DEVELOPMENT OF

THE SASTEP FIELD TESTING GUIDELINE

WRC Report No. 3045/1/22

SASTEP
South African Sanitation Technology Enterprise Programme

WATER RESEARCH COMMISSION

Development of the SASTEP field testing guideline

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About the Guidelines

Background

These guidelines have been developed under a South African Water Research Commission (WRC) funded project to develop guidance on how to demonstrate and test innovative sanitation systems in real world environments prior to manufacture and commercialisation. The guidelines have been written for local technology and commercialisation partners (LTCPs) in the sanitation field and are based on the experiences of the Engineering Field Testing Platform (EFTP) established under a Bill & Melinda Gates Foundation grant in 2017 in eThekwini, South Africa.

The EFTP team is a partnership between the Pollution Research Group (PRG) and the School of Built Environment and Development Studies (BEDS) at the University of KwaZulu-Natal (UKZN), eThekwini Municipality's water and sanitation unit (EWS), and Khanyisa Projects, an independent engineering consulting firm.

Aim and Scope

The aim of these guidelines is to:

- Provide standardised sanitation field-testing and demonstration guidelines for LTCPs
- Provide standardised assessment and evaluation criteria for all sanitation field-testing and demonstration activities in South Africa
- Contextualise sanitation field-testing and demonstration requirements for LTCPs

The guidelines aim to assist LTCPs, regulators and laboratories to understand the various stages required for the field-testing and demonstration of sanitation systems. Case studies and examples are incorporated to show how other innovative sanitation technologies have been tested in 'real world' environments, and the challenges and benefits of this approach. Milestones during the field-testing and demonstration programme are highlighted, and where applicable, templates for surveys and key documentation are included. Recommended further reading is also provided.

Target Audience

The primary target audience of these guidelines are the LTCPs interested in testing and demonstrating sanitation systems in 'real world' environments. Secondary audiences are the regulators and the laboratories who have an interest in supporting this work. Regulators play a key role in the testing and demonstration of such systems, as they assist in identifying potential demonstration sites in communities, and are responsible for communicating with political and community leadership. In addition, the outcomes of the demonstration will inform them of the opportunities for implementing innovative sanitation systems to support service delivery. Testing of innovative sanitation systems involves sampling and analysis of various input and output streams, and every demonstration will require access to an analytical laboratory capable of undertaking the necessary analyses.

Development Process

South Africa has played an important role in testing innovative sanitation systems in 'real world' environments. The aim of field testing and demonstrating technologies in this way is to determine robustness of the system, user acceptance, and applicability of the system to the South African environment. Between 2017 and 2020, the EFTP tested nearly 20 prototype sanitation systems in the laboratory, in communities, in households and in a primary school, and it is based on these experiences that the authors are able to share guidance on best practice with LTCPs. The EFTP followed a series of six core steps that took place in eThekwini, and two additional steps that were carried out by the technology developer (construction and shipping) for each sanitation technology (Figure 0.1). These steps are explained in detail in these guidelines.

Figure 0.1 – The Engineering Field Testing Platform process as followed by the South African team

These guidelines were prepared with input from members of each organisation that makes up the EFTP team. In addition, two workshops were held to obtain additional input from LTCPs and regulators:

- Durban, November 2019: Introduced the concept of the guidelines to the LTCPs, and obtained feedback as to what information would be useful for them to have included
- Pretoria, March 2020: Shared key sections of the guidelines with LTCPs, and obtained feedback on areas where greater detail might be valuable

These workshops were attended by a total of 35 participants: from companies developing sanitation systems (6), commercialisation partners (21), and government entities (7).

Structure

These guidelines aim to assist LTCPs to undertake field testing and demonstration of their systems with a step-by-step approach as followed by the EFTP in eThekwini. Chapters with specific guidance for regulators and laboratory partners are also included.

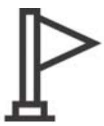
The guidelines are divided into 14 chapters, each of which focuses on one of the steps in field-testing and demonstration. A summary of these chapters is given on the following page.

Chapter 1: Setting the Scene	Summarises the various programmes initiated to develop "Reinvented Toilets"
Chapter 2: What You Need to Know Before You Start	Provides important information that you should be aware of before undertaking a sanitation technology demonstration, including ethical testing, and implications of the project's aims on budget and timeline
Chapter 3: Planning for a Sanitation Prototype Demonstration	Details the documents needed to plan for a sanitation technology demonstration and provides suggestions of what testing should be carried out during the demonstration
Chapter 4: Site Identification and Selection	Describes the process of selecting a suitable demonstration site, including understanding the site characteristics, the practicalities of identifying sites, and including key stakeholders in decision-making
Chapter 5: Shipping and Logistics	Provides a guide to shipping and logistics considerations that are specific to the demonstration of non-sewered sanitation systems
Chapter 6: Community Engagement	Covers the community engagement process, including methods for engagement, managing expectations, and community compensation
Chapter 7: Site Design and Preparation	Discusses how to develop a design basis for site infrastructure, as well as the appointment and management of construction contractors
Chapter 8: Installation and Commissioning	Illustrates the technical aspects of installation and process commissioning, as well as necessary safety checks, and user education
Chapter 9: Setting Performance Acceptance Criteria	Describes the criteria against which the results of a prototype demonstration will be measured for performance to be considered successful and how these criteria are selected
Chapter 10: Technical Aspects of Testing	Outlines the aspects of the prototype that require analysis, including process performance, operation, maintenance, and health and safety
Chapter 11: Social Aspects of Testing	Discusses the process, and data collection tools for social assessments, and the importance of involving a diverse cross-section of users
Chapter 12: Decommissioning and Site Rehabilitation	Explains the technical process of decommissioning, the rehabilitation of the site, disposal or reuse of prototype components, and the importance of a close-out meeting with the users
Chapter 13: Specific Guidance for Laboratories	Presents guidance for new or established laboratories on the handling of faecal sludge and other biohazardous samples, appropriate analysis methods, and an overview of certification and accreditation processes
Chapter 14: Specific Guidance for Regulators or Municipalities	Guides municipalities or regulators through the value of their involvement in sanitation demonstrations, the role they can play to support these, and the resources required

The chapters make reference to five appendices, which support their content through the provision of templates, example documents, standard operating procedures, and checklists, as summarised below.

