U.10**	**U.11**	**U.12**
	Dry toilet	Urine diverting dry toilet	Flush urinal	Pour flush toilet	Cistern flush toilet	Urine diverting flush toilet	Dry toilet with mechanical advancement	Urine diverting dry toilet with mechanical advancement	Urine diverting pour flush toilet	Leak-free cistern flush toilet	Leak-free cistern flush toilet with urine diversion	Waterless urinal
Potential for urine recovery	*** = urine diverting, * = not urine diverting*											
	*	**	**	*	*	**	*	**	**	*	**	**
Risk of trash in sludge	**** = little to no risk; ** = some risk; * = high risk; – = N/A*											
	*	*	-	***	***	***	**	**	***	***	***	-

Collection and storage/treatment

Onsite collection and storage/treatment options have potential to encourage product reuse by containing products with reuse potential and even, in some case, providing onsite treatment. Different technologies are rated based on the ways in which the enable or restrict the reuse of urine and sludge, and these ratings are summarised in Table 25. Furthermore, the technologies are rated in terms of whether further treatment is required.

Table 25: Ratings for onsite collection and storage/treatment in terms of reuse potential

COLLECTION, STORAGE/ TREATMENT		S.1	S.2	S.3	S.4	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16
		Urine storage tank/container	Single pit	Single ventilated improved pit	Double ventilated improved pit	Fossa alterna	Twin pits for pour or low flush	Dehydration vault	Composting chamber	Septic tank	Anaerobic baffled reactor	Anaerobic filter	Anaerobic digester	Single pit for pour flush	Incineration vault	Soakaway for Urine	Sludge storage container
Reuse Potential	Urine	**+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sludge	-	*	*	*	**	*	**	***	*	*	*	**	*	***	-	*
	**** = solution produces a reusable by product* *** = solution produces a partially-treated product* ** = potential for reuse with further treatment* *- = N/A or none, solution disposes of products*																
Further treatment required?		**	**	**	**	***	**	**	**	*	*	*	**	*	***	**	**
		**** = No, products can be reused* *** = Only if reuse is desired (products can be safely and simply discharged or disposed of)* ** = Yes, further treatment required for discharge or reuse*															

Treatment

The treatment approaches are rated below based on how each approach favours reuse of urine, sludge, and/or effluent. While all approaches *can* achieve reuse based on the treatment systems employed, some approaches are either directly aimed at resource recovery or explicitly favour this approach. In general, conventional approaches are typically designed to produce outputs that are safe to dispose of, while newer technologies may have resource recovery has an explicit goal.

Table 26: Ratings for treatment in terms of reuse potential

TREATMENT	*Liquid treatment*				*Sludge treatment*			*Urine*
	T.1	**T.2**	**T.3**	**T.4**	**T.5**	**T.6**	**T.7**	**T.8**
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Urine	-	-	-	-	-	-	-	***
Sludge	*	**	*	***	*	**	***	-
Effluent	*	*	*	***	*	*	-	***
Ratings	**** = Approach designed to produce a reusable by-product* *** = Approach favours resource recovery, but recycling is not an explicit goal* ** = Approach designed for sludge disposal* *- = N/A or none*							

Use and/or disposal

The selected use and/or disposal method of products from the earlier stages of the sanitation value chain have different outcomes in terms of reuse. At this stage, the success of reuse efforts along the value chain is realised. In some cases, it is worth investing in earlier technologies that enable reuse while in other cases, safe disposal is the only manageable option. Some use/disposal technologies involve active recycling of by-products (e.g. applying by-products as fertiliser) while others provide for "passive" recycling (e.g. burying sludge which improves soil properties). Some options are focused on safe disposal and thus do note achieve reuse objectives. In many cases, the final use and/or disposal method should inform technology decisions earlier in the value chain.

Table 27: Ratings for use or disposal in terms of reuse/recycling potential

USE AND/OR DISPOSAL	*Sludge options*							*Effluent/liquid options*					*Urine options*		*Sludge /urine*	*Biogas options*	
	D.1	**D.2**	**D.3**	**D.4**	**D.5**	**D.6**	**D.7**	**D.8**	**D.9**	**D.10**	**D.11**	**D.12**	**D.13**	**D.14**	**D.15**	**D.16**	**D.17**
	Fill and cover/Arborloo	Surface application of treated sludge	Deep row entrenchment	Land application of compost or other soil conditioner	Fuel	Landfill disposal	Surface disposal and storage	Irrigation	Soakaway	Pond	Water disposal/ Groundwater recharge	Recycling for non-consumption	Application of stored urine	Application of concentrated urine nutrients	Building materials	Biogas combustion for fuel	Biogas flaring to atmosphere
Score	**	***	**	***	***	*	*	***	*	***	**	***	***	***	***	***	*
Ratings	****=Active recycling **=Passive recycling * =No recycling*																

5.2.10 Electricity Requirement

Electricity requirement is an important consideration for treatment technologies, particularly in settings where electricity is unreliable and/or off-grid electricity options (e.g. solar panels) are cost-prohibitive. Technologies that do not require electricity may be appropriate in very rural settings. Though most technologies that require electricity can be operated with an off-grid electricity supply, the fact that it requires electricity makes it by nature more vulnerable to failure.

T **Electricity requirement** is relevant when selecting **treatment** options for the various products in the sanitation value chain.

Table 28: Ratings for treatment in terms of electricity requirement

TREATMENT	*Liquid treatment*				*Sludge treatment*			*Urine*
	T.1	**T.2**	**T.3**	**T.4**	**T.5**	**T.6**	**T.7**	**T.8**
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Score	*	***	*	**	***	***	**	**
Ratings	**** = No electricity required* *** = Off-grid electricity provided* ** = constant and considerable electricity required from the grid*							

5.2.11 Space requirement

Land requirement is important particularly in urban and peri-urban areas where space is limited. This refers to the space required to implement a technology in comparison with other options.

S T D **Space requirement** may be important when selecting technologies for onsite **collection and storage/treatment**; **treatment**; and **use/disposal.**

Technologies in each of these categories are rated in the tables below based on their relative space requirement compared to other options in that category. The scores are as follows:

- * = Large area required
- ** = Medium area required
- *** = Limited area required

Table 29: Ratings for onsite collection and storage/treatment in terms of space requirement

COLLECTION, STORAGE/TREATMENT	**S.1**	**S.2**	**S.3**	**S.4**	**S.5**	**S.6**	**S.7**	**S.8**	**S.9**	**S.10**	**S.11**	**S.12**	**S.13**	**S.14**	**S.15**	**S.16**
	Urine storage tank/container	Single pit	Single ventilated improved pit	Double ventilated improved pit	Fossa alterna	Twin pits for pour or low flush	Dehydration vault	Composting chamber	Septic tank	Anaerobic baffled reactor	Anaerobic filter	Anaerobic digester	Single pit for pour flush	Incineration vault	Soakaway for Urine	Sludge storage container
Score	***	***	***	**	**	**	***	***	*	*	*	*	***	***	**	***

Table 30: Ratings for treatment in terms of space requirement

TREATMENT	*Liquid treatment*				*Sludge treatment*			*Urine*
	T.1	**T.2**	**T.3**	**T.4**	**T.5**	**T.6**	**T.7**	**T.8**
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Score	*	*	**	**	***	**	***	***

Table 31: Ratings for use or disposal in terms of space requirement

USE AND/OR DISPOSAL	*Sludge options*							*Effluent/liquid options*					*Urine options*		*Sludge/ urine*	*Biogas options*	
	D.1	**D.2**	**D.3**	**D.4**	**D.5**	**D.6**	**D.7**	**D.8**	**D.9**	**D.10**	**D.11**	**D.12**	**D.13**	**D.14**	**D.15**	**D.16**	**D.17**
	Fill and cover/Arborloo	Surface application of treated sludge	Deep row entrenchment	Land application of compost or other soil conditioner	Fuel	Landfill disposal	Surface disposal and storage	Irrigation	Soakaway	Pond	Water disposal/ Groundwater recharge	Recycling for non-consumption	Application of stored urine	Application of concentrated urine nutrients	Building materials	Biogas combustion for fuel	Biogas flaring to atmosphere
Score	**	*	***	**	***	*	*	*	**	*	**	***	**	***	***	***	***

5.2.12 Input products

Different technologies can accommodate different input products, and the appropriateness of a technology will be determined by the products produced by previous steps in the sanitation value chain. As such, input products are used to consider which technologies should be considered at each step. Input products are determined by the preceding technology.

S C T D

Input products will determine the compatibility of technology options for onsite **collection and storage/treatment**; **conveyance**; **treatment**; and **use/disposal.**

Technologies in the above categories are rated below in terms of input products that they can handle, with a “Y” for “yes”, “N” for “no”, and “M” for “maybe”.

Table 32: Compatibility of onsite collection and storage/treatment with various input products

	S.1	S.2	S.3	S.4	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16
	Urine storage tank/container	Single pit*	Single ventilated improved pit	Double ventilated improved pit	Fossa alterna	Twin pits for pour or low flush	Dehydration vault	Composting chamber	Septic tank	Anaerobic baffled reactor	Anaerobic filter	Anaerobic digester	Single pit for pour flush	Incineration vault	Soakaway for Urine	Sludge storage container
Urine	N	N	Y	N	N	N	Y	N	N	N	Y	N	N	N	Y	N
Faeces	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Flushwater	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Dry cleansing material	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Excreta	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Blackwater	Y	N	N	N	Y	N	N	N	Y	N	N	N	Y	N	N	N
Brownwater	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Greywater	N	N	Y	N	N	N	Y	N	N	N	Y	N	N	N	Y	N

Table 33: Compatibility of conveyance with various input products

	C.1 Jerrycan/ Tank	C.2 Human-Powered emptying and transport	C.3 Motorized Emptying and Transport (Honeysucker)	C.4 Simplified Sewer	C.5 Solids-Free Sewer	C.6 Conventional Gravity Sewer	C.7 Transfer Station (Underground Holding Tank)	C.8 Hybrid Human-Powered/ Motorised Emptying and Transport
Stored Urine	Y	Y	Y	Y	Y	Y	Y	Y
Sludge*	N	Y	M	N	N	N	Y	Y
Pit Humus	N	Y	M	N	N	N	Y	M
Dried Faeces	N	Y	N	N	N	N	Y	N
Compost	N	Y	N	N	N	N	Y	N
Effluent	N	N	N	Y	Y	Y	N	N
Biogas	N	N	N	N	N	N	N	N
Ash	N	Y	N	N	N	N	N	N

*NOTE: Consistency, moisture content, and trash content in sludge and pit humus will influence whether human-powered and/or motorized emptying are appropriate.

Table 34: Compatibility of treatment options with various inputs

	T.1	T.2	T.3	T.4	T.5	T.6	T.7	T.8
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Stored Urine	M	M	M	M	N	N	N	Y
Sludge	N	N	N	N	Y	Y	Y	N
Dry cleansing material	N	N	N	N	Y	Y	Y	N
Excreta	Y	Y	Y	Y	Y	Y	Y	N
Effluent	Y	Y	Y	Y	N	N	N	N
Greywater	Y	Y	Y	Y	N	N	N	N
Stormwater	N	N	N	N	N	N	N	N
Blackwater	Y	Y	Y	Y	N	N	N	N
Brownwater	Y	Y	Y	Y	N	N	N	N
Pit Humus	N	N	N	N	Y	Y	Y	N

Table 35: Compatibility for use or disposal with different input products

	D.1	D.2	D.3	D.4	D.5	D.6	D.7	D.8	D.9	D.10	D.11	D.12	D.13	D.14	D.15	D.16	D.17
	Fill and cover/Arborloo	Surface application of treated sludge	Deep row entrenchment	Land application of compost or other soil conditioner	Fuel	Landfill disposal	Surface disposal and storage	Irrigation	Soakaway	Pond	Water disposal/ Groundwater recharge	Recycling for non-consumption	Application of stored urine	Application of concentrated urine nutrients	Building materials	Biogas combustion for fuel	Biogas flaring to atmosphere
Concentrated urine nutrients	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N
Treated sludge	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	Y	N	N
Effluent	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	N	N	N	N
Pre-treatment products	N	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
Sludge	Y	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Stored Urine	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N
Urine	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N
Biogas	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y

5.2.13 Established technology

The level to which the technology has been tested, proven, and implemented may influence confidence levels in the technology. Implementing proven or established technologies may be less risky for decision makers, while implementing new technologies may be advantageous for opening up options and being at the forefront of technology development. Decision makers can select the degree to which a technology's level of establishment will influence their decision making, and to ensure that innovative technologies are included and considered, they have been scored in terms of how established they are. Though this may be relevant for technologies across the sanitation value chain, emphasis has been placed on the treatment approaches, because these have the greatest potential to be technologically advanced.

T D

Whether a technology is an **established technology** may influence decision-makers choices when it comes to **treatment** processes or **use and/or disposal** options.

Treatment technologies are scored below in terms of their level of establishment, based on the following:

- - = Only understood in theory or laboratory scale
- * = Piloted but not demonstrated at scale
- ** = Proven but not widely used in South Africa
- *** = Proven and widely used in South Africa

Table 36: Ratings for treatment in terms of current level of technology establishment

TREATMENT	*Liquid treatment*				*Sludge treatment*			*Urine*
	T.1	T.2	T.3	T.4	T.5	T.6	T.7	T.8
	Conventional Centralised Wastewater Treatment Works	Decentralised Wastewater Treatment System (DEWATS)	Package Wastewater Treatment Plant	Off-Grid Package Wastewater Treatment Plant	Co-treatment of faecal sludge in conventional WWTW	Designated faecal sludge treatment plant	Self-contained faecal sludge treatment unit	Treatment of urine for recovery of nutrients
Score	***	**	***	*	*	**	*	*

Table 37: Ratings for use and/or disposal methods in terms of level of technology establishment

USE AND/OR DISPOSAL	*Sludge options*							*Effluent/liquid options*					*Urine options*		*Sludge/ urine*	*Biogas options*	
	D.1	**D.2**	**D.3**	**D.4**	**D.5**	**D.6**	**D.7**	**D.8**	**D.9**	**D.10**	**D.11**	**D.12**	**D.13**	**D.14**	**D.15**	**D.16**	**D.17**
	Fill and cover/Arborloo	Surface application of treated sludge	Deep row entrenchment	Land application of compost or other soil conditioner	Fuel	Landfill disposal	Surface disposal and storage	Irrigation	Soakaway	Pond	Water disposal/ Groundwater recharge	Recycling for non-consumption	Application of stored urine	Application of concentrated urine nutrients	Building materials	Biogas combustion for fuel	Biogas flaring to atmosphere
Score	***	**	**	***	*	***	***	**	***	*	***	*	*	-	-	**	***

6 Introduction to the SaniSelect tool

This document is accompanied by *SaniSelect*, a Microsoft Excel-based tool which allows users to input their project information and see which unit processes might be applicable. *SaniSelect* follows the categories described above and in the *Compendium of Sanitation Systems*, namely: User interface (U); onsite Collection, Storage and Treatment (S); Conveyance (C); Treatment (T); and Use and/or Disposal (D). The tool does not select technologies for the user. Rather, the user can see how different solutions compare in terms of the criteria descried above and then create a short-list and/or select a preferred option. The tool works using filters based on different criteria and ratings, rather than providing a numerical score. Each results sheet has a series of “Gate Selection Criteria”, which determine whether a solution is or is not appropriate based on the project-specific data. There is a list of rating criteria, each of which can be filtered based on the specific project aims and requirements. These criteria include aspects related to the technology, such as user preference, water demand, capital cost, and O&M needs. The sheets also include some considerations about each technology to allow users to make an informed decision. From the filtered list, users can select the preferred option.

The user will then proceed to the subsequent sheets to select the next technology or approach in the sanitation value chain. The relevant options will be informed by the products from the first stages (e.g. if sludge is a product from the collection/storage/treatment selection, the user will need to select a conveyance method for the sludge). If more than one output is produced from a selected technology (e.g. excreta and urine produced by a urine diverting toilet), the user will be able to select separate processes for each output (e.g. pit for excreta and storage tank for urine). The user proceeds in the same way through all parts of the sanitation value chain, and the full system is then displayed on the “Sanitation System” sheet. This process empowers users to consider the full sanitation value chain, which will ensure that certain aspects are not overlooked.

The user then ends up with a Sanitation System of general technologies and approaches. The tool does NOT address specific suppliers of technologies or detailed treatment trains that are appropriate for the project. Information on specific technology suppliers would be gathered elsewhere, ideally using a centralised database maintained by the Department of Water and Sanitation. If a treatment approach is selected, the user would then need to consult a qualified professional (i.e. design engineer in the field of wastewater treatment and/or sanitation) to design the detailed treatment process to achieve the desired goals (i.e. outputs for use and/or disposal).

7 How does SaniSelect work?

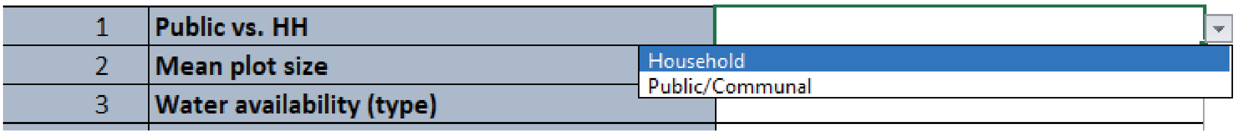
The cells in the workbook are formatted based on the type of information in the cells. This is to help guide users to the cells where their input is required. A description of the different cell formatting types is provided in Table 38. The spreadsheet has been protected to avoid any edits being made to the master copy. Cells that require editing are unprotected, along with macros for hiding or showing cells and/or those for clearing editable cells. The spreadsheet password is “saniselect”, and can be entered if it is absolutely necessary to edit the structure of the sheet.

Table 38: Cell formatting description

Cell type	What to do	Description of formatting
Data entry cells	DO edit these cells; red "CLEAR CELLS" buttons will remove data from these cells	Thick, coloured cell border with white fill colour. Most of these are drop-down lists.
Linked cells	DO NOT edit these cells	Blue fill colour with regular text
Titles/labels	DO NOT edit these cells	Coloured cell fill colour with bold text
CLEAR CELLS	Button to press	If you press this button, the Data Entry Cells on the given sheet will be cleared.
Remove inappropriate solutions	Button to press	This button filters the list to remove solutions that are inappropriate based on the compatibility of gate selection criteria
Show all solutions	Button to press	This button removes the filter from the above button, thus showing all solutions on the list. Note this button does not remove filters added to the rating criteria. These must be manually edited.

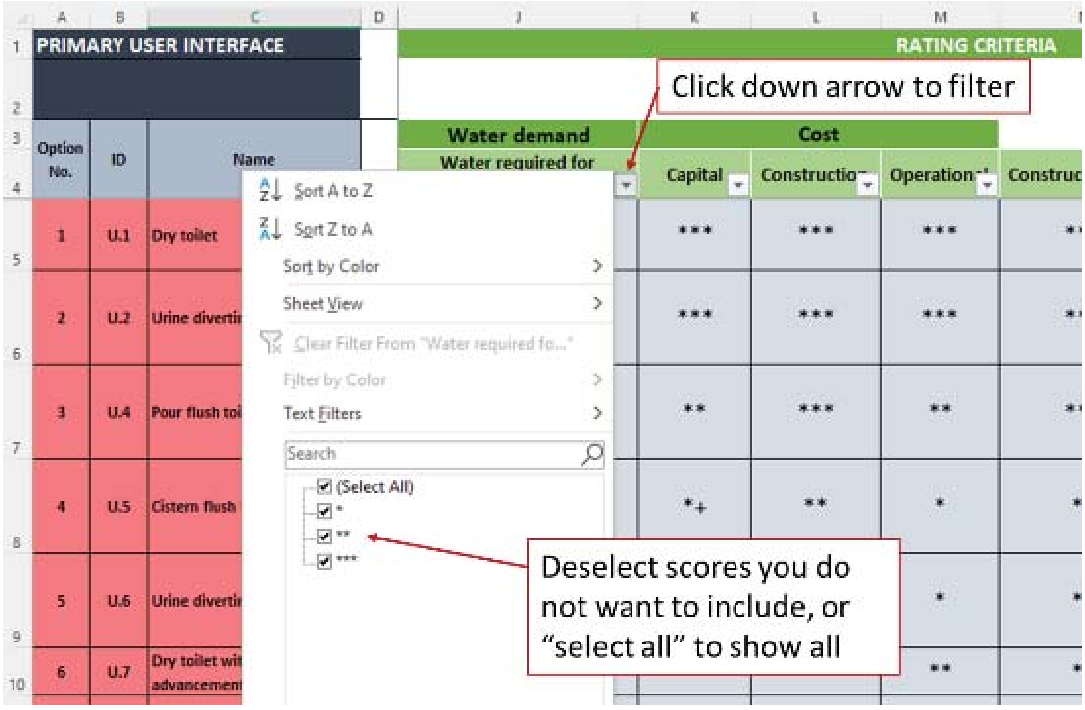
There are certain general rules of use of the spreadsheet in addition to the formatting guide. These are presented below.

1. **Drop down lists:** Drop-down lists are used as much as possible to avoid errors (e.g. typos) and to ensure automation. To select an item from a dropdown list, simply click on the cell and select the option you want. If you want to clear or change the response, you can press "backspace" or click the cell again and select a different option.



2. **Gate Selection Criteria** refers to criteria that determine the appropriateness of a specific technology. These include compatibility criteria (e.g. if you select a specific user interface, only some collection/storage/treatment options are applicable) and project-specific criteria (e.g. if water is not available, waterborne systems are not appropriate). On some of the sheets, you are asked to "shortlist" options that you want to score. It is advised that you do not shortlist items that say "not appropriate" for any of the Gate Selection Criteria.
3. **Rating Criteria** refers to technology-specific criteria that you may consider when selecting a sanitation system. With rating criteria, you are able to weight different criteria based on what matters most in your project. Your weightings should add up to 100, so each individual weighting should be equal to a portion of 100. The ratings are generally on a scale from 0-3 points, and the point allocations are described on each sheet.
4. **Filters** are used throughout the tool to allow users to create a list filtered based on different criteria. To use filters, the user clicks on the down arrow, selects the ratings that they want to consider and deselects the ratings they want to exclude. For example, if the user wants to look at only user interfaces with low water demand, they will filter Column J (below) to only show those receiving a score of ** or *** (i.e. excluding *). If the user decides that a given criteria is not critical to their

project, they can tick "select all" to shop filtering data in that column. More information about how to select which columns to filter is provided below.



7.1 Data Entry Sheet

Work begins on the *Data Entry* Sheet, where the user enters information about themselves and the project they are working on. This information is important for selecting systems that are appropriate for a specific context.

Users are first asked to communicate their vision or for sanitation by selecting three primary goals. These goals are *in addition* to the general goal of providing safe, dignified, and healthy sanitation systems to people. The goals selected may influence which criteria the user will consider when creating short lists, and they are shown in Figure 18. To select a goal, the user simply types an **X** in the box next to it.

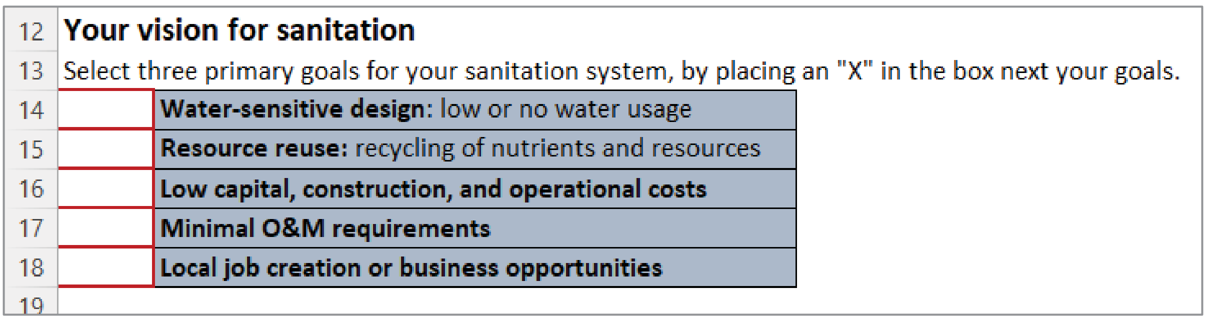


Figure 18: Data entry section for defining your vision for sanitation

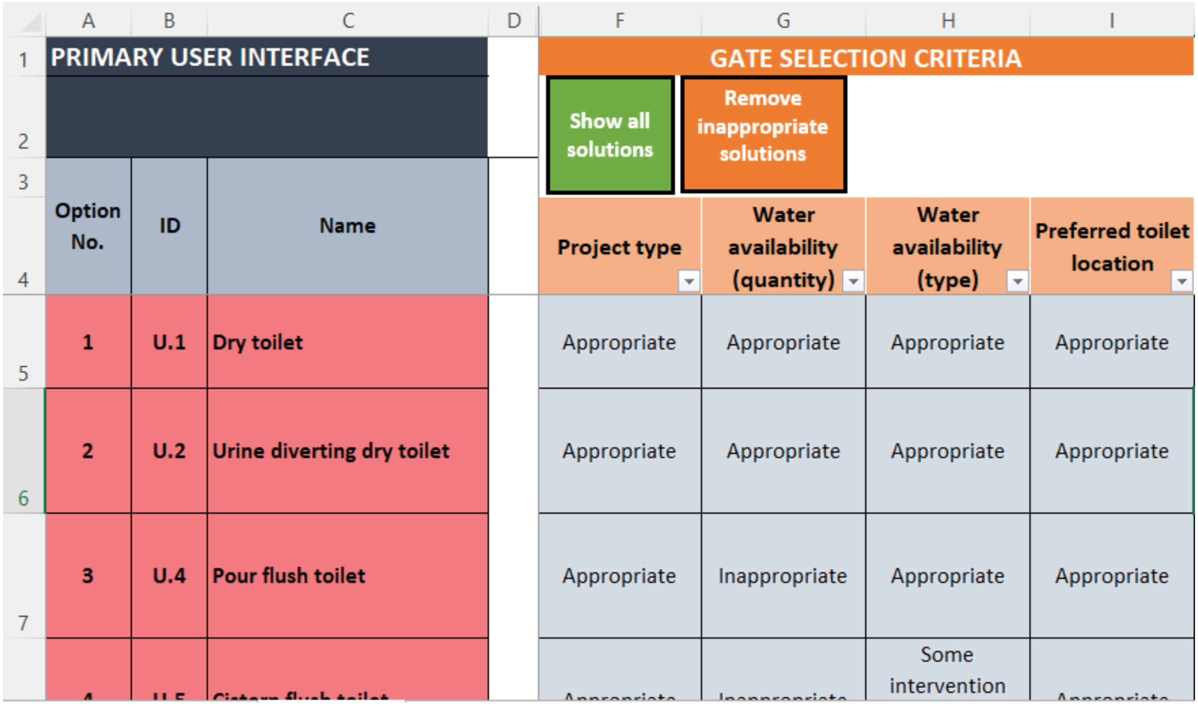
After setting a vision for sanitation, the user provides project information/data that will dictate which options are available for the project. The fields included on this sheet are described in Table 39.

Table 39: Description of inputs on Data Entry sheet

No.	Input	Description
1	Location of user interface (HH vs. communal)	Select where the user interface(s) are going to be located (e.g. at individual households or in a communal/public facility).
2	Mean plot size	Plot size may influence the appropriate solutions
3	Water availability (type)	What type of water is available at the site(s)? This refers to the method of water supply and the source.
4	Water availability (amount)	This refers to the quantity of water available to households
4	Groundwater table depth	Depth to groundwater table, which is one factor in determining the risk of groundwater pollution
5	Soil type	Soil type also helps determine the risk of groundwater pollution and how well the soil will drain
6	Groundwater vulnerability class	This cell is automatically calculated based on both the soil type and groundwater table depth. The vulnerability class is based on the Department of Water and Sanitation's Groundwater Protocol.
7	Percolation rate	This must be measured through a percolation test and influences whether the soil can drain fast enough to accommodate systems that rely on infiltration (e.g. soakaway).
8	Terrain	This refers to the slope of the terrain and influences whether the site is accessible for emptying by a vacuum truck.
9	Housing density	This also impacts which emptying technologies are appropriate and whether unsealed containment options are feasible.
10	Is there interest in reuse of resources at the household level?	This will inform whether you prioritize reuse potential in your decision making.
11	Is there interest in reuse of resources in the community in general?	This will inform whether you prioritize reuse potential in your decision making.
12	Flood prone	Flood prone areas are not suitable for unsealed containment systems.
13	Access	Access refers to the ability to access households with a truck, and this informs emptying approaches.
14	Distance to main sewer	This will help determine whether full waterborne sanitation is an option.
15	WWTP capacity	This will help determine whether full waterborne sanitation is an option, using the existing WWTW.
16	Sewer availability	This is a calculated cell based on responses to questions 14 and 15.
17	Anal cleansing method	This may influence the appropriate user interface options. Communities using only hard paper may be more susceptible to clogging flushing systems, though many low flush systems can accommodate hard paper.
18	Preferred toilet location	For household systems, the preferred location (inside or outside the house) may influence the appropriate user interface options due to the need for effective odour control for indoor installations.
19	Do you need a sanitation system that can handle greywater as well?	This will influence the type(s) of onsite collection, storage, and treatment technologies and treatment approaches available for the project. In some cases, greywater is minimal or is dealt with separately. However, in many cases, a water and sanitation solution will require consideration of greywater.

7.2 User Interface

This sheet presents the list of different User Interface options, which can be filtered based on the gate selection and rating criteria. The sheet first presents the results for the gate criteria based on data entered on the *Data Entry* sheet. This is shown in Figure 19. By pressing the orange button, the user will filter the list so that solutions that are inappropriate for any reason are removed. The list in Figure 19 is filtered to remove inappropriate solutions (e.g. Pour flush toilet) and this filtered list is shown in Figure 20.

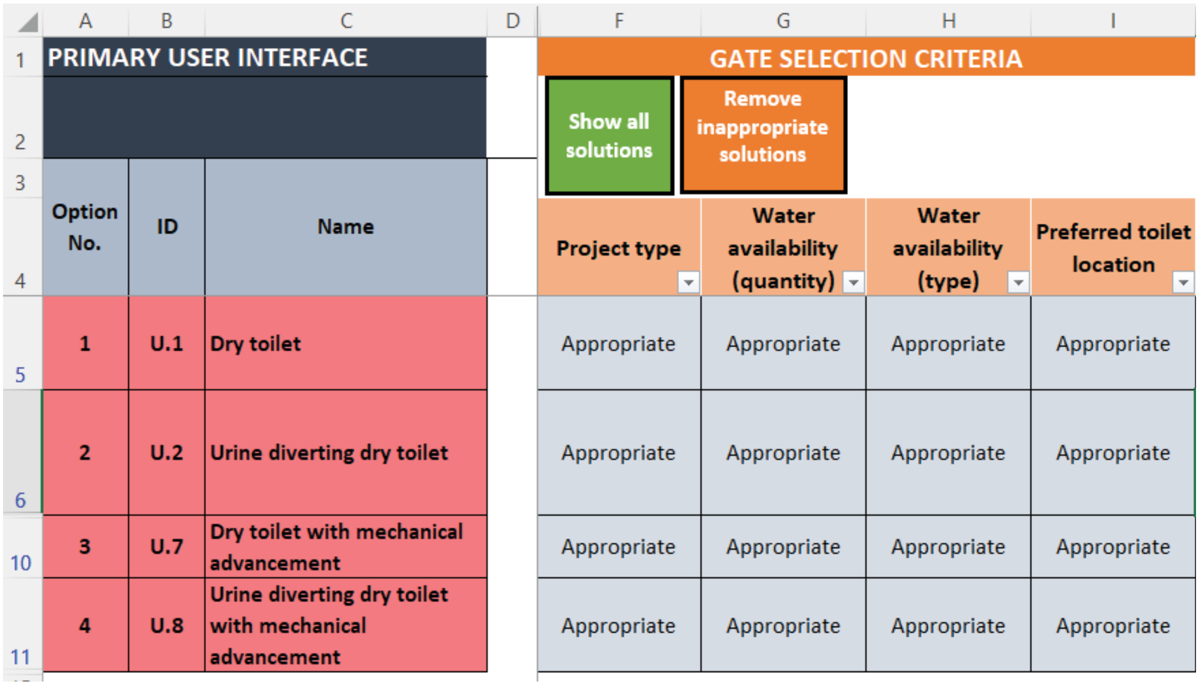


PRIMARY USER INTERFACE | GATE SELECTION CRITERIA

Show all solutions | Remove inappropriate solutions

Option No.	ID	Name	Project type	Water availability (quantity)	Water availability (type)	Preferred toilet location
1	U.1	Dry toilet	Appropriate	Appropriate	Appropriate	Appropriate
2	U.2	Urine diverting dry toilet	Appropriate	Appropriate	Appropriate	Appropriate
3	U.4	Pour flush toilet	Appropriate	Inappropriate	Appropriate	Appropriate
4	U.5	Cistern flush toilet	Appropriate	Inappropriate	Some intervention	Appropriate

Figure 19: User interface gate selection criteria section



PRIMARY USER INTERFACE | GATE SELECTION CRITERIA

Show all solutions | Remove inappropriate solutions

Option No.	ID	Name	Project type	Water availability (quantity)	Water availability (type)	Preferred toilet location
1	U.1	Dry toilet	Appropriate	Appropriate	Appropriate	Appropriate
2	U.2	Urine diverting dry toilet	Appropriate	Appropriate	Appropriate	Appropriate
3	U.7	Dry toilet with mechanical advancement	Appropriate	Appropriate	Appropriate	Appropriate
4	U.8	Urine diverting dry toilet with mechanical advancement	Appropriate	Appropriate	Appropriate	Appropriate

Figure 20: User interface list filtered to remove inappropriate solutions based on gate criteria

Once the list has been filtered based on gate selection criteria, the user can scroll to the rating criteria in **Column J through Q**. The meanings of the ratings shown in this section are summarised in Table 40. Depending on what goals were selected under the Sanitation Vision on the Data Entry Sheet, tips for filtering based on different criteria will be displayed in **Row 2**. This is shown in Figure 21. The user can then select which criteria to filter based on project goals and constraints, creating the ultimate final filtered list, shown in Figure 22.