Appendix 1: Brief History of Reinvented Toilets in South Africa	Provides an overview of the "Reinvent the Toilet Challenge" and the subsequent drive to further develop and commercialise the most promising innovations with a focus on the activities that have taken place in South Africa
Appendix 2: Templates	Provides document templates for use during sanitation technology demonstrations
Appendix 3: Example Documents	Provides example documents that may be useful to refer to during sanitation technology demonstrations
Appendix 4: Standard Operating Procedures	Provides standard operating procedures (SOPs) for tasks that may be common to a number of sanitation technologies under demonstration
Appendix 5: Document checklists	Provides checklists of documentation that are required or useful at different stages of a sanitation technology demonstration

Various symbols are used throughout the guideline document to indicate where a particular point is being emphasised. These are:

	**Who's involved:** Guide to which stakeholders are involved in a part of the testing		**Case Study:** An example that illustrates a concept described in the guidelines
	**Time guide:** Gives indication of normal timescale for a particular part of the process		**Handy tip:** Advice on how to get the best out of field testing
	**Link:** Cross-reference to another part of the guidelines		**In Brief:** Quick summary of the contents of a chapter at the end of a chapter
	**Milestone:** Completion of a key activity		**Further reading:** Additional reading material on the subject

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Role Player Terminology

The following terminology is used to identify different role players throughout the guidelines:

Role player	Definition
Commercial partner	Organisation demonstrating the prototype in order to move towards turning it into a commercially available product; applies for SASTEP funding; has accountability for the completion of the sanitation technology demonstration
Community engagement team	Individuals responsible for liaising with community leadership and community throughout demonstration programme
Community liaison officer	Community member appointed by the commercial partner or the demonstration platform, and in conjunction with the community leadership, to act as a point of contact for the community to ask questions relating to the demonstration programme; should be present whenever the prototype engineer or other personnel are on-site
Demonstration platform	Collaborative platform made up of one or more organisations and designed to support field testing and demonstration of sanitation prototypes; may be contracted to carry out demonstration programme on behalf of commercial partner
Engineering consultant	Organisation or individual with expertise to support sanitation technology demonstration by appointing and overseeing work of engineering contractors and tradespeople, including, where necessary, the community engagement required for these activities
Engineering contractors	Organisations contracted to support with site preparation, installation, and site rehabilitation tasks; could include riggers, logistics companies
Laboratory team	Laboratory technicians and management at the faecal sludge analysis laboratory that will be responsible for analysis of samples collected from the prototype
Local technology and commercialisation partners (LTCPs)	Collective term to describe the commercial partner and technology developer who are working together for the purposes of carrying out a sanitation technology demonstration
Municipal community liaison	Individual or team from municipality responsible for securing approval for demonstration programme from ward councillor and introducing demonstration programme personnel to community leadership at demonstration site
Municipal management	Management within the water and sanitation department of the municipality who can support with the identification of an appropriate demonstration site and offer further support to the demonstration programme if required

Role player	Definition
Proportional representation (PR) councillor	Councillors elected to the municipal council from party lists to ensure that overall party representation at council level is proportional to the votes received by each political party
Prototype engineer	Individual responsible for operation, maintenance and sampling of the prototype and associated reporting, including troubleshooting when operational issues arise
Social assessment team	Data collectors and interpreters responsible for carrying out and reporting on social acceptance surveys
South African Sanitation Technology Enterprise Platform (SASTEP)	WRC-run programme offering funding to LTCPs for the field-testing and demonstration of sanitation technologies in South Africa
Technology developer	Organisation who developed prototype or has in-depth knowledge of its current manufacture and operation
Tradespeople	Organisations or individuals contracted to carry out electrical, plumbing or other skilled maintenance tasks beyond the capabilities of the prototype engineer
Traditional authority leadership	The king (*Inkosi*), headmen (*Iziduna*) and other leaders in areas under dual governance, who play a critical role in the running of their communities and the enactment of customary law. N.B.: In these guidelines, isiZulu terms for these roles are used as the authors are based in KwaZulu-Natal but other terms are used in other areas of South Africa
Ward councillor	The directly elected representative for a specific geographically-defined ward within the municipality, whose role is to represent the views of their constituents to the municipal council and to liaise with the community on issues that affect them