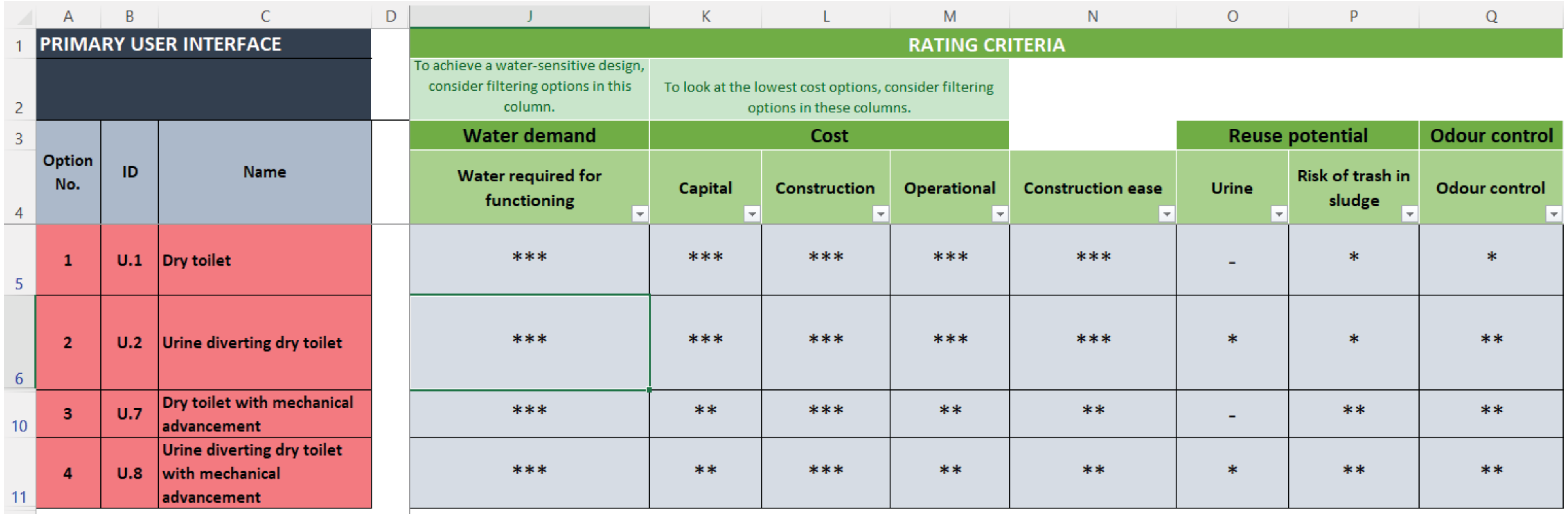
Finally, in **Columns R through U**, the sheet presents various considerations for the technologies, including comments on operations and maintenance, inputs, valorisation, and other special requirements or features. This added information can assist the user in either presenting the short list of options to the project team and community members or selecting a preferred option.

In **Cell C17**, the user selects the preferred primary user interface. If a secondary user interface is desired (i.e. a urinal), the user scrolls to **Row 19** and repeats the filtering and decision-making process before selecting the desired urinal in **Cell C26**.

With the *User Interface* sheet complete, the user can move to the *Onsite Collection,Stor,Trmt* sheet.

Table 40: Description of rating criteria on the User Interface sheet

Score	Water demand	Costs			Construction ease	Reuse potential		Odour control
		Capital	Construction	Operational		Urine Reuse	Risk of trash in sludge	
***	No water required	Relatively low cost	Relatively low cost	Relatively low cost	No specialist involvement required		Little to no risk	No odour expected
**	Some water required (2-5 litres) but no cistern	Medium cost	Medium cost	Medium cost	Some specialist involvement may be required	Urine-diverting	Some risk	Some odour control
*	Some water required (2-5 litres) and cistern included	High cost	High cost	High cost	Specialist involvement definitely required	Not urine-diverting	High risk	No odour control



PRIMARY USER INTERFACE

RATING CRITERIA

To achieve a water-sensitive design, consider filtering options in this column.

To look at the lowest cost options, consider filtering options in these columns.

Option No.	ID	Name	Water demand: Water required for functioning	Cost: Capital	Cost: Construction	Cost: Operational	Construction ease	Reuse potential: Urine	Reuse potential: Risk of trash in sludge	Odour control
1	U.1	Dry toilet	***	***	***	***	***	-	*	*
2	U.2	Urine diverting dry toilet	***	***	***	***	***	*	*	**
3	U.7	Dry toilet with mechanical advancement	***	**	***	**	**	-	**	**
4	U.8	Urine diverting dry toilet with mechanical advancement	***	**	***	**	**	*	**	**

Figure 21: Rating Criteria for User Interface with tips based on project goals of water-sensitive design and low costs

	A	B	C	D	J	K	L	M	N	O	P	Q
1	**PRIMARY USER INTERFACE**				**RATING CRITERIA**							
2					To achieve a water-sensitive design, consider filtering options in this column.	To look at the lowest cost options, consider filtering options in these columns.						
3					**Water demand**	**Cost**				**Reuse potential**		**Odour control**
4	**Option No.**	**ID**	**Name**		**Water required for functioning**	**Capital**	**Construction**	**Operational**	**Construction ease**	**Urine**	**Risk of trash in sludge**	**Odour control**
5	**1**	**U.1**	**Dry toilet**		***	***	***	***	***	-	*	*
6	**2**	**U.2**	**Urine diverting dry toilet**		***	***	***	***	***	*	*	**

Figure 22: Final filtered user interface short list based on suggestions for filtering the rating criteria

7.3 Onsite Collection, Storage, and/or Treatment

This sheet presents the list of onsite collection, storage, and/or treatment technologies that can be filtered based on various criteria. The sheet presents options for solid inputs in **rows 1 through 23**. In the second half of the sheet, options are evaluated for liquid inputs in **row 27 through 54**. The various inputs are taken from the *Sanitation System* sheet, based on the selected user interface(s).

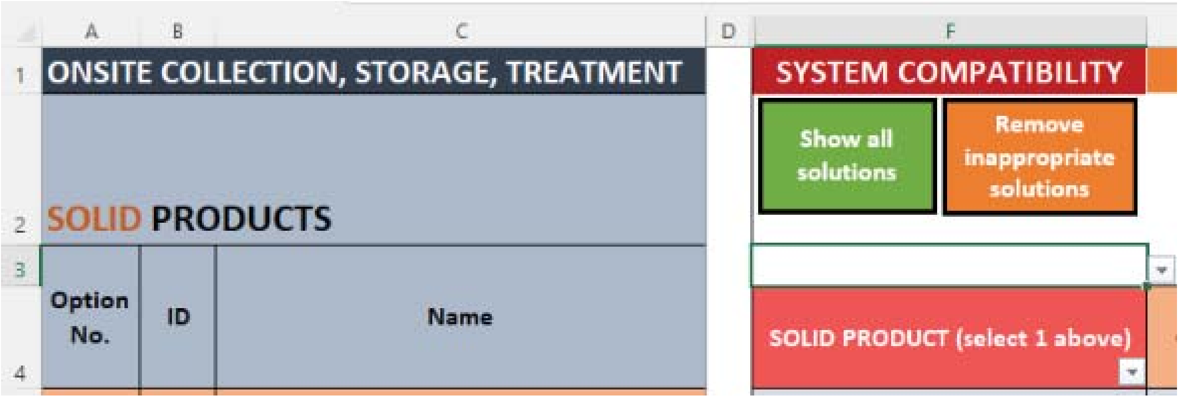


Figure 23: The user starts by selecting a product in cell F3

Column F firstly shows the system compatibility based on an input product selected from the drop-down list in **cell F3.** The system compatibility then shows in **column F,** and the gate selection criteria are shown in **columns G through J.** Again, if the user presses the orange button, the list is filtered by removing solutions that are inappropriate for any reason (either system compatibility or gate selection criteria).

Once the list is filtered, the user can view the rating criteria in **columns K through Q**. Similar to the *User Interface* sheet, suggestions for filtering may appear in **row 2** based on the project's aims or constraints.

Finally, comments on the solutions are provided in **columns R through U** to allow the user to evaluate the options and/or present the options to the project team and community.

Once a decision is made, the user selects the collection, storage, and/or treatment option from the drop-down menu in **cell C23**.

The same process is repeated for liquid inputs in **rows 27 through 54**. However, in **rows 49 through 54**, all liquid inputs are listed. The user must then select a collection, storage, and treatment option for all of the listed inputs. Using the single filterable list, the user can evaluate options for each input by selecting the liquid input in cell **F29**. The process should be repeated until a technology has been selected for each product listed in **cells A49 through A54**.

ONSITE COLLECTION, STORAGE, TREATMENT | **SYSTEM COMPATIBILITY** | **GATE SELECTION CRITERIA**

Show all solutions | Remove inappropriate solutions

SOLID PRODUCTS

Excreta

Option No.	ID	Name	SOLID PRODUCT (select 1 above)	Groundwater contamination risk	Soil percolation rate	Flood prone?	Housing density
1	S.1	Urine storage tank/ container	N	Minimal risk	Appropriate	Appropriate	Appropriate
2	S.2	Single pit	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
3	S.3	Single ventilated improved pit	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
4	S.4	Double ventilated improved pit	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
5	S.5	Fossa alterna	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
6	S.6	Twin pits for pour or low flush	N	Minimal Risk	Appropriate	Appropriate	Appropriate

Figure 24: System compatibility and gate selection criteria for onsite collection, storage, and treatment

ONSITE COLLECTION, STORAGE, TREATMENT | **SYSTEM COMPATIBILITY** | **GATE SELECTION CRITERIA**

Show all solutions | Remove inappropriate solutions

SOLID PRODUCTS

Excreta

Option No.	ID	Name	SOLID PRODUCT (select 1 above)	Groundwater contamination risk	Soil percolation rate	Flood prone?	Housing density
1	S.2	Single pit	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
2	S.3	Single ventilated improved pit	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
3	S.4	Double ventilated improved pit	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
4	S.5	Fossa alterna	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
5	S.8	Composting chamber	Y	Minimal Risk	Appropriate	Appropriate	Appropriate
6	S.14	Incineration vault	Y	Minimal Risk	Appropriate	Appropriate	Appropriate

Figure 25: Collection, storage, and treatment list filtered to remove inappropriate solutions based on system compatibility and gate selection criteria

Table 41: Description of rating criteria for collection, storage, and treatment

Score	Capital and construction cost	Construction ease	Operational requirements	Space requirement	Further treatment required?	Reuse potential	
						Urine	Sludge/by-products from storage
***	Relatively low cost	No specialist involvement required	*Limited (desludging required every 5-10 years*	Limited area required	*No, products can be reused*	*Solution produces a reusable by product*	*Solution produces a reusable by product*
**	Medium cost	Some specialist involvement may be required	*Moderate (difficult desludging required every 5-10 years (e.g. with excessive trash in sludge)*	Medium area required	*Only if reuse is desired (products can be safely and simply discharged or disposed of)*	*Solution produces a partially-treated product*	*Solution produces a partially-treated product*
*	High cost	Specialist involvement definitely required	*Average (regular maintenance required (1 to 4 times a year))*	Large area required	*Yes, further treatment required for discharge or reuse*	*Potential for reuse with further treatment*	*Potential for reuse with further treatment*
-			*Extensive (at least weekly maintenance required)*			*N/A or none, solution disposes of products*	*N/A or none, solution disposes of products*

	A	B	C	K	L	M	N	O	P	Q
1	**ONSITE COLLECTION, STORAGE, TREATMENT**			**RATING CRITERIA**						
2	**SOLID PRODUCTS**			To look at the lowest cost options, consider filtering options in this column.			Consider space requirements, since plot sizes are small.			
3									**Reuse potential**	
4	**Option No.**	**ID**	**Name**	**Capital and construction cost**	**Construction ease**	**Operational requirements (frequency and difficulty)**	**Space requirement**	**Further treatment required?**	**Urine**	**Sludge/byproducts from storage/treatment**
6	1	S.2	Single pit	***	**	**	***	**	-	*
7	2	S.3	Single ventilated improved pit	***	**	**	***	**	-	*
8	3	S.4	Double ventilated improved pit	**	**	**	**	**	-	*
9	4	S.5	Fossa alterna	**	**	***	**	***	-	**
12	5	S.8	Composting chamber	**	*	*	***	**	-	***
18	6	S.14	Incineration vault	-	*	*	***	***	-	***
20	7	S.16	Sludge storage container	***	***	-	***	**	-	*

Figure 26: Rating criteria for collection, storage, and treatment, with tips for filtering based on project aim of low cost and the small plot sizes

	A	B	C	K	L	M	N	O	P	Q
1	**ONSITE COLLECTION, STORAGE, TREATMENT**			**RATING CRITERIA**						
2	**SOLID PRODUCTS**			To look at the lowest cost options, consider filtering options in this column.			Consider space requirements, since plot sizes are small.			
3									**Reuse potential**	
4	**Option No.**	**ID**	**Name**	**Capital and construction cost**	**Construction ease**	**Operational requirements (frequency and difficulty)**	**Space requirement**	**Further treatment required?**	**Urine**	**Sludge/byproducts from storage/treatment**
6	1	S.2	Single pit	***	**	**	***	**	-	*
7	2	S.3	Single ventilated improved pit	***	**	**	***	**	-	*
20	3	S.16	Sludge storage container	***	***	-	***	**	-	*

Figure 27: Final filtered list for collection, storage, and treatment

	Liquid Products	Selected Collection, Storage, Treatment
49	Greywater	
50		
51		
52		
53		
54		

Figure 28: Location on collection, storage, and treatment sheet to enter technology selections for each liquid product generated by the user interface(s)

7.4 Conveyance

This sheet works very similarly to the *Onsite Collection, Storage, and Treatment* sheet. The sheet is divided into solid products in **rows 1 through 20** and liquid products in **rows 22 through 38**. Again, the products to deal with are based on the technologies selected in the previous sheets.

The user initially selects a product to find a solution for from the drop-down menu in **cell F3**. By pressing the orange button, the user can filter the list to remove solutions that are inappropriate for any reason.

CONVEYANCE — SOLID PRODUCTS | SYSTEM COMPATIBILITY | GATE SELECTION CRITERIA

Show all solutions | Remove inappropriate solutions | Sludge

Option No.	ID	Name	Solid product (select one above)	Accessibility	Terrain
1	C.1	Jerrycan/ Tank	N	Appropriate	Appropriate
2	C.2	Human-Powered emptying and transport	Y	Appropriate	Appropriate
3	C.3	Motorized Emptying and Transport (Honeysucker)	M	Appropriate for some households	Appropriate
4	C.4	Simplified Sewer	N	Appropriate	Appropriate
5	C.5	Solids-Free Sewer	N	Appropriate	Appropriate
6	C.6	Conventional Gravity Sewer	N	Appropriate	Appropriate
7	C.7	Transfer Station (Underground Holding Tank)	Y	Appropriate	Appropriate
8	C.8	Hybrid Human-Powered/ Motorised Emptying and Transport	Y	Appropriate	Appropriate

Figure 29: System compatibility and gate selection criteria on the Conveyance sheet

CONVEYANCE

SOLID PRODUCTS

SYSTEM COMPATIBILITY — Show all solutions | Remove inappropriate solutions

GATE SELECTION CRITERIA

Option No.	ID	Name	Sludge Solid product (select one above)	Accessibility	Terrain
1	C.2	Human-Powered emptying and transport	Y	Appropriate	Appropriate
2	C.3	Motorized Emptying and Transport (Honeysucker)	M	Appropriate for some households	Appropriate
3	C.7	Transfer Station (Underground Holding Tank)	Y	Appropriate	Appropriate
4	C.8	Hybrid Human-Powered/ Motorised Emptying and Transport	Y	Appropriate	Appropriate

Figure 30: Filtered conveyance list to remove inappropriate solutions

In **columns I through K,** the rating criteria are presented with similar guidance provided in **row 2** based on project aims and constraints.

Table 42: Description of conveyance ratings

Score	Capital cost	Simplicity of operation	Operation efficiency and hygiene
***	Low (<R10,000)	No special skills needed	Very efficient, limited contact with sludge
**	Medium (R10,000-R50,000);	Some special skills needed	Efficient, some contact with sludge
*	High (>R50,000)	Only trained operators	Relatively inefficient, extensive contact with sludge probable

CONVEYANCE

SOLID PRODUCTS

RATING CRITERIA

To look at the lowest cost options, consider filtering options in this column.

Option No.	ID	Name	Capital cost	Simplicity of operation	Operation efficiency and hygiene
1	C.2	Human-Powered emptying and transport	**	***	*
2	C.3	Motorized Emptying and Transport (Honeysucker)	*	*	**
3	C.7	Transfer Station (Underground Holding Tank)	**+	*	**
4	C.8	Hybrid Human-Powered/ Motorised Emptying and Transport	**	**	**

Figure 31: Conveyance rating criteria with guidance based on the aim of a low-cost solution

CONVEYANCE			RATING CRITERIA		
SOLID PRODUCTS			To look at the lowest cost options, consider filtering options in this column.		
Option No.	ID	Name	Capital cost	Simplicity of operation	Operation efficiency and hygiene
1	C.7	Transfer Station (Underground Holding Tank)	**	*	**
2	C.8	Hybrid Human-Powered/ Motorised Emptying and Transport	**	**	**

Figure 32: Final filtered list of conveyance options

The user can repeat the filtering process for solid products and enter the selected conveyance solution in **cells C15 through C20**.

The process is then repeated with liquid products in **rows 22 through 38**, until a conveyance system has been selected for each product. Note that multiple products may use a common conveyance system (e.g. greywater and blackwater in a sewer).

7.5 Treatment

The *Treatment* sheet follows the same approach, with selection of approaches for solid products in **rows 1 through 20** and liquid products in **rows 23 through 39**. The user first selects a solid product from the drop-down menu in **cell F3** and can then filter the list to exclude those treatment approaches that are not applicable by pressing the orange button.

TREATMENT			SYSTEM COMPATIBILITY
SOLID PRODUCTS			Show all solutions / Remove inappropriate solutions
			Sludge
Option No.	ID	Name	Solid product (select one above)
1	T.1	Conventional Centralised Wastewater Treatment Works	N
2	T.2	Decentralised Wastewater Treatment System (DEWATS)	N
3	T.3	Package Wastewater Treatment Plant	N
4	T.4	Off-Grid Package Wastewater Treatment Plant	N
5	T.5	Co-treatment of faecal sludge in conventional WWTW	Y
6	T.6	Designated faecal sludge treatment plant	Y
7	T.7	Self-contained faecal sludge treatment unit	Y
8	T.8	Treatment of urine for recovery of nutrients	N

Figure 33: Treatment approach list, system compatibility section – the user begins by selecting a solid product in cell F3

TREATMENT

SOLID PRODUCTS

SYSTEM COMPATIBILITY

Show all solutions | Remove inappropriate solutions

Sludge

Option No.	ID	Name	Solid product (select one above)
1	T.5	Co-treatment of faecal sludge in conventional WWTW	Y
2	T.6	Designated faecal sludge treatment plant	Y
3	T.7	Self-contained faecal sludge treatment unit	Y

Figure 34: Treatment approach list, filtered based on system compatibility

Table 43: Summary of rating criteria for treatment approaches

Score	Capital and construction cost	Installation time	Job creation opportunities	Space requirement	O&M	Reuse potential			Electricity requirement	Established technology?
						Urine	Sludge	Effluent		
***	Relatively low cost	None	Numerous – civil-based, labour intensive construction	Limited area required or uses existing infrastructure	*Limited O&M required*	Designed to produce recycled urine nutrients	*Designed to product a reusable sludge by-product*	*Designed for effluent recycling*	*No electricity required*	*Yes, proven and widely used in South Africa*
**	Medium cost	Limited time required (prefabricated solutions)	*Some, during site preparation)*	Medium area required	*Semi-regular manual labour required*		*Approach favours resource recovery, but sludge recycling is not an explicit goal*		*Off-grid electricity provided*	*Yes, proven but not widely used in South Africa*
*	High cost	Long timeframe (civil-based works)	*None*	Large area required	*Electricity, chemical, or specialist input required and/or replacement parts difficult to get*		*Approach designed for sludge disposal*	*Approach generally aims for effluent disposal or discharge*	*Constant and considerable electricity required from the grid*	*Piloted but not demonstrated at scale*
-						*N/A or none*	*N/A or none*	*N/A*		*Only understood in theory or at laboratory scale*

TREATMENT			RATING CRITERIA									
SOLID PRODUCTS			To look at the lowest cost options, consider filtering options in this column.							To look at water-sensitive designs, consider filtering based on effluent reuse.		
								Reuse potential				
Option No.	ID	Name	Capital and construction cost	Installation time (from appointment to commissioning)	Job creation opportunities	Space requirement	Operation and maintenance requirements	Urine	Sludge	Effluent	Electricity requirement	Established technology?
1	T.5	Co-treatment of faecal sludge in conventional WWTW	***	***	*	***	***	-	*	*	***	*
2	T.6	Designated faecal sludge treatment plant	**	*	***	**	**	-	**	*	***	**
3	T.7	Self-contained faecal sludge treatment unit	*	**	**	***	*	-	***	-	**	*

Figure 35: Rating criteria for treatment approaches with tips for filtering based on project aims and constraints

TREATMENT			RATING CRITERIA									
SOLID PRODUCTS			To look at the lowest cost options, consider filtering options in this column.							To look at water-sensitive designs, consider filtering based on effluent reuse.		
								Reuse potential				
Option No.	ID	Name	Capital and construction cost	Installation time (from appointment to commissioning)	Job creation opportunities	Space requirement	Operation and maintenance requirements	Urine	Sludge	Effluent	Electricity requirement	Established technology?
1	T.5	Co-treatment of faecal sludge in conventional WWTW	***	***	*	***	***	-	*	*	***	*
2	T.6	Designated faecal sludge treatment plant	**	*	***	**	**	-	**	*	***	**

Figure 36: Final filtered treatment approach list for solid product

The user then selects a treatment approach for the given products listed in **cells A15 through A20**. Once treatment approaches have been selected for each of the solid products, the process is repeated for liquid products in **rows 23 through 39**. The selected treatment approach(s) can then be designed in detail by a competent individual, based on the final selected end use or disposal options (below).

7.6 Use/Disposal

This sheet presents all final treatment products in **cells A24 through A31** and allows the user to filter for each product by selecting from the drop-down list in **cell E3**.

TREATMENT			SYSTEM COMPATIBILITY	GATE SELECTION CRITERIA
			Show all solutions / Remove inappropriate solutions	
			Treated sludge	
Option No.	ID	Name	SELECT PRODUCT ABOVE	Percolation rate
1	D.1	Fill and cover/Arborloo	Y	Appropriate
2	D.2	Surface application of treated sludge	Y	Appropriate
3	D.3	Deep row entrenchment	Y	Appropriate
4	D.4	Land application of compost or other soil conditioner	Y	Appropriate
5	D.5	Fuel	Y	Appropriate
6	D.6	Landfill disposal	Y	Appropriate
7	D.7	Surface disposal and storage	Y	Appropriate
8	D.8	Irrigation	N	Appropriate

Figure 37: System compatibility and gate selection criteria for use and/or disposal

Table 44: Summary of rating criteria for use and/or disposal options

Score	Space requirement	Capital and construction cost	Operation, maintenance, and monitoring	Recycling	Established technology?
***	Limited area required	Relatively low cost	*Little/no O&M required*	*Active recycling*	*Yes, proven and widely used in South Africa*
**	Medium area required	Medium cost	*Semi-regular O&M required*	*Passive recycling*	*Yes, proven but not widely used in South Africa*
*	Large area required	High cost	*Regular O&M and supervision required*	*No recycling*	*Piloted but not demonstrated at scale*
-					*Only understood in theory or at laboratory scale*

TREATMENT | **RATING CRITERIA**

To look at the lowest cost options, consider filtering options in this column.

Option No.	ID	Name	Space requirement	Capital and construction cost	Operation, maintenance, and monitoring requirements	Recycling	Established technology?
1	D.1	Fill and cover/Arborloo	**	***	***	**	***
2	D.2	Surface application of treated sludge	*	***	**	***	**
3	D.3	Deep row entrenchment	***	*	**	**	**
4	D.4	Land application of compost or other soil conditioner	**	***	***	***	***
5	D.5	Fuel	***	**	***	***	*
6	D.6	Landfill disposal	*	**	*	*	***
7	D.7	Surface disposal and storage	*	**	**	*	***
8	D.15	Building materials	***	*	***	***	-

Figure 38: Rating criteria on use and/or disposal sheet, with tips for filtering based on project aim of low cost

TREATMENT			RATING CRITERIA				
				To look at the lowest cost options, consider filtering options in this column.			
Option No.	**ID**	**Name**	**Space requirement**	**Capital and construction cost**	**Operation, maintenance, and monitoring requirements**	**Recycling**	**Established technology?**
1	D.1	Fill and cover/Arborloo	**	***	***	**	***
2	D.2	Surface application of treated sludge	*	***	**	***	**
3	D.4	Land application of compost or other soil conditioner	**	***	***	***	***
4	D.5	Fuel	***	**	***	***	*

Figure 39: Final filtered use/disposal list for treated sludge

Product	Selected use/disposal method
Treated sludge	Land application of compost or other soil conditioner
Effluent	Water disposal/ Groundwater recharge
Pre-treatment products	Deep row entrenchment

Figure 40: Example list of selected use/disposal methods for various treatment products

7.7 Sanitation System

Finally, the *Sanitation System* sheet summarises all selections made on the previous sheets. The layout of this sheet is based on the sanitation system templates from EAWAG's *Compendium of Sanitation Systems*. The sheet is auto populated with the inputs and outputs from each step in the FSM value chain and the selected technologies. Reviewing this sheet can provide the user with an idea of whether they have considered every output produced at each stage.

7.8 Including user preference

The tool has not explicitly considered user preference in the rating criteria, as this is expected to vary from one project to the next. Instead, the tool can be used to create short-lists of different options along the sanitation value chain, which can then be evaluated with users. It is suggested that the users generate short-lists based on project goals and constraints and then initiate a process of community consultation to select the most appropriate solution. This can be done with individual lists of technologies under, for example, user interface, or by producing multiple final sanitation system outputs that are evaluated with users.

7.9 How to use the SaniSelect output

After using the *SaniSelect* tool to filter and assess various options along the sanitation value chain, the user has a diagram depicting a full sanitation solution from user interface to ultimate use or disposal of products. This product provides a starting point for competent personnel to select specific technologies and suppliers, develop detailed designs, and ultimately implement several projects that will address each part of the value chain. Detailed design of treatment systems should be done by qualified individuals, based on the selected approach and the desired end-use or disposal (e.g. if fuel products are desired, the treatment system will be designed to achieve this).

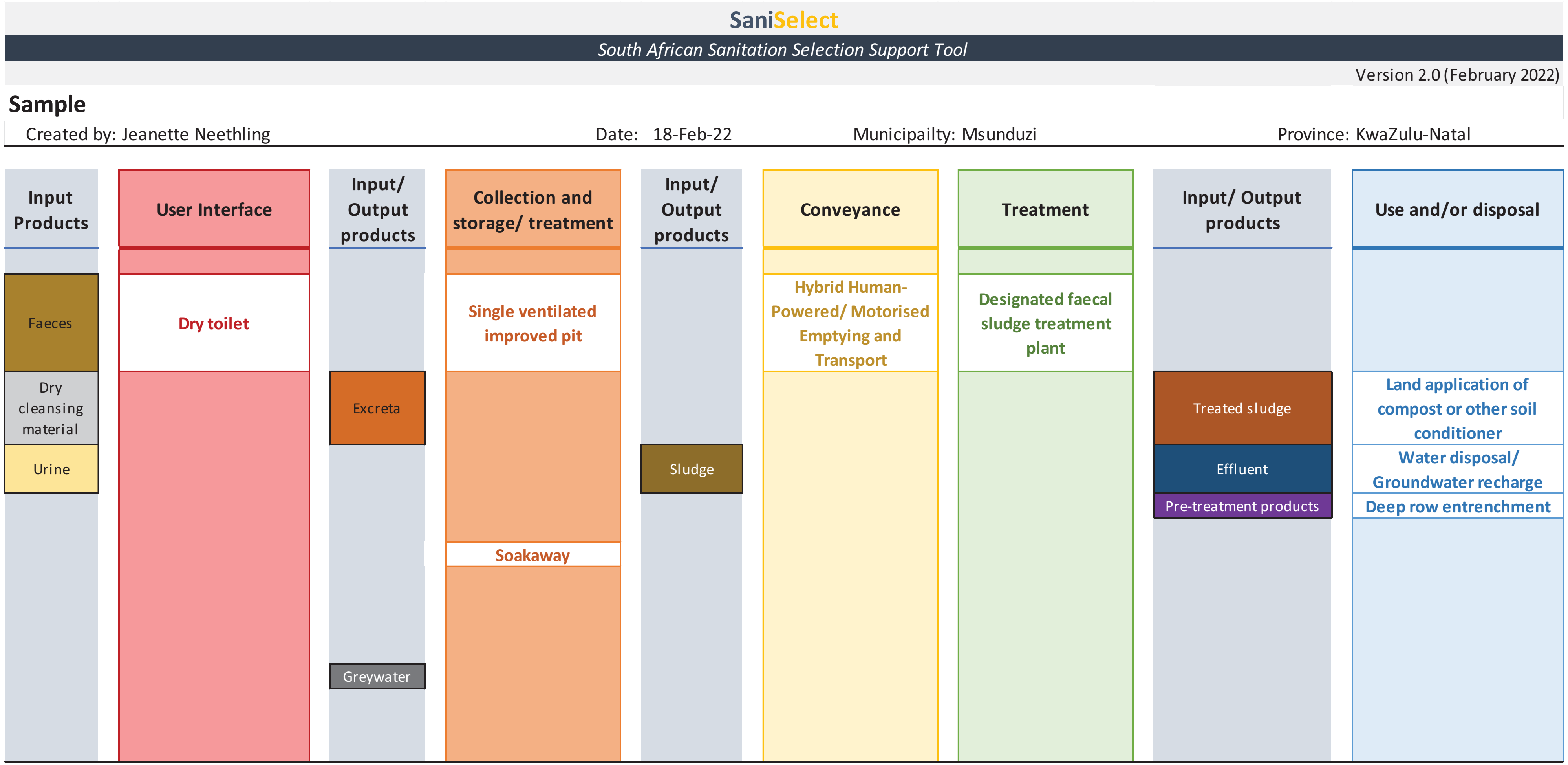
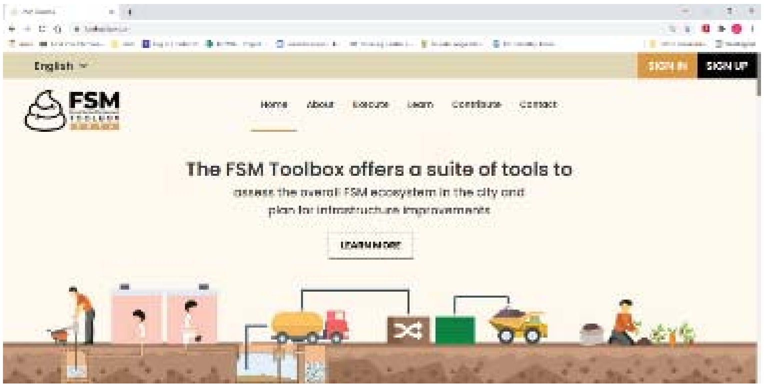


Figure 41: Sanitation system summary sheet

8 Other tools for planning, designing, and managing sanitation projects

8.1 FSM Toolbox

The FSM Toolbox is a web-based platform that includes several tools and resources designed to assist and guide those interested in undertaking assessments and planning faecal sludge management infrastructure improvements. The tools are grouped into two categories: Assess and Plan. The Assess module includes three tools, namely the AIT Situational Assessment Tool, World Bank CSDA toolkit, and the Shit Flow Diagram (SFD) graphic generator. SFDs have started to be generated in South Africa to begin assisting municipalities in understanding their faecal sludge management systems. The Plan module includes tools to assist with the following: infrastructure planning, stakeholder engagement, and business models. The toolbox can be accessed at this link: https://www.fsmtoolbox.com/.



8.2 Smart sanitation economy

The smart sanitation economy refers to the digitization of sanitation technologies, which will involve the collection of data from sanitation systems with the goal of improving and maintaining sanitation systems efficiently. Using technology to collect data can enable service providers to optimize their offerings and to detect maintenance needs in the system. It can also lead to advances in disease surveillance by public health officials.

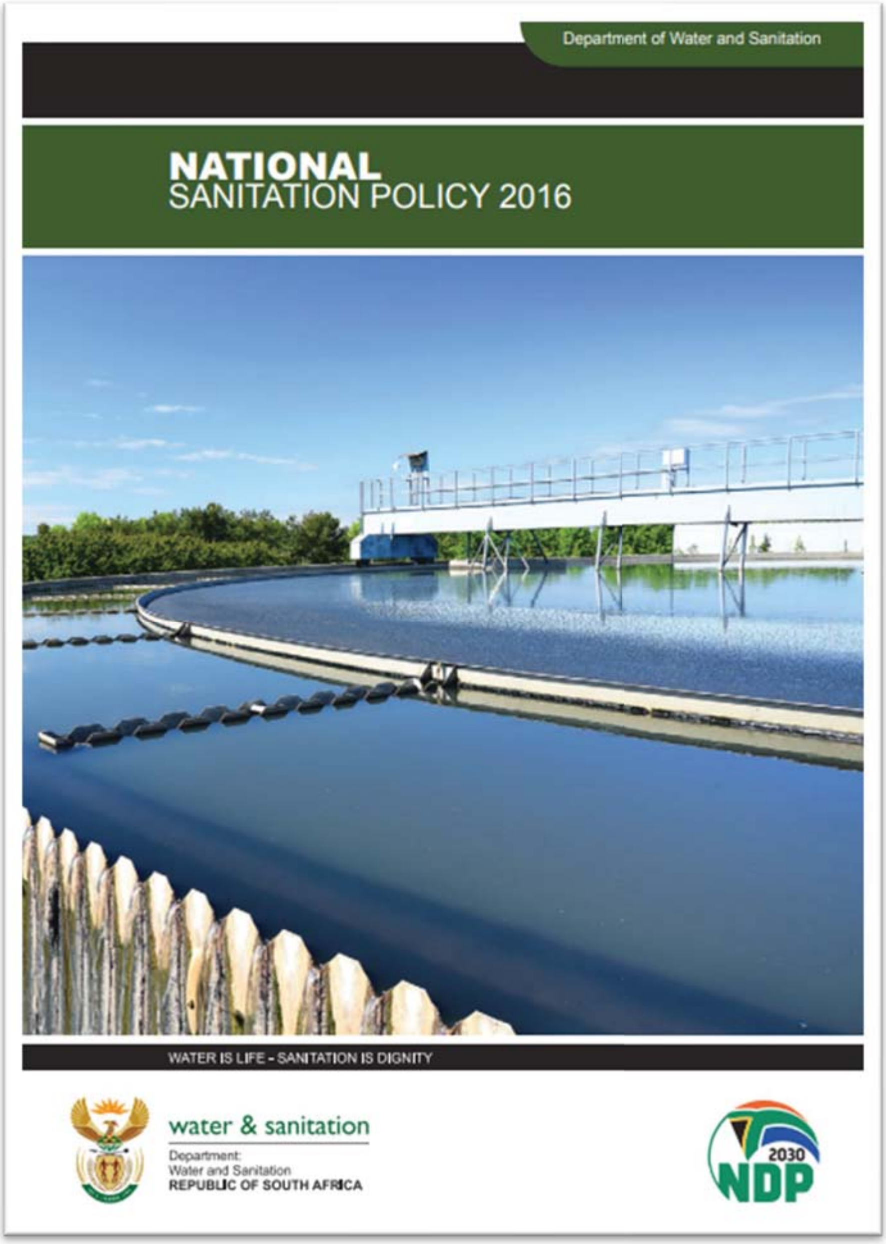
The smart sanitation economy is still relatively unexplored, but there are many potential applications that have been identified, using mobile applications, GIS tracking, and sensors. Some examples have been described by Frost & Sullivan (2020) and are summarized below:

- **Mobile phone** use is constantly growing in South Africa. It was estimated in 2020 that between 20 and 22 million people in South Africa were using smart phones. Beyond that, more than 90 million mobile connections existed, which accounts for the large number of feature phones in use (O'Dea, 2020). https://www.statista.com/statistics/488376/forecast-of-smartphone-users-in-south-africa/ Mobile phones and applications can enable a connection between service providers (private or government) with hard-to-reach customers. An example of this is the Pay-As-You-Go model used in the energy sector. Mobile phone technology can be used as a method for payment of services along with a simple communication tool to keep service providers and customers in touch.
- **GIS tracking** also has application in the smart sanitation economy by optimising faecal sludge management activities, such as emptying and transport.

- **Smart toilet sensors** aim to optimise management of the sanitation value chain by allowing technologies along the chain to be monitored, managed, and controlled remotely. This reduces the need for human intervention and expensive trips to site, which is key if citywide sanitation systems become more decentralised. Where service providers lack capacity to send operators to hundreds of treatment facilities, sensors and remote monitoring can provide continuous updates to those managing them.
- **Health data** can be collected by analysing human waste, again using sensors. This health data can help doctors and public health officials monitor disease outbreaks.

The report titled *The Digitisation of Sanitation* by Toilet Board Coalition (2016) provides further information about the outlook of the Smart Sanitation Economy.

CHAPTER 4: WRITING A SANITATION POLICY



This chapter is intended to support water and sanitation officials in municipalities in writing a sanitation policy that will guide their pursuit of universal and sustainable access to sanitation. and

Specifically, this chapter:

* **Presents the national policy framework** for sanitation as a basis for setting local policies
* **Makes the case for municipalities** writing their own sanitation policies
* **Lays out key aspects that a policy should cover**

1 South Africa's policy framework for sanitation

Tissington (2011) analysed the Legislative and Policy framework for basic sanitation in South Africa, highlighting the following key documents: the White Paper on Water Supply and Sanitation Policy (1994); the Constitution (1996); the National Sanitation Policy (1996); the Water Services Act (1997); the Housing Act (1997); the Upgrading of Informal Settlements Programme (UISP) and the Emergency Housing Programme (EHP); the Municipal Systems Act (2000); the White Paper on Basic Household Sanitation (2001); the Strategic Framework for Water Services (2003); the National Sanitation Strategy (2005); and the Free Basic Sanitation Implementation Strategy (2009). Since this policy framework was established, the South African National Sanitation Policy (2016) was published to address the changing landscape around sanitation and key hurdles that had come up in the previous 20 years of sanitation implementation. The National Sanitation Policy supersedes all other policy positions and has expanded discourse around sanitation beyond the basic means to address backlogs, in support of a wider range of appropriate sanitation solutions.

Though the 2016 National Sanitation Policy establishes a shift in the national discourse around sanitation, the previous policies mentioned above have defined what sanitation looks like currently in the country. For this reason, the definitions and policy positions of previous documents is presented in brief below. The 2016 Policy sets the stage for the current and future approach to sanitation, which will encourage a wider range of solutions to address the many nuanced challenges faced across the country.

While the Constitution speaks broadly about human rights, the White Paper (1994) specifically defines adequate sanitation as follows:

> *The immediate priority is to provide sanitation services to all which meet basic health and functional requirements including the protection of the quality of both surface and underground water. Higher levels of service will only be achievable if incomes in poor communities rise substantially. Conventional waterborne sanitation is in most cases not a realistic, viable and achievable minimum service standard in the short term due to its cost. The Ventilated Improved Pit toilet (VIP), if constructed to agreed standards and maintained properly, provides an appropriate and adequate basic level of sanitation service.*
>
> *Adequate basic provision is therefore defined as one well-constructed VIP toilet (in various forms, to agreed standards) per household.* (DWAF, 1994)

The above definition sets the stage for the binary paradigm that has been widely observed across South Africa: flushing systems connected to full sewerage networks being the norm in urban areas and dry, on-site systems being the norm in rural and peri-urban areas. The White Paper defines VIP toilets as the *minimum* level of sanitation service and alludes to conventional waterborne sanitation as the goal in the long-term. However, it does not explicitly state that sanitation technologies located somewhere on the spectrum between VIP toilets and full waterborne sanitation are unacceptable.

The 2016 National Sanitation Policy acknowledges this dichotomy and addresses it by highlighting the DWS position on "Appropriate Sanitation Technologies":

> *Currently, selection of sanitation technologies for an area is largely based on the guidelines for the levels of services in the country, with flush systems being the norm in formal settlements and dry, on-site system being provided in the rural areas of the country. However, experience has shown that these selections of technologies are often not the most appropriate for the area in which they are currently provided. The policy needs to address the issue of appropriate technology and change the preconceived notion of sanitation from either waterborne in urban and dry systems in rural areas to one where the most appropriate technology is provided to an area. Technology choice needs to be based on resource availability within a settlement area.* (DWS, 2016)

The Policy further states that the *definition* of sanitation does not define the *technology* to be used in providing the service. According to the Policy, a "basic sanitation facility" is defined as: "The infrastructure which considers natural (water; land; topography) resource protection, is safe (including for children), reliable, private, socially acceptable, skills and capacity available locally for operation and maintenance, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases by facilitating the appropriate control of disease carrying flies and pests, facilitates hand washing and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner." (DWS, 2016) The policy also highlights the need to select sanitation solutions that minimise consumption of limited water resources and recognise the value of sanitation by-products. As quoted in the introduction to the Policy:

> *We must introduce new technologies that appreciate that water is a scarce resource and as such provide solutions to dispose of effluent via alternative methods. It's not all about flushing… We must begin by challenging the property development sector through regulation and licensing requirements to invest itself in developing properties less reliant on water for sanitation in order to ensure we introduce the alternative solutions to low, middle- and high-income areas.* – The Minister of Water and Sanitation, Ms. Nomvula Mokonyane, National Sanitation Indaba (DWS, 2015, as cited by DWS (2016))

The National Sanitation Policy for South Africa (2016) broadens the range of technologies available for sanitation provision by focusing on *characteristics* of suitable sanitation systems as opposed to *specific technology options* (e.g. flush toilets and VIP toilets). The acceptable basic level of sanitation, as defined by the Policy, is:

1 appropriate health and hygiene awareness and behaviour
2 the **lowest cost, appropriate** system for disposing of human excreta, household wastewater, **grey-water**, which **considers resource constraints,** is **acceptable and affordable to the users**,

safe including for children, **hygienic** and easily accessible and which does not have a detrimental impact on the environment;

3 a **toilet** and **hand washing** facility;

4 enhances a **clean living environment** at the household and community level; and

5 the consideration of defecation practices of **small children** and **people with disabilities** and special needs.

The Policy further states a position on research and innovation for sanitation services, in an attempt to support more solutions for the unique situations in South Africa's many settlements. Generally, research and innovation is supported by the policy, with a focus on minimizing resource use through reduction, reuse, recycling, and reclamation. Furthermore, the DWS has a policy position around the development of skills and capacity to conduct research and innovation so that research and innovation of appropriate technologies can be strengthened. (DWS, 2016) However, the policy does not provide further detail on other requirements that may be required to move research and innovation to implementation (e.g. changes in procurement policies).

The Free Basic Sanitation Implementation Strategy provides guidance for decision-making around sanitation technologies by defining the following considerations: community acceptance of the service level and willingness to pay the associated tariff; viability for the WSA and WSP; environmental impact; and technical feasibility (DWAF, 2008).

The above summary highlights the fact that numerous South African Policy documents provide criteria for meeting the minimum sanitation services. While some documents in the past have specifically mentioned VIP toilets and waterborne sanitation as the two main options, there are numerous other options which meet the criteria identified, and the South African sanitation sector, particularly through the National Sanitation Policy (2016) has expressed support for innovative solutions.

2 Why write a sanitation policy?

According to the National Sanitation Policy (2016), Water Services Authorities (WSAs) are responsible for preparing sanitation plans and ensuring the realisation of the right to adequate sanitation. The Policy describes specific criteria that should be considered when WSAs are providing basic sanitation, thus placing the burden of technology selection, design, and planning on the WSA. The Water Services Provider (WSP) is responsible for providing water services, including sanitation services. The WSP service is usually provided by the WSA's own staff but in some instances aspects of water and sanitation services are contracted out by the WSA. Water Services Development Plans (WSDPs) lay out a municipality's plan for tackling water and sanitation issues, including addressing backlogs in basic sanitation. In most cases, these plans identify the minimum level of service as a Ventilated Improved Pit latrine (VIP) and higher levels as full waterborne sanitation, in line with South Africa policies. In addition to WSDPs, municipalities are led by their water service by-laws and water and sanitation policies.

A sanitation policy can set a common vision and value for sanitation that will stand firm in the municipality through elections, personnel changes, and any other changes that may come. It also provides the municipality a set document to periodically review to ensure that sanitation is being provided to a level and standard that they want.

While the National Sanitation Policy defines the minimum requirements for sanitation in the country, it does not define specific technologies, as discussed above. As each municipality exists in its own unique context in terms of geography, politics, and socioeconomics, among others, the decisions around specific technology options are made by municipalities. The appropriate options can be included in a sanitation policy for each municipality that recognizes their own context and the constantly growing options for sanitation provision. A sanitation policy also provides an opportunities for municipalities to define how they will tackle broader faecal sludge management aspects, such as emptying of on-site sanitation systems.

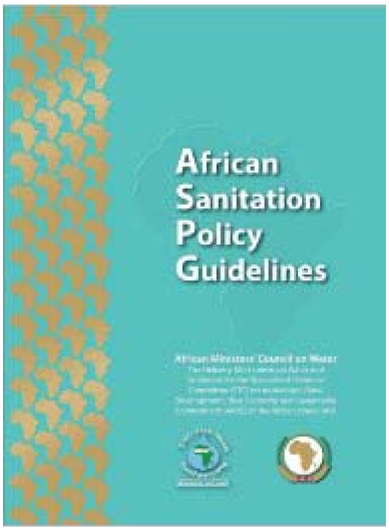
Why write a sanitation policy?

1. To **define appropriate sanitation options** and service levels for your specific context
2. To elaborate on your **key aims** as a municipality when providing sanitation
3. To set **minimum requirements for maintenance** of on-site sanitation systems
4. To create a **living document** that can adapt regularly to the changing sanitation landscape and can be used to measure your progress

CHECK OUT THIS TOOL:

In addition to this document and examples from other South African municipalities, you can consult the *African Sanitation Policy Guidelines*, which was published by the African Ministers' Council on Water (AMCOW) in 2021. The *Guidelines* provide background information, advice on process design, and suggested contents for a sanitation policy. This includes sample policy statements, which may assist in drafting a progressive, inclusive, and forward-thinking sanitation policy.

Click the icon to the right to view it.



3 What should a sanitation policy cover?

Sanitation policies can be structured similarly to other policies drafted by the municipality. Some of the key aspects that should be covered by the sanitation policy are discussed below, with examples from eThekwini's 2021 Sanitation Policy and the City of Cape Town's 2021 Draft Water and Sanitation Policy. In addition, the 2021 eThekwini Sanitation Policy can be found in Annexure B. The two policies referred to here are written differently, with the eThekwini policy consisting largely of numbered lists and the Cape Town policy taking a more narrative approach. eThekwini chose to split their water and sanitation policies into two, while the City of Cape Town has created a single policy for both. You will know the best way to organise your sanitation policy to ensure that it is read and implemented. The *African Sanitation Policy Guidelines* described above provide information on different approaches to drafting and implementing a sanitation policy.

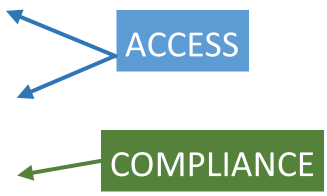
The way the policy is written does not matter as much as its content and implementation. To better support South African municipalities, the Department of Water and Sanitation, in cooperation with SALGA, should create a sanitation policy template.

> **Municipal bylaws** are effective tools for enforcing the principles and positions set out in a municipal policy. Municipal bylaws on sanitation provision should fit within the national, provincial, and municipal policy and can be used to encourage responsible and appropriate sanitation provision. This might include, inter alia: stating discharge limits in line with the National Water Act, defining appropriate sanitation technology options, or setting maximum flush volumes. Bylaws can be used by the municipality to ensure individuals, businesses, and institutions implement sanitation systems that reflect the municipality's sanitation aims.

3.1 Purpose and vision

The purpose of establishing a sanitation policy is generally to ensure **access** to acceptable sanitation systems for the entire population and to ensure **compliance** with various bylaws and policies in place to protect public health and the environment. A sanitation policy generally applies to all sanitation services provided throughout the municipality, including onsite and sewered systems. The 2021 eThekwini sanitation policy states its purpose as follows:

1. *To ensure that all residents of eThekwini have access to an acceptable sanitation system.*
2. *To ensure that indigent households receive a free basic sanitation service.*
3. *To ensure that property owners comply with legislation and by-laws governing disposal of sewage.*



To take it one step further, the sanitation policy can establish a **vision** for sanitation provision in the municipality. A vision statement sets the policy in the broader context of service provision and sets a long-term goal. In the City of Cape Town's 2021 Draft Water and Sanitation Policy, the vision statement is stated as follows(City of Cape Town, 2021):

> *In serving the City's water strategy, the desired vision of this Policy is for Cape Town to be a water sensitive city, by 2040, that optimizes and integrates the management of water resources to improve resilience, competitiveness, and liveability for the prosperity of its people.*

In the above statement, the policy is set within the broader context of the City of Cape Town's vision to become water sensitive by 2040, setting a specific vision and timeframe for that vision. The statement further establishes resilience, competitiveness, and liveability as defining features of the City of Cape Town's vision for water and sanitation.

3.2 Problem statement

The problem statement should clearly define what challenges the policy aims to address and what gaps it aims to fill. The problem statement will be unique to a given context. As an example, the 2021 eThekwini Sanitation Policy addresses the following problems (eThekwini Municipality, 2021):

1. **Limited access to sanitation:** "Not all households in the Municipality receive sanitation."
2. **Insufficient revenue:** "There is insufficient revenue to provide sanitation to provide an effective sanitation service to all residents."
3. **Poor compliance**: "Many property owners do not comply with legislation and by-laws governing disposal of sewage."
4. **Environmental impacts**: "The environment is negatively affected by the impact of inadequate sanitation."
5. **Low revenue collection**: "Many households liable to pay for water and sanitation are not paying."

Other challenges that a sanitation policy may seek to address include but are not limited to:

- Water scarcity
- Low user acceptance of the current sanitation offerings
- Need for ongoing maintenance of sanitation systems

3.3 Legislative and policy framework

The legislative and policy framework sets the context within which the policy must be read. The framework should present relevant national, provincial, and municipal documents that will govern and guide the policy. The 2021 eThekwini Sanitation Policy lists the following as key to the legislative and policy framework (eThekwini Municipality, 2021):

1. Constitution of the Republic of South Africa
2. Local Government: Municipal Structures Act (Act 117 of 1998)
3. Local Government: Municipal Systems Act (Act 32 of 2000)
4. Local Government: Municipal Finance Management Act (Act 56 of 2003)
5. Water Services Act (Act 208 of 1997)
6. National Water Act (Act 36 of 1998)
7. Water Services Provider Contract Regulations, Gazette No. 7414, Vol. 445 No. 23636 of 2002
8. The National Sanitation Policy 2016
9. eThekwini Sewage Disposal Bylaws
10. National Building Regulations and Building Standards Act (Act 103 of 1977)

3.4 Definitions and acronyms

A section dedicated to definitions and acronyms aims to set a common language for talking about sanitation, both in the policy document and within the municipality. Establishing a common language and understanding will ensure that municipal officials familiar with the policy are speaking to each other and not over each other. This can help avoid inconsistencies in service provision due to differing understandings of specific terms. The list of definitions and acronyms from eThekwini's Sanitation Policy can be found in the Annexure to this document. In addition, the list of definitions from the ***Selecting Sanitation Systems*** document produced as part of this project may be helpful in drafting a list of definitions for your sanitation policy.

3.5 Policy rules and procedures

Policy rules and directives establish basic minimums to achieve access and compliance effectively. Some guidance for what policy rules in a sanitation police should cover is provided below:

1. **Define minimum levels of service:** This includes describing the different service scenarios and defining what technologies are acceptable. For example, eThekwini establishes three levels of service, namely: conventional sewerage, rated properties; onsite sewage disposal – rated properties; and free basic sanitation. eThekwini's Sanitation Policy includes the following policy rule in Section 6.4 (d), which defines the acceptable technology for free basic sanitation:

   > *Where single households have no access to waterborne sanitation and are not serviced by a Community Ablution Block (CAB), the Municipality must provide a urine diversion (UD) toilet. UD toilets must: i. Separate urine from faeces. ii. Dispose of the urine in a safe and environmentally acceptable manner, either for reuse or into the ground. iii. Store the faeces in a pit for later collection and disposal.*

   The above is prescriptive to ensure that lower levels of sanitation provision are not provided to households. However, there is no allowance for alternatives that may be applicable in different contexts or more widely accepted by users (e.g. pour flush toilets). This decision was likely taken due to a limited number of alternatives demonstrated throughout the municipality. To ensure that the above statement does not become so limiting as to restrict innovation, the following are important in the roll-out of sanitation:

   - Demonstration projects for alternative sanitation technologies (e.g. the eThekwini Alternative Sanitation Contract that is currently being implemented).
   - Regular review of the policy to ensure that newly proven technologies can be incorporated.

   Along with defining the permitted **technologies**, a sanitation policy should establish **servicing requirements** for those technologies. For example, in Section 7 of the eThekwini Sanitation

Policy, they define that sludge from UD toilets is to be removed and disposed of *every two years* and sludge from VIP toilets is to be removed and disposed of *every five years.* In doing so, eThekwini acknowledges the ongoing maintenance required to ensure continued provision of sanitation.

2. **Define processes for technology selection**: If more than one option is available, define a process for selecting the most appropriate solution for a given setting. In the example from eThekwini above, should additional options become available for households receiving free basic services, the policy would need to set criteria for selecting one alternative over another (e.g. "In areas with high water table (within 1.5 metres of surface), UD toilets should be used. In areas with at least a yard tap on each site, low flush toilets can be used").

3. **Establish priorities for achieving sanitation provision**: For example, the City of Cape Town's Draft policy stated as one policy position: "The intermediate and higher levels of service wherever practical, affordable, and sustainable shall be implemented without compromising the national priority of universal access to at least a basic level of service." This statement establishes that the City's main priority is provision of basic services, but they are also motivated to pursue higher levels of service where practical.

4. **Define the municipality's stance on innovation and research**: The municipality may have a separate policy on innovation and research, but the sanitation policy provides a good opportunity for reiterating or establishing it in relation to sanitation innovation. Since sanitation systems are important for protection of public and environmental health, it can be helpful to establish a policy position on innovation and research. The City of Cape Town's Draft Water and Sanitation Policy establishes policy positions on research and innovation in Section 7.13. In summary, the following policy positions are defined (City of Cape Town, 2021):

    a. High quality research will be supported by the municipality
    b. Research done by the City's Water and Sanitation department will be internally coordinated and added to a database
    c. Research studies can be done with research institutions and will be managed in accordance with City policies and agreements
    d. The City will not do research or product testing on behalf of a product supplier
    e. Information and proof of performance required by the City are to be provided by the supplier at their own cost
    f. The City can conduct further in-house testing if required to clarify or confirm information
    g. If the product satisfies minimum requirements, the City may consider the product for future use, subject to standard procurement processes
    h. Existing City Policies and Procedures must be followed

    The above positions establish an openness to innovation within the City of Cape Town while also clearly defining the City's role in research and testing. The City's role must be clearly stated to avoid favouritism down the line. Furthermore, the above positions establish a general path for new technologies to move from testing into implementation, though the finer details of what is required at each step are not fully defined.

The above policy rules and procedures should be further defined through municipal bylaws (e.g. Sewage Disposal Bylaw by eThekwini, Annexure C). Whereas a sanitation policy may state, "the homeowner must apply for permission to install a low volume sewage treatment plant," the bylaws will establish the specific process for the application. Bylaws are effective mechanisms for regulating individuals, businesses, and institutions that implement sanitation systems throughout the municipality.

3.6 Roles of stakeholders

Policy procedures define the different actors involved in sanitation provision and their different roles. eThekwini and the City of Cape Town address this differently in their policies. In Section 7, "Policy Procedures", eThekwini defines the processes for provision of the different levels of service and in doing so defines the responsibilities of different stakeholders(eThekwini Municipality, 2021). The City of Cape Town presents a chapter about role players, which describes the role of each stakeholder in the provision of sanitation.

3.7 Policy monitoring and review

Finally, a sanitation policy must establish a protocol for monitoring the implementation of the policy and the periodic review of the policy. This is vital, because without monitoring, lessons will not be learned and the policy will not be revised when necessary. This section must establish who has a responsibility for monitoring the implementation and how the findings should be reported. Ideally, **sanitation policies should be reviewed annually to ensure that they remain current.** This will require prioritisation of the review process and allocation of time and personnel.

What should a sanitation policy cover?

1. **Purpose** of the policy and **vision** for sanitation in the municipality
2. **Problem statement**, highlighting the context of the municipality
3. **Legislative and policy framework**, including national, provincial, and municipal policies, bylaws, and guidelines
4. **Definitions and acronyms**
5. **Policy rules and procedures** to define minimum levels of service and specifics about how those levels will be achieved. This is also a good opportunity to establish the municipality's stance on research and innovation in sanitation.
6. **Roles of stakeholders** in provision of sanitation
7. Position on policy **monitoring**, which should be ongoing, and **review**, which should happen at least annually

4 Suggestions for working with consultants

Many municipalities require assistance from outside consultants due to a lack of capacity. Consultants may be called upon to assist with drafting sanitation policies or implementing policies through sanitation projects. If a consultant is appointed, they may fulfil various roles, such as:

1. Selecting sanitation technologies for onsite or sewered applications
2. Designing sanitation systems
3. Drafting tender specifications and evaluating submissions
4. Supervising construction

To ensure that sanitation solutions are cost-effective and appropriate, it is important that consultants with sufficient sanitation expertise are appointed and that their work is monitored and interrogated by municipal officials throughout the entire process. The following guidance will help ensure that consultant relationships are beneficial:

1. **Selecting a consultant:** South Africa has many engineering consultants, but for sanitation projects, it is important to appoint consultants with sufficient understanding of how sanitation systems work. Look for consultants with the following minimum qualifications or similar:
    a. Set a minimum number of years' experience working on **sanitation** projects specifically. Specify onsite or sewered sanitation depending on the specific project.
    b. When asking for project experience, specifically request information about sanitation projects carried out, with a minimum number of projects required. Experience with consulting on other engineering projects is still valuable, but the consultant should have a demonstrated track record with sanitation projects.
    c. Consider asking about the consultant's experiences with alternative sanitation solutions, especially if you are looking for innovative systems. This may be reflected in their involvement in research, development, and piloting innovative sanitation systems. Even if they have not done any work on innovative sanitation projects, you can ask for a brief write-up about their understanding of appropriate sanitation solutions for a specific context. This can help you interrogate whether they are keeping up with the latest advancements in sanitation.
    d. When evaluating engineering qualifications, while civil engineers may seem like the obvious target, remember that much of sanitation is defined by processes related to chemical engineering, microbiology, and chemistry. Consider looking for a multi-disciplinary team so that your solutions are not all biased towards civil-intensive approaches.

2. **Monitoring the consultant:** The consultant's work should be checked by someone in the municipality with the technical capacity to interrogate the decisions made. This will require the following:
    a. Establishing technical capacity at the municipality. You can use the *Selecting Sanitation Systems* document as a starting point for understanding how different

solutions work and what should inform the decision-making process. The individual(s) tasked with monitoring the consultant's work do not necessarily need design expertise, but they must understand how and why certain systems work.

b. Establishing a monitoring protocol. Municipalities should establish key points during a project at which the consultant's work will be interrogated. Municipal personnel should be involved throughout the process, from technology selection through to selection of a contractor.

3. **Writing a sanitation policy**: A sanitation policy provides everyone with a framework to select and design appropriate sanitation systems, including consultants. It ensures that even with personnel changes at all levels, there is vision to refer to. The sanitation policy can also define the specific roles and responsibilities of consultants, particularly if consultants have a large role in sanitation system selection and roll-out. Emphasis should be placed in the sanitation policy on where the municipality has the final say, highlighting elements of consultants' work that must be interrogated and approved before proceeding.

CHAPTER 5: PROCUREMENT PROCESSES FOR ALTERNATIVE SANITATION SYSTEMS

This chapter is intended to support water and sanitation officials in municipalities procuring alternative sanitation technologies while upholding the constitutional principles of fairness, equity, transparency, competitiveness, and cost-effectiveness. Specifically, this chapter presents:

- **A summary of key issues** identified in the research findings
- **Example templates** for future tender documents for sanitation systems

1 How procurement processes and technology *selection* are linked

Procurement processes can be linked to the technology selection process in two ways, with the selection of a specific sanitation solution technology suitable for the implementation context occurring either **before or after** a tender/quotation process is carried out:

1) A municipality might review available technology options in detail, potentially using the technology selection tools outlined elsewhere in this study, select a suitable solution(s) and then issue a tender for one or two specific technology options. In this instance the tender specifications would clearly be technology-specific, and the procurement process would need to be appropriate to receiving tenders from a narrow pool of candidates.
2) Alternatively, the tender/quotation process itself could be used as part of the technology selection process, with a broad set of requirements for the sanitation solution stated in the tender specifications. The tender responses would provide a shortlist of sanitation technologies to be considered further.

These two approaches clearly require somewhat different approaches and procurement documentation to be used, and they create different opportunities and barriers in the selection and adoption of innovative non-sewered sanitation technologies. Regardless of which approach is used, they both require sufficient technical capacity to assess the appropriateness of technologies. This expertise may be available in-house, or it may require the input of expert consultants.

2 How procurement processes and technology *adoption* are linked

Once a technology selection process has been implemented successfully, and the technology solution(s) appropriate to the implementation context have been identified, procurement policies and processes may either support or hinder the adoption of that desired technology by a municipality. A frequently cited example is the difficulty faced with the piloting of a technology from a single supplier and the transition to then procuring that specific technology for wider roll-out. While there is provision for procurement from a “sole supplier”, municipal representatives consulted in this project were extremely reticent to pursue this option, as it is very difficult to prove that a single supplier provides a solution that cannot be procured elsewhere. While specific suppliers may fabricate specific treatment systems, there are likely to be many options available that could achieve the same objectives. These issues are also explored in this chapter.

3 Sources of information

The following sources of information were used in the compilation of this chapter:

- Previous tender documents
- Interviews with those issuing tenders (e.g. municipalities) and those submitting bids (e.g. technology suppliers)

The findings from this exercise were presented in detail in Chapter 2, Section 5 of this *Guide for the Selection of Appropriate Sanitation Systems*.

4 Structure of this chapter

This chapter is divided into three main sections:

1) Summary of key issues faced, which summarises the aspects detailed in the two sections that follow
2) General aspects of the municipal procurement environment that impact on the selection and adoption of innovative sanitation technologies
3) Issues specific to municipal tenders issued for the procurement of innovative sanitation technologies

5 Summary of the key issues faced

The obstacles to the introduction of innovative technology are partly related to the making of informed choices (technology selection), and then to giving effect to those choices (technology procurement). These key issues are presented below.

5.1 Selection of sanitation systems

a) Limited understanding about sanitation systems and how they are meant to function. This limited understanding can lead to a one-dimensional view of sanitation (e.g. as a toilet seat only), failure of municipal decision makers to evaluate new technologies that are presented to them, and a lack of understanding of the full sanitation value chain that must be considered.
b) Lack of knowledge about systems that are available among municipalities and consultants.
c) Lack of certification and testing of technologies. There is a further need for field testing and demonstration pilots of new technologies, as that will give decision makers more confidence.
d) Many municipalities are looking for a low or NO maintenance solution, but those solutions simply do not exist. It is thus crucial that maintenance requirements are specified early-on to help inform decision-makers and enable them to compare systems. They need sufficient knowledge to determine whether they want to invest more now or later in the life of the technology.
e) Many municipalities are stuck in the way things have always been done, either due to risk aversion, lack of knowledge, or lack of capacity and time. Changing this requires time and budget to be allocated towards upskilling and training of sanitation personnel.
f) There is limited capacity to consider various options and all relevant factors for each project. Thus, municipalities require support in simple yet effective methods to evaluate alternatives and select appropriate solutions.

5.2 Procurement of non-sewered sanitation systems

a) Specifications must be specific enough to ensure appropriate technologies but not too specific to limit those who can tender and favour a specific supplier.
b) Methods should be explored for receiving alternative offers or pursuing design and build contracts with sanitation experts.

c) Evaluation protocols that look at life cycle costs should be established so that O&M requirements are considered from the beginning, along with capital cost.
d) Methods for incorporating service contracts in supply contracts should be investigated.
e) Options should be explored for separating the sanitation system design and supply portion of the contract from the construction and civil works portion. This may ensure that sanitation systems are designed and implemented by individuals with understanding of how systems should work, though this arrangement does have its own challenges.
f) It is difficult to move from a successful pilot project to procurement due to the PFMA/MFMA requirements for tendering. The requirements ensure tendering processes are fair and competitive, but they can also lead to municipalities being unable to implement a system that they know works. This requires tender specifications to be written effectively and requirements to be added, such as a proven piloting track record and certification.
g) All the above require that those writing tender specifications have a deeper understanding of how sanitation systems work and what makes a certain system appropriate in a specific instance. This will enable them to write specifications that cover all their requirements and encourage innovation.

6 Aspects of the municipal procurement environment that affect the selection and adoption of innovative non-sewered sanitation systems

This section summarises key issues that affect the selection and adoption of innovative non-sewered sanitation systems by municipalities, which relate specifically to the procurement environment in which South African municipalities operate. Supporting examples from case studies are given – the full case studies can be found in **CHAPTER 2: *Understanding the barriers and enabling factors to uptake of alternative sanitation systems*.**

6.1 Lack of awareness of technology options and/or lack of sufficient experience to make an informed selection between options

There is a lack of broad experience in the implementation of non-sewered sanitation (NSS), both within municipalities and within the engineering consulting firms that are frequently appointed by municipalities to assist with the selection and design of new or replacement sanitation systems. Added to this, the non-sewered sanitation landscape is changing quickly, and unless NSS is the focus of someone's job, they are unlikely to be aware of the current status and detailed design aspects of all the technology options that might be suitable for their context of application. Without understanding the nuances of different technologies, it is impossible to make an informed selection between them.

Case study examples:

a) Technology supplier B cited examples of municipalities where a particular sanitation solution has worked well in one location, and on that basis has been rolled out to the rest of the municipality, with no thought given to its suitability for different use contexts.
b) Chris Hani District Municipality (CHDM): Pour flush toilets have been implemented in CHDM, but the vast majority are single pit. A twin pit system results in less frequent and safer emptying of pits, and thus normally lower lifecycle costs than a single pit system. It was not clear whether the design implications on lifecycle costs were understood or considered, or whether they had been, but the lower capital cost of the single pit system swayed the decision.
c) Technology supplier C noted the lack of deep knowledge and experience with non-conventional sanitation systems within the engineering consulting firms appointed by smaller municipalities to assist with their sanitation system selection and design, and the impact that previous negative experiences with particular package plants has had on their overall perception of all package plants and non-sewered sanitation systems.

Recommended actions:

1. Increase knowledge and awareness of non-sewered sanitation systems: **CHAPTER 3: *Selecting Sanitation Systems*** aims to establish a common language around sanitation systems, along with a technology selection tool, *SaniSelect,* which can give decision-makers some understanding of how different technologies might perform based on different criteria.
2. Write policies in a way that recognizes differences from one project location to another: Many municipalities do not have their own policies around sanitation and have thus not spent much time thinking about the options that are available, rather drawing on previous projects. Where policies are in place, they are sometimes written in such a way that the sanitation binary paradigm is perpetuated (i.e. one solution for one broad scenario and one solution for another broad scenario). Policies can be written in a way that establishes a minimum standard but also encourages innovation and alternative approaches. A basic guide for municipalities is provided in **CHAPTER 4: *Writing a Sanitation Policy*** to guide municipalities in crafting a sanitation policy, including examples from other municipalities.
3. Increase benchmarking between municipalities, so that experiences with sanitation alternatives can be shared and built upon.
4. Require that the outputs from tools, such as *SaniSelect*, are presented as a prerequisite for funding approval from Department of Treasury.

6.2 Perceptions around package plants and other non-sewered sanitation options based on previous negative experiences

Most personnel working in the sanitation sector will have encountered at least one example of an on-site sanitation system not performing well, including package treatment plants. These failures may be due to a poor product or to the technology having been implemented in an inappropriate context and/or not operated or maintained in the correct way. Poor performance of one sanitation technology can hinder adoption across the spectrum of all similar options, and this links to the previous point around a lack of deep knowledge of alternative sanitation systems and where/how they should be applied. This emphasises the need for more reference cases where sanitation alternatives, such as non-sewered sanitation systems, are implemented successfully.

Case study example

a) Supplier C, a manufacturer of package plants, commented on the perceptions that exist around package plants, many of which are not generally true but are based on a previous negative experience.

Recommended actions:

1. Increase benchmarking between municipalities
2. Make outcomes of piloting and demonstration projects accessible to decision-makers. This should be done via a central database that covers different technologies and gives decision-makers access to results and evaluations of them. This databased should be 'owned' by an entity that allocates sufficient resources to keeping it maintained and publicising its existence.

6.3 The need for more successful reference cases for NSSS

When NSSS are implemented successfully, it generates positive awareness and increases the confidence in NSSS for others considering the implementation of such systems. Without successful examples of a particular NSSS in operation elsewhere it is very difficult for municipalities and other entities that roll out sanitation to justify the selection of that system. Pilots of new systems are extremely valuable, but can be difficult to implement, for a number of reasons:

1. Staff turnover at some municipalities is high, making it difficult to maintain support for innovation and secure the investment needed to run a pilot (comment from Supplier A).
2. Municipalities often do not have resources available to run a short-term pilot project which is outside of their routine operations.
3. Pilots of new NSSS have to come with a backup sanitation option, in case the new system fails, which increases the overall cost of running the pilot.

Demonstration programmes that are funded by external and neutral bodies, such as the South African Sanitation Technology Enterprise Platform (SASTEP), funded by the Water Research Commission (WRC), play a unique role in supporting piloting and demonstration of new technologies. These pilots benefit both decision-makers and technology developers, as the lessons generated can be applied to the future implementation of the system(s).

Case study examples

a) Supplier B commented that municipalities tend to adopt established sanitation solutions as they are lower risk and logistically easier to implement (expertise and processes already exist).
b) Supplier C, a manufacturer of package plants, emphasised the value of having numerous reference plants when trying to market their products. The company publishes a detailed, up-to-date list on their website.
c) Chris Hani District Municipality used the established VIP toilet implementation programme as an opportunity to try out another technology at the same time (pour flush toilets).

Recommended actions:

1. Support grant funding specifically for pilots of NSSS and involve research institutions, so that the establishment of pilots is not dependent on municipal funding and personnel.
2. The establishment of 'testbeds' or testing platforms for NSSS has been a successful approach to piloting NSSS (e.g. the Engineering Field Testing Platform in eThekwini, run in partnership between the university, municipality and an engineering consulting firm) as it creates and retains the necessary infrastructure and expertise to test systems quickly and at a lower cost than standalone testing. Explore the establishment of testing platforms in other locations around the country, noting that partnership with municipalities is critical.
3. Municipalities can consider how pilots can be 'tagged on' to existing programmes, thus reducing the investment required in them.