List of Abbreviations

AIA	Authorised Inspection Authority
BEDS	School of Built Environment and Development Studies
CAB	Communal ablution block
CER	Chlorine evolution rate
CFU	Colony forming unit
CIDB	Construction Industry Development Board
CLO	Community liaison officer
CNS	Carbon, nitrogen, sulphur
COC	Certificate of electrical compliance
COD	Chemical oxygen demand
COGTA	Department of Cooperative Governance and Traditional Affairs
DBE	Department of Basic Education
DV	Design validation
EFTP	Engineering Field Testing Platform
EV	Engineering validation
EWS	eThekwini Water and Sanitation
FDS	Functional design specification
GLP	Good lab practice
H&S	Health and safety
HAZOP	Hazards and Operability Study
ICP-MS	Inductively coupled plasma – mass spectroscopy
IP	Intellectual Property
IRB	Institutional Review Board
ISO	International Organization for Standardization
LTCP	Local technology and commercialisation partner
MFC	Microbial fuel cell
MPN	Most probable number
MSDS	Material safety data sheet
NDA	Non-disclosure agreement
NEM:AQA	National Environment Management: Air Quality Act
NEM:WA	National Environment Management: Waste Act
NEMA	National Environment Management Act
NGO	Non-governmental organisation
NHREC	National Health Research Ethics Council
NPD	New product development
O&M	Operations and maintenance
OSH	Occupational Health and Safety
PC	Project Committee
PER	Pressure Equipment Regulations
PFD	Process Flow Diagram
PM	Particulate matter
PoC	Proof of concept
POPI	Protection of Personal Information
ppbv	Parts per billion by volume
PPE	Personal protective equipment
ppmv	Parts per million by volume
PR	Proportional representation

PRG	Pollution Research Group
RACI	Responsible, Accountable, Consulted, Informed
RT	Reinvented Toilet
SABS	South African Bureau of Standards
SAFE	Sanitation Appropriate for Education
SANAS	South African National Accreditation System
SANS	South African National Standards
SASTEP	South African Sanitation Technology Enterprise Programme
SCADA	Supervisory Control and Data Acquisition
SMART	Specific, Measurable, Acceptable, Realistic, Time-bound
SOP	Standard operating procedure
STeP	Sanitation Technology Platform
STH	Soil transmitted helminths
TN	Total nitrogen
TP	Total phosphorus
TRL	Technology Readiness Level
TS	Total solids
TSS	Total suspended solids
UDT	Urine diversion toilet
UKZN	University of KwaZulu-Natal
UPS	Uninterruptible power supply
VAT	Value added tax
VOCs	Volatile organic compounds
VS	Volatile solids
WHO	World Health Organization
WRC	Water Research Commission
ZAR	South African Rand (taken at time of writing as USD$ 1 = ZAR 15)

What's in It for Me?

	How I benefit	What I offer
As a technology developer	• Space to test systems in a 'real world' environment • Feedback on prototype designs from users • Feedback on operation and maintenance • Generation of performance data • Identification of areas for improvement	• Sanitation prototypes • Existing performance data
As a commercial partner	• Feedback on prototype designs from users • Feedback on operation and maintenance • Generation of performance data • Identification of areas for improvement • Exposure to potential customers	• Market and product development expertise
As a user	• Safely managed and socially acceptable sanitation • Job opportunities including skill building	• Feedback on prototypes • Access to communal spaces
As a municipality or regulator	• Early exposure to emerging technology • Safely managed and customer tested sanitation solutions for underserved communities • Exposure to potential partnerships	• Access to community sites • Existing community engagement systems
As a laboratory partner	• Income • Expertise in a growing sector of analysis	• Chemical and physical properties analysis

Project Milestones

The milestones that are highlighted throughout the guidelines relate to the content of each chapter and hence do not necessarily appear in chronological order in the guidelines. For reference, all of the milestones are listed as close to chronological order as possible below. Field-testing and demonstration is complex and this order should be taken as a guide only; some degree of judgement on the part of the project team will always be required. Each milestone in the table cross-references to where it appears in the guidelines.

Project Stage	Milestone	Reference
Planning	Technology developer and commercialisation partner determine system is appropriate for South African market	2.3
	All necessary documentation required prior to testing and demonstration collated	3.103.1
	Aim of testing and demonstration agreed by all stakeholders	3.1
	Relevant standards applicable to testing identified and agreed by all stakeholders	3.8
	Performance acceptance criteria document approved by all stakeholders prior to the start of field-testing and demonstration	9.2
	Test plan agreed by all stakeholders	0
	Aim of social assessments agreed by all stakeholders	11.1
	Ethical clearance granted for demonstration and testing	0
	Social assessment interview, survey and focus group questions agreed by commercial partner, technology developer and SASTEP	11.4
Site Selection	Site requirements recorded in site selection criteria document	4.1
	Testing plan approved by regulator and local government	4.5
	Community leadership and community members approve plan for testing and demonstration (for community sites)	6.3
	Household members approve plan for testing and demonstration (for household sites)	6.4
	School governing body and head teacher approve plan for testing and demonstration (for school sites)	6.5
	Testing and demonstration site agreed by all stakeholders	4.6
	Relevant environmental approvals identified and granted	2.8
	Ethical clearance obtained for social assessment studies	11.5
	Appropriate insurance put in place for testing and demonstration	5.3
Site Preparation	Design basis document approved by relevant stakeholders	7.1
	Design pack approved (including drawings and equipment)	7.2
	Community Liaison Officer appointed for community site	6.3
	Contractors appointed for site preparation	7.3
	Relevant documentation for end of site preparation phase collated	7.6
	Critical spares documented and appropriate in-country suppliers found where possible	5.4
	Social assessment team introduced to all relevant stakeholders at testing and demonstration site	11.2