6.4 Difficulties with transitioning from pilot to implementation

A successful pilot of a new sanitation system is extremely valuable, but is not a guarantee of a successful transition to full-scale implementation in a normal operational environment. In the best case, the pilot will have shown a specific technology to be an excellent option for a particular implementation context. Unlike 'standard' sanitation hardware such as toilet pedestals and pipework, a non-sewered sanitation system produced by one manufacturer varies substantially from the product produced by another in how it works, the performance if offers and the contexts it is suitable for. A successful pilot provides confidence only in the specific system that was piloted, but municipalities face significant challenges should they wish to procure that specific system for roll-out:

- Regulations around procurement from sole suppliers of products, designed to prevent corruption
- Non-sewered sanitation systems which require routine specialist technical support from the manufacturer and/or a supply of system-specific consumables, that can only be purchased from the manufacturer, are not an attractive option for municipalities, as they are wary of being locked into a dependency on one supplier who might not remain in existence, or alternatively who would have the power to increase prices without competition.

This is a difficult balance between ensuring fair procurement processes and implementing systems that have been shown to be fit for context and purpose.

Case study examples:

a) The City of Johannesburg is piloting several NSSS but expressed concerns about how they would eventually move from the pilot to larger scale implementation, specifically around how to ensure a fair procurement process that did not favour specific technologies. They cited a lack of an established process for getting new technologies into the supply chain.
b) In eThekwini municipality, a main contractor was appointed for the construction of a housing project, through a normal tender process. The contractor then sub-contracted the design and construction of the DEWATS sanitation system to a specific company with expertise in the particular system that was desired. This company had an existing relationship with the municipality, along with an official MoU to provide support to the municipality on DEWATS

implementation. Thus, they were an appropriate subcontractor to work with the construction contractor.

c) The representative from eThekwini municipality commented on the high level of will required to get an innovative system through the municipal supply chain process. There are multiple stages of approvals required and the process can be demoralising. The DEWATS system referenced above has taken several years to get to the point where it is being implemented in a full-scale housing project.
d) The City of Cape Town expressed concerns about the adoption of a particular container-based sanitation system, due to the dependency that it would create on one manufacturer for the supply of plastic film liners for the toilets and for the machine required to process the waste.
e) Supplier A is the sole manufacturer of various components of sanitation systems but sells to multiple clients, who in turn submit tenders for municipal contracts for delivery of sanitation systems. This opens the tender process up to many different construction companies. Municipal tenders can specify specific products but must include “or similar approved” in the specification, to ensure that other available appropriate products are not excluded.

Recommended actions:

1. More pilots of alternative sanitation systems so that municipalities have several options of sanitation systems that they have confidence will work in their implementation context. A minimum number of reference cases in relevant implementation contexts can then be made a pre-condition of tenders.
2. Explore licensing of a specific technology design to multiple manufacturers.
3. Where there is only a single manufacturer of a technology, explore making it possible for multiple suppliers to purchase it and offer it as a product offering to municipalities, alongside any specialist technical support and consumables that are required. This could be a franchise model or similar.

6.5 Guidance documents that are biased for or against specific technology options, regardless of context

The sanitation landscape has changed rapidly in the last ten years, and many existing guidance documents on sanitation technologies have not incorporated the options that are now available. The innovation in the sector means that any guidance document that is written is out of date soon after it is published. Water scarcity has also increased in severity. It is also difficult to write a good guidance document on the selection of a suitable sanitation technology, as the context of application has a huge bearing on the appropriateness of a technology. Political and commercial bias also influences the content of guidance documents. In the South African context, the National Sanitation Policy (2016) adopts a broad approach to sanitation system selection, as does the updated Red Book. However, it becomes difficult mirror this openness at the municipal level, where clear guidance is required (as opposed to a visionary view). How can municipalities establish a consistent stance in their policies and guidance documents without being restrictive in their language? How can municipalities support decision makers while not simply dictating what should be done in all instances?

Case study examples:

a) Johannesburg Water approved the *Guideline for the Installation of Privately Owned Package Plants for Domestic Sewage Treatment* in 2014. The guideline is aimed at developers, professionals, property owners, and treatment plant suppliers that want approval from Johannesburg for installation of a package treatment plant. The Guideline applies to on-site wastewater treatment systems that have a capacity of less than 2,000 m^3/day. The Guideline only permits alternative sanitation systems (e.g. package plants) in areas where waterborne sewer systems are not available, **establishing a preference for full waterborne sanitation.**
b) Sanitation policies reviewed in this study all had some form of technology guidance based on specific contexts in the municipality, and this is necessary to ensure a consistent approach across the municipality. Some municipalities gave only one or two options for each context (e.g. sewered vs. not sewered), whereas others, such as City of Johannesburg, provided a suite of technology options based on many different contexts.

Recommended actions:

1. Provide support to municipalities in developing sanitation policies, incorporating training which raises awareness of the biases present in sanitation technology selection
2. Adopt an approach of focusing on *characteristics* of acceptable sanitation technologies as opposed to *specific technology options*, as is the case in the National Sanitation Policy for South Africa (2016).
3. WRC and/or DWS to publish a list of recommended guidance documents on sanitation technology
4. Allocate resources to updating the guidance documents that are most widely used by municipalities (e.g. the Red Book) in the selection of sanitation systems and provide training on the updated versions.

6.6 Municipalities frequently outsource sanitation system selection and design

Municipalities, large and small, frequently outsource the selection and design of sanitation solutions to consultants due to a lack of internal capacity (particularly in the chemical/process engineering field). This has a number of implications:

- The majority of consultants do not have detailed, up-to-date knowledge of NSS technologies and therefore cannot make an informed decision about them.
- Consultants bear the liability for design (and accordingly pay a large amount for professional indemnity insurance) and are therefore inclined to minimise design risk by selecting established technologies (frequently traditional treatment plants with a large component of civils works).
- The consultant’s fee for construction supervision is often a percentage of the capital value of the works, and therefore if the same consultant is appointed for process selection and design and construction supervision, there is an in-built motivation to specify a larger, more expensive solution – often a centralised treatment system.

Case study examples

a) Johannesburg Water pointed out that turnkey projects could offer a partial solution to this issue – making the liability for the design rest with the contractor who builds the system. One stage further is the Design-Build-Operate model, where the contractor is then motivated to build a system that is easily maintainable at a reasonable cost, and which meets its performance targets over an extended period.

b) Supplier C, a manufacturer of package plants, highlighted the challenges of consultants carrying out work for municipalities, including the lack of process engineering expertise and previous negative experiences with package plants.

Recommended actions:

1. Where municipalities outsource sanitation system selection and design to consultants, they should make it a requirement that an experienced chemical/process engineer is a core part of the consultant's team. The required experience of this person can also be stipulated – e.g. ideally must include experience with NSSS as well as conventional wastewater treatment.
2. Consider how appropriate expertise – process/chemical engineering expertise in NSSS and conventional sanitation systems – can be made available to municipalities (particularly smaller ones) without having to outsource to consultants. Could a national department create a team of experts to support municipalities in this area?
3. Support municipalities to create high quality sanitation policies and ensure that consultants have to show that they have carried out their work in line with these policies.

6.7 MFMA/PFMA issues

The Municipal Finance Management Act (MFMA) governs financial management in local governments, while the Public Finance Management Act (PFMA) governs financial management in national and provincial government departments. Each of these acts includes the requirement of government entities to establish supply chain management processes and policies to ensure **fairness, equity, transparency, competitiveness, and cost-effectiveness.** While the requirements in these acts are vital to the effective management of government funds, some aspects may hinder the uptake of innovative non-sewered sanitation systems.

The PFMA and MFMA have a statutory mark on 3 financial years only as a budget commitment. In practice this means that service contracts do not exceed three years, because budget is only committed for a 3-year period. While three years is sufficient for most current sanitation service provision, some innovative sanitation systems require regular, ongoing, and, in some cases, specialised servicing (e.g. requires specialized knowledge or equipment/facilities). There are provisions in the legislation where Memorandums of Understanding/Public Private Partnerships can exceed the three-year period. This requires a public participation process that must occur and other clauses in the legislation applied in conjunction with this.

The process of appointing a sole supplier has some promise for innovative sanitation systems. If, for example, a municipality identifies a specific technology as meeting its needs in a specific context, they would prefer to specify that technology rather than going to open tender and risking receiving submissions that do not meet the specific needs. However, appointing a sole supplier is an involved process and one that many Supply Chain Management units are reticent to use (Gounden, personal communications, 1 March 2022). Below are requirements in the eThekwini SCM policy for procuring goods and services from sole suppliers:

Procuring goods and services from sole supplier occur in instances where:-

a. *Only one supplier manufactures or renders goods and services due to unique nature of the requirements;*
b. *Goods and services already in the municipality's value chain/employ are only supplied by an Original Equipment Manufacturer (OEM) or by a licensed agent thereof and there is a requirement for compatibility, continuity and alignment.*
c. *The process for approved list of sole supplier(s) will be as follows:*
    i. *Departments requiring the use of sole supplier must issue a circular calling for the of sole supplier(s) who wish to be on the list or database of sole suppliers. SCM Unit shall manage and maintain the list of sole suppliers.*
    ii. *Response to the circular must contain appropriate motivation in terms of constitutional pillars of fair, equitable, transparent, cost effective and competitive.*
    iii. *The response to the circular and compilation of the list of sole suppliers must be categorized, screened and supported by a relevant appointed team. In instances where there is no consensus among the team members such be escalated to Head: SCM for decision and support.*
    iv. *The supported list of sole suppliers be advertised for public comments and or objections.*
    v. *In instances where there are objections, such objections be referred to the Head SCM for decision and support. eThekwini Municipality: Revised SCM Policy V8.4/04/06/2020 Page 61 of 168*
    vi. *The list of sole suppliers must be reviewed and reported annually to Head: SCM.*
    vii. *The report must outline how value for money will be achieved and managed.*

While there may be allowance for appointment of sole suppliers in the law and in SCM policies, SCM committees are often reticent to pursue that path. Many say that projects should still go out to tender in order to test the market, with the thinking that going to open tender can increase the market and entrepreneurship in the country. Another primary concern is that sole suppliers can hold a monopoly and not charge fair value for products or services provided. Item vii in the list above states that the sole suppliers list must explain how value for money will be achieved and managed. With no competition in the sole supplier space, suppliers can overcharge. Municipalities may have to request suppliers to show their costs so that the municipality can negotiate down to a fair value, but some suppliers may be resistant to doing this. Another approach some SCM committees take is to require sole suppliers to enter into a joint venture with an SMME or other suitable partner, but sole suppliers and innovators prefer not to do this, particularly where intellectual property may be involved. (Teddy Gounden, personal communications, 1 March 2022)

Case study examples:

a) The City of Cape Town has for many years procured portable flush toilets from an Italian company, as at the time when they were first implemented, no South African supplier was available. This has become an annual purchase that is made as the supply of portable flush toilets increases in the city's informal settlements.

Recommended actions:

1. If sole supplier appointments are not desired, equip municipalities to write sanitation tender specifications that are specific enough to garner technically acceptable solutions while not being restrictive.
2. Write more sanitation tenders with a 3-year service period incorporated, which will allow for any specialised servicing required along with knowledge transfer during the period.

6.8 Community engagement process not given required focus

Effective community engagement is critical to the successful roll-out of NSSS, particularly where sewered flush toilets are seen as the gold standard. Procurement processes do not always consider the time and resources that need to be given to the community engagement processes (district municipality, local municipality, ward councillors, ward committees, community meetings and finally the appointment of a project steering committee).

Case study examples:

a) Johannesburg Water shared about a pilot of a waterborne sanitation system that was implemented in an informal settlement, which included a package treatment plant powered by solar panels. While community acceptance initially appeared high, the project ultimately failed, as the solar panels were stolen. As has been demonstrated in the eThekwini technology demonstration platform, community buy-in and appointment of an active community liaison officer has a major benefit of preventing theft by encouraging community accountability.

b) Chris Hani District Municipality introduced pour flush toilets alongside the roll out of VIP toilets to communities. When going to a new ward, both options would be introduced to the community, and they could then decide which one they preferred. While most communities accepted the pour flush, some communities indicated that they did not want it due to water shortages. Even after being educated on using greywater for flushing, these communities insisted on having VIPs because they do not even have sufficient water in the first place.

Recommended actions:

1. Make community engagement an integral part of the sanitation technology selection process and write this into sanitation policy documents.
2. Tender documents need to be explicit about the level of community engagement expected and the specific processes that need to be followed by contractors. It may be necessary to stipulate that a specialist Institutional Social Development (ISD) sub-consultant is appointed by the main contractor. The budget for the sanitation project needs to reflect this commitment to the engagement process.

3. Consider national-level ISD expertise that smaller municipalities can call on when considering new sanitation options.

6.9 Difficulties where service plans are required

Some NSSS, by design, require frequent operation and/or maintenance interventions. This could include the removal of treated products from the system and their transport off-site for disposal. Municipalities may be reluctant or unable to take on this operational burden. Other maintenance or repair tasks might require specific expertise (e.g. calibration of instruments or making system adjustments for a variation in the feed stream), requiring the municipality to rely on the system manufacturer rather than performing maintenance themselves. These situations again raise procurement difficulties for municipalities:

- Difficulties with relying on one entity for maintenance, particularly where a maintenance contract needs to be issued – sole supplier issues
- Difficulties with implementing long-term service contracts
- Reluctance to tie the municipality to one supplier and not be able to do operation and maintenance of systems in house

Case study examples:

a) Supplier B, who manufactures dry sanitation systems and is piloting an innovative NSSS, offers service contracts with the dry sanitation systems that they sell. They noted that municipalities are not, in general, keen to take up service contracts
b) Supplier C, a manufacturer of package plants, noted that their clients are in many cases not initially keen to take up service contracts, but frequently find they cannot adequately maintain the plants themselves and return at a later date for assistance. They also commented that most servicing tasks associated with their plants could be put out to tender to multiple suppliers, with handover of knowledge from Supplier C.
c) The City of Cape Town regularly advertises service contracts for the large number of onsite sanitation systems used in informal settlements throughout the municipality. These contracts are generally on a 3-year basis and could provide a model for service contracts for other NSSS. However, the servicing of the existing onsite sanitation systems is a general service that many contractors can provide. The municipality expressed concern about other options that might require a *specialist* or the manufacturer themselves to do the servicing, citing sole-supplier issues.

Recommended actions:

1. Structural changes (e.g. to the PFMA) to make longer-term service contracts more feasible for municipalities, where there is a good case for them
2. Develop draft tender documentation which allows for the service contract to be put out to tender to multiple suppliers, incorporating handover of required knowledge from the manufacturer of the system (who would also be able to tender for the service contract)
3. Support the inclusion of remote monitoring on NSSS, which makes the operation and maintenance of multiple systems much more cost-effective

6.10 Difficulties with standardised quality assurance for NSSS

The ISO 30500 standard was published in 2018 (as SANS 30500 in South Africa), specifically for the certification of NSSS. The standard is not yet in widespread use in South Africa, principally because the infrastructure required to carry out the testing required is still being established in-country. The cost of certification is also currently a concern. In addition, a number of commonly used NSSS are ineligible to be certified under SANS 30500, for example, systems that include the discharge of untreated urine to a soakaway (as many dry sanitation systems do). Manufacturers of NSSS make certain claims about their systems, in many cases without adequate testing data to back them up. It is therefore difficult for municipalities to consider new NSSS as there is no standardised quality assurance system.

Case study examples:

a) eThekwini municipality commented on the lack of proven NSSS available on the market.

Recommended actions:

1. Support the development of the infrastructure needed to certify systems to SANS 30500 in South Africa (this is in progress, supported by the WRC).
2. Development of testing protocols relevant to systems that are ineligible to be certified under SANS 30500 but are still very relevant to the sanitation landscape in South Africa (this is in progress for dry sanitation systems, under another WRC project).
3. Third party evaluation of pilots of NSSS in South Africa, to provide an independent assessment of the performance of the systems.

6.11 Preferential Procurement and Capital Cost

Preferential Procurement is a method for evaluating the B-BBEE status of suppliers who submit bids for government contracts, and it is allowed for in Section 217 of the Constitution and supported by the Broad-Based Black Empowerment Act (No 53 of 2003) and the Preferential Procurement Policy Framework Act (No 5 of 2000) (van der Westhuizen, 2015). In the Preference Point system, points are allocated based on the expected value of the contract. For contracts between R30 000 and R50 million, 80 points are allocated based on price, and 20 points are allocated based on B-BBEE status (80/20 rule). For contracts over R50 million, the points are allocated based on the 90/10 rule. Price points are allocated based on the price of the tender compared to the minimum price of lowest acceptable tender (i.e. the lowest priced acceptable tender receives the maximum number of points). This system is meant to ensure that historically disadvantaged communities receive benefits from the procurement process and that the government receives the greatest value for money.

Functionality criteria may also be provided when writing a tender specification, though they are not required. These criteria must be clear and objective to ensure fair evaluation. Furthermore, according to the 2017 Preferential Procurement Regulations, the minimum qualifying score for functionality must be defined and "may not be so low that it may jeopardise the quality of the required goods and services; or high that it is unreasonably restrictive." Writing criteria for a functionality evaluation can be challenging, and this in practice leads to municipalities being heavily driven by capital costs in the procurement process, with far less weighting given to either the technical performance/suitability of the system or the operational costs of it.

One result of this is that systems not suitable for the context of application can still be selected by the tender process. The other aspect is that the overall lifecycle cost of the selected system may be very high, even though its capital cost was low, because operation and maintenance costs were not requested in the tender submissions or taken into account in the evaluation process. This can lead to excessive unforeseen costs down the road for the municipality or, more commonly, maintenance simply not being done as it was not adequately planned for.

See section 5.4.3 in Chapter 2 of this guide for more information.

Case study examples:

1. Supplier C, a manufacturer of package plants, highlighted the emphasis placed on capital costs and the neglect of lifecycle costs, linked to the 90/10 procurement rule
2. Johannesburg Water advertised a tender for a Turnkey sanitation pilot project, which took a two-stage approach to tender evaluation. This approach is relatively common, in which proposals are initially scored on a technical basis, and only those achieving a certain score are evaluated based on the 80/20 or 90/10 Rule. In the case of the Johannesburg Water tender, the evaluation criteria for the technical evaluation were specific and extensive, which allowed them to filter out inappropriate solutions. While the cost and preference evaluation ultimately applies, this two-stage approach is one way to factor in additional criteria.
3. In Chris Hani District Municipality, single pit pour flush toilets are implemented on a wide scale, though twin pit systems are likely to cost the municipality less in the long-term due to lower expected costs associated with emptying. If a pour flush tender were advertised and twin pits were not specified, a twin pit system would never win over a single pit system, due to the difference in capital cost and the emphasis on capital cost. However, the twin pit system would likely lead to lower costs in the long-term.
4. Supplier A shared about the process of introducing single pit pour flush toilets to one municipality that had only previously implemented VIP toilets for onsite sanitation. The supplier of the pour flush toilets essentially provided them at the same price point as VIP toilets, which made it easy for the municipality to begin implementing the technology. After a few years of implementing that solution, the municipality has now adjusted its tenders to implement single pit pour flush toilets with an externally-mounted water storage tank, which increases the cost. Thus, an incremental approach to alternative technologies has worked in this instance.

Recommended actions:

1. Operation and maintenance costs should be required to be included with system specifications in bids, with suitable back-up evidence. This may require adjustments to the Preferential Procurement Policy to allow for consideration of life-cycle or operational costs in the “cost” portion of the formula.

2. Methods must be developed to create standard methods for specifying O&M costs, so that the estimate provided by a supplier of one system can be accurately compared with that provided by another supplier.

6.12 Separation of responsibilities for capital projects and long-term operation and maintenance

Onsite sanitation systems are often only thought of in terms of capital requirements, which has led to most municipalities in South Africa not planning for maintenance. Since maintenance is often only required every 5 or 10 years (i.e. for VIP toilets), the capital project is separate from the operation and maintenance of the system. Then, if a municipality does provide pit emptying, a separate tender is issued for emptying. This works, as the construction and O&M processes require different skills and infrastructure. However, this standard process limits capacity to understand and implement systems that require O&M on a more regular basis. This separation can also contribute to no O&M being done.

Case study examples:

a) In Chris Hani District Municipality, precast concrete structures were implemented with VIP toilets, with the overall view that once the pits filled up, households would dig a new pit and relocate the structure before closing the old pit. Though this arrangement is acceptable if households are made aware of it, there has not been evidence yet that households have actually done this. The length of time between the initial capital project and the O&M activity can create grey areas and neglect of O&M, both on the part of the municipality and the households.
b) In eThekwini Municipality, the guidance on package plant implementation specifies that proof must be provided of a minimum 2-year service agreement between the supplier and the owner of the package plant. This agreement ensures that the system maintenance is considered from the beginning.

Recommended actions:

1. Incorporate service agreements into capital expenditure tenders for a period after installation of sanitation systems. This service period, whether for complex package plants or onsite dry sanitation systems will hold the contractor accountable for the initial ongoing success of the system.

6.13 Systems produced overseas

The Preferential Procurement Regulations 2017 allows Department of Trade and Industry to develop policies for local production and content in terms of a percentage of the contract value. These regulations can be set for different sectors to stimulate the South African manufacturing sector and grow South African jobs. Where there is a minimum threshold of local content, suppliers that manufacture new sanitation systems overseas may be disadvantaged. On one hand, this is positive, as it will encourage international suppliers to partner with local South African partners to fabricate new systems locally. On the other hand, this may limit the ability of municipalities to pilot new systems through standard procurement processes.

Case study examples:

1. Two of the interviewed technology suppliers are currently investigating options to manufacture innovative non-sewered sanitation systems locally. As part of a piloting process with the WRC/SASTEP, these local companies are investigating the requirements for complete local fabrication of these systems. Should local manufacturing prove possible, this will open job opportunities, stimulate the South African economy, and ensure that procurement of these systems is not complicated by any current of future local content specifications.

Recommended actions:

1. Encourage more piloting and local fabrication investigations to encourage local production of innovative sanitation systems/products.

6.14 Summary of recommended actions

The recommended actions presented in the above sections are listed in Table 45.

Table 45: Recommended actions to address aspects of the municipal procurement environment that hinder uptake of innovative sanitation solutions

Issue to address	Recommended actions
Lack of awareness of technology options and/or lack of sufficient experience to make an informed selection between options	Increase knowledge and awareness of non-sewered sanitation systems: This project includes a report titled *Selecting Sanitation Systems*, which aims to establish a common language around sanitation systems, along with a technology selection tool, *SaniSelect,* which can give decision-makers some understanding of how different technologies might perform based on different criteria.
	Write policies in a way that recognizes differences from one project location to another: Many municipalities do not have their own policies around sanitation and have thus not spent much time thinking about the options that are available, rather drawing on previous projects. Where policies are in place, they are sometimes written in such a way that the sanitation binary paradigm is perpetuated (i.e. one solution for one broad scenario and one solution for another broad scenario). Policies can be written in a way that establishes a minimum standard but also encourages innovation and alternative approaches. This project produced a document titled *Writing a Sanitation Policy* to guide municipalities in crafting a sanitation policy, including examples from other municipalities.
	Increase benchmarking between municipalities, so that experiences with sanitation alternatives can be shared and built upon.
	Require that the outputs from tools, such as *SaniSelect*, are presented as a prerequisite for funding approval from Department of Treasury.
Perceptions around package plants and other non-sewered sanitation options based on previous negative experiences	Increase benchmarking between municipalities
	Make outcomes of piloting and demonstration projects accessible to decision-makers. This should be done via a central database that covers different technologies and gives decision-makers access to results and evaluations of them. This databased should be 'owned' by an entity that allocates sufficient resources to keeping it maintained and publicising its existence.

Issue to address	Recommended actions
The need for more successful reference cases for NSSS	Support grant funding specifically for pilots of NSSS and involve research institutions, so that the establishment of pilots is not dependent on municipal funding and personnel.
	The establishment of 'testbeds' or testing platforms for NSSS has been a successful approach to piloting NSSS (e.g. the Engineering Field Testing Platform in eThekwini, run in partnership between the university, municipality and an engineering consulting firm) as it creates and retains the necessary infrastructure and expertise to test systems quickly and at a lower cost than standalone testing. Explore the establishment of testing platforms in other locations around the country, noting that partnership with municipalities is critical.
	Municipalities can consider how pilots can be 'tagged on' to existing programmes, thus reducing the investment required in them.
Difficulties with transitioning from pilot to implementation	More pilots of NSSS so that municipalities have several options of NSSS that they have confidence will work in their implementation context. A minimum number of reference cases in relevant implementation contexts can then be made a pre-condition of tenders.
	Explore licensing of a specific NSSS design to multiple manufacturers.
	Where there is only a single manufacturer of a NSSS, explore making it possible for multiple suppliers to purchase it and offer it as a product offering to municipalities, alongside any specialist technical support and consumables that are required. This could be a franchise model or similar.
Municipalities frequently outsource sanitation system selection and design	Where municipalities outsource sanitation system selection and design to consultants, they should make it a requirement that an experienced chemical/process engineer is a core part of the consultant's team. The required experience of this person can also be stipulated – e.g. ideally must include experience with NSSS as well as conventional wastewater treatment.
	Consider how appropriate expertise – process/chemical engineering expertise in NSSS and conventional sanitation systems – can be made available to municipalities (particularly smaller ones) without having to outsource to consultants. Could a national department create a team of experts to support municipalities in this area?
	Support municipalities to create high quality sanitation policies and ensure that consultants have to show that they have carried out their work in line with these policies.

Issue to address	Recommended actions
MFMA/PFMA Issues	If sole supplier appointments are not desired, equip municipalities to write sanitation tender specifications that are specific enough to garner technically acceptable solutions while not being restrictive.
	Write more sanitation tenders with a 3-year service period incorporated, which will allow for any specialised servicing required along with knowledge transfer during the period.
Community engagement process not given required focus	Make community engagement an integral part of the sanitation technology selection process and write this into sanitation policy documents.
	Tender documents need to be explicit about the level of community engagement expected and the specific processes that need to be followed by contractors. It may be necessary to stipulate that a specialist Institutional Social Development (ISD) sub-consultant is appointed by the main contractor. The budget for the sanitation project needs to reflect this commitment to the engagement process.
	Consider national-level ISD expertise that smaller municipalities can call on when considering new sanitation options
Difficulties where service plans are required	Structural changes (e.g. to the PFMA) to make longer-term service contracts more feasible for municipalities, where there is a good case for them
	Develop draft tender documentation which allows for the service contract to be put out to tender to multiple suppliers, incorporating handover of required knowledge from the manufacturer of the system (who would also be able to tender for the service contract)
	Support the inclusion of remote monitoring on NSSS, which makes the operation and maintenance of multiple systems much more cost-effective
	Support the development of the infrastructure needed to certify systems to SANS 30500 in South Africa (this is in progress, supported by the WRC).

Issue to address	Recommended actions
Difficulties with standardised quality assurance for NSSS	Development of testing protocols relevant to systems that are ineligible to be certified under SANS 30500 but are still very relevant to the sanitation landscape in South Africa (this is in progress for dry sanitation systems, under another WRC project).
	Third party evaluation of pilots of NSSS in South Africa, to provide an independent assessment of the performance of the systems.
Preferential Procurement and Capital Cost	Operation and maintenance costs should be required to be included with system specifications in bids, with suitable back-up evidence. This may require adjustments to the Preferential Procurement Policy to allow for consideration of life-cycle or operational costs in the "cost" portion of the formula.
	Methods must be developed to create standard methods for specifying O&M costs, so that the estimate provided by a supplier of one system can be accurately compared with that provided by another supplier.
Separation of responsibilities for capital projects and long-term operation and maintenance	Incorporate service agreements into capital expenditure tenders for a period after installation of sanitation systems. This service period, whether for complex package plants or onsite dry sanitation systems will hold the contractor accountable for the initial ongoing success of the system.
Systems produced overseas	Encourage more piloting, and local fabrication investigations to encourage local production of innovative sanitation systems/products.

7 Tender-specific issues that support and hinder the selection and adoption of innovative non-sewered sanitation systems

7.1 Sanitation tenders are construction-focused

Typical tenders for onsite sanitation systems are construction-focused, requiring minimum CIDB gradings for all contractors. While this is important, as a large portion of a sanitation project is construction-focused, it also excludes suppliers of sanitation solutions that are sanitation experts, not construction experts. In some cases, this can lead to contractors being appointed who do not understand how the system is meant to work and constructing it inappropriately (e.g. VIP toilets with pits that are plastered/sealed when they should be able to freely drain). Even if technical drawings are provided, they may not be fully understood.

Tenders can be adjusted to include some requirement for sanitation expertise in the functionality criteria and/or issue two tenders: e.g. one for the construction-based work (supply of top structures) and another for the process-related aspects (low flush pedestals and septic tank/soakaway).

7.2 No allowance for alternative offers

There is often no allowance made for alternative offers submitted in addition to a Conforming Tender. At times there will be good reasons for this, but the effect is also to narrow the range of technologies and/or implementation models considered for application.

7.3 Technology evaluation criteria are too broad

There is little experience currently of implementing innovative non-sewered sanitation technologies at scale. Reasonable performance acceptance criteria (in terms of acceptable effluent quality, level of operation and maintenance required, running costs, etc.) are still being established for these types of systems. The language currently used in tender documents provides very broad criteria (see Figure 42 below). In one sense this can be advantageous, as it widens the net to as many potential technologies as possible. However, it also then requires municipalities to carry out a longer screening and selection process post-tender, which may miss the best solution in the midst of many options being considered.

The solution methodology must respond to the Scope of Work and the details outlined below:

Solution Methodology

- Technology proposed;
- Suitability for purpose, reliability and related attributes;
- Technology must include a whole system as well as a retrofit.
- Sound scientific evidence of the performance of the technology.
- Suitabilty of materials utilised.
- Robustness of materials utilised.
- Operation & maintenance management procedures.

Figure 42: Example of technology evaluation criteria from a tender for alternative sanitation technologies (2019)

Standards such as SANS 30500, *Non-sewered sanitation systems – Prefabricated integrated treatment units – General safety and performance requirements for design and testing,* provide a useful basis for specifying the required performance acceptance criteria for novel NSS technologies.

7.4 Tender specifications are too broad and/or unrealistic

Specifications may seem as though they are targeting a 'silver bullet' solution that can be applied successfully in all use contexts (see example below in Figure 43, particularly requirement ii). Many innovative NSS technologies work very well in some contexts but are completely inappropriate for others – for example, an incineration toilet can function very well as a household solution but is likely to fail in a high-urination public toilet use context. The requirement in a tender for a technology to work in all possible contexts can exclude numerous solutions from consideration. In reality, a requirement for a technology to work in all possible contexts SHOULD exclude all solutions, because there really is no 'silver bullet' in sanitation.

The new alternative on-site toilet technology should offer the following:

i) Easy for use in areas with less or no waterborne sanitation;
ii) Technology that can be used in all environments and all areas including rural, peri-rural and or urban;
iii) Technology that requires less maintenance and maintenance user-friendly;
iv) New technology material should be replaceable and made available as and when required;
v) Technology should be odour and insects free at all times;
vi) Technology that is safe to the consumer and the public as a whole;
vii) The technology should be environmental friendly;

Figure 43: Example tender specification criteria for alternative sanitation solutions (2019)

In another example, a technology supplier of low-flush pedestals mentioned that tenders often specify only a "flush toilet", rather than incorporating compliance with given standards (e.g. Agrément). This leads to contractors purchasing the lowest cost, low-quality toilet, regardless of its appropriateness.

It is advisable for specific performance acceptance criteria to be considered and defined, for inclusion in the tender document. This will aid in the technology selection process and will also ensure that the appointed supplier is held to specific performance standards when the project is implemented. Chapter 9 of the SASTEP Guideline for *Field Testing and Demonstration of Sanitation Technologies* provides a good guide for setting the performance criteria for NSS technologies.

7.5 Tender specifications are too specific

Some tender specifications are so specific that they restrict different suppliers and technologies from tendering, which goes against the principles of competitiveness and cost-effectiveness. As described in Chapter 3, there may be motivations in some instances to specify a single supplier but establishing a sound basis for this is difficult. Tenders that are too specific, favouring a single alternative technology, have potential to restrict innovation and violate the Public Finance Management Act. Based on the strict procurement rules in South Africa, it is surprising that such tenders get approved. However, a lack of capacity and understanding of sanitation systems among supply chain management personnel may contribute to the continued proliferation of specifications like these. Furthermore, when reputable companies see these glaring issues and do not tender and challenge the process, it paves the way for these practices to proliferate

Some tender specifications were reviewed, which would fall under this category of being too specific. This manifests either by mentioning specific suppliers in a specification or writing a detailed functionality specification that is tailored to a specific supplier. Examples are shown below.

	SUPPLY OF TOILETS MATERIALS			
a)	Supply & Delivery of Prefabricated Concrete top structure SUPPLIER 1 or similar approved)	Prov Sum		126
b)	Supply & Delivery of SPECIFIC SUPPLIER 2 substructure	Prov Sum		126
c)	Contractor's charge to allow for handling costs and Profit in respect of subitem (a & b):	%		
	INSTALLATION OF TOILETS SPECIFIC SUPPLIER 2 STRUCTURES)			
PSGA 8.6	Iinstallation of Prefabricated Concrete top structure	No	LIC	126
	Rate to include assembling and commisioning			
PSGA 8.6	Provision and installation SPECIFIC SUPPLIER 2 substructure to supplier's specification; model to be supplied by the Supplier	No	LIC	126
	Rate to include assembling and commisioning (incl. related products, user-education)			
	Supply, Deliver and apply ABE products	No	LIC	126
PSGA 8.1.3	Concrete			

Figure 44: Tender BOQ with reference to two specific suppliers. Note that with Supplier 1, the BOQ includes the words "or similar approved", but this is not true with products from Supplier 2. This is an issue and limits those that can supply on this contract. (2020)

SPECIFICATION

The product to be delivered must contain the following information to meet the requirements of the municipality:

1. SPECIFIC TECHNOLOGY **Low Flush System**

Materials meet requirements of SANS 10400 (National Building Regulations)

This entails:

1. Precast concrete panel top structure:
   - Floor Area (1600mm x 970mm)
   - Front Height (2047mm)
   - Rear panel wall thickness (150mm)
   - Lockable pressed steel door (2032mm x 800mm)
   - Concrete roof slope (5 degrees)
   - 36 litre PVC water storage tank
   - 1 litre flush PVC Cistern
   - Porcelain seat and PVC seat cover
2. SPECIFIC TECHNOLOGY
3. Sewer Pipes
   - Long Bend SPECIFIC TECHNOLOGY
   - 110mm diameter pipe to soakaway (3m)
   - 50mm diameter vent pipe (2.7m)
4. Soakaway with 40mm Concrete Slab Cover
   - Area (2.05m x 1.27m)
5. Training local labour on how to erect and handle the toilet structure.

Figure 45: Tender specification for a specific, branded low flush toilet technology (2020)

1.1.3 Specifications (Extent of Works)

- The toilet system should be sealed to prevent leakage and possible infiltration of flood and / or groundwater.
- The separation of human liquid and solid waste should occur under gravity within the unit tank.
- An extraction point will have to be provided on the domestic type of toilets, to avoid liquid overload, under high usage applications and wet climatic conditions.
- The forced extraction ventilation system should be well designed to facilitate continuous air flow through the unit, maximising Aerobic, Waste Separation decomposition and evaporation of liquid waste. This airflow through the unit should also maintain a negative pressure to prevent the escape of odours through the ceramic toilet pan. The air flow should be assisted by a ventilation extraction unit positioned on top of the outlet vent pipe, with air being drawn into the container via the inlet vent pipes.
- The design of the system should provide the right environment in terms of sufficient heat, prolonged retention periods in relation to number of users, adequate airflow and oxygen, to dehydrate and decompose the waste efficiently.
- The human waste should be converted via a stimulated bacterial and biological activity into an inoffensive / or stabilised material. The accumulated dried waste that will be periodically removed should be stabilised and safe to handle. The periodic removal must be cost effective and as infrequent as possible.
- The waterless, aerobic toilet system should be of an effective and efficient design, in order to capitalize on air circulation [wind] and heat from the sun to promote aerobic, waste separation of solids and evaporation of liquids. Effectively the system should be fully tested, with an acceptable track record be an environmentally sound zero discharge system, having the following benefits:
  - ✓ Needing no water to operate, conserving water resources
  - ✓ Zero discharge system, with reduced waste volume and cleaning cycles
  - ✓ Preventing pollution and risk to human health, as well as no odours and flies
  - ✓ Minimizing operating cost and the need for reticulation networks
  - ✓ No need to use any chemicals

Figure 46: Tender specification that is written for a specific supplier of a proprietary technology. Later in the installation details, the contact information for a specific company supplying this technology is provided. (2013)

As a general approach, writing a functionality specification may be appropriate for specifying alternative sanitation systems. However, unlike the example in Figure 46, such specifications should be general enough to still allow different technology suppliers of a given sanitation solution (e.g. dehydrating toilets) to tender. An example of how this has been done is shown in Chapter 2, section 5.5.

7.6 Exclusion of systems that rely on specialist maintenance personnel

The maintenance requirements of traditional flush toilets and VIPs have not relied on the services of specialist technicians. Some of the innovative NSS technologies entering the market are relatively high-tech, and more akin in maintenance requirements to a domestic appliance such as a refrigerator or cell phone. Interventions by specialist maintenance personnel may be a requirement over the lifetime of the product. This is not necessarily a barrier to adoption, provided that the necessary local technical support is in place to support the roll-out of these new products. Some tender specifications exclude systems that require specific technical support, on the grounds that municipalities may be left with un-maintainable systems should a technology provider go out of business, or that they may be held to ransom if the technology is provided by sole supplier. These are valid concerns and need to be addressed if tenders are written to allow the inclusion of high-tech systems.

The guidance on implementation of package plants in eThekwini Municipality requires inclusion of a 2-year service agreement between the supplier of the package plant and the owner. A similar arrangement could be investigated for sanitation systems that require specialist maintenance. Such a commitment could include a set period of support after installation along with a commitment to transfer the skills for maintenance to local/municipal maintenance personnel.

7.7 Accounting for systems that rely on service contracts

Some sanitation systems, such as so-called Container Based Sanitation (CBS), rely on frequent servicing of toilets. Chemical toilets are an example of an established system that rely on this arrangement. Other CBS systems rely on service contracts because a reliable waste stream is needed to feed into a beneficiation process. Other sanitation technologies may not require a service contract when installed in a household context, but if installed in a communal situation (e.g. a school) will only be viable if implemented with a service contract. Tender specifications need to ensure that technology suppliers provide clear details of how they envisage their systems operating and if a service contract is part of the model that ensures sustainable operation. The costs associated with such service contracts also need to be clearly stated.

In Cape Town, where container-based systems are common, separate supply and service contracts are generally implemented. The service contracts will for example specify servicing of units three times per week, with delivery of sludge to a wastewater treatment works. These service contracts do not generally rely on specialist servicing and are therefore quite competitive.

One system that is widely used in South Africa and relies on quarterly servicing is the Enviroloo system. The supplier includes a 2-year servicing contract in their price for the toilet, and thus tenders based around this technology specify that contractors must provide for this servicing. This is incorporated into the duration of the contract and as an item in the Bill of Quantities, for example: "Annual Service Maintenance Contract@ R70.00 per. After every service performed, a detailed service report will be sent to the client for perusal and for records. Subjected to Customer Operations and Maintenance Budget." It should be noted that it is not proper for the BOQ to specify the price, except in the case of a provisional sum. The tendering contractors should specify the price.

Incorporating servicing contracts at the time of supply of the new sanitation systems sets the municipality up for ensuring maintenance continues.

8 Examples for future sanitation system procurement

This section presents a series of examples or opportunities for procurement processes and tenders for non-sewered sanitation systems. The ideas in this section are based on discussions with municipalities as well as the framework for defining the sanitation value chain, presented in Chapter 3 of this Guide. While Section 5 of this chapter provided a more comprehensive list of actions to adjust procurement to encourage uptake of sanitation systems (e.g. structural policy changes), this resource focuses primarily on options within the existing policy framework. The focus is primarily on the approach taken in procurement and writing tender specifications that are technical sound and specific but not restrictive.

8.1 Alternative procurement processes

Before writing a tender document, a procurement process must be established. While the typical process for non-sewered sanitation systems is one of construction-based contracts, these often limit who can tender for these projects and the types of solutions that can be implemented. A few alternative approaches are described below, along with guidance on how to implement these.

8.1.1 Design-Build model

The approach was used by City of Johannesburg in their turnkey pilot sanitation project. This process incorporates design and construction of a sanitation solution into one contract, thus incorporating all liability for the system in one contract. The benefit of this is that the designer cannot blame a separate construction contractor if the system fails. This also opens contracts to sanitation or wastewater treatment experts instead of having a bias towards construction contractors who may or may not have any experience with sanitation systems.

Appointment would typically be aimed at competent designers who would likely appoint a subcontractor for construction while supervising the construction of the system. Thus, requirements such as CIDB rating would need to be rethought. The minimum CIDB rating could be included to state that either the main contractor must have a minimum CIDB rating or partner with a subcontractor with the minimum CIDB rating. Technical evaluation requirements would look more like those for design contracts, with practical evidence of related projects.

This approach may be risky to the municipality in that the cost of construction will be contingent on the design phase. It is therefore important that municipalities define what type of system they are looking for (e.g. defined as above using the *SaniSelect* tool) and have capacity (either internally or through consultants) to estimate the system's cost in order to budget. Tenderers may also be required to submit a preliminary design and cost estimate for a system, with a large contingency allowance.

The Design-Build model may be appropriate in the following scenarios:

1. Where (semi-) centralised treatment is required, and the treatment train must be designed.
2. Where the municipality does not have internal design capacity and/or has relied on consultants in the past but is looking to diversify its approach to sanitation (e.g. looking at innovative systems).

8.1.2 Design-Build-Operate model

This process is like the Design-Build model, but also incorporates a servicing period into the contract. This is appropriate for systems that require regular maintenance to succeed, and where this maintenance may require specialised personnel (e.g. package wastewater treatment plants). This arrangement provides motivation for the contractor to implement a system that is simple to operate. The operation period could last two years and have the requirement that the contractor transfer the skills, knowledge, and operating plan to the municipality within that period. Like the Design-Build option, this arrangement would likely be geared towards companies with sanitation expertise that collaborate with others with, for example, minimum CIDB ratings or minimum operational capacity/equipment.

The Design-Build-Operate model may be appropriate in the following scenarios:

1. Where (semi-) centralised treatment is required, the treatment train must be designed, and where internal maintenance capacity is limited.
2. Where the municipality does not have internal design capacity and/or has relied on consultants in the past but is looking to diversify its approach to sanitation (e.g. looking at innovative systems).
3. Where there is interest in non-conventional treatment systems that require different operation and maintenance models. The "operate" period can provide an opportunity to investigate what model will be sustainable in the long-term.

8.1.3 A two-phase tender with multiple technologies: Piloting and implementation

In 2021, eThekwini Municipality advertised a tender for onsite sanitation alternatives that included two phases: piloting and widescale implementation. This approach allows the municipality to trial different alternatives in the target communities before committing to widescale implementation. Tenderers submitted cost proposals for each phase, and proposals were accepted for the piloting phase, with provisional acceptance for the larger scale project. The tenderers appointed are those that meet the same minimum requirements as for a full-scale implementation project. This ensures that even those solutions that may be rejected after the pilot phase are still adequate sanitation solutions.

This approach incorporates community consultation throughout the process, as households must agree to participate in the pilot and community members are asked to provide their feedback during the piloting phase. In the case of the eThekwini project, the solutions selected for the piloting phase were all similar in that they all incorporated a low-flush system at the household level. Challenges may arise where significantly different technologies are piloted in the first phase (e.g. flush system vs. composting toilet), within the same or neighbouring communities.

A two-phase tender may be appropriate in the following scenarios:

1. Where user-acceptance of current onsite sanitation systems is low, and alternatives are needed.
2. Where innovative systems are desired for various reasons, but limited piloting data is available to allow for confident technology selection.
3. Where there is a desire for more community engagement in the technology selection process, this approach could be used to give individual households or neighbourhoods their own say on which of the piloted systems they receive.

8.1.4 Technology provision with a multi-year service contract

For innovative systems requiring regular maintenance, incorporation of a service contract may be one way to ensure maintenance happens and the system does not fail immediately. Similar contracts are advertised for supply and servicing of chemical toilets, but in this scenario, the infrastructure provided is permanent and remains an asset of the municipality after the servicing period. After the initial service period, a separate tender would be advertised for ongoing servicing (if not done internally), but the initial service period ensures that a contractor acquainted with the system establishes the servicing plan for the new system. Furthermore, this arrangement holds the contractor accountable for the ongoing operation of the system for a few years after installation.

This type of arrangement has already been incorporated in certain dry sanitation contracts that require regular maintenance. Often, the servicing period provides an opportunity for ongoing local job creation, and this can be specified in the tender to ensure maximum local benefit.

A technology provision/service contract arrangement may be appropriate in the following scenarios:

1. Where the selected sanitation technology(s) requires frequent maintenance, and maintenance capacity is not available at the municipality. For example, container-based sanitation systems or dry sanitation systems requiring frequent mixing or emptying. This may be especially relevant where the current onsite systems consist of those requiring infrequent maintenance (e.g. VIP toilets requiring emptying every 5-10 years).

2. Where selected sanitation technologies are innovative and therefore existing maintenance personnel may require training from the specialist before taking on the maintenance burden. For example, innovative non-sewered sanitation treatment systems may require regular servicing, but as the systems are innovative, the municipality may not have the skills to do this maintenance immediately.

8.1.5 Separate contracts for sanitation infrastructure and civil works

To encourage participation by companies with sanitation-specific expertise and not just those with construction expertise, separate contracts can be provided for the sanitation infrastructure and the civil works. This can work well where it is possible to distinguish sanitation infrastructure vs. civil works clearly, but it can become complicated where the two contracts rely on one another heavily. Splitting liability can lead to disputes between the two contractors and even community misunderstandings. For example, if the two contractors are not appointed at the exact same time, delays by one contractor could lead to misunderstandings (e.g. civil works done but no toilets delivered).

Separate contracts for sanitation infrastructure and civil works may be appropriate in the following scenarios:

1. Where some components of the selected sanitation system requires a specialist product/system with potentially complicated installation
2. Where package treatment plants are implemented, the civil/site preparation work can be on one designated contract and the delivery and installation of the treatment plant can be on a separate contract.

8.2 Tender language

In addition to considering alternative tender processes, the language of all tenders, including standard sanitation tenders, can be improved to provide the necessary level of specificity without being restrictive. Various examples of improvements to tender language in the specifications, bill of quantities, and functionality criteria are provided below.

8.2.1 Starting with the specification

It can be difficult to write a tender specification that opens submissions up to a variety of technology solutions. One risks being too broad such that many solutions are received that really do not meet the needs of the project. On the other hand, tenders can be too restrictive such that they limit submissions to only one supplier, which is not in line with the principles of the constitution and the Public Finance Management Act. Thus, some thought needs to put into how to craft specifications that are specific without being restrictive.

Instead of just thinking in terms of one technology or another, rather think about the following aspects when writing a specification for non-sewered sanitation:

1. **Scope:** Which components are you looking for? User Interface? On-site containment, storage, or treatment? Conveyance (e.g. sewers or servicing contract)? (Semi-) centralised treatment (e.g. package treatment plants)? Use and/or disposal (incorporated into a service contract? Or sale of products?)? It can be helpful to define solutions by their functional groups, because there may be multiple suppliers that tender together with a single system (e.g. user interface manufacturer with a specific treatment technology). This way, you can also specify the standards for each aspect of the system (e.g. a toilet pedestal with Agrément certification coupled with a SANS 30500-compliant treatment system).
2. **Application:** What type of area are you servicing (e.g. informal settlements, RDP houses) and what type of system are you looking for (e.g. individual households or decentralised treatment?)? Are you looking for something temporary and movable or something permanent?
3. **Type of system:** Having assessed water availability and user preferences, are you looking for a waterborne or dry system? Have you decided on a specific type of technology (e.g. pour flush with leach pits or dry pedestal with ventilated improved pit) or are you open to different approaches?
4. **O&M requirements:** Is there a maximum frequency with which maintenance should be required? Do you need the supplier to include a service plan in their tender price?
5. **Output requirements:** Must the system produce an output of a specific quality? e.g. General discharge limits? Special limits? Faecal sludge of a specific quality or for a specific use? No pathogens?
6. **Specific requirements** that may be needed for your project, e.g.:
   a. Job creation and local labour
   b. Local solution
   c. Monitoring (e.g. remote monitoring)
   d. Redundancy/backups
   e. Protection against theft and vandalism

Table 46: Sample specification text for different sanitation systems

Section	Sample text for pour flush system with onsite containment	Sample text for low flush system with SANS 30500 treatment	Sample text for onsite dry system with on-site containment and storage	Sample text for onsite dry system with sealed containment
Scope	*The proposed sanitation solution must incorporate a user interface manufactured with SABS/Agrément approved material and an on-site containment system that provides some passive treatment through storage and infiltration.*	*The proposed sanitation solution must incorporate a user interface manufactured with SABS/Agrément approved material and a decentralised treatment facility, along with all necessary plumbing. The system must also incorporate a recycling mechanism for reusing treated effluent for flushing.*	*The proposed sanitation solution must incorporate a user interface manufactured with SABS/Agrément approved material and an on-site containment system that provides some passive treatment through storage and infiltration.*	*The proposed sanitation solution must incorporate a user interface manufactured with SABS/ Agrément approved material and an on-site containment system that provides drying in a sealed chamber.*
Application	*The solution should be implementable and appropriate in a rural housing development, in individual houses.*	*The solution must be appropriate for installation in an informal settlement community ablution block/public toilet. The solution must be prefabricated and movable such that it can be removed when a bulk sewer network becomes available.*	*The solution must be applicable at peri-urban households.*	*The solution must be applicable in peri-urban households in an area with high groundwater table and where many households rely on borehole water.*
Type of system	*The pedestal should be a low flush system requiring no more than 3 litres of water to flush. A pour flush system that can be flushed with recycled greywater is*	*The system should be waterborne and use low-flush fittings that require 3 litres or less to function.* *The treatment system must not require electricity from the grid to operate (i.e. if electricity is required, it*	*The system should be a dry system (not requiring water to flush).*	*The system should be a dry system (not requiring water to flush)*

Section	Sample text for pour flush system with onsite containment	Sample text for low flush system with SANS 30500 treatment	Sample text for onsite dry system with on-site containment and storage	Sample text for onsite dry system with sealed containment
	preferred. If a dry option with a comparable level of odour control is available, this can be considered as an alternative.	*should be provided as off-grid electricity).*		
O&M requirements	*Large-scale maintenance (e.g. emptying) should not be required more frequently than every 5 years, and replacement parts should be easily accessible within South Africa.*	*The proposal should include a 3-year service contract for ongoing maintenance of the treatment system. This service period should include the training of the municipality's in-house maintenance personnel. Any replacement parts required in the span of 10 years must be obtainable within South Africa.*	*Large scale maintenance (e.g. emptying) should not be required more frequently than every 5 years, and replacement parts should be easily accessible within South Africa.*	*The unit should not require maintenance more frequently than every 3 months. Replacement parts should be easily accessible within South Africa.* *A 2-year servicing period should be included in the cost of the unit, including detailed account of what maintenance is required. The servicing period should include training of a local SMME to ensure long-term sustainability.*
Output requirements	*The solution should produce faecal sludge that is safe to empty manually by the time emptying is required.*	*The treatment system must be SANS 30500 compliant and produce an effluent suitable for recycling for flushing.*	*The solution should produce faecal sludge that is safe to empty manually by the time emptying is required.*	*The output should be somewhat stabilised and dried, allowing for hygienic manual emptying and burial in trenches.*

Section	Sample text for pour flush system with onsite containment	Sample text for low flush system with SANS 30500 treatment	Sample text for onsite dry system with on-site containment and storage	Sample text for onsite dry system with sealed containment
Specific requirements	*All solutions must be accompanied by necessary user education for the households and municipal officials involved.*	*The treatment system should include protections against vandalism and theft.* *The treatment system should provide the option for remote monitoring.* *At least 50% of the treatment system components should be fabricated in South Africa.*	*The opening on the pedestal must not exceed 200 mm, to ensure safety.* *A 110 mm ventilation pipe must be included to reduce odours. The ventilation pipe must be covered with a flyscreen made from aluminium mesh.* *The pedestal must be installed on a reinforced concrete slab, and the pit must be lined but open-jointed, allowing for infiltration of liquids.*	*The opening on the pedestal must not exceed 200 mm to ensure safety.*

8.2.2 Bill of Quantities

Similar to specifications, the bill of quantities provides a space for the authors of a tender document to indicate the specific quality of product they want. This ensures that those tendering provide accurate prices for products that meet the minimum requirements. Where specifics are not provided in the BOQ, the tenderer will likely provide the lowest rate they can, in order to be competitive. For this reason, it is important to specify any minimum requirements and specifications in the BOQ, *in addition to* the specification. Some specific aspects that can be included in the BOQ items are listed below:

1. Specific materials (e.g. UV-resistant plastic, galvanised steel)
2. Specific dimensions or capacity (e.g. maximum pedestal height or opening, minimum containment size)
3. Required certification (e.g. Agrément, SANS)
4. Specific outputs (e.g. final outputs from the supplied treatment system)

Or similar approved

This phrase is often included in BOQs and specifications, particularly where specific brands and products are listed. For example, a BOQ may call for a "5,000 litre JoJo water storage tank *or similar approved"*. While a water storage tank is a generic product, the author of the BOQ has chosen to state a specific brand as a marker of what standard product they are looking for. The addition of "or similar approved" ensures that this single brand is not favoured over other brands that make similar products that would meet the minimum requirements. The inclusion of this phrase is not only vital to comply with the PFMA; it is also critical to encouraging alternative suppliers. It represents an openness to solutions outside of those specified, provided those meet the minimum requirements.

8.2.3 Functionality Criteria

Funcionality criteria can be adjusted in two ways to encourage more emphasis on sanitation-specific aspects:

1. Adjust weighting of different aspects so that solution methodology is given as much consideration as staff experience.
2. Adjust wording to more specifically reflect sanitation-specific experience.

Figure 47 shows an example of scores from a functionality evaluation adjusted to provide a balanced evaluation of the solution methodology and the tenderer's experience. As a tenderer only requires 60 points to be evaluated further, the allocation of 60 points to tender and staff experience suggests that a tenderer could submit a tender without any detailed description of the solution methodology and qualify for further evaluation. This does not make sense, particularly since the requirements for tenderer and staff experience do not specifically talk to sanitation experience and only to "similar projects".

Functionality Criteria / Sub Criteria		Maximum Points Score
Tenderer's Experience on wastewater treatment or sanitation projects		15
Experience of Key Staff	Contracts Manager	~~20~~ 15
	Site agent	~~15~~ 10
	Foremen	10
Solution Methodology • Technology proposed; • Suitability for purpose, reliability and related attributes; • Technology must include a whole system as well as a retrofit. • Sound scientific evidence of the performance of the technology. • Suitabilty of materials utilised. • Robustness of materials utilised. • Operation & maintenance management procedures.		~~40~~ 50
Maximum possible score for Functionality (M_s)		100

The minimum number of evaluation points for Functionality is **60**. Only those tenderers who achieve the minimum number of Functionality evaluation points (or greater) will be eligible to have their tenders further evaluated.

Figure 47: Example of adjusted scores on functionality assessment to provide equal weight to experience and solution methodology

When adjusting functionality criteria to better reflect a desire for sanitation-specific experience, this can be done by adjusting the evaluation methodology. For example, one tender was reviewed, which lists "experience with respect to specific aspects of the project/comparable projects" as a criteria receiving a weighting of 20 out of 100 points. This represents the highest weighting seven criterion, aside from a presentation made to the client. The evaluation methodology for this experience is shown in Table 39, and specific reference is made to sanitation projects.

Table 47 :Evaluation approach for "experience" criteria as part of the functionality assessment

(Score 0)	The Tenderer did not submit any documentation for evaluation.
Poor (score 30)	Tenderer has limited experience in sanitation projects.
Satisfactory (score 60)	Tenderer has relevant experience of at least two completed **sanitation projects** but has not dealt with the critical issues specific to the assignment.
Good (score 100)	Tenderer has extensive experience in relation to the project and has worked previously under similar conditions and circumstances.

CHAPTER 6: ADVOCATING FOR ALTERNATIVE SANITATION SYSTEMS

This chapter is intended for advocates of alternative sanitation solutions, including suppliers of specific technologies and advocates for innovative systems in general. The guidance in this chapter is based on feedback received during interviews with municipalities and technology developers and advocates throughout the course of this project. The document presents **advice for these individuals to encourage uptake by municipalities while supporting a competitive and fair process.**

Wider implementation of sanitation alternatives can benefit all those in the innovation space, whether it is their technology or not. This is because more openness to innovation will likely lead to municipalities that are more willing to try new things. The National Sanitation Policy should establish rules around advocacy for innovation so that municipalities are more equipped and empowered to receive advocacy and respond appropriately.

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1 Be realistic

Let's be honest. There really is no silver bullet when it comes to sanitation solutions. Know where your technology does and does not work and be realistic about it. Be realistic about the maintenance requirements. There is no technology that requires NO maintenance, so know that you are competing against other solutions with maintenance needs. There is no need to over-sell your solution.

2 Be transparent

In a similar vein, be transparent about where your technology has come from. Sharing about failures and lessons learned can demonstrate to decision makers that you as the technology developer have committed to continuous improvement. Decision makers need to be aware of the risks they are taking when pursuing a new technology, and they will be grateful to you for your transparency.

3 Pilot responsibly

Piloting is critical to uptake of new solutions, because most decision makers insist on seeing the product in action before committing to it. Piloting also serves as a proof of concept for end users, whose buy-in is critical for project success. If you pilot, do so responsibly. Remember that sanitation is in place to protect public health. Thus, failures can lead to infringements on people's right to health and safety. Follow these principles when piloting your solution:

1. Get consent to participate from those using the system
2. Set expectations from the beginning: will the system remain the property of the household or institution? What will happen in the event of failure?
3. Ensure that the unit is installed to your specifications
4. Start small and then expand. Don't begin with 100 households. Rather, find one or two to work with and then, if the trials go well, look at scaling up.
5. Document the exercise well
6. Seek the evaluation of an independent body (e.g. research institution or consultant) and publish the results so that they are accessible to decision makers
7. In the evaluation, document lessons learned, and mitigation actions taken

For more detailed information on piloting and field-testing of innovative systems, refer to ***Field-testing and Demonstration of Sanitation Technologies: Guidelines for the South African Sanitation Technology Enterprise Programme (SASTEP)*** (Sindall et al., 2021).

4 Pursue certification

Certification is one way to improve the confidence of municipalities in alternative sanitation solutions. There is no clear path that sanitation systems should take to certification, partly due to the varied nature of different solutions and partly due to the gap in certifications available for sanitation systems up to the current point. In short, certification is an endorsement of a specific solution by an accredited or recognized third-party agency. A list of potential routes for certification is provided below:

1. **Agrément Certification**: Agrément is a South African body that provides certification of various alternative technologies in different industries. Technologies are evaluated based on in-service history, expert opinions, comparison to acceptable solutions, and comparison to previously approved solutions. The process involves the applicant submitting an application and paying the fee, preparation of a work offer and programme of assessment, and then certification based on review of test reports and meetings by the technical committee. The certificate requires ongoing maintenance to stay up-to-date.
2. **SABS**: The South African Bureau of Standards can certify the materials with which a system is built, but it will not certify processes. Thus, manufacturers of sanitation components can pursue SABS accreditation based on the materials used.
3. **WRC Technical Advisory Note**: Some tenders have asked for a Technical Advisory Note from the Water Research Commission, which is an expert opinion provided on a given technology. The Advisory Note is not an endorsement but does provide some evaluation and suggestion for further evaluation and testing that should be done. The advisory note is done at the request of a technology supplier or municipality made directly to the WRC. These notes are not public and are shared directly with the requester.
4. **SANS 30500 Certification**: This standard, titled *Non-sewered sanitation systems – Prefabricated integrated treatment units – General safety and performance requirements for design and testing* has been adopted by South Africa to evaluate and measure the viability of non-sewered sanitation technologies which do not make use of soakpits or leach pits. The purpose of the standard is

   > *to support the development of stand-alone sanitation systems designed to address basic sanitation needs and promote economic, social, and environmental sustainability through strategies that include minimizing resource consumption (e.g. water, energy) and converting human excreta to safe output.* (ISO, 2018)

   Thus, certification will apply to treatment systems that are off-grid and produce an output that is safe for disposal or reuse. Work is currently underway to establish testing and certification capacity in South Africa. While the testing process will be expensive, SANS 30500 accreditation will provide decision makers with increased confidence in prefabricated systems.

5. **Department of Water and Sanitation Technology Evaluation process:** The Department of Water and Sanitation, as part of the Sanitation Master Plan, is currently investigating a pathway to utilising the *Sanitation Technology Evaluation Protocol* (WRC, 2018) to evaluate innovative technologies and add them to their database. This may fall within the scope of the National Water and Sanitation Advisory Committee, established in the 2016 National Sanitation Policy. If these opportunities come up, suppliers are encouraged to participate and provide information to the DWS, as endorsement by the DWS will also contribute to a higher level of confidence in alternative systems.

5 Pursue partnerships

Partnering with other organisations and individuals can help build credibility for your solution. Technology developers and manufacturers might partner with research institutions, independent consultants, or other technology providers in the testing, development, and provision of sanitation solutions. These partnerships can demonstrate that you are open to collaboration and seeking to improve your solution. The partnerships can also help provide a second opinion on your solution from someone who is well-acquainted with it. Finally, partnerships are a great way to gain piloting opportunities. If a partner that you have a good relationship with gets an opportunity to pilot, they may be able to find ways for your solution to be involved as well. By establishing active partnerships with municipalities, they may be more open and comfortable with developing a framework for testing new technologies.

In summary, the overarching goal is for increased deployment of sanitation alternatives, and there should be a common understanding that there is no “on size fits all” solution, as mentioned above. So, collaboration is important and beneficial to all!

6 Listen to stakeholders

Learn from the people you are trying to serve and listen to what they express as main drivers in their decision-making process. Rather than making assumptions or criticising the approaches taken, listen and try to understand what angle they are coming from. In this way, you’ll be able to tailor your marketing and advocacy efforts towards those needs.

Furthermore, every time your technology is piloted or implemented, see it as an opportunity to learn from the users. Take criticism and feedback seriously. It is an opportunity to improve your solution so that it is more appropriate for those you’re aiming to serve.

7 Focus on process

Understand the specific treatment processes happening in your system and find simple ways to convey them. Some decision makers do not understand technical jargon. For some, an unknown solution is automatically considered inappropriate. However, with a small amount of effort, you can explain *how* your solution works in a way that they will understand. Empowered with knowledge and understanding, they will be able to ask questions about the solution and make an informed decision.

It is also important to focus on process, so the solution is implemented appropriately. For example, if heating and drying are key aspects of your treatment process, the orientation of the installation in relation to the sun will be key.

8 Educate others about your process

Use your technology to educate others about processes that are available for treatment of sludge, effluent, and urine. Being transparent about the process you're using increases the overall technical capacity of sanitation professionals, but it can also increase confidence in your specific solution. If certain aspects of your technology are proprietary, you can keep those private, but you can still speak to the general treatment processes that are employed by a variety of technologies.

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ANNEXURE A: Full list of technologies and approaches included in this tool

No.	Name	Description
U.1	**Dry toilet**	A dry toilet pedestal receives human waste and wiping material. Without a flushing mechanism, waste falls directly below the pedestal.
U.2	**Urine diverting dry toilet (UDDT)**	A urine diverting dry toilet pedestal incorporates a mechanism for separating urine from faeces and wiping material. The solid waste drops directly below the pedestal, and the urine is diverted to a separate compartment or soakaway.
U.3	**Flush urinal*** [24]	A urinal handles only urine. Though typically installed in public restrooms for males, innovations are being made to design urinals that are appropriate for use by females who squat over the urinal. Flush urinals incorporate a water seal to limit odours.
U.4	**Pour flush toilet**	A pour flush toilet incorporates a P-trap with a water seal. The toilet is flushed manually by pouring water down the toilet.
U.5	**Cistern flush toilet** [25]	A cistern flush toilet incorporates a water seal and includes a cistern with float valve that is opened when the user turns a handle, pushes a button, or other mechanism. The cistern stores water for flushing, and once a flushing event occurs, it is refilled with water. Due to the water scarcity in South Africa, it is recommended that only low flush toilets are utilised in new sanitation projects.
U.6	**Urine diverting flush toilet (UDFT)**	A urine diverting flush toilet operates in the same way as U.5 but incorporates a urine diversion mechanism.
U.7* [26]	**Dry toilet with mechanical advancement**	A dry toilet pedestal can incorporate a mechanism for advancing the faeces, as a way of separating the user from their waste. This may take many forms; a few examples are an auger which must be turned by the user; a "door" which is opened when in use and closed after use; or a plastic film which is opened to receive human waste and then closed again.

[24] In *The Compendium*, U.3 is "Urinal", but for this guide, it has been changed to "Flush Urinal", to allow for separate evaluation of waterless urinals (U.12). The two approaches have different applications, and a variety of waterless urinals are at different stages of development

[25] For the purposes of this guide, U.5 is assumed to be a low flush toilet with a cistern. This is due to the water scarcity in South Africa and the wide availability of different low flush options. A low flush toilet generally requires 5 or less litres of water to flush, while a full flush toilet requires anywhere from 9 to 16 litres of water.

[26] U.7 is not included in the EAWAG *Compendium* (2014). It has been added to this guide due to several innovative systems that are becoming available.

No.	Name	Description
U.8* [27]	**Urine diverting dry toilet with mechanical advancement**	A urine diverting dry toilet with mechanical advancement is like U.7 but incorporates urine diversion as well.
U.9* [28]	**Urine diverting pour flush toilet**	The urine diverting pour flush toilet operates on the same principle as U.4 but incorporates a urine diversion mechanism. Flush water, faeces, and wiping material are separated from urine at the pedestal interface.
U.10* [29]	**Leak-free cistern flush toilet**	Leak-free cisterns have been in development by a few companies to address the challenge with constant leakages in cistern flush toilets. These cisterns will work with different low-flush pedestals and use different innovative methods to limit or eliminate the opportunity for leakages.
U.11* [30]	**Leak-free cistern flush toilet with urine diversion**	This user interface will operate in the same way as U.10 but incorporate a pedestal with a urine diversion mechanism.
U.12* [31]	**Waterless urinal**	A waterless urinal operates in the same way as U.3, but it does not use water for flushing. Alternatively, a waterless urinal incorporates an alternate seal (e.g. floating liquid or a valve) to minimise odours.

[27] U.8 is not included in the EAWAG *Compendium* (2014)

[28] U.9 was not included in the EAWAG *Compendium* (2014). While urine diverting flush toilets (U.6) are included in the *Compendium*, the inclusion of U.9 allows for pour flush versions (i.e. without a cistern). This is important, because the decision to use pour flush or cistern flush systems is influenced by many factors.

[29] U.10 is not included in the EAWAG *Compendium* (2014). This is a relatively new innovation, and there are a few suppliers in South Africa currently working on solutions. This technology has potential to overcome the main drawback of cistern flush toilets when compared to pour flush toilets, i.e. constant leakage and wastage. Thus, it has been included here as an innovative solution that may be feasible in the near future, pending further technical development and commercialisation.

[30] U.11 is not included in the EAWAG *Compendium* (2014).

[31] U.12 is not included in the EAWAG *Compendium* (2014), which includes urinals broadly (U.3), but does not distinguish between waterless urinals and those requiring water. For this document, the two solutions have been split, because various criteria will influence whether one or the other is selected.

No.	Name	Description
S.1	**Urine storage tank/ container**	A urine storage container stores urine collected from urine diverting systems and urinals on site. From the storage container, urine is either applied as a fertiliser or transported off site for treatment.
S.2[32]	**Single pit**	A single pit is a commonly used storage technology throughout South Africa, particularly older and homebuilt dry toilets. The pit should be lined (e.g. with bricks) to prevent collapse. In general, single pits without ventilation are not considered adequate for minimum sanitation service.
S.3	**Single ventilated improved pit**	A single ventilated improved pit (VIP) is the most implemented onsite sanitation system in South Africa. It consists of a lined pit (e.g. with bricks) which is not sealed, allowing urine and water to percolate through the soil. The pit is equipped with a ventilation pipe to reduce odours and flies.
S.4	**Double ventilated improved pit**	A double ventilated improved pit (DVIP) has a similar construction as a single VIP, but the provision of two pits allows them to be used continuously. While one pit is in use, the contents of the other pit are decomposing, which leads to a pit humus material that is more stabilised and safer to remove.
S.5	**Fossa alterna**	Fossa alterna is also a ventilated two-pit system like a DVIP, but it differs in that the rotational cycles are short and aim specifically to produce a soil conditioner by-product. This is accomplished by digging shallow pits (maximum 1.5 m) and adding organic material (e.g. soil, ash, leaves) after every defecation event. The organic material speeds up the decomposition process, leading to shorter cycles (e.g. 1 year) compared to the DVIP.
S.6	**Twin pits for pour or low flush**	Twin pits for pour flush consist of two alternating pits that are permeable to allow infiltration of liquids. Only one pit is in use at a time, and when that pit fills up, the pipework is adjusted to direct flow to the other pit. The first pit then rests until the second it is full, at which point the pit humus is removed.
S.7	**Dehydration vault**	Dehydration vaults are used to collect, store, and dehydrate faeces and dry anal cleansing material. They are sealed and ventilated to encourage dehydration and are typically used with urine diverting dry toilets, which limits moisture entering the vault. They are also typically used in pairs, which allows one vault to fill up while the

[32] This technology has been listed here, but it is not acceptable in the South African context, as it is below the minimum standard for sanitation.