	Baseline social assessment carried out before prototype is opened for use	0
Installation and Commissioning	Prototype installed on-site and connected to all necessary utilities	8.3
	Certificate of electrical compliance (COC) obtained for prototype	8.3
	All safety requirements met during commissioning phase	8.4
	Steady-state reached	8.4
	Users educated on prototype usage, function, and care; prototype opened for use	8.5
Testing	All necessary documents required at start of testing phase collated	10.3
	Risk assessments for all activities relating to operation and maintenance of the prototype drafted and available for updating as necessary during testing phase	10.7
	Standard operating procedures for all regularly scheduled activities relating to operation and maintenance of the prototype drafted and available for updating as necessary during testing phase	10.7
	Maintenance schedule for the prototype drafted and available for updating as necessary during testing phase	10.8
	Engineering validation or design validation completed if aim of testing is to move prototype to higher technology readiness level	10.11
	Installation and operational costs of the system post-commercialisation estimated based on experience from the testing phase	10.9
Decommissioning and Site Rehabilitation	Decision to decommission agreed and communicated to all stakeholders	12.1
	Appropriate compensation identified and agreed with stakeholders at testing and demonstration site	6.8
	Relevant tests carried out during decommissioning	12.1
	Prototype removed from site and site left in as good or better state than before testing and demonstration	12.2
	Final social assessment study carried out after prototype has been decommissioned	11.7
	Report of social assessment studies validated by household, school or community and shared with commercial partner, technology developer and SASTEP	11.8
	Community close-out meeting held to give feedback to community	12.3

Chapter 1: Setting the Scene

1.1 The Reinvented Toilet Challenge: A Global Wave

More than 4.5 billion people worldwide live without safely managed sanitation services (WHO & UNICEF, 2017). Approximately 2.0 billion people still do not have basic sanitation facilities such as toilets or latrines. Of these, 673 million still defecate in the open, for example in street gutters, behind bushes, or into open bodies of water. In addition, where sanitation systems exist, they are not always properly maintained or emptied, and traditional water-borne sanitation systems are costly and, and both water and energy intensive. Poor sanitation reduces human well-being, social development, economic development and contributes to malnutrition (WHO, 2019).

What is a Reinvented Toilet?

"Reinvented Toilets" refers to the systems developed under the Reinvent the Toilet Challenge issued by the Bill & Melinda Gates Foundation in 2011. These toilets are designed to:

- *Remove germs from human waste and recover valuable resources such as energy, clean water, and nutrients*
- *Operate "off the grid" without connections to water, sewer, or electrical lines*
- *Cost less than USD$ 0.05 (ZAR 0.74) per user per day*
- *Promote sustainable and financially profitable sanitation services and businesses that operate in poor, urban settings*
- *Be truly aspirational next-generation product that everyone will want to use – in developed as well as developing nations*

In February 2011, The Bill & Melinda Gates Foundation announced a major challenge to universities and other research organisations to "Reinvent the Toilet". The aim was to develop innovative next-generation sanitation technologies that were on-site or decentralised, where water, energy, and nutrients were recovered and reused, and which were suitable for regions that are flood-prone, or land, water, or money-poor. Sanitation has diversified beyond sewers, giving people and cities flexible new options for decentralised or on-site sanitation systems. The vision was for Reinvented Toilets (RTs) to be installed anywhere, including in crowded urban areas.

Since the issuing of this challenge, a number of programmes have been introduced by the Gates Foundation to encourage the development of RTs as shown in Figure 1.1. More information on how RTs have been tested and developed in South Africa can be found in Appendix 1.