No.	Name	Description
		other one rests. Organic cover material should be added to improve drying.
S.8	**Composting chamber**	A composting chamber is a sealed system, consisting of a reactor (storage chamber), a ventilation unit, a leachate collection system, and an access door. Composting is an aerobic process, which leads to the decomposition of excreta by microorganisms, and it is assisted by the addition of organic material (e.g. organics, food waste, bulking material) and ventilation.
S.9	**Septic tank**	A septic tank is a water-tight chamber with at least two compartments, which allow for settling and anaerobic processes to reduce solids and organics. A septic tank can be constructed with brick/blockwork or prefabricated with fibreglass, PVC, or plastic. Settled solids are removed periodically from the tank, and liquid effluent flows to further treatment.
S.10	**Anaerobic baffled reactor**	An Anaerobic Baffled Reactor (ABR) is essentially an improved septic tank with a series of baffles under which wastewater is forced to flow. The baffles lead to increased contact time between the active biomass and wastewater, leading to improved treatment.
S.11	**Anaerobic filter**	An Anaerobic Filter (AF) is a fixed-bed biological reactor with one or more filtration chambers in series. Wastewater flows through the filter, which traps particles and degrades organic matter.
S.12	**Anaerobic digester**	An Anaerobic Digester (AD) is an anaerobic treatment technology that produces a digested slurry (digestate) that can be used as a fertiliser and biogas that can be use for energy. An AD must be airtight and be domed at the top to accommodate the biogas produced. They can be constructed with bricks or prefabricated.
S.13* [33]	**Single pit for pour flush**	A single pit for pour flush consists of one pit that is permeable to allow infiltration of liquids. A single pit system may cost less up-front, but it will require more frequent emptying and further treatment after emptying, when compared to the twin-pit system.

[33] S.13 is not included in the EAWAG *Compendium* (2014), but it has been included here as this is a relatively common technology used in South Africa. Including it in the list of technologies allows for comparison between single pit and twin pit systems for low and pour flush.

No.	Name	Description
S.14* [34]	**Incineration vault**	An incineration vault includes a fuel source that is used to burn (incinerate) excreta. The incineration process converts excreta to a pathogen-free ash product, which can be disposed of or used as a soil enhancement.
S.15* [35]	**Soakaway for Urine**	Source-separated urine can alternatively be sent directly to a soakaway, which is a covered, porous chamber that allows urine to slowly soak into the ground. A soakaway is typically filled with some media (e.g. gravel), which creates voids for infiltration.
S.16* [36]	**Sludge storage container**	Container-based solutions utilise a storage container for human excreta, which is emptied on a regular basis.
S.17* [37]	**Conservancy Tank**	A conservancy tank is a water-tight chamber which stores blackwater and/or greywater until emptying is required. A conservancy tank can be constructed with brick/blockwork or prefabricated with fibreglass, PVC, or plastic. A conservancy tank must be emptied frequently, as there is no overflow. While conservancy tanks are typically at least 1000 litres in volume, for the purposes of this guideline, any completely sealed containment system that exceeds 50 litres and is not specifically for source-separated urine is considered a conservancy tank. Furthermore, though conservancy tanks are typically used with waterborne sanitation systems only, any sealed containment for dry sanitation systems that do not provide any on-site treatment (e.g. drying or composting) and exceed 50 litres is considered a conservancy tank.
C.1	**Jerrycan/ Tank**	Jerrycans are light, plastic containers that are readily available and can be carried by one person. When sealed, they can be used to safely store or transport urine.

[34] S.14 is not included in the EAWAG *Compendium* (2014), likely because there were few proven options on the market at the time. However, advancements have been made since 2014, and incineration vaults are becoming more available and currently undergoing evaluation in the South African context.

[35] S.15 is not included in the EAWAG *Compendium* (2014).

[36] S.16 is not included in the EAWAG *Compendium* (2014), but with the growth of container based sanitation solutions and the wide-scale implementation of chemical and container toilets in South Africa, it is appropriate to include it in this guide.

[37] S.17 is not included in the 2014 EAWAG *Compendium*, but it has been included here as it is a relatively common technology employed in South Africa in areas that are at risk of groundwater contamination and/or out of reach of the municipal sewer network.

No.	Name	Description
C.2	**Human-Powered emptying and transport**	Human-powered emptying and transport refers to the different ways by which people can manually empty and/or transport sludge and solid products generated in onsite sanitation facilities. Human-powered emptying of pits, vaults and tanks can be done in one of two ways: 1) using buckets and shovels, or 2) using a portable, manually operated pump specially designed for sludge (e.g. the Gulper, the Rammer, the MDHP or the MAPET)
C.3* [38]	**Motorized Emptying and Transport (Honeysucker)**	Motorized emptying and transport refers to a vehicle equipped with a motorized pump and a storage tank for emptying and transporting faecal sludge and urine. Humans are required to operate the pump and manoeuvre the hose, but sludge is not manually lifted or transported.
C.4	**Simplified Sewer**	A simplified sewer describes a sewerage network that is constructed using smaller diameter pipes laid at a shallower depth and at a flatter gradient than Conventional Sewers (C.6). The simplified sewer allows for a more flexible design at lower costs.
C.5	**Solids-Free Sewer**	A solids-free sewer is a network of small-diameter pipes that transports pre-treated and solids-free wastewater (such as septic tank effluent). It can be installed at a shallow depth and does not require a minimum wastewater flow or slope to function.
C.6	**Conventional Gravity Sewer**	Conventional gravity sewers are large networks of underground pipes that convey blackwater, greywater and, in many cases, stormwater from individual households to a (Semi-) Centralized Treatment facility, using gravity (and pumps when necessary). The conventional gravity sewer system is designed with many branches. Typically, the network is subdivided into primary (main sewer lines along main roads), secondary and tertiary networks (networks at the neighbourhood and household level).
C.7	**Transfer Station (Underground Holding Tank)**	Transfer stations or underground holding tanks act as intermediate dumping points for faecal sludge when it cannot be easily transported to a (semi-) centralized treatment facility. A motorised emptying tool is required to empty transfer stations when they are

[38] In the EAWAG *Compendium* (2014), C.3 refers both to vacuum tanks and alternative motorised emptying tools (e.g. the Pitvaq). However, in this guide, vacuum trucks have been allocated to C.3 and a separate technology (C.8) has been included which covers hybrid mechanised/human-powered emptying systems. The inclusion of a separate item is because these tools have been designed to specifically fill serve communities that vacuum trucks cannot serve. Thus, selection of the appropriate emptying and conveyance technique relies heavily on site specific characteristics and the financial implications.

No.	Name	Description
		full. Operators of Human-Powered or small-scale Motorized Sludge Emptying Equipment (see C.2 and C.3) discharge the sludge at a local transfer station rather than illegally dumping it or travelling to discharge it at a remote treatment or disposal site. When the transfer station is full, a vacuum truck empties the contents and takes the sludge to a suitable treatment facility. Municipalities or sewerage authorities may charge for permits to dump at the transfer station to offset the costs of operating and maintaining the facility.
C.8* [39]	**Hybrid Human-Powered/ Motorised Emptying and Transport**	Hybrid emptying systems have been designed to provide the power of motorised emptying with the flexibility of human-powered emptying. They provide pumping in some form while also being able to access difficult-to-reach areas. Often, sludge is removed by the pumping device and then transported in a bakkie, trailer, or tuk tuk to the disposal/treatment/transfer site.
T.1 [40]	**Conventional Centralised Wastewater Treatment Works**	Conventional wastewater treatment works (WWTWs) in the South African context generally consist of preliminary treatment (e.g. screening), primary treatment (e.g. clarifiers for settling), secondary treatment (e.g. activated sludge), and tertiary treatment (e.g. nutrient removal and disinfection). The design of conventional WWTWs is influenced by numerous constraints, such as influent characteristics and expected fluctuations, available space, and electricity availability. Processes in conventional WWT often require electricity, and installation of these systems is typically civil-intensive. These systems are generally applied on a city-wide scale, such that all city sewers contribute to the treatment plant's influent.

[39] C.18 is not included in the EAWAG *Compendium* (2014). A number of innovative tools are at different stages in the technology development process, but they generally all seek to meet the needs of emptying difficult-to-reach systems.

[40] All treatment solutions listed here are approaches, rather than specific technologies. The EAWAG *Compendium* presents a list of specific treatment technologies, and so these approaches listed do not match the list from the *Compendium*. This is because this guide is not a design tool but rather a decision-making tool. Thus, once a treatment approach is selected, a competent individual must be appointed to design the detailed treatment train.

No.	Name	Description
T.2	**Decentralised Wastewater Treatment Systems (DEWATS)**	DEWATS is an approach to wastewater treatment for flows of domestic and/or industrial wastewater between 1 m^3 and 1000 m^3 per day. To achieve treatment, DEWATS typically incorporate primary treatment (e.g. sedimentation ponds, septic tanks), secondary treatment (e.g. anaerobic baffled reactors, anaerobic filters), secondary aerobic treatment (e.g. horizontal gravel filters), and post-treatment (e.g. aerobic polishing ponds). DEWATS treatment systems are designed with the following principles in mind: reliability, longevity, tolerance towards inflow fluctuation, cost efficiency and, most importantly, low control and maintenance requirements (Ulrich et al., 2010). These systems are typically implemented on a neighbourhood scale, rather than a citywide scale.
T.3	**Package Wastewater Treatment Plants**	A package treatment plant is an onsite, waterborne, domestic wastewater treatment system with a total capacity less than 2,000 m^3/day (van Niekerk et al., 2009). They are typically constructed and packaged off-site and brought onsite for installation. For the purposes of this list, this option encompasses traditional package plants using one of the following as their primary treatment process: activated sludge, trickling filter, submerged bio-contactor, or rotating bio-contactor. In addition to these primary treatment processes, most package treatment plants incorporate pre- and post-treatment to ensure discharge at General Authorisation limits. For the purposes of this document, T.3 includes all prefabricated treatment units that are not "closed-loop" systems for one or more of the following reasons: require a connection to electrical mains, require connection to a sewer, discharge effluent to a watercourse or to a soakaway/leach field.
T.4	**Off-Grid Package Wastewater Treatment Plants**	Off-grid package wastewater treatment plants are like those above except, for the purposes of this document, they are characteristically "closed loop". This means that any energy requirement is met by the system itself, either through solar power, treatment by-product, or other renewable energy source. It further means that treated effluent is recycled within the system for flushing, and thus the toilet system does not require a connection to an external water supply. Finally, any solid by-products produced by the system are in a form that is safe to reuse or dispose of.
T.5	**Co-treatment of faecal sludge in conventional WWTWs**	This approach involves discharging faecal sludge from onsite sanitation systems (e.g. septic tanks and VIP latrines) into a conventional wastewater treatment plant. Faecal sludge is either discharged into the sewer network or directly at the headworks of the treatment works. While this approach is not recommended for many reasons, there are some limited options available for co-treatment of FS with blackwater in conventional WWTWs, provided that the amount of FS added is strictly controlled to maintain the correct balance of organic matter. There is potential for co-treatment of FS with the sludge produced from WWTW (biosolids) in, e.g., drying beds or lagoons.

No.	Name	Description
T.6	**Designated faecal sludge treatment plants**	A designated faecal sludge treatment plant (FSTP) is designed specifically to treat faecal sludge from onsite sanitation systems. These plants typically consist of a combination of processes to achieve solid/liquid separation (e.g. settling tanks), dewatering (e.g. unplanted drying beds), and stabilisation (e.g. co-composting). The number and types of treatment technologies used will be determined by factors, such as land availability, faecal sludge quality (e.g. trash contents), and desired end use of products (e.g. soil conditioner or fuel). For the purposes of this document, treatment processes that fall under this solution are those that are constructed *in situ* (i.e. civil-based work).
T.7	**Self-contained faecal sludge treatment units**	Self-contained Faecal Sludge Treatment Units (FSTUs) are energy-independent, community scale resource recovery units. A variety of standalone treatment units exist, and a new standard, ISO 31800, has recently been developed. This standard applies to units that treat primarily faecal sludge, are able to operate in non-sewered and off-grid environments, are prefabricated, and exhibit resource recovery capability. These FSTUs vary based on their treatment methods and recovered resources.
T.8	**Treatment of urine for recovery of nutrients**	Various technologies have been piloted for recovering nutrients from source-separated urine. Urine contains nutrients that are valuable for agricultural use, but transport of large volumes of urine can lead to excessive costs. Thus, these treatment systems aim to extract the nutrient value from urine while reducing the volume. Examples of this include recovery of struvite ($MgPO_4$), nitrified effluent, and urea. The processes vary and all of them are at different stages of development.
[41]**D.1**	**Fill and cover/Arborloo**	To decommission a pit, it can simply be filled with soil and covered. Although there is no benefit, the full pit poses no immediate health risk and the contents will degrade naturally over time. Alternatively, the Arborloo is a shallow pit that is filled with excreta and soil/ash and then covered with soil; a tree planted on top of the nutrient-rich pit will grow vigorously.

[41] Some of the use/disposal methods listed here match those in the EAWAG *Compendium*, but not all of them. These options are purposefully kept more general (e.g. saying "fuel" instead of "briquettes"). The use/disposal method(s) are selected as the "end goal", and then a competent individual must be enlisted to design a process that will lead to that end goal (e.g. a treatment system that produces fuel for the desired purpose).

No.	Name	Description
D.2	**Surface application of treated sludge**	Sludge that has been treated (e.g. removed from a Planted Drying Bed) can be used in agriculture, home gardening, forestry, sod and turf growing, landscaping, parks, golf courses, mine reclamation, as a dump cover, or for erosion control. Although sludge has lower nutrient levels than commercial fertilizers (for nitrogen, phosphorus and potassium, respectively), it can replace an important part of the fertilizer need. Additionally, treated sludge has been found to have properties superior to those of fertilizers, such as bulking and water retention properties, and the slow, steady release of nutrients. Solids are spread on the ground surface using conventional manure spreaders, tank trucks or specially designed vehicles. Liquid sludge can be sprayed onto or injected into the ground.
D.3	**Deep row entrenchment**	Deep row entrenchment is the burial of sludge from a variety of sources (e.g. WWTP or VIP latrine) in trenches, ideally in areas where crops are grown. Buried sludge is covered by soil (approximately 300 mm). Deep Row Entrenchment (DRE) can be done on a household basis, a decentralised community basis, or on a commercial basis.
D.4	**Land application of compost or other soil conditioner**	Compost and pit humus can be beneficially used to improve the quality of soil. They add nutrients and organics and improve the soil's ability to store air and water. They can be mixed into the soil before crops are planted, used to start seedlings or indoor plants, or simply mixed into an existing compost.
D.5	**Fuel (e.g. biogas, briquettes)**	Sludge can be treated to produce various fuel products that can be used to supply electricity or fuel for cooking or heating. Products may include biogas produced during anaerobic digestion or briquettes produces through pyrolysis of faecal sludge. Recycling of faecal sludge for fuel production can reduce deforestation where wood is used for cooking, and it can reduce reliance on grid electricity. Recycling faecal sludge for electricity production can contribute to the energy independence of some treatment systems. Furthermore, use of treated faecal sludge as a source of heat can also improve treatment efficiency (e.g. raising temperatures of anaerobic digesters).

No.	Name	Description
D.6	**Landfill application**	Disposal of sludge in landfills is common with sludge produced at WWTPs but may also be used for faecal sludge. However, for sludge to be disposed of in a landfill, it requires treatment as it is considered a hazardous substance. The same is true of pre-treatment products (e.g. trash) that have been removed during treatment. These are contaminated with sludge and therefore also considered hazardous, requiring some treatment prior to landfill disposal. This option is not recommended for sludge, as it does not realize the potential benefits of sludge and contributes to climate change, as landfills are source of greenhouse gas emissions. It furthermore requires the payment of gate fees at landfills and the transport of sludge to landfills, many of which are at or near capacity.
D.7	**Surface disposal and storage**	Surface disposal refers to the stockpiling of sludge, faeces or other materials that cannot be used elsewhere. Once the material has been taken to a surface disposal site, it is not used later. Storage refers to temporary stockpiling. It can be done when there is no immediate need for the material and a future use is anticipated, or when further pathogen reduction and drying is desired before application.
D.8	**Irrigation**	Wastewater of varying quality can be used in agriculture to reduce dependence on freshwater. Only water that has had secondary treatment (i.e. physical and biological treatment) should be used to limit the risk of crop contamination and health risks to workers. This is typically done with drip irrigation to minimise evaporation losses, but it can also be done through surface application.
D.9	**Soakaway**	A soakaway is a covered, porous chamber that allows water to slowly soak into the ground. A soakaway is typically filled with some media (e.g. gravel), which creates voids for infiltration. A soakaway is an appropriate solution to receive wastewater (greywater or blackwater after primary treatment). A soakaway should be used in soils with good absorptive properties (i.e. not clay, hard packed or rocky soils).
D.10	**Pond**	Effluent can be discharged to a pond, where it will receive further treatment and can provide a habitat for fish and/or floating plants. Any remaining nutrients in the effluent will be used up by the fish and/or plants, and the fish and/or plants can provide a useful by-product.

No.	Name	Description
D.11	**Water disposal/ Groundwater recharge**	Treated effluent and/or stormwater can be directly discharged into receiving water bodies (such as rivers, lakes, etc.) or into the ground to recharge aquifers. The receiving water body should be analysed to ensure that disposal of the water will not negatively impact the receiving water.
D.12	**Recycling for non-consumption (e.g. flushing toilets, washing)**	Effluent treated to a suitable level can be recycled for non-potable use. Water recycling in areas where human contact is likely (e.g. flushing toilets) must be treated sufficiently to reduce risks to humans and must be treated to a higher degree than water to be reused for agriculture. This use/disposal option may be costly to achieve, but it can make it feasible for waterborne systems to be used in areas with no reliable water connection (e.g. extremely rural areas).
D.13	**Application of stored urine**	Stored urine is a concentrated source of nutrients that can be applied as liquid fertiliser in agriculture, replacing some or all chemical fertilisers. Guidance is provided by the WHO on how to safely apply stored urine. The generally accepted guidance is that urine stored for 1 month is safe for agricultural application at the household level. Urine to be used on food crops should be stored for at least 6 months.
D.14	**Application of concentrated urine nutrients**	Products from urine treatment systems include concentrated fertilizers, such as struvite ($MgPO_4$) or concentrated nitrogen fertiliser solution. These products can be applied as fertiliser to various crops. Due to the treatment processes, these products are considered free from pathogens and can be used at agronomic rates for various plants, including timber, food crops, or ornamentals.
D.15	**Building materials**	Building materials may be produced from both sludge and source-separated urine streams. Processes to achieve this have not yet been widely demonstrated, but some are currently being researched. Treatment processes to produce building materials can be investigated if demand is large.
D.16	**Biogas combustion**	In principle, biogas can be used like other fuel gas. When produced in household-level biogas reactors, it is most suitable for cooking. Additionally, electricity generation is a valuable option when the biogas is produced in large anaerobic digesters.

No.	Name	Description
D.17	**Biogas flaring to atmosphere**	If biogas is produced in the system but no infrastructure is available for using it as a fuel source, it may be flared. Burning biogas off ensures that methane and volatile organic compounds are converted to carbon dioxide, reducing the environmental impact of released biogas. This practice is common in WWTWs where there is little appetite for use of biogas produced in anaerobic digesters.

ANNEXURE B: eThekwini's Sanitation Policy (2021)

TRADING SERVICES

eThekwini Sanitation Policy

Policy Drafted or Review Team	Rob Dyer, Lungi Zuma, Teddy Gounden, Prishah Narsai & Sibonisile Mashiyane
Policy Implementing Departments	Sanitation Operations, Scientific Services
Policy Mandated by	Head: Water & Sanitation Unit
Signature of Mandating Official	12/05/2021
Approved by	Council
Date Adopted	29 April 2021
Date of Next Review	
Reviewed Yes/No	

Table of Contents

1. PREAMBLE

eThekwini Municipality is a Water Services Authority as legislated through the Water Services Act (Act 108 of 1997), and is responsible for ensuring that sanitation services are provided to all its residents.

The eThekwini Water and Sanitation Unit is the Municipality's Water Services Provider, and is responsible for the installation, operation and maintenance of water and sanitation services within the Municipality.

This policy and related bylaws under which sanitation services are provided must conform to the national policy of the Department of Water and Sanitation.

Internal stakeholder consultation with senior officials of from the Sanitation Operations Branch started on 26 November 2019 and was completed on 11th December 2019. The draft policy was circulated to all Deputy Heads in the Water & Sanitation Unit, including the Deputy Head: Sanitation Operations, on 11th February 2020.

This policy covers all sanitation services provided by the Municipality both as the Water Services Authority and Water Services Provider, and it also covers the disposal of industrial effluent.

2. PURPOSE

(1) To ensure that all residents of eThekwini have access to an acceptable sanitation system.

(2) To ensure that indigent households receive a free basic sanitation service.

(3) To ensure that property owners comply with legislation and by-laws governing disposal of sewage.

3. PROBLEM STATEMENT

This policy addresses the following problems

(1) Not all households in the Municipality receive sanitation.

(2) There is insufficient revenue to provide sanitation to provide an effective sanitation service to all residents

(3) Many property owners do not comply with legislation and by-laws governing disposal of sewage.

(4) The environment is negatively affected by the impact of inadequate sanitation.

(5) Many households liable to pay for water and sanitation are not paying

4. LEGISLATIVE AND POLICY FRAMEWORK

(1) Constitution of the Republic of South Africa

(2) Local Government: Municipal Structures Act (Act 117 of 1998)

(3) Local Government: Municipal Systems Act (Act 32 of 2000)

(4) Local Government: Municipal Finance Management Act (Act 56 of 2003)

(5) Water Services Act (Act 108 of 1997)

(6) National Water Act (Act 36 of 1998)

(7) Water Services Provider Contract Regulations, Gazette No. 7414, Vol. 445 No. 23636 of 2002

(8) The National Sanitation Policy 2016

(9) eThekwini Sewage Disposal Bylaws

(10) National Building Regulations and Building Standards Act (Act 103 of 1977)

5. DEFINITIONS AND ACRONYMS

5.1 DEFINITIONS

Term	Definition
A certificate	A certificate issued if sanitation is available at the boundary of the premises.
B certificate	A certificate issued when construction of reticulation is completed and approved.
Approval	Obtaining approval by the authorised delegate.
Approved	Approved by the authorised delegate.
Backflow	The flow of water from the point where the water is normally used towards the pipe or tank normally supplying the water for that length of pipe.
Basic sanitation	Means, a) appropriate health and hygiene awareness and behaviour; b) the lowest cost, appropriate system for disposing of human excreta, household wastewater, grey-water, which considers resource constraints, is acceptable and affordable to the users, safe including for children, hygienic and easily accessible and which does not have a detrimental impact on the environment; c) a toilet and hand washing facility; d) a clean living environment at a household and community level; and e) the consideration of defecation practices of small children and people with disabilities and special needs.
Common areas	In relation to a scheme, means, (a) the land included in the scheme;

<u>Term</u>	<u>Definition</u>
	(b) such parts of the building or buildings as are not included in a section.
Community ablution block	Communal toilet, showers and washing facility.
Connection point	The manhole or rodding eye inside the property at which a drainage installation joins a connecting sewer.
Conservancy tank	Sealed tank that contains and stores sewage from premises and is required to be emptied on a regular basis.
Council	The eThekwini Municipal Council; a council composed and elected in terms of section 157 of the Constitution.
Development	A new building or collection of buildings, that may be residential, commercial or industrial, that are constructed in one or more phases.
Domestic sewage	Effluent which meets strength characteristics relating to chemical oxygen demand and settleable solids as prescribed by the Municipality from time to time as being appropriate to sewage discharges from domestic premises, but excludes trade effluent.
Drainage	All drains that transports sewage to a sewer connection, holding tank or treatment system.
Free basic sanitation	Affordable ongoing services to at least the basic level of sanitation for indigent households.
Freehold	Having full ownership rights on a property, which includes the building and the land it is built on.
Grey water	Sewage emanating from baths and basins, and excluding sewage emanating from sinks, washing machines, dishwashers, toilets and urinals.
Household	A family unit of persons, or individuals, in occupation of a building or part of a building, designed for residential occupation by such family unit, or individuals.
Indigent	Lacking the necessities of life such as, but not necessarily limited to, sufficient water, basic sanitation, refuse removal, housing and/or a supply of basic electricity.
Industrial effluent	Effluent emanating from industrial use of water.
Legal entity	An individual, company, or organization that has legal rights and obligations.
Low volume treatment system	A wastewater treatment system that treats less than 2000 kilolitres per day and that complies with eThekwini Water and Sanitation guidelines.
Mini sub-development	A development consisting of freehold and sectional title properties within its boundary.

Municipality	The eThekwini municipality, a category A municipality as envisaged in terms of section 155(1) of the Constitution and established in terms of PN343 of 2000 (KZN).
Owner	The person registered in the Deeds Registry as the owner of land, and includes the beneficial owner of the land, and the owner of land by virtue of vesting in terms of any applicable law.
Person	Natural and juristic persons, partnerships, trusts, body corporates, home owners associations and organs of state.

Term	Definition
Premises	Any piece of land, with or without any building or structure thereon where– (a), the external surface boundaries of which are delineated on— (i) a general plan or diagram registered in terms of the Land Survey Act, 1927 (Act No. 9 of 1927), or in terms of the Deeds Registry Act, 1937 (Act No. 47 of 1937; or (ii) a sectional plan registered in terms of the Section Titles Act, 1986 (Act No. 95 of 1986); (b) there is an official document in respect of rural land or Ingonyama Trust land, which is situated within the area of jurisdiction of the Municipality; or a municipal service is rendered on land which is not specified on a plan, and a portion of such land which is not so delineated but which is connected to the sewage system or is capable of being so connected.
Prescribed	Means set by legislation or regulation.
Professional engineer / technologist	A person registered as a professional engineer or technologist in terms of the Engineering Profession Act, 2000 (Act No. 46 of 2000)
Property	a) immovable property registered in the name of a person, including, in the case of a sectional title scheme, a sectional title unit registered in the name of a person; b) a right registered against immovable property in the name of a person; c) a land tenure right registered in the name of a person or granted to a person in terms of legislation; d) public service infrastructure; or any immovable property or a portion thereof of which a person has taken occupation or possession without title: Provided that this in no way infers the granting of permission or the regularisation by the Municipality for the illegal occupation of land or property by any person.
Pump station	An installation that contains sewage pumps, associated motors, electrical and electronic equipment, and a holding tank.

Registered private plumber	(a) A person who has passed a qualifying trade test in plumbing or has been issued with a certificate of proficiency for plumbing in terms of the Skills Development Act, 1998 (Act 97 of 1998), or holds such other qualification as may be required under the National Qualifications Framework Act, 2008 (Act 67 of 2008).
Rising main	Any pipe or conduit which conveys sewage from a pump station to a sewer that operates under gravity.
Sanitation service	The collection, removal, disposal or purification of human excreta, domestic wastewater, sewage and effluent resulting from the use of water for commercial purposes.
Sanitation system	The structures, pipes, valves, pumps, meters or other associated items used in the collection, transport and disposal of excreta and sewage.
Sectional title	Separate ownership of units or sections within a complex or development.
Septic tank	A tank designed to receive and retain sewage for such a time and in such a manner as to ensure adequate decomposition, and which drains to a soak pit and/or an evapotranspiration area as specified in the

Term	Definition
	Building Regulations and the eThekwini Water and Sanitation Unit's guidelines.
Sewage	Wastewater, trade effluent, standard domestic effluent and other liquid waste, either separately or in combination, but excludes stormwater.
Sewer connection	A pipe owned and installed by the Municipality for the purpose of conveying sewage from a drainage installation (drain, soil-water pipe, stack, wastewater pipe, ventilation pipe, antisiphonage pipe, soil-water fitting, wastewater fitting, mechanical appliance or any other appliance or fitting, or a combination of such drain, pipe, stack, fitting and appliance, for the collection and conveyance of sewage) on a premises to a sewer, connecting from a private drain into the sewerage system– a) beyond the boundary of those premises; b) within a servitude area; or within an area covered by a way leave or by agreement.
Sewer	Any pipe or conduit which is the property of or is vested in the Municipality and which may be used for conveying sewage from the connecting sewer, but excludes any drain.
Sewerage system	The structures, pipes, valves, pumps, meters or other associated items used in conveying sewage to a wastewater treatment works.
Shareblock development	A development where a block of shares is allocated to a specific part or parts of the building, the apartment, parking bay, garden, etc.

Sludge	A concentrated stream of solids in liquid generated in wastewater treatment works and low volume treatment systems Organic slurry or solids resulting from storage of excreta in septic tanks, UD toilets and septic tanks.
Stormwater	Water resulting from natural precipitation or accumulation and includes rainwater, subsoil water or spring water.
Surveyor's diagram	A diagram showing existing and/or proposed property boundaries, drawn up by a land surveyor.
Tanker	A vehicle fitted with a pump and a tank which is used to transport the collected material (liquids, sludge, slurries) to a treatment or disposal site.
Trade effluent	Any liquid, whether or not containing matter in solution or suspension, which is given off in the course of or as a result of any industrial, trade, manufacturing, mining or chemical process or any laboratory research or agricultural activity, and includes any liquid other than standard domestic effluent or stormwater.
Urine diversion toilet	A toilet which separates urine and faecal matter through the use of a special pedestal and separate urinal to divert urine to a soak away or to a urine reticulation system in order that only faecal matter collects in a pit or that only faecal matter and grey water is transported in the reticulation system.
Ventilated Improved Pit Latrine	A toilet consisting of an above ground structure with a toilet pedestal, and a pit beneath the structure, which is vented by a pipe, with a fly screen on top. The pit may be unlined, lined and sealed depending on soil conditions.
Term	Definition
Waste	Any material that is or may be suspended, dissolved or transported in water (including sediment) and which is spilled or deposited on land or into a water resource in such volume, composition or manner as to cause, or to be reasonably likely to cause, the water resource to be polluted.
Wastewater treatment works	An installation which treats incoming sewage so that the resulting liquid effluent and solids may be safely disposed of.
Water Services Authority	Any municipality, including a district or rural council as defined in the Local Government Transition Act, 1993 (Act No. 209 of 1993) responsible for ensuring access to water services.
Water Services Intermediary	Any person who is obliged to provide water services to another in terms of a contract where the obligation to provide water services is incidental to the main object of that contract.
Water Services Provider	Any person who provides water services to consumers or to another water services institution but does not include a water services intermediary.

5.2 ACRONYMS

CAB	Community Ablution Block
EWS	eThekwini Water and Sanitation Unit
UD	Urine Diversion
VIP	Ventilated Improved Pit

6. POLICY RULES

6.1 PROHIBITION ON MORE THAN ONE SANITATION SYSTEM PER SITE

If a site is served by waterborne sewerage, no other sanitation system is permitted on the same site. Similarly, if a site is served by septic tanks, no other sanitation system is permitted.

6.2 CONVENTIONAL SEWERAGE, RATED PROPERTIES

(1) Properties capable of being connected to the municipal reticulation system

a) A property is considered as being capable of being connected to the municipal reticulation system when any part of the premises is within 40 metres of a municipal sewer provided that
   i. there are no material hindrances to the municipal sewer being extended to the boundary of the premises.
   ii. the sewer extension can be laid without going across adjoining premises.
   iii. the sewer extension can be carried out at a cost which is reasonable in relation to the tariff amount.

(2) General requirements

a) All Owners of properties able to be connected to the municipal sewerage system must ensure that sewage is disposed of through a connection to the system.

b) Only sewage complying with municipal standards may be disposed to the sewerage system.

c) The design of the private drainage must be approved by the Municipality.

d) The acceptance of an application to connect to the municipal system by the Municipality constitutes an agreement between the Owner and the Municipality.

e) Grey water may be disposed of on site or used for flushing toilets or gardening. The grey water system must be designed by a professional engineer or professional engineering technologist, and be approved by the Municipality.

(3) Privately developed freehold land subdivision

a) The Municipality may provide a sewer connection at its own cost to the boundary of every sub-division which

i. existed in the area of the former Durban Metropolitan Council as at 26 June 1996 (the date on which the Metropolitan Council, by proclamation 80 of 1996 formally became responsible for the sewerage function), or

ii. existed within the area bounded by the former Durban Metropolitan Council boundary and the eThekwini Municipal boundary as at 6 December 2000 (the date on which the Durban Metropolitan Unicity Municipality – subsequently renamed eThekwini Municipality – came into existence).

b) After completion of the development, each freehold land subdivision must have its own connection to the municipal sewerage system.

c) A sanitation agreement will exist for each of the freehold sites.

(4) Sectional title and shareblock developments

a) The Municipality must provide a sewer connection for the development at the boundary of the site.

b) The sectional title body corporate or shareblock company must be responsible for all the internal drainage on the site.

(5) Mini subdevelopments

a) Every common area with a water supply and every freehold property must have an individual connection to the municipal sewerage system.

b) Where a development contains privately owned common areas, there must be access to the sewerage infrastructure on privately owned land and to indemnify the municipality against damage to that infrastructure.

(6) Municipal housing projects

a) The Developer must install, to the Municipality's specifications, the sewerage system, including any pump stations and rising mains, to serve each freehold site in the development.

b) On completion of the sewerage system, the Municipality must take over the system up to each sewer connection point.

(7) Sanitation tariff

a) The Municipality sets a sanitation tariffs each financial year.

b) A sanitation charge must be payable when premises are capable of being connected to the municipal system.

c) A lower tariff is payable for premises with roof tank water supply systems.

d) A connection fee must be payable on application to connect to the municipal system.

e) Owners must pay a monthly volume-based tariff for sanitation. The wastewater volume is calculated as a percentage of the metered water consumption.

f) In special circumstances, owners may apply to the Municipality to have the standard percentages reduced.

g) In the event of an undetected leak in the private water supply system, a reduction in the tariff that is calculated on the basis of the metered water consumption will be made.

6.3 ON SITE SEWAGE DISPOSAL – RATED PROPERTIES

(1) Septic tanks

a) Owners must obtain approval from the Municipality before installing a septic tank system. (b) Only domestic sewage may be discharged into a septic tank system.

b) Owners must be responsible for the construction and maintenance of their septic tank systems, including the disposal of sludge.

c) The Municipality may inspect the Owner's drainage system, and may require improvements to the system. The Owner must be responsible for the costs of any improvements.

(2) Conservancy tanks

a) Owners must obtain approval from the Municipality before installing a conservancy tank.

b) Only domestic sewage may be discharged into a conservancy tank unless special authorisation is given by the Municipality.

c) Owners must be responsible for the construction and maintenance of their conservancy tanks, including the disposal of sewage.

d) Owners must only use tanker companies that are registered with the Municipality to transport sewage or effluent.

(3) Low volume treatment systems

a) Only sewage from properties where the volume of non-domestic effluent from kitchens and laundries is less than 20% of the total may be treated in privately owned systems.

b) All privately owned systems must be approved by the Municipality before construction, and must comply with the Municipality's guidelines. The Developer or the legal entity representing homeowners must provide a financial guarantee as determined by the Head: Water and Sanitation for the performance of the treatment system. The financial guarantee shall be an irrevocable and unconditional written undertaking issued by a registered South African Bank on behalf of the Developer or legal entity as security for system performance, damage or loss caused by the treatment system.

c) The legal entity must be responsible for the construction and maintenance of the system, including the disposal of sludge and all environmental compliance requirements.

d) The Municipality may inspect the treatment system, and may require improvements to the system. The legal entity must pay for any such improvements.

(4) Grey Water reuse systems

a) Owners must obtain approval from an authorised official of the Municipality for the installation of a grey water reuse system.

b) The design of the grey water system must be approved by the Municipality (c) Grey water may only be for outside use or for the flushing of toilets and urinals.

c) A grey water system may not be connected to a yard tap.

d) No wastewater from kitchen sinks or laundry systems may be connected to the grey water system.

e) There must be no possibility of backflow into the potable water system, and no sprays using treated or untreated grey water may be used.

6.4 FREE BASIC SANITATION

a) The Municipality's Indigent Policy defines who is eligible for free basic sanitation.

b) Where households eligible for free basic services connected to the municipal sewerage system consume less than the allowable free basic water allocation, there will be no charge for sanitation.

c) Where households eligible for free basic services are connected to the municipal sewerage system consume more than the allowable free basic water allocation, a sanitation charge will be payable.

d) Where single households have no access to waterborne sanitation and are not serviced by a Community Ablution Block (CAB), the Municipality must provide a urine diversion (UD) toilet. UD toilets must:
   i. Separate urine from faeces.
   ii. Dispose of the urine in a safe and environmentally acceptable manner, either for reuse or into the ground.
   iii. Store the faeces in a pit for later collection and disposal.

e) No UD toilets may be installed at premises with metered water connections.

f) Ventilated improved pit

   Existing ventilated improved pits (VIPs) must be serviced by the Municipality, but no new VIPs will be permitted.

g) Sanitation for informal settlements is provided by a CAB connected to the municipal sewerage or to a septic tank system.

h) The Municipality must provide emergency sanitation when required.

i) The Municipality must deliver a programme to provide health and hygiene information about the use of the sanitation system to householders:
   i. Before the construction of UD toilets
   ii. Before UD toilets or VIPs are emptied
   iii. After UD toilets or VIPs are emptied
   iv. After the construction of CABs

(2) Water Services Providers

a) EWS is the Water Services Provider for the eThekwini area in accordance with the Water Services Act, and is responsible for the installation, operation and maintenance of sanitation services.

b) In terms of the Water Services Act and associated regulations, the Municipality may nominate private WSPs to carry out water and sanitation services in designated portions of the Municipal area. The Municipality may only enter into a contract with a private sector WSP after it has considered all known public sector WSPs which are willing and able to perform the relevant functions.

7. POLICY PROCEDURES

7.1 CONVENTIONAL SEWERAGE, RATED PROPERTIES

(1) Provision of individual sewer connections and provision of waterborne sewerage to sectional title or shareblock developments

a) The Owner or Developer must submit a plan for the internal drainage to the Regional Coordinator, Land Use Management, in the Engineering Unit together with the stipulated fees.

b) The Regional Co-ordinator, Land Use Management, must send the plan to the Regional Coordinator, Development Applications and Approvals, in the Engineering Unit.

c) The Regional Co-ordinator, Development Applications and Approvals, must send the plan to the Regional Engineer, Sanitation Operations, for comments.

d) When the Regional Co-ordinator, Development Applications approves the plan, the Owner appoints a registered private plumber to install the drainage.

e) The Owner or Developer may appoint the registered private plumber to install the connection from the inspection manhole to the municipal sewer. Alternatively, the Owner may pay a prescribed fee to the Municipality to install the connection.

f) On completion of the work, a municipal official mandated by the Regional Co-ordinator, Development Applications and Approvals, inspects the private drainage. If the connection has been installed by the registered private plumber, the connection must be overseen and approved by a municipal official mandated by the Regional Engineer, Sanitation Operations.

g) The internal drainage work must be approved by the Regional Co-ordinator, Development Applications and Approvals.

h) The Owner or Developer must provide the Municipality with as-built drawings.

(2) Provision of sewerage to privately developed subdivisions and mini subdevelopments

a) The Developer or his/her agent must submit a surveyor's diagram and building plans to the Regional Co-ordinator, Land Use Management, in the Engineering Unit

b) The building plans must show full designs for

   i. sewerage reticulation which will be taken over by the Municipality on completion of the development, and

   ii. the internal drainage for each subdivision.

c) The Regional Co-ordinator, Land Use Management, must send the plans to the Regional Co-ordinator, Development Applications and Approvals, in the Engineering Unit.

d) The Regional Co-ordinator, Development Applications and Approvals, must send the plans to the Regional Engineer, Sanitation Operations, for approval.

e) The sewerage plans must be approved by the Regional Engineer, Sanitation Operations.

f) The sewerage reticulation plans must be approved by the Regional Engineer who may issue an A Certificate for the development.

g) The Developer installs the sewerage system.

h) A municipal official mandated by the Regional Engineer, Sanitation Operations, must oversee and approve the connection to the municipal sewerage system.

i) The construction must be approved by the Regional Engineer who will issue a B Certificate.

j) The Owner or Developer must provide the Municipality with as-built drawings.

(3) Provision of sewerage to municipal housing projects

a) The Developer must install, to the Municipality's specifications, the sewerage system, including any pump stations and rising mains, to serve each freehold site in the development.

b) On completion of the sewerage system, the Municipality must take over the system up to each sewer connection point.

c) The Owner or Developer must provide the Municipality with as-built drawings.

(4) Installation of new septic tanks in single properties and new subdivisions

a) The Owner or Developer must submit a design report and plans for the septic tank and drainage to the Regional Co-ordinator, Land Use Management, in the Engineering Unit.

b) The design report and plans must comply with EWS's guideline on septic tanks.

c) The Regional Co-ordinator, Land Use Management, must send the plans to the Regional Co-ordinator, Development Applications and Approvals, in the Engineering Unit.

d) The Regional Co-ordinator, Development Applications and Approvals, must send the plans to the Regional Engineer, Sanitation Operations, for approval.

e) Once the Regional Engineer, Sanitation Operations has approved the plans, the Owner appoints a registered private plumber to install the drainage.

(5) Installation of conservancy tanks

a) The Owner or Developer must submit plans for the conservancy tank and drainage to the Regional Co-ordinator, Land Use Management, in the Engineering Unit.

b) The Regional Co-ordinator, Land Use Management, must send the plans to the Regional Co-ordinator, Development Applications and Approvals, in the Engineering Unit.

c) The Regional Co-ordinator, Development Applications and Approvals, must send the plans to the Regional Engineer, Sanitation Operations, for approval.

d) If a conservancy tank is designed to hold any industrial effluent, Regional Engineer, Sanitation Operations must request a letter from the Senior Manager, Land Use Management, in the Engineering Unit.

e) Once the Regional Engineer, Sanitation Operations has received the letter from the Senior Manager, Land Use Management, and approved the plans, the Owner appoints a registered private plumber to install the drainage.

(6) Low volume treatment systems

a) A professional engineer or professional technologist acting on behalf of the Owner or Developer must apply for permission to install a low volume treatment.

b) The application must be submitted in accordance with EWS's current guideline on Low Volume Treatment Systems.

c) Regional Engineer, Sanitation Operations must approve the plans and may issue an A Certificate for the development.

d) The Developer installs the sewage system including the treatment system.

e) The Regional Engineer must approve the construction, and issue a B Certificate.

f) The Owner or Developer must provide the Municipality with as-built drawings.

g) The Regional Engineer, Sanitation Operations, must inform the Pollution Control Branch of all low volume treatment systems that have been approved.

h) The authorised official from the Pollution and Environment Branch must undertake periodic inspection of the system and sampling of the effluent to monitor compliance with the prescribed effluent standards.

i) The Municipality levies a charge for monitoring.

j) The legal entity's professional engineer / technologist must monitor the operation of the system and submits reports to the Municipality in accordance with the Municipality's requirements.

k) In the event that there is inadequate compliance with the effluent standards, the sum held under the bank guarantee may be used by the Municipality to alter or replace all or part of the installed system.

(7) Grey water reuse systems

Plans for a grey water reuse system must be included with the drainage, septic tanks and conservancy tank plans.

The Area Engineer, Sanitation Operations, must approve the design and construction of grey water reuse systems.

7.2 FREE BASIC SANITATION

(1) On site systems

a) The Sanitation Operations Branch installs UD toilets for households identified by the Deputy Head, Sanitation.

b) The Sanitation Operations Branch appoints service providers to remove and dispose of sludge from UD toilets once every two years.

c) The Sanitation Operations Branch appoints service providers to remove and dispose of sludge from VIP toilets once every five years.

(2) Community ablutions blocks

a) The Sanitation Operations Branch must install CABS for informal settlements identified by the Deputy Head, Sanitation.

b) The Sanitation Operations Branch, must maintain the CABs.

c) The Senior Manager, Special Programs, must appoint a caretaker for every CAB.

(3) Education and information

The Manager, Community Services, must provide health and hygiene education to residents

a) before construction of UD toilets,
b) before and after pit emptying programmes, and
c) before and after construction of CABs.

7.3 WATER SERVICES PROVIDERS

a) The Water and Sanitation Unit's Senior Manager, Commercial and Business, prepares draft contracts between the Municipality and private Water Services Providers. The Manager, Corporate Legal Services will vet the contract. Final approval shall be granted by Council.
b) The Senior Manager, Commercial and Business, monitors all private Water Services Provider contracts.

8. POLICY EVALUATION AND REVIEW

(1) This policy will be monitored by the Deputy Head, Sanitation who must report to the Head, Water and Sanitation annually.

(2) The Head, Water and Sanitation must provide a report annually to Council.

(3) Policy will be reviewed annually.

ANNEXURE C: eThekwini Sewage Disposal By-law, 2016

eThekwini
South Africa

Sewage Disposal By-law, 2016

Published in KwaZulu-Natal Provincial Gazette no. 1763 on 1 December 2016

Commenced on 1 December 2016

[This is the version of this document from 1 December 2016 and includes any amendments published up to 30 May 2022.]

To provide for efficient, affordable, economical and sustainable access to sanitation and sewage services; to provide for different mechanisms of sanitation; to provide for the management and regulation of sewage; to provide assistance to those who cannot afford to pay for sanitation and sewage services; to provide offences and penalties; to provide for the repeal of laws and savings; and to provide for matters incidental thereto.

WHEREAS the eThekwini Municipal Council recognises that effective and sustainable sanitation and sewage services are essential to community life, business and the environment;

WHEREAS the Water Services Act establishes the Municipality as a water services authority and the Municipality‘s Water and Sanitation Unit as a water supply services provider for the Municipality‘s area of jurisdiction;

WHEREAS the eThekwini Municipal Council recognises that, as a water services authority, it has a duty to all customers or potential customers in its area of jurisdiction to progressively ensure efficient, affordable, economical and sustainable access to basic sanitation services;

WHEREAS the eThekwini Municipal Council has competence in terms of Part B of Schedule 4 of the Constitution of the Republic of South Africa, 1996 relating to such matters as sanitation services;

WHEREAS the eThekwini Municipal Council has competence, in terms of section 156(2) of the Constitution of the Republic of South Africa, 1996 to make and administer By-laws for the effective administration of the matters which it has the right to administer;

AND WHEREAS the eThekwini Municipality has a duty to make By-laws for the provision of water services in terms of section 21 of the Water Services Act;

NOW THEREFORE the eThekwini Municipal Council, acting in terms of section 156 read with Part B of Schedule 4 of the Constitution of the Republic of South Africa, 1996 and read with section 11 of the Local Government:

Municipal Systems Act, 2000 (Act No. 32 of 2000), hereby makes the following By-law

Chapter 1

Interpretation

1. Definitions

In this By-law, unless the context indicates otherwise, any word or expression used has the meaning ascribed to it by the National Building Regulations and Standards Act, 1977 (Act No. 103 of 1977), and–

"approved" means approved by an authorised official;

"authorised official" means a person authorised to implement the provisions of this By-law, including but not limited to–

(a) peace officers as contemplated in section 334 of the Criminal Procedure Act, 1977 (Act No. 51 of 1977);

(b) municipal or metropolitan police officers as contemplated in the South African Police Service Act, 1995 (Act No. 68 of 1995); and

(c) such employees, agents, delegated nominees, representatives and service providers of the Municipality as are specifically authorised by the Municipality in this regard: Provided that for the purposes of search and seizure, where such person is not a peace officer, such person must be accompanied by a peace officer;

"best practicable environmental option" means the option that provides the most benefit or causes the least damage to the environment as a whole, at a cost deemed to be acceptable to society by the Municipality, in the long term as well as in the short term;

"borehole" means a hole sunk into the earth for the purpose of locating, abstracting or using subterranean water;

"chemical toilet" means a toilet which uses chemicals to deodorize waste instead of storing it in a hole or piping it away to a sewage treatment plant where the effluent is fit to be disposed of at a municipal wastewater treatment works through a discharge point designed at the facility;

"connecting point" means the point at which a drainage installation joins a connecting sewer;

"connecting sewer" means a pipe owned and installed by the Municipality for the purpose of conveying sewage from a drainage installation on a premises to a sewer–

(a) beyond the boundary of those premises;

(b) within a servitude area; or

(c) within an area covered by a wayleave or by agreement;

"conservancy tank" means a sealed tank that contains and stores sewage from premises and is required to be emptied on a regular basis;

"Constitution" means the Constitution of the Republic of South Africa, 1996;

"Council" means the eThekwini Municipal Council, a municipal council referred to in section 157(1) of the Constitution;

"customer" means–

(a) a person who is supplied with water by the Municipality; and

(b) where water is supplied through a single water meter to a number of persons, the person to whom the Municipality has agreed to supply water;

"drain" means that portion of the drainage installation which conveys sewage within any premises;

"drainage installation" means a system which is used for, or intended to be used for or in connection with, the reception, storage, treatment or conveyance of sewage on any premises to the connecting point and includes–

(a) drains;

(b) fittings;

(c) appliances;

(d) septic tanks;

(e) conservancy tanks;

(f) pit latrines; and

(g) private pumping installations forming part of, or ancillary to, such systems;

"duly qualified sampler" means a person who has been certified by a suitably competent municipal employee to take samples for analysis from the sewage systems, the stormwater disposal systems and from public waters;

"environmental cost" means the full cost of all measures necessary to restore the environment to its condition prior to a damaging incident;

"environmental impact assessment" means the process of identifying and evaluating the effects of development proposals on the environment before decisions and commitments are made toward that development;

"high strength sewage" means sewage with a strength or quality greater than standard domestic effluent;

"French drain" means a trench filled with suitable material which is used for the disposal of–

(a) liquid effluent from a septic tank; or

(b) wastewater;

"metering period" means the time interval between successive meter readings;

"Municipal Manager" means a person appointed in terms of section 54A of the Municipal Systems Act;

"Municipality" means the eThekwini Municipality, a category A Municipality as envisaged in terms of section 155(1) of the Constitution and established in terms of Provincial Notice No. 343 of 2000 (KZN);

"National Building Regulations" means the National Building Regulations made in terms of the

National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977);

"National Water Act" means the National Water Act, 1998 (Act 36 of 1998);

"occupier" means–

(a) any person, including the owner, in actual occupation of premises regardless of the title under which he or she occupies those premises, if any; and

(b) in the case of premises let to more than one tenant, the person who receives the rent payable by the tenants, whether for his or her own account or as an agent for a person entitled to the rent;

"on-site privately-owned sewage disposal system" means either a septic tank, a conservancy tank system or a low-volume sewage treatment plant owned by the owner of the premises on which it is situated;

"owner" means–

(a) the person who is the registered owner of the premises in the relevant Deeds Office;

(b) where the registered owner of the premises is insolvent or dead or is under any form of legal disability whatsoever, the person in whom the administration and control of his or her property is vested as curator, trustee, executor, administrator, judicial manager, liquidator or other legal representative;

(c) where the Municipality is unable to determine the identity of such person, a person who is entitled to the benefit of the use of the premises or a building or buildings on the premises;

(d) where the premises concerned have been leased for a period of 30 years or longer, the lessee of the premises; or

(e) in relation to–

(i) a piece of land delineated on a sectional plan registered in terms of the Sectional Titles Act, 1986 (Act No. 95 of 1986) as common property, the developer or the body corporate in respect of the common property; or

(ii) a section as defined in the Sectional Titles Act, 1986 (Act No. 95 of 1986), the person in whose name such section is registered under a sectional title deed, and includes the lawfully appointed agent of a person;

"person" means any natural person, juristic person, voluntary association or the trustees of any trust;

"premises" means any piece of land, with or without any building or structure thereon where–

(a) the external surface boundaries of which are delineated on#

(i) a general plan or diagram registered in terms of the Land Survey Act, 1927 (Act No. 9 of 1927), or in terms of the Deeds Registry Act, 1937 (Act No. 47 of 1937; or

(ii) a sectional plan registered in terms of the Section Titles Act, 1986 (Act No. 95 of 1986);

(b) there is an official document in respect of rural land or Ingonyama Trust land, which is situated within the area of jurisdiction of the Municipality; or

(c) a municipal service is rendered on land which is not specified on a plan, and a portion of such land which is not so delineated but which is connected to the sewage system or is capable of being so connected;

"prescribed" means as determined by resolution of the Council from time to time;

"public water" means any river, watercourse, bay, estuary, the sea and any other water which the public has a right to use or to which the public has the right of access;

"septic tank" means a tank designed to receive and retain sewage for such a time and in such a manner as to ensure adequate decomposition;

"sewage" means waste water, trade effluent, standard domestic effluent and other liquid waste, either separately or in combination, but excludes stormwater;

"Sewage Disposal By-laws of 1999" means the Durban Transitional Metropolitan Council Sewage Disposal By-law, MN No. 27 of 1999;

"sewage disposal system" means the structures, pipes, valves, pumps, meters or other associated items used in–

(a) conveying sewage through the sewer reticulation system;

(b) treating sewage at the treatment works under the control of the Municipality; and

(c) the disposal of sewage, including sea outfalls;

"sewer" means any pipe or conduit which is the property of or is vested in the Municipality and which may be used for conveying sewage from the connecting sewer, but excludes any drain;

"standard domestic effluent" means domestic effluent which meets strength characteristics relating to chemical oxygen demand and settleable solids as prescribed by the Municipality from time to time as being appropriate to sewage discharges from domestic premises, but excludes trade effluent;

"stormwater" means water resulting from natural precipitation or accumulation and includes rainwater, subsoil water or spring water;

"trade effluent" means any liquid, whether or not containing matter in solution or suspension, which is given off in the course of or as a result of any industrial, trade, manufacturing, mining or chemical process or any laboratory research or agricultural activity, and includes any liquid other than standard domestic effluent or stormwater;

"trade premises" means premises upon which trade effluent is produced;

"**urine diversion toilet**" means a toilet which–

(a) separates urine and faecal matter through the use of a special pedestal and separate urinal to divert urine to soak away in order that only faecal matter collects in the pit; and (b) consists of–

(i) two pits;

(ii) a cover slab;

(iii) a superstructure; and

(iv) a vent pipe to each pit;

"VIP" means a ventilated improved pit latrine;

"Water Services Act" means the Water Services Act, 1997 (Act 108 of 1997);

"working day" means a day other than a Saturday, Sunday or public holiday.

"1 in 50-year flood level" means that level reached by flood waters resulting from a storm of a frequency of one in 50 years; and

"1 in 50-year flood plain" means the area subject to inundation by flood waters from a storm of a frequency of one in 50 years;

2. Interpretation of By-law

If there is a conflict of interpretation between the English version of this By-law and a translated version, the English version prevails.

3. Objects of By-law

The object of this By-law is to regulate sewage disposal in a manner which–

(a) progressively ensures efficient, affordable, economical and sustainable access to sanitation and sewage services;

(b) regulates the duty of customers to pay for sanitation and sewage services;

(c) provides various measures to assist those who are economically unable to meet normal service charges; and

(d) complies with the Water Services Act.

4. Application of By-law

This By-law applies to all areas which fall under the jurisdiction of the eThekwini Municipality and is binding on all persons to the extent applicable.

Chapter 2
General provisions

5. Provision of services to trade premises

A person who wants to construct or cause to be constructed any building or development must, when undertaking an environmental impact assessment, ensure that provision is made for the treatment and disposal of domestic sewage, trade effluent and stormwater.

6. Objectionable discharge

(1) A person may not cause or permit, whether wilfully or negligently, any solid, liquid or gaseous substance other than stormwater to enter any–

(a) stormwater drain, stormwater sewer or excavated or constructed watercourse;

(b) river, stream or natural watercourse or any public water, whether ordinarily dry or otherwise, except in accordance with the provisions of the National Water Act, 1998 (Act No. 36 of 1998);

(c) street; or

(d) premises.

(2) The Municipality may prescribe the minimum standards and criteria dealing with the discharge of sewage or any substance into the sewage disposal system.

(3) A person may not discharge or permit the discharge or entry into the sewage disposal system of any sewage or other substance–

(a) which does not comply with the standards and criteria prescribed by the Municipality;

(b) which–

(i) is offensive;

(ii) has an odour;

(iii) has fats;

(iv) has excessive foam; or

(v) has colour dyes, and may cause an obstruction or public health nuisance in the inflow of any treatment works;

(c) which contains any substance in such concentration as will produce or is likely to produce any offensive or otherwise undesirable taste, colour, odour, obstruction or any foam in the final treated effluent–

(i) at any treatment works;

(ii) at any sea outfall discharge point; or

(iii) in any public water;

(d) which may prejudice the re-use of treated sewage or adversely affect any of the processes by which sewage is purified for re-use or treated to produce sludge for disposal; (e) which contains any substance or thing which–

(i) is not amenable to treatment to a satisfactory degree at a treatment works; or

(ii) causes or is likely to cause a breakdown, pass-through or inhibition of the treatment processes in use at such works with the exception of an electrical conductivity below 95 mS/m at the head of the treatment works;

(f) which contains any C.O.D, substance or thing which is of such strength or nature, or which is amenable to treatment only to a limited degree, and will result in effluent from the treatment works or discharge from a sea outfall being unable to comply satisfactorily with any requirements of or under the National Water Act;

(g) which may–

(i) cause danger to the health or safety of any person;

(ii) be injurious to the structure or materials of the sewage disposal system; or

(iii) prejudice the use of any ground used by the Municipality for the sewage disposal system, other than in compliance with any permission issued in terms of this By-law; or

(h) which may inhibit the unrestricted conveyance of sewage through the sewage disposal system.

(4) No trade effluent may be allowed to enter a septic tank or a French drain.

(5) A person may not cause or permit any stormwater to enter the sewage disposal system.

(6) An authorised official may, by written notice, order the owner or occupier of any premises to conduct, at his or her own cost, periodic expert inspections of the premises in order to identify precautionary measures which would ensure compliance with this By-law and to report such findings to an authorised official.

(7) An authorised official may by written notice order the owner or occupier of any premises to execute, at his or her own cost, any precautionary measures required by the Municipality to prevent any contravention of the provisions of this By-law.

(8) An authorised official may, by written notice, order a person who breaches this By-law or condition imposed in terms of this By-law to remedy such breach within a period specified in the notice at the persons own cost.

(9) If any person contravenes any provision of subsection (1) or (3), he or she must within 12 hours advise an authorised official of the details of the contravention and the reasons for it.

Chapter 3
Use of sewage disposal system

7. Agreement to provide services

Subject to any applicable law an authorised official may enter into an agreement with any person on behalf of the Municipality to provide a sewage disposal service.

8. Application for use of sewage disposal system

(1) A person wishing to use the sewage disposal system must make application to the Municipality in the form required, accompanied by such information as the Municipality may require from time to time.

(2) An application for the use of the sewage disposal system which has been granted by the Municipality constitutes an agreement between the Municipality and the customer.

(3) The owner is liable for all the prescribed fees in respect of the use of the sewage disposal system granted to him or her until the agreement between the Municipality and the owner is terminated.

(4) Where premises have been connected to the sewage disposal system, or are reasonably capable of being so connected, it must be deemed for the purpose of this By-law that an agreement in terms of subsection (1) exists.

9. Special agreements for disposal of sewage

(1) The Municipality may enter into a special agreement for the disposal of sewage with a person–

(a) inside the area of jurisdiction of the Municipality, if the disposal necessitates the imposition of conditions not contained in this By-law; or

(b) outside the area of jurisdiction of the Municipality.

(2) A special agreement must be subject to any resolution passed by an authorised official.

(3) If the Municipality, in terms of a special agreement, provides a means of disposal of sewage to a person outside the area of jurisdiction of the Municipality, it may permit him or her to accept sewage for eventual disposal by the Municipality from other persons outside the area of jurisdiction of the Municipality, subject to such conditions as the Municipality deems fit.

10. Termination of agreement

A person may terminate an agreement referred to in section 8 or 9 by giving the Municipality not less than five working days‘ notice in writing of his or her intention to do so: Provided that the authorised official is satisfied with the manner in which sewage arising from the premises will be disposed of on the termination of the contract.

11. Provision of connecting sewer

(1) In the event that–

(a) an agreement for the use of the sewage disposal system in accordance with section 8 or 9 exists; and

(b) no connecting sewer exists in respect of the premises, the owner or his or her agent must immediately make application on the prescribed form and pay the prescribed charge for the installation of a connecting sewer.

(2) If an application is made for use of the sewage disposal system for premises which are so situated that it is necessary to extend the sewer in order to connect the sewage disposal system to the premises, an authorised official may agree to the extension subject to such conditions as he or she may impose.

(3) An authorised official may agree, at the request of any person and subject to such conditions as the authorised official may impose, to a connection to a sewer other than that which is most readily available for the drainage of the premises: Provided that the applicant must be responsible for–

(a) any extension of the drainage installation to the connecting point designated by an authorised official; and

(b) obtaining at his or her cost, such servitudes over other premises as may be necessary.

(4) A connecting sewer provided and installed by the Municipality must– (a) be located in a position determined by an authorised official;

(b) terminate–

(i) at a connection point approximately one metre inside the premises from the boundary of the land owned by or vested in the Municipality or over which it has a servitude or other right; or

(ii) when subsection (3) applies, at the connecting point designated in terms of that subsection; and

(c) be of a size determined by an authorised official.

(5) An owner or his or her agent must pay the connection charge prescribed by the Council.

(6) Where an owner or his or her agent is required to provide a sewage lift as contemplated in the National Building Regulations, the rate and time of discharge into the sewer are subject to the approval of an authorised official.

12. Acceptance of sewage delivered by road haulage

(1) An authorised official may, and subject to such conditions as he or she may specify, accept sewage for disposal delivered by road haulage to a specified treatment works facility of the Municipality.

(2)

(a) A person may not discharge sewage into the facilities of the Municipality by road haulage, except with and in terms of the written permission of an authorised official.

(b) The charges for any sewage delivered for disposal to any Municipal facility must be assessed by an authorised official in accordance with the charges prescribed from time to time in terms of section 28.

(3) When delivery is by road haulage, the–

(a) time of delivery must be arranged with an authorised official; and

(b) nature and composition of the sewage must be established to the satisfaction of an authorised official prior to the discharge thereof,

Provided that a person may not deliver sewage which does not comply with the standards laid down in accordance with this By-law.

(4) An authorised official may withdraw any permission to discharge sewage delivered: Provided that

14 days written notice is given to the permit holder, if the permit holder–

(a) fails to ensure that the sewage so delivered conforms to the standards prescribed in

Schedule "A" or "B", as applicable, or in the permit;

(b) fails or refuses to comply with any notice lawfully served on him or her in accordance with this By-law or contravenes any provisions of this By-law or any condition imposed on him or her in terms of any permission granted to him or her; or

(c) fails to pay the assessed charges in respect of any sewage delivered.

Chapter 4
Levels of supply: households and informal settlements

13. Levels of supply of sanitation to households

(1) The sanitation provided to domestic households must be in the form of one of the following methods:

(a) a privately owned urine diversion toilet;

(b) if a municipal waterborne sewerage reticulation system is available, connection to such system; or

(c) if a municipal waterborne sewerage reticulation system is not available, an on-site privately-owned sewage disposal system. (2)

(a) The sanitation must match the available water supply to the premises concerned.

(b) Where–

(i) water supply to a household is limited to 300 litres per day via a ground tank or yard tap, sanitation must be provided in the form of a urine diversion toilet or an alternative approved by an authorised official; and

(ii) either a semi-pressure supply or a full pressure water supply is provided by the Municipality, sanitation must be provided in the form of the municipal waterborne sewerage reticulation system or an on-site privately-owned sewage disposal system.

(3)

(a) The Municipality may prescribe that a particular sanitation method must be applied in a particular area.

(b) Any form of sanitation other than that prescribed for an area as contemplated in paragraph

(a) may be used only with the permission of an authorised official: Provided that the–

(i) sanitation method matches the level of available water supply;

(ii) sanitation method is implemented by the householder; and

(iii) water supply system is able to sustain the level of water demand.

(4) The following sanitation methods for domestic households are not permitted without an authorised official's consent, which may only be granted under exceptional circumstances:

(a) night soil pail;

(b) a simple, unimproved pit latrine; and

(c) a conventional VIP or chemical toilet.

14. Sanitation of informal settlements

(1) Sanitation to informal settlements must be provided by means of either–

(a) an ablution block connected to the municipal waterborne sewerage reticulation system; or

(b) a toilet block where no connection to the municipal waterborne sewerage reticulation system is available: Provided that each toilet must be equipped with its own VIP pit which must be emptied as and when required.

(2) The minimum level of access to sanitation provided in informal settlements must be an ablution block or toilet block within 200 metres of every household.

Chapter 5
Drainage installation

15. Drains in streets or public places

A person may not, for the purpose of conveying sewage, construct a drain on, in or under a street, public place or other land owned by, vested in, or under the control of the Municipality, except with the prior written permission of an authorised official and subject to such conditions as he or she may deem fit.

16. Construction by Municipality on private premises

(1) The Municipality may, by agreement with the owner of any premises, construct drains on those premises at the cost of the owner.

(2) When agreeing with the owner of premises to construct drains on those premises, a term of the agreement must be that the owner will be liable for the full cost of construction as certified by an authorised official, either in advance or on demand.

17. Maintenance of drainage installation

(1) In the event that the owner or occupier of any premises fails to–

(a) provide a drainage installation and a sewer connection; or

(b) keep the drainage installation on those premises in proper working condition, the Municipality may itself carry out any necessary work on the premises, and recover the full cost thereof from the owner or occupier.

(2) Any person who requests that a drainage installation be cleared by the Municipality is liable to pay the fee as prescribed.

(3) An authorised official may, on the written application of the owner or occupier of any premises, inspect and test the drainage installation of such premises or any section

of the installation and recover from the owner or occupier the cost of such inspection and test, calculated at the rate specified in the prescribed tariff of charges.

18. Installation of pre-treatment facility

(1) Pre-treatment facilities must satisfy the requirements of the National Building Regulations and Building Standards Act, and must be provided in accordance with SANS 10400-P.

(2) Where necessary an authorised official, in his or her discretion, may require that new premises be provided with such additional pre-treatment facility of a type specified by him or her prior to such premises being connected to the sewage disposal system.

19. Protection from ingress of floodwaters

Where premises are situated in the 1 in 50-year flood plain, the top level of manholes, inspection chambers and gullies must be placed above the 1 in 50-year flood level, except in the case of manholes and inspection chambers, where the cover is secured in place by means approved by an authorised official.

Chapter 6
Developments

20. Sewage disposal in sectional title developments

(1) The developer of a new sectional title development must, at his, her or its own cost, construct an approved sewage reticulation system, including any pump-stations and rising mains, which is adequate to serve each household and any common areas as required.

(2) Where the municipal waterborne sewage reticulation system is available to serve the development, the developer must at his, her or its own cost connect the internal sewage reticulation system to the municipal reticulation system.

(3) Where the municipal waterborne sewage reticulation system is not available to serve the development, the developer must install a suitable on-site privately-owned sewage disposal system.

21. Sewage disposal to mini-sub developments

(1) The developer of any new mini-sub development is required to construct, to the specifications of the Municipality, a sewage reticulation system, including any pump-stations and rising mains, to serve each freehold site and any common areas as required.

(2) Where the municipal waterborne sewage reticulation is available to serve the development, the developer must connect the internal sewage reticulation system to the municipal reticulation system.

(3) The Municipality may take over the reticulation, up to the connection point, at no cost to the

Municipality once–

(a) the sewage reticulation system has been completed to the satisfaction of the Municipality; and

(b) a complete set of as-built drawings have been received from the developer.

(4) Where the municipal waterborne sewage reticulation is not available to serve the development, the developer may investigate the provision of a suitable on-site privately owned sewage disposal system, subject to the home owner‘s association fulfilling its obligations as water services provider or water services intermediary.

Chapter 7
Privately-owned sewage disposal systems

22. Septic tanks

Septic tank systems must be designed in accordance with SANS 10400-P, or by a competent person as defined therein, to satisfy the requirements of Part P of the National Building Regulations and Building Standards Act.

23. Conservancy tanks

(1) A conservancy tank may only be installed on premises with the prior permission of an authorised official, which will only be granted in exceptional circumstances.

(2) If permission for a conservancy tank on premises is granted in areas where there is municipal waterborne sewerage, the following conditions apply: (a) the conservancy tank must–

(i) satisfy the requirements set out in Part P of the National Building Regulations and Building Standards Act; and

(ii) be designed in accordance with SANS 10400-P, or by a competent person as defined therein;

(b) the scale of the proposed development must be limited;

(c) the authorised official must be satisfied that adequate arrangements have been made for the required emptying service; and

(d) for a–

(i) domestic application, the conservancy tank must have a minimum capacity of 7000 litres and a minimum retention capacity for seven days; and

(ii) non-residential application, the conservancy tank must have a minimum capacity sufficient to hold four days retention of the potential flow generated.

24. Privately-owned sewage treatment plant

(1) A–

(a) privately-owned sewage treatment plant may only be installed on premises; and

(b) privately-owned low volume domestic sewage treatment plant may only be installed on domestic premises, with the prior permission of an authorised official, which will only be granted in exceptional circumstances.

(2) If permission for a privately-owned low volume domestic sewage treatment plant on domestic premises is granted, the following conditions apply:

(a) the plant must comply with the eThekwini guideline document: Package Plants for The

Treatment of Domestic Wastewater, as published and amended from time to time;

(b) the developer must appoint a professional engineer at the commencement of the project and such professional engineer–

(i) is responsible for the design and selection of the plant;

(ii) must supervise the construction, installation and commissioning of the plant; and

(iii) is responsible for the operational control, monitoring and maintenance of the plant for a period of five years in terms of a service contract to the satisfaction of an authorised official; and

(c) the developer must lodge a financial guarantee with the Municipality in an amount equal to 1,5 times the total cost of the plant for a period of five years.

(3) The Municipality may prescribe additional requirements for privately-owned low volume domestic sewage treatment plants.

(4) If the discharge from a privately-owned low volume domestic sewage treatment plant does not comply with the General Limit Values as set by the Department of Water Affairs and Forestry's General Authorisations in terms of Section 39 of the National Water Act, an authorised official

may instruct the owner of such plant to discharge into an approved municipal facility on such conditions as an authorised official may prescribe.

(5) If it becomes apparent that a privately-owned low volume domestic sewage treatment plant does not meet the discharge standards set by the Department of Water Affairs as in subsection (4) above, an authorised official may instruct the owner of the plant to remove and replace the plant at his or her own cost.