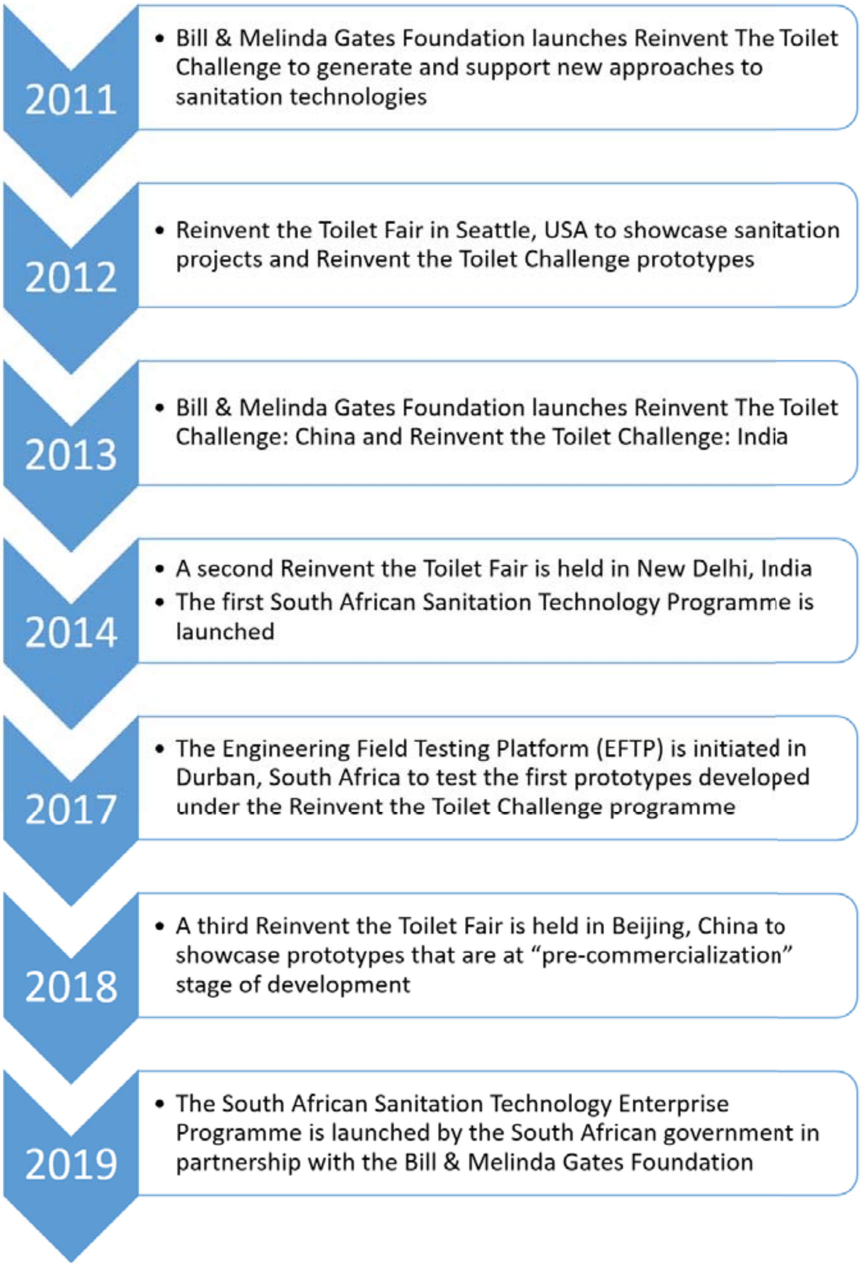


Figure 1.1 – Timeline of key events related to the development of Reinvented Toilets

Chapter 1: Setting the Scene – In Brief

- *Reinvented Toilet Challenge initiated in 2011 by Bill & Melinda Gates Foundation*
- *Programmes to develop and test innovative sanitation technologies underway in China, India and South Africa*
- *Engineering Field Testing Platform (EFTP) in eThekwini formed in 2017*
- *South African Technology Sanitation Enterprise Programme (SASTEP) initiated by South African Government in partnership with the Gates Foundation in 2019 to support commercialisation of promising RT technologies in South Africa*

Chapter 1: Setting the Scene – Further Reading

For more on the state of global sanitation and how it affects lives and livelihoods, see:

- *WHO and UNICEF Joint Monitoring Programme: https://washdata.org/*
- *WHO Fact Sheet on Sanitation: https://www.who.int/news-room/fact-sheets/detail/sanitation*

For more on the Gates Foundation's support for Reinvented Toilets, see:

- *Gates Foundation WASH Strategy: https://www.gatesfoundation.org/what-we-do/global-growth-and-opportunity/water-sanitation-and-hygiene/reinvent-the-toilet-challenge-and-expo*

For an overview of the EFTP in eThekwini, see:

- *Sanitation for the Future video: https://www.youtube.com/watch?v=kkdQ7hr90q8*

Chapter 2: What You Need to Know Before You Start

Before you start a sanitation technology demonstration, there are certain aspects that you should be aware of upfront. It is important to read this chapter first so that when you are looking at more detailed chapters later in the guidelines, you will see how the various stages fit together.

Technology developer, commercial partner, demonstration platform (if relevant)

2.1 The Sanitation Value Chain

A term that is frequently used when discussing innovative sanitation technologies, is the "sanitation value chain". This refers to each stage in the sanitation pipeline from containment through to reuse (Figure 2.1). The idea is to investigate means of processing waste from on-site sanitation systems, such that a value can be obtained from by-products and the impact on the environment is minimised. This could involve treating the waste for direct reuse, such as separating and processing liquid wastes for recycling as toilet flush water, or the processing of solid waste for reuse as soil amendments or fertilisers. Innovative sanitation systems identified under the SASTEP programme will fall into one of the categories described in the sanitation value chain in Figure 2.1.

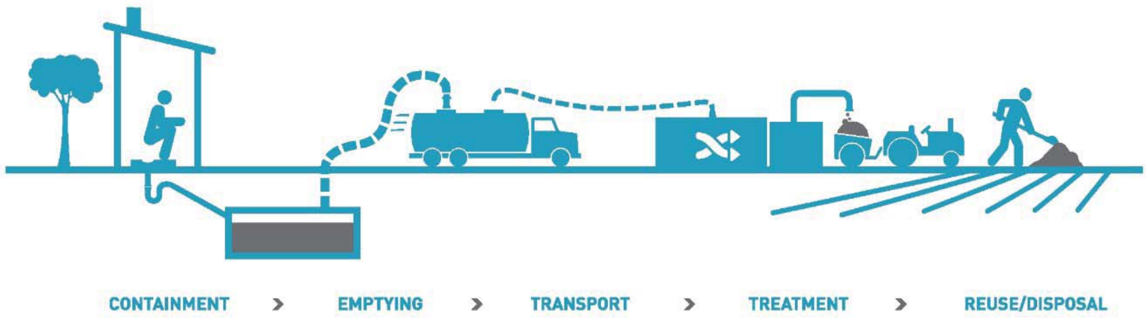


Figure 2.1 – The sanitation value chain as developed by the Gates Foundation

2.2 Technology Readiness Level

The technology readiness level (TRL) is a type of measurement system used to assess the maturity of a particular technology. A technology project is evaluated against the requirements for each technology level and is then assigned a TRL based on the project's progress. There are nine technology readiness levels: TRL 1 is the lowest and TRL 9 is the highest. Table 2.1 shows the TRL definitions and Figure 2.2 shows the new product development (NPD) process and how the technology maturity (as indicated by the TRLs) relates to NPD.