Chapter 8
Trade effluent

25. Permission to discharge trade effluent

(1) A person may not discharge, cause or permit to be discharged into the municipal sewage disposal system any trade effluent, except in terms of permission granted in accordance with–

(a) this By-law;

(b) any conditions relating to the permission granted; and

(c) any standards and criteria prescribed by an authorised official from time to time.

(2) Any application for permission to discharge trade effluent into the sewage disposal system must be made in accordance with the requirements stipulated by an authorised official and against payment of the prescribed fee.

(3) An authorised official may grant an applicant permission to discharge trade effluent into the municipal sewage disposal system if, in his or her opinion, there is sufficient capacity in the sewage disposal system to permit the–

(a) conveyance;

(b) effective treatment; and

(c) lawful disposal, of the additional trade effluent.

(4) The person to whom permission has been granted in terms of this Chapter shall ensure that no trade effluent is discharged into the sewage disposal system unless it complies with the standards and criteria set out in Schedules "A" and "B" hereto.

(5) In granting permission to discharge effluent into the municipal sewage disposal system, an authorised official may–

(a) specify the duration of the permission;

(b) impose any conditions in addition to those which may be prescribed by an authorised official; and

(c) relax or vary the standards set up in Schedules "A" and "B" or any conditions prescribed by an authorised official if he or she is satisfied that any relaxation or variation is the best practicable environmental option taking into account the following factors:

(i) whether the applicant‘s plant is operated and maintained at optimal levels;

(ii) whether the technology used by the applicant represents the best available technology to the applicant‘s industry and, if not, whether the installation of such technology would entail unreasonable cost to the applicant;

(iii) whether the applicant is implementing a programme of waste minimisation which complies with waste minimisation or management standards prescribed in terms of applicable legislation;

(iv) the cost to the Municipality of granting the relaxation or variation; and

(v) the environmental impact, or potential impact, were the relaxation of variation to be granted and in doing so must apply a risk-averse and cautious approach.

(6) A duly qualified sampler may take test samples at any time to ascertain whether the trade effluent complies with the provisions of this By-law and any standard or condition prescribed by the permit from time to time.

(7) The authorised official may in the permit or at any time, by written notice, require a permit holder to–

(a) subject trade effluent to any preliminary treatment that, in the opinion of the authorised official, ensures that such effluent conforms with this By-law and any standard or condition prescribed by the authorised officer, and in Schedules "A" and "B" before being discharged into the municipal sewage disposal system;

(b) install equalising tanks, valves, pumps, appliances, meters and other equipment as, in the opinion of the authorised official, is necessary to control the rate and time of discharge into the sewage disposal system in accordance with the conditions imposed on the permit holder;

(c) install for the conveyance of his or her trade effluent into the sewage disposal system at a given point, a drainage installation separate from the drainage installation for waste water and standard domestic effluent, and may prohibit such permit holder from disposing of his or her–

(i) trade effluent at any other point; and

(ii) waste water and standard domestic effluent by means other than into a sewage disposal system;

(d) construct on any pipe conveying his or her trade effluent to any sewer, a manhole or stopvalve in such position and of such dimensions and materials as the authorised official may require;

(e) provide all such information as may be required by the authorised official to enable him or her to assess the charges due to the Municipality in accordance with this Bylaw;

(f) provide adequate facilities to prevent a discharge into the sewage disposal system which is in contravention of the provisions of this By-law, including but not limited to level or overflow detection devices, standby equipment, overflow catchpits or other appropriate means;

(g) cause any meter, gauge or other device installed in terms of this section to be calibrated by an independent authority at the cost of the permit holder at times laid down by the authorised official, and to forward copies of the calibration certificate to him or her; and

(h) cause his or her trade effluent to be analysed as often and in such manner as may be prescribed by the authorised official, and to provide the Municipality with returns of these tests when completed.

(8) The owner or occupier of any premises must at his or her own cost install precautionary measures to prevent the contravention of any provision of this By-law as contemplated in any guidelines set out by the Municipality relating to the approval of building plans, which include but are not limited to the following:

(a) installing an impermeable containing structure or bund around all liquid containers with a volume not less than the volume of the largest liquid container therein; and

(b) ensuring all containing structures are roofed with gutters to ensure that clean stormwater run-off is directed to the stormwater drainage system.

(9) The authorised official may grant a relaxation of the requirements set out in subsection (8) if the permit holder applies for such relaxation in writing and is able to–

(a) prove that there would be no increased risk to the environment; and

(b) demonstrate what other provisions he or she would put in place to minimise the risk.

(10) In the event of failure or a faulty recording meter or other device, the volume must be assessed by such means as an authorised official may decide.

(11) The cost of any treatment, plant, works or analysis which the permit holder may be required to carry out, construct or install in accordance with subsection (7) must be borne by the permit holder concerned.

(12) A permit holder must obtain the written permission of the authorised official for any proposed changes to the composition of trade effluent discharged into the sewage disposal system.

(13) If a permit holder discharges into the sewage disposal system any trade effluent which does not comply with the permit issued in respect of that process or premises, the permit holder or his or her agent must, within 12 hours of the discharge, notify an authorised official of the incident and the reasons for it.

(14) The authorised official may withdraw any permission to discharge trade effluent into the sewage disposal system if the permit holder–

(a) fails or refuses to comply with any notice lawfully served on him or her in terms of this Bylaw or contravenes any provisions of this By-law or any condition imposed on him or her in terms of any permission granted to him or her;

(b) fails to pay the assessed charges in respect of any trade effluent discharged; or

(c) fails to ensure trade effluent quality complies with Schedules "A" and "B", : Provided that the permit holder must be given 14 days written notice.

(15) If the authorised official withdraws permission to discharge trade effluent, he or she may–

(a) in addition to any steps prescribed in this By-law, and on 14 days written notice served on the permit holder, authorise the closing or sealing of the connecting sewer of the premises concerned to any sewer for such charge as may be prescribed by the authorised official; and

(b) continue to refuse to accept any further trade effluent from the permit holder until he or she is satisfied that the permit holder concerned has taken adequate steps to ensure that the trade effluent to be discharged conforms with the standards prescribed in this By-law.

(16) If the authorised official authorises the reopening of the connection or seal after it being closed, the permit holder is liable for the charge in terms of the prescribed charges.

(17)

(a) If it comes to the attention of the authorised official that a person is discharging trade effluent which has the potential, if allowed to continue, to seriously damage the sewage disposal system or the environment, he or she may immediately authorise the sealing of the sewer connection through which the trade effluent is being discharged.

(b) A person may not permit the opening of the connection contemplated in paragraph (a) until an authorised official is satisfied that the trade effluent will comply with the prescribed standards.

(18) The provisions of this section apply equally to trade effluent discharged into any of the sea outfalls of the Municipality, subject to applicable legislation, and further subject to the following provisions:

(a) where trade effluent is accepted for discharge into a sea outfall, it must be delivered to the point of acceptance approved by the authorised official by means of a pipeline constructed and maintained by the permit holder at his or her own expense;

(b) no trade effluent may be accepted for discharge into a sea outfall unless it complies with the standards and criteria set out in Schedule "B";

(c) trade effluent may not be accepted for discharge into a sea outfall unless it, whether alone or in combination with other substances, can be demonstrated to the satisfaction of the authorised official not to be toxic to marine fauna or flora and not to contain any–

(i) other constituents in concentrations which–

(aa) can create a nuisance on the beaches or in the sea, or a health hazard; or

(bb) may have an adverse effect on bathing or other recreational areas;

(ii) floating material;

(iii) substance which may be prejudicial or injurious to the sea outfalls of the

Municipality and associated sumps, sewers, plant and equipment or to its employees;

(iv) materials capable of creating a nuisance by frothing; and

(v) standard domestic effluent;

(d) subject to the provisions of subsection (c), the authorised official may, in writing in the permission concerned, relax or vary the standards and criteria prescribed by Schedule "B";

(e) the delivery pipeline from the premises concerned to the point of acceptance must be maintained in a proper condition and free from all leaks;

(f) acceptance of the trade effluent must be subject to periodic review: Provided that such review may be made at any time if, in the opinion of the authorised official, special circumstances which may include but is not limited to, the pollution of the sea or beaches, the killing of fish, or other incidents, arise as a result of the acceptance thereof into a sea outfall;

(g) a suitable sampling point to the satisfaction of the authorised official must be provided by the permit holder in respect of the trade premises concerned;

(h) the above mentioned sampling point shall be labeled to the satisfaction of the authorised official; and

(i) the authorised official must be notified of any proposed changes in the process of manufacture or in the quantity or nature of the materials used which is likely to affect the nature, composition or quantity of the trade effluent discharged: Provided that the permission of the authorised official must be obtained for the continued discharge of such effluent.

Chapter 9
Payment for services

26. Payment for use of sewage disposal system

(1) Payment for the use of the sewage disposal system must be made–

(a) in accordance with the prescribed tariff for the disposal of sewage;

(b) in terms of a special agreement entered into between the Municipality and a person in terms of section 9; or

(c) in terms of some other means as prescribed by the authorised official.

(2) Payment is due and payable on the due date stipulated in the account.

27. Trade effluent charge when sewage rates applied

When the charge for the use of the sewage disposal system is by means of sewage rates and a person holds a permit for the discharge of trade effluent in excess of the prescribed minimum volume of 'T' kilolitres per month, the permit holder is liable to charges in addition to that levied by means of sewage rates, calculated in accordance with section 28.

28. Trade effluent charges

The Municipality may prescribe trade effluent charges and amend such charges as it deems necessary.

29. Sewage disposal charge when tariff rates applied

When a charge for the use of the sewage disposal system is by means of prescribed tariff rates, charges for standard domestic effluent become payable by the customer when a premises–

(a) is connected to the sewage disposal system or is reasonably capable of being so connected; or
(b) receives a supply of water from the Municipality.

30. Trade effluent charge when tariff rates applied

(1) A person who holds a permit for the discharge of trade effluent in excess of the prescribed minimum volume of 'T' kilolitres per month, is liable for a minimum charge per kilolitre of trade effluent which is equivalent to the charge for the disposal of standard domestic effluent.

(2) In addition to the provisions of subsection (1), a permit holder who discharges a trade effluent with a strength or quality greater than standard domestic effluent is liable for an additional charge in respect of high strength sewage calculated in accordance with the provisions of section 28.

31. Volume of standard domestic effluent determined for payment purposes

(1) The volume of standard domestic effluent must be determined–

(a) by a percentage of water supplied by the Municipality in accordance with any prescribed procedures;

(b) on an assessment made by the authorised official based on criteria such as the number of employees at a premises, the number of shifts worked, number of meals served and the like; or

(c) where premises are supplied with water from a source in addition to the water supply system of the Municipality, by river abstraction or partially or wholly by a borehole, on an assessment made by the authorised official based on such criteria as he or she deems relevant.

(2) Notwithstanding the provisions of subsection (1)(a), where the authorised official is of the opinion that the percentage applicable in respect of specific premises is excessive, having regard to the purposes for which water is consumed on those premises, he or she may reduce the percentage applicable to those premises to a figure which, in his or her opinion and in the light of information then available, more realistically reflects the proportion between the likely volume of sewage discharged from the premises and the quantity of water supplied thereto.

32. Volume of trade effluent determined for payment purposes

The volume of trade effluent discharged into the sewage disposal system or to sea outfalls must be determined in the following ways:

(a) where direct measurements of the volume of trade effluent discharged from a premises are made, such volume must be used for the purposes of calculating the amount payable;

(b) where no direct measurement of the volume of trade effluent discharged from the premises are made, then the volume must be determined as a percentage of water supplied by the Municipality in accordance with procedures prescribed by the Municipality;

(c) where premises are supplied with water from a source in addition to the Municipality's water supply system, by river abstraction or partially or wholly by a borehole, the volume must be assessed by the authorised official based on such criteria as he or she may deem relevant; and

(d) where a portion of the water supplied to a permit holder forms part of the end product of any manufacturing process or is lost by reaction or evaporation during the manufacturing process or for any other reason, the authorised official may, in his or her sole discretion, on application by the permit holder, reduce the assessed volume of trade effluent.

33. Other charges

(1) Notwithstanding anything to the contrary contained in this By-law, the authorised official may prescribe and levy the following charges:

(a) a charge payable by any person in respect of a minimum volume of sewage;

(b) a charge payable by any person in the form of a general surcharge on the prescribed charges for use of the sewage disposal system in the event that there is any prohibition or restriction in the consumption or use of water;

(c) a charge for the recovery of costs incurred by the Municipality for trade effluent control and monitoring of permit holders who dispose of trade effluent into the sewage disposal system;

(d) a charge payable by a person who disposes of an objectionable discharge as referred to in section 6 for the recovery of full costs incurred by the Municipality in tracing the source of such objectionable discharge and in remedying the effects thereof: Provided that such full cost must include the environmental cost; (e) a charge payable by any person at–

(i) the applicable prescribed tariff rate; or

(ii) if no tariff has been prescribed, the full cost for any other service rendered or goods sold;

(f) additional charges for any charges relating to water quality that may be levied by the national government;

(g) a charge payable by any person who exceeds the discharge limits as set out in Schedules "A" and "B"; and

(h) charges in respect of the estimated volume of storm water discharged into sewer by the owner of any premises where storm water infiltration into the sewerage reticulation has been found: Provided that the volume of storm water entering the sewer system must be estimated by the authorised official.

(2) No person must establish or operate an industry or a commercial undertaking, producing waste or water containing waste in an area zoned for residential purposes.

34. Payment of deposit

(1) The authorised official may require any person to deposit with the Municipality a sum of money representing the cost of sewage disposal charges which in his or her opinion would be incurred by the person during a period specified by the Municipality.

(2) A deposit contemplated in subsection (1) must accompany the application submitted in accordance with section 8 or subsection (1).

(3) A deposit paid in accordance with subsection (1) may not be regarded as being in payment or part payment of a current account due for the disposal of sewage.

(4) Subject to the Credit Control and Debt Collection By-law the Municipality may, by notice in writing, require the person concerned to increase the deposit by an amount specified in such notice.

(5) Subject to the Credit Control and Debt Collection By-law the Municipality may of its own accord, or at the request of a customer, reduce the amount of a deposit or a guarantee required by him or her if the Municipality is satisfied that the reduction is justified by– (a) the present level of sewage disposal charges to the customer; or

(b) a change in the circumstances pertaining to the assessment of the original amount of the deposit or guarantee.

35. Reduction of amount payable if water wasted or leakage undetected

(1) A person is entitled to a reduction of the amount payable for the disposal of sewage in the event that the water meter readings upon which the charge is calculated include any period during which–

(a) water was wasted; or

(b) a leakage was undetected, : Provided that the customer demonstrates to the satisfaction of the authorised official that the water was not discharged into the sewage disposal system.

(2) The amount payable for the disposal of sewage may be reduced by an amount based on the volume of standard domestic effluent calculated from the volume of potable water lost through leakage or wastage during the leak period.

(3) The leak period must be either the metering period immediately prior to the date or repair of the leak or the metering period during which the leak is repaired, whichever results in the greater reduction of the amount payable.

(4)

(a) The volume of lost water must be calculated as the consumption for the leak period less an average consumption, based on the preceding three months, for the same length of time.

(b) If–

(i) there is no previous consumption history existing; or

(ii) the average consumption is not considered representative by the authorised official, the average water consumption is that amount determined by him or her, after due consideration of all relevant information.

(c) There may be no reduction of the amount payable as a result of a loss of water directly or indirectly caused by or resulting from–

(i) subsidence or landship;

(ii) refilling of swimming or other pools or ponds, whether following leakage or otherwise;

(iii) the deliberate act of the person who has suffered such loss or any person acting on his or her behalf if such act results in loss of water; or

(iv) water installations that do not conform to any installation guidelines of the Municipality.

36. Amendments to amount payable

If, for any reason, a person liable under this By-law is–

(a) not charged at all; or

(b) charged for sewage at a rate lower than that for which he or she is liable, he or she may not be absolved from payment, and must on demand remit all sums due to the Municipality, calculated in accordance with the provisions of this By-law.

37. Amendments to prescribed charges

Where amendments to the prescribed tariff rates for disposal of sewage become operative on a date between meter readings, the customer must pay charges calculated on the same quantity of sewage as was disposed of in each period of 24 hours during the interval between meter readings.

Chapter 10
Protection of sewage disposal system

38. Trespassing on sewage disposal system

Except with the prior authority of the authorised official, a person may not enter–

(a) upon an area used for the purpose of the sewage disposal system which is enclosed by a fence or where entry is prohibited by notice boards; or

(b) a structure used by the Municipality in connection with its sewage disposal system.

39. Interference with sewage disposal system

Except with the prior authority of the authorised official, a person may not–

(a) interfere or tamper with the sewage disposal system except under the provisions of section 43;
(b) make a connection to the sewage disposal system except under the provisions of section 11; or

(c) construct a building or raise or lower the ground level within an area that is subject to a sewer servitude.

40. Damage to sewage disposal system

(1) A person may not damage or endanger the sewage disposal system, or cause or permit it to be damaged or endangered.

(2) A person who intends performing work which may cause damage to the sewage disposal system on land owned by or vested in the Municipality or over which it has a servitude or other right must, prior to commencement of such work, ascertain from the Municipality whether any part of the sewage disposal system is situated on the land.

(3) If work, which in the opinion of the authorised official could damage or endanger the sewage disposal system, is to be performed or is being performed on land contemplated in subsection (2), or on land adjacent thereto, he or she may by notice in

writing require the person concerned not to commence, or to cease performing, the work until such time as he or she has complied with the conditions specified in the notice.

41. Consequential maintenance of sewers

Whenever a sewer is damaged or becomes obstructed or in need of repair as a result of the act or omission of any person, whether by reason of the failure of such person to comply with the requirements of this By-law or otherwise, the authorised official may–

(a) carry out such work, maintenance or repair as the authorised official considers necessary; or

(b) remove the obstruction, at the expense of such person and recover from that person the full cost of doing so.

42. Obstruction of access to sewage disposal system

(1) A person may not prevent or restrict access to the sewage disposal system.

(2) In the event that a person contravenes the provisions of subsection (1), the authorised official may–

(a) by written notice require the person to restore access at his or her own cost within a specified period; or

(b) if he or she is of the opinion that the situation is a matter of urgency, without prior notice restore access and recover the full cost of doing so from the person.

43. Work by private persons

(1) The authorised person or his or her agents must lay all sewers and connecting sewers unless it elects not to do so, in which case the work shall be executed in accordance with the Municipality‘s conditions of contract applicable to the work and the provisions contemplated in subsection (2).

(2) If the authorised official elects to allow another person to lay a sewer or connecting sewer, the work must be done in accordance with the standards and procedures approved by the Municipality for such work, including the following provisions:

(a) any person carrying out work must, prior to commencement of such work, lodge with the authorised official a written indemnity to the satisfaction of the authorised official, indemnifying the Municipality against all liability in respect of any accident or injury to persons or loss or damage to property which may occur as the direct or indirect result of the execution of such works;

(b) where a connection is to be made with any sewer, it must be made at a point indicated by the authorised official;

(c) whenever the surface of any street or road has been disturbed in the course of work, the restoration of the surface of the street or road must be undertaken solely by the Municipality at the expense of the person carrying out such work; and

(d) before disturbing the surface of any street or road, a deposit must be made with the Municipality which in the opinion of the authorised official is sufficient to cover the estimated cost of restoration: Provided that when the actual cost is greater or less than the amount deposited, any–

(i) excess must be recoverable from such person; or (ii) balance must be refunded to him or her.

(3) All work must be carried out in accordance with the requirements, and to the satisfaction of, the authorised official.

Chapter 11
Enforcement

44. Entry by authorised official

(1) An authorised official may for any purpose connected with the implementation or enforcement of this By-law, at all reasonable times or in an emergency at any time–

(a) enter premises;

(b) request information;

(c) take samples; and

(d) make such inspection, examination and enquiry and carry out work,

as he or she may deem necessary, and for those purposes operate any component of the drainage installation.

(2) If an authorised official considers it necessary that work be performed to enable him or her to properly and effectively implement a function contemplated in subsection (1), he or she may–

(a) by written notice require the owner or occupier of the premises at his or her own cost to do specified work within a specified period; or

(b) if in his or her opinion the situation is a matter of urgency, without prior notice do such work or cause it to be done, the cost of which must be recovered from the owner or occupier.

(3) If the work contemplated in subsection (2) is carried out for the sole purpose of establishing whether a contravention of this By-law has been committed and no such

contravention is proved, the Municipality must bear the expense connected therewith together with that of restoring the premises to its former condition: Provided that in all other circumstances, the owner of the premises must bear such expense.

(4) All health and safety and access control policies and procedures in place at a premises must be amended to prevent any delays in the carrying out of a person‘s responsibilities in terms of this By-law.

(5) A person may not refuse access to, interfere with, hinder or obstruct an authorised official in the exercise of his or her powers in terms of the provisions of this By-law.

(6) An authorised official must, when entering any premises, produce a valid identification document issued to him or her by the Municipality, to the owner or occupier.

45. Powers of authorised officials

An authorised official may, when entering any premises–

(a) inspect, monitor or investigate any part of those premises relating to the water system, sewage disposal system or other drainage system as well as where chemicals of any nature are handled, stored or disposed of; (b) question the owner or any occupier of the building;

(c) take photos of the premises;

(d) take samples;

(e) seize pertinent evidence relating to water quality; or

(f) do anything necessary to implement the provisions of this By-law.

46. Service of notices

(1) Whenever a compliance notice is required to be served on a person in terms of the provisions of this By-law, it is deemed to have been effectively and sufficiently served on that person–

(a) when it has been delivered to him or her personally;

(b) when it has been left at his or her place of residence, employment or business in the

Republic of South Africa with a person apparently over the age of 16 years;

(c) when it has been posted by registered or certified mail to his or her last known residential or business address in the Republic of South Africa and an acknowledgement of the posting thereof is produced;

(d) if his or her address in the Republic of South Africa is unknown, when it has been served on his or her agent or representative in the Republic of South Africa in the manner contemplated in paragraphs (a), (b) or (c); or

(e) if his or her address and agent in the Republic of South Africa are unknown, when it has been affixed to a door, gate or in any other conspicuous place on the building.

(2) When a compliance notice is required to be served on a person by reason of his or her being or having been the owner or holding some other right in respect of immovable property–

(a) it is not necessary to name him or her; and

(b) he or she may be described as the owner or holder of such premises or other right, as the case may be.

47. Indemnity

The Municipality and any authorised official are not liable to any third party for any damage caused by anything lawfully done or omitted by the Municipality or any authorised official in carrying out any function or duty in terms of this By-law.

48. Lawful instructions

Failure to comply with a lawful request of an authorised official constitutes a contravention of this Bylaw.

49. Recovery of costs

If a person–

(a) contravenes the provisions of this By-law or of any other By-law; or

(b) fails or refuses to comply with a compliance notice issued in accordance with this By-law, such person is guilty of an offence and the Municipality may take any steps required in the compliance notice itself and recover the costs from such person: Provided that such liability is in addition to any fine which may be imposed on such person.

50. Offences

A person who–

(a) contravenes any provision of this By-law;

(b) fails or refuses to comply with a compliance notice issued to him or her;

(c) fails to comply with any lawful instruction given in accordance with this By-law;

(d) contravenes any conditions imposed in the granting of any application, consent, approval, concession, relaxation, permit or authority in terms of this By-law;

(e) threatens, resists, interferes with or obstructs any authorised official in the performance of official duties or functions in terms of or under this By-law; or

(f) deliberately furnishes false or misleading information to an authorised official, is guilty of an offence.

51. Penalties

(1) Any person who is convicted of an offence under this By-law shall be liable to a fine of an amount not exceeding R300 000 or to imprisonment for a period not exceeding three years, or to both such fine and imprisonment.

(2) Failure to comply with the terms of this By-law or any terms of any condition or notice shall constitute a continuing offence and a person failing to comply with the terms of such condition or notice shall be guilty of a separate offence for each hour during which he or she fails to comply with such terms.

(3) A person who commits an offence stated in subsection (1) or (2) shall be liable, in addition to the penalties prescribed in this By-law and any other law, to such charges as an authorised officer may assess as the full cost including the environmental cost incurred by the Municipality as a result of that offence.

Chapter 12
Miscellaneous provisions

52. Delegations

(1) Subject to the Constitution and applicable national and provincial laws, any–
(a) power, excluding a power referred to in section 160(2) of the Constitution;

(b) function; or

(c) duty,

conferred, in terms of this By-law, upon the council, or on any of the Municipality's other political structures, political office bearers, councillors or staff members, may be delegated or subdelegated by such political structure, political office bearer, councillor, or staff member, to an entity within, or a staff member employed by, the Municipality.

(2) The delegation in accordance with subsection (1) must be effected in accordance with the system of delegation adopted by the Council in accordance with

section 59(1) of the Local Government: Municipal Systems Act, 2000 (Act No.32 of 2000), subject to the criteria set out in section 59(2) of said Act.

(3) Any delegation contemplated in this section must be recorded in the Register of Delegations, which must contain information on the–

(a) entity or person issuing the delegation or sub-delegation;

(b) recipient of the delegation or sub-delegation; and

(c) conditions attached to the delegation or sub-delegation.

53. Appeals

(1) A person whose rights are affected by a decision taken by an authorised official in terms of this Bylaw may appeal against that decision in terms of the appeals provision contained in Section 62 of the Local Government: Municipal Systems Act, 2000 (Act No. 32 of 2000) by giving written notice of the appeal and reasons to the Municipal Manager within 21 days of the date of the notification of the decision.

(2) The Municipal Manager must promptly submit the appeal to the appropriate appeal authority.

(3) The appeal authority must commence with an appeal within six weeks and decide the appeal within a reasonable period.

(4) The appeal authority must confirm, vary or revoke the decision, but no such variation or revocation of a decision may detract from any rights which may have accrued as a result of the decision.

(5) The appeal authority must furnish written reasons for its decision on all appeal matters.

(6) All appeals lodged are done so in terms of section 62 of the Local Government: Municipal Systems Act, 2000 (Act No. 32 of 2000) and not in terms of this By-law.

54. Repeal of laws and savings

(1) The laws mentioned in the first and second columns of Schedule C to this By-law are hereby repealed to the extent set out in the third column of the said Schedule.

(2) All notices published under the Sewage Disposal By-laws of 1999 remain in full force and effect as if the said By-law has not been repealed as contemplated in subsection (1).

(3) Any rights accrued or obligations incurred as contemplated in the laws referred to in subsection (2) remain in force, as if those laws have not been repealed.

55. Short title and commencement

This By-law is called the eThekwini Municipality: Sewage Disposal By-law, 2015 and takes effect on the date of publication thereof in the Provincial Gazette.

SCHEDULE A ACCEPTANCE OF TRADE EFFLUENT FOR DISCHARGE INTO THE SEWAGE DISPOSAL SYSTEM

No trade effluent shall be accepted for discharge into the sewage disposal system unless it complies with the following conditions.

All analyses must be undertaken by a laboratory accredited by an authority recognised by the Municipality using methods applicable for the given matrix, suitable detection limits and ranges.

The effluent shall not contain concentrations of substances in excess of those stated below— Large Works‘ general quality limits are applicable when an industry‘s effluent discharges in a catchment leading to a sewage works of greater than 25 Mℓ/d capacity. Small Works‘ quality limits apply for catchments leading to sewage works with less than 25 Mℓ/d capacity.

GENERAL QUALITY LIMITS		LARGE WORKS > 25 Mℓ/d	SMALL WORKS	UNITS
1.	Temperature (°C)	< 44°C	< 44°C	Degrees Celsius
2.	pH	6 < pH < 10	6,5 < pH < 10	pH units
3.	Oils, greases, waxes of mineral origin	50	50	mg/ℓ
4.	Vegetable oils, greases, waxes	250	250	mg/ℓ
5.	Total sugar and starch (as glucose)	1 000	500	mg/ℓ
6.	Sulphates in solution (as S02-4)	250	250	mg/ℓ
7.	Sulphides, hydrosulphides and polysulphides (as S2-)	1	1	mg/ℓ
8.	Chlorides (as Cl-)	1 000	500	mg/ℓ
9.	Fluoride (as F-)	5	5	mg/ℓ
10.	Phenols (as phenol)	10	5	mg/ℓ
11.	Cyanides (as CN-)	20	10	mg/ℓ
12.	Settleable solids	Charge	Charge	mg/ℓ
13.	Suspended solids	2 000	1 000	mg/ℓ

14.	Electrical Conductivity	400	400	mS/m
15.	Anionic Surfactants	-	500	mg/ℓ
16.	C.O.D.	Charge	Charge	mg/ℓ
Heavy Metal Limits				
17.	Copper (as Cu)	50	5	mg/ℓ
18.	Nickel (Ni)	50	5	mg/ℓ
19.	Zinc (Zn)	50	5	mg/ℓ
20.	Iron (Fe)	50	5	mg/ℓ
21.	Boron (B)	50	5	mg/ℓ
22.	Selenium (Se)	50	5	mg/ℓ
23.	Manganese (Mn)	50	5	mg/ℓ
24.	Lead (Pb)	20	5	mg/ℓ
25.	Cadmium (Cd)	20	5	mg/ℓ
26.	Mercury (Hg)	1	1	mg/ℓ
27.	Total chrome (Cr)	20	5	mg/ℓ
28.	Arsenic (As)	20	5	mg/ℓ
29.	Titanium (Ti)	20	5	mg/ℓ
30.	Cobalt (Co)	20	5	mg/ℓ

31.	Colour as measured by American Dye Manufacturerâ€™s Index	450	450	ADMI
32.	Benzene, Toluene, Ethyl Benzene and Xylene	4	4	mg/ℓ

SPECIAL LIMITATIONS

1. No calcium carbide, radioactive waste or isotopes.
2. No yeast & yeast wastes, molasses spent or unspent.
3. No cyanides or related compounds capable of liberating HCN gas or cyanogens.
4. No degreasing solvents, petroleum spirit, volatile flammable solvents or any substance which yields aflammable vapour at 21ºC.
5. No substance discharged at a flow rate and concentration that will cause interference with any TreatmentWorks.

SCHEDULE B
ACCEPTANCE OF TRADE EFFLUENT FOR DISCHARGE
EITHER DIRECTLY OR INDIRECTLY INTO SEA OUTFALLS

No trade effluent shall be accepted for discharge into the sea outfall unless it complies with the following conditions. The effluent shall not contain concentrations of substances in excess of those stated below—

SEA OUTFALL QUALITY LIMIT			**UNIT**
1.	Temperature	44	ºC
2.	pH	5,5 < pH < 9,5	
3.	Settleable solids	2	mg/ℓ

4.	Oils, greases and waxes of mineral origin	50	mg/ℓ
5.	Arsenic (expressed as As)	5	mg/ℓ
6.	Cadmium (expressed as Cd)	1,5	mg/ℓ
7.	Total chromium (expressed as Cr)	3	mg/ℓ
8.	Copper (expressed as Cu)	3	mg/ℓ
9.	Lead (expressed as Pb)	5	mg/ℓ
10.	Mercury (expressed as Hg)	0,05	mg/ℓ
11.	Cyanides (expressed as CN)	10	mg/ℓ
12.	Nickel (expressed as Ni)	10	mg/ℓ
13.	Zinc (expressed as Zn)	20	mg/ℓ
14.	Sulphide (expressed as S2-)	1	mg/ℓ
15.	Sulphates in solution (expressed as S04)	250	mg/ℓ
16.	Toxicity as Minimum Acceptable Toxicant Dilution	200	Number of dilutions

17.	Benzene, Toluene, Ethyl Benzene and Xylene	4	mg/ℓ

SCHEDULE C
LAWS REPEALED

Part A – BY-LAWS

Number and year of law	**Title**	**Extent of repeal**
Provincial Notice No. 87 of 1953 has been adopted by the Township of Amanzimtoti by Provincial Notice No. 198 of 1967	Drainage By-laws, Amanzimtoti	Chapter VIII
Provincial Notice No. 21 of 1942	Local Government Ordinance, Isipingo	Chapter VIII
Provincial Notice No. 87 of 1953 has been adopted by the Township of Isipingo by Provincial Notice No. 1 of 1972	Standard By-laws, Isipingo	Chapter III, Part C and Chapter VIII
Provincial Notice No. 39 of 1968	General Regulations, Lower Illovo Health Committee	Chapter 1
Provincial Notice No. 346 of 1953	General By-laws, Umbogintwini	Chapter 1
Provincial Notice No. 382 of 1958	General By-laws, Windenham Health Committee	Chapter 1
Provincial Notice No. 60 of 1957	General By-laws, SAICCOR Township Health Committee	Chapter 1

Provincial Notice No. 87 of 1953 has been adopted by the Township of Umkomaas by Provincial Notice No. 538 of 1971	Standard By-laws, Umkomaas	Chapter III, Part C
Provincial Notice No. 87 of 1953 has been adopted by the Township of Umkomaas by Provincial Notice No. 538 of 1971	Drainage By-laws, Umkomaas	Chapter VIII
Provincial Notice No. 380 of 1961	General Regulations, Canelands Health Committee	Chapter 1
Provincial Notice No. 87 of 1953	Standard By-laws, Mount Edgecombe	Chapter III, Part C and Chapter VIII
Provincial Notice No. 87 of 1953 has been adopted by the Township of Tongaat by Provincial Notice No. 276 of 1966	Standard By-laws, Tongaat	Chapter III, Part C and Chapter VIII

Provincial Notice No. 87 of 1953 has been adopted by the Township of Umhlanga Rocks by Provincial Notice No. 398 of 1966	Standard By-laws, Umhlanga Rocks	Chapter III, Part C
Provincial Notice No. 287 of 1963	General By-laws, Verulam	Chapter XIII, Section 2 and Chapter XXV
Provincial Notice No. 528 of 1973	General By-laws, Assagay Health Committee	Chapter 1
Provincial Notice No. 109 of 1948	General By-laws, Botha's Hill Health Committee	Chapter 1

Provincial Notice No. 397 of 1955	General By-laws, Cato Ridge Health Committee	Chapter 1
Provincial Notice No. 153 of 1990	Trade Effluent Regulations By-law	Whole
Provincial Notice No. 446 of 1955	General By-laws, Drummond Health Committee	Chapter 1
Provincial Notice No. 154 of 1971	General By-laws, Everton Health Committee	Chapter 1
Provincial Notice No 755 of 1971	Conservancy Tank By-laws, Kloof	Whole
Provincial Notice No. 231 of 1985	Drainage By-laws, Kloof	Whole
Provincial Notice No. 565 of 1953	Standard By-laws, Mariannhill Health Committee	Chapter 1
Provincial Notice No. 196 of 1992	Industrial Effluent, Pinetown	Whole
Provincial Notice No. 407 of 1975	Industrial Effluent, Queensburgh	Whole
Provincial Notice No. 491 of 1955	General Regulations, Waterfall Health Committee	Chapter 1
Provincial Notice No. 179 of 1989	Drainage Regulations, Yellow Wood Park Health Committee	Chapter 1
Provincial Notice No. 466 of 1961	General Regulations, Yellow Wood Park	Chapter 1
Provincial Notice No. 27 of 1999	Sewage Disposal By-laws	Whole

Provincial Notice No. 87 of 1953 has been adopted by the Township of New Germany by Provincial Notice No. 305 of 1967	Standard By-laws, New Germany	Chapter VIII and Chapter X

Provincial Notice No. 236 of 1977	Conservancy Tank Regulations By-laws	Whole