Table 2.1 – Technology Readiness Level definitions; PoC = Proof of Concept, EV = Engineering Validation, DV = Design Validation

Stage	Level	Definition
Research and Development	1	Basic principles observed and reported
	2	Technology concept and/or application formulated
	3	Analytical and experimental critical function and/or characteristic proof-of-concept
Technology Demonstration	4	Component validation in laboratory environment
	5 (PoC)	System/subsystem model or prototype demonstration in a laboratory environment
	6 (EV)	System/subsystem model or prototype demonstration in a relevant environment
Production and Deployment	7 (DV)	System prototype demonstration in an operational environment
	8	Actual system completed and qualified through test and demonstration
	9	Actual system proven through successful product launch

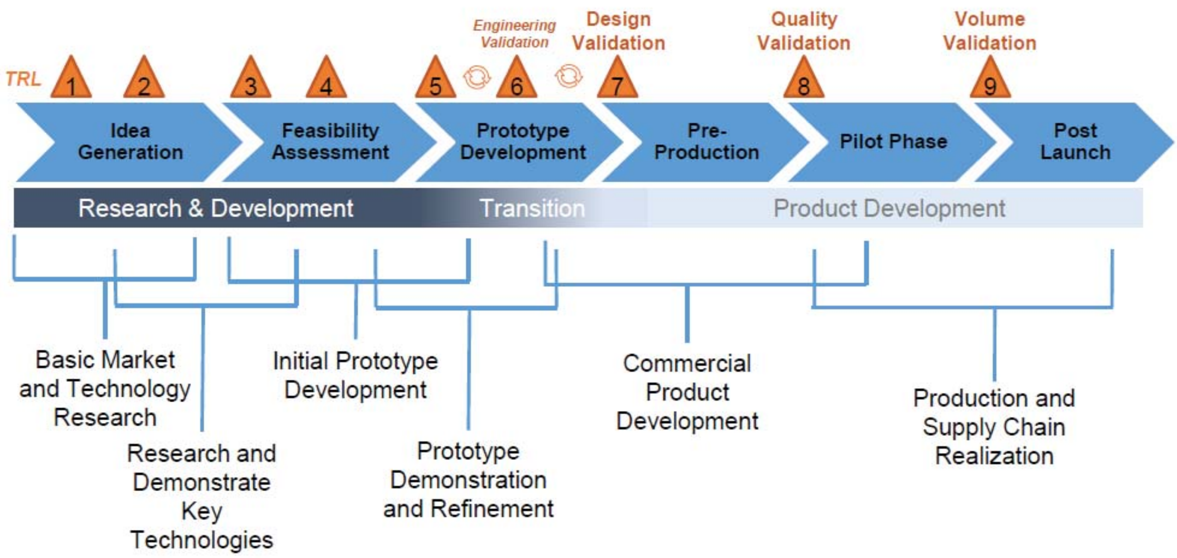


Figure 2.2 – New Product Development (NPD) process, as developed by the Gates Foundation

Most systems tested under SASTEP are at TRL 5-7. How a system moves from one TRL to the next is described in more detail in Section 10.11.

2.3 Appropriateness for South African Market

Before starting a demonstration programme, it is important to consider if a sanitation prototype is appropriate for the South African market or if modifications will be required for it to function well.

Even if the prototype has been tested in other locations prior to testing in South Africa, the following considerations must be taken into account:

- Wipers, not washers – South Africans use toilet paper or other anal cleansing material such as newspaper or rags. Prototypes that have been designed or tested in countries or communities where people use water for anal cleansing may need modification before introduction to the South African market. Toilet paper can have an impact on prototype functionality if it wraps around moving parts or is allowed to dry in tanks or pipes where it sets hard and can cause blockages.
- Load shedding – Scheduled or unscheduled power outages can have a negative impact on the operation of prototypes that require a constant power supply for e.g. aeration. This can be mitigated with the use of an uninterruptible power supply (UPS) or an off-grid power supply to protect against short- or long-term outages respectively. These adaptations come with their own costs and potential challenges.
- Scum – Due to the high fat content of many South African diets, and behaviour relating to toilet usage, scum formation is a common challenge in South African wastewater. The high likelihood of these floating solids being present in wastewater streams should be taken into account when designing operation and maintenance schedules.
- Climate – Depending on the location of the test, the local temperature and humidity should be considered when selecting materials for the prototype. This can have an impact on the rate of corrosion and may also affect processing performance. For example, drying processes may be less effective in a more humid location.
- Off-grid operation – If the prototype is to be tested in an off-grid location where it cannot be connected to water and power, the provision of hand washing water must be considered, as recycled water must not be used for hand washing during testing and demonstration. Having an alternative source of water may also be useful for toilet flushing until recycling standards are met.

Technology developer and commercialisation partner determine system is appropriate for South African market

Impact of Toilet Paper on Treatment of Waste

Under the EFTP, a back-end system was installed in a community which treated the waste from a single toilet in a community ablution block. Solids and liquids were separated from one another via a porous conveyer belt, before each waste stream was treated separately. The system had previously been tested and worked well in India where toilet paper is not used as the population are washers, not wipers. During testing in South Africa, the separation system did not manage the presence of toilet paper well, resulting in blockages, breakages, and inefficient separation of waste. Clearly, any sanitation system that is to be installed in South Africa needs to be able to deal with toilet paper, and even the use of other wiping material such as newspaper and rags.

2.4 Roles and Responsibilities

There are a number of role players in a sanitation technology demonstration, each with different responsibilities at various stages of the project. Each chapter of the guidelines indicates who should be involved in the stage described in the chapter. This section gives guidance on how to ensure that roles and responsibilities as they relate to SASTEP are clear for all stakeholders.

2.4.1 General Roles and Responsibilities

It is essential to understand the roles and responsibilities of each organisation and person involved in field-testing and demonstration to ensure that everyone is aware of their respective tasks and that no activity "falls through the gap". It also prevents duplication of work.

It is useful to create a RACI matrix which identifies who is Responsible, Accountable, Consulted, and Informed for each task. For each stage of the demonstration, create a matrix where the tasks or activities are listed down the side, and each of the organisations involved are listed across the top. Then identify the role each organisation plays for each task as follows:

- **Responsible:** People or stakeholders who do the work. They must complete the task or objective or make the decision. Each task has to have at least one organisation responsible, but several people can be jointly responsible.

How to Draw a RACI Matrix

A RACI matrix shows who is responsible for carrying out a task (R), who is accountable for the completion of the task (A), who should be consulted about the task (C), and who needs to be kept informed (I). An example is shown below.

	Technology Developer	***Commercial partner***	***Regulator***	***Laboratory***
Collate existing documentation	*R*	*A*	*I*	
Set up test plan	*R*	*R/A*	*C*	*C*
Determine roles during testing	*C*	*R/A*	*C*	*I*
Identify site requirements	*C*	*R/A*	*C*	
Etc.				

- **Accountable:** Person or stakeholder who is the "owner" of the work. He or she must sign off or approve when the task, objective, or decision is complete. This person must make sure that responsibilities are assigned in the matrix for all related activities. Success requires that there is only one person Accountable.
- **Consulted:** People or stakeholders who need to give input before the work can be done and signed off. These people are active participants in the decision-making process.
- **Informed:** People or stakeholders who need to be kept updated on progress or decisions, but they do not need to be formally consulted, nor do they contribute directly to the task or decision. They are passive recipients of information.

This matrix must be discussed in detail with all stakeholders to ensure that there is agreement on the roles and responsibilities.

2.4.2 SASTEP Programme

This section deals specifically with the roles and responsibilities related to applying for funding under the SASTEP programme. If funding has been sourced elsewhere, you will need to understand the roles and responsibilities for applying and accepting funding from that source.

When accessing funding from SASTEP, the WRC requires a technology developer to have a commercial partner in place prior to application. The application should be submitted as a joint approach. The WRC (should they wish to provide funding) would then provide funding to the commercial partner for the work to be arranged either in-house or sub-contracted to a demonstration platform. Alternatively, should the commercial partner also be the developer of the prototype, the approach can be made directly by the commercial partner. Unless there is a commercial partner in place, the WRC does not provide funding under SASTEP. The roles and responsibilities of the different actors should be clear before testing commences. This is shown in Figure 2.3.

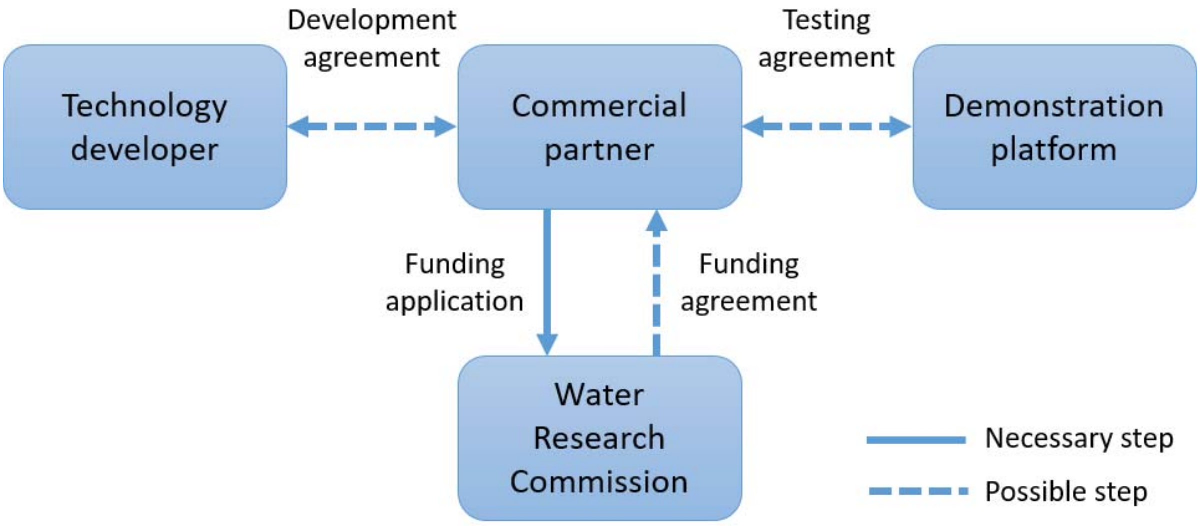


Figure 2.3 – Roles and responsibilities for making an application to SASTEP for field testing and demonstration

2.5 Timeline for Testing

The time required to thoroughly test a prototype is often underestimated. In particular, the time that it takes to prepare a site (including community engagement) before the testing phase can commence is often overlooked as a considerable contributor to the overall length of the timeline. Table 2.2 gives indicative timelines for testing a sanitation technology prototype in eThekwini municipality, South Africa, based on work carried out between 2017 and 2020 on the EFTP. It should be noted that this prototype testing took place as part of a demonstration platform, with multiple prototypes in the field concurrently. In some cases, this allowed for shorter timelines for particular tasks as it was possible to use in-house personnel and equipment that existed due to the platform being in place.

Table 2.2 – Indicative timelines for sanitation technology prototype testing in eThekwini municipality, South Africa

Project stage	Typical timeline	Comments
Site identification	1 to 4 weeks	• This does not include the time for community engagement • Shorter time for households than communities
Community engagement	1 month (household) 2 weeks to 3 months (community)	• This can be lengthy depending on the local political environment and the number of people that need to be consulted and informed
Ethical clearance	2 to 3 months	• Ethical clearance is required for the testing of any system where human samples (faeces and urine) are being analysed, and for undertaking surveys
Site preparation	1 to 3 months	• Includes design and construction time • Generally longer time for community sites or lower TRL systems • Applications for new utility connections can lengthen this project stage
Installation and commissioning	1 to 3 months	• Shorter time for front-end only than integrated or back-end systems • Shorter time for high TRL and non-biological systems
Testing	3 to 12 months	• Highly dependent on the aims of testing and the current TRL of the prototype (see cost benefit of extended testing in Section 2.6 below)
Decommissioning	1 week to 2 months	• Timeline includes site rehabilitation which can increase length of decommissioning stage

The factors that have the greatest impact on the duration of field testing are:

- The number of users the system is designed to serve (single user or multi-user) and therefore whether it will be tested at a household or in a community setting

- Existing relationship with community at the demonstration site and thus the complexity of the community engagement interactions
- Whether there are existing utility connections at the demonstration site that can be used
- Time taken for prototype to reach steady state operation after installation
- Number of testing sites and whether a single prototype is tested at multiple consecutive sites or multiple prototypes are tested at different sites concurrently
- The TRL of the prototype, which impacts on the complexity of the site infrastructure required and the time required to achieve the aims of field-testing and demonstration

Example Timelines for Testing on the EFTP in eThekwini

For the testing of three different prototypes in different locations on the EFTP, the following table shows the time taken for each project stage.

Project stage	***Pedestal in a household***	***Back-end system in a community***	***Integrated system in a school***
Site identification	*1 week*	*3 weeks*	*4 weeks*
Community engagement	*2 weeks*	*2 months upfront, plus 1 meeting per week (group or individuals)*	*6 weeks*
Ethical clearance	*2 months*	*4 months*	*4 months*
Site design & preparation	*3 weeks*	*3 months*	*3 months*
Installation and commissioning	*1 week per household*	*2 weeks for installation, 2 months for commissioning for a biological system*	*1 month for installation, including rectifying compliance issues, 3 months for commissioning for a biological system*
Testing	*1 month per household*	*12 to 18 months*	*18 months*
User surveys	*1 day per household, and 1 month to write up*	*3 days for baseline survey, 1 day for interim survey, 2 days for final survey, and 1 month to write up*	*1 day per focus group, and 1 month to write up*
Decommissioning	*1week per household, excludes reporting time*	*1 month, excludes reporting time*	*1 month for decommissioning of site and rehabilitation, with additional time to implement appreciation gesture to school for hosting testing, excludes reporting time*

2.6 Budgeting for Testing

The costs of demonstrating and testing a sanitation technology are highly dependent on the aims of the testing and the context in which the testing takes place. Table 2.3 gives indicative costs for testing a sanitation technology prototype in eThekwini municipality, South Africa, between 2017 and 2020 on the EFTP. It should be noted that the capital cost of the prototype and international shipping costs are not included in the costs shown in Table 2.3. The costs are given for typical household and community testing sites, based on six months of testing a single prototype at steady state (i.e. after installation and commissioning have been completed) on one site. These costs assume the testing site is a new site with no existing testing infrastructure and where significant community engagement is required. The costs of testing and demonstration on an established platform such as the EFTP are in many cases lower as infrastructure and resources are shared across multiple prototypes. Cost ranges are given for each stage of the project. Further detail on the factors that influence costs can be found in Table 2.3 and in the text that follows.

The factors that overall have the greatest impact on the cost of field-testing and demonstration are:

- Whether a completely new site is being developed and whether there is opportunity to share costs between multiple prototypes (e.g. by testing on an established platform)
- Number of users the system is designed to serve (single user or multi-user) and thus whether it will be tested at a household or in a community setting
- The nature of the demonstration site and the on-site staffing requirements (community liaison officer, caretaker and/or security guard)
- Duration of testing period at steady state operation
- Time taken for system to reach steady state operation (i.e. installation and commissioning period – significantly longer for back-end systems and particularly biological systems)
- Number of demonstration sites used and whether a single prototype is tested at multiple consecutive sites or multiple prototypes are tested at different sites concurrently
- The TRL of the prototype, which impacts on staffing requirements (e.g. is an engineer required on-site full time or only one day a week?), the site infrastructure required and the laboratory analysis required
- Laboratory analyses required to achieve aims of testing

It is important to bear in mind the following:

- Testing one system in a 'real-world' environment requires a wide variety of skills, and it can be easier and less costly to access these skills under the umbrella of an established demonstration platform
- Testing multiple prototypes at the same site significantly reduces the costs per prototype as staff and infrastructure can be shared
- The costs associated with community and municipal engagement are a significant and often unpredictable factor in project costs

Table 2.3 – Indicative direct costs of sanitation technology prototype testing in eThekwini, South Africa

Project stage	Indicative costs for prototype at single household, 6 months of testing at steady state (total project period 12 months)	Indicative costs for prototype at community site, 6 months of testing at steady state (total project period 14 months)	Comments
General and start-up costs	ZAR 250,000-450,000	ZAR 350,000-550,000	• Project management and administration including: review of documentation, application for ethical clearance, development of testing plan, initial community engagement • Training on prototype with technology developer • Community Liaison Officer salary (for community site) • Insurance
Site design, construction & testing equipment procurement	ZAR 100,000-300,000	ZAR 200,000-750,000	• Excludes cost of prototype • Development of design basis, site infrastructure design, construction and other site preparation • Costs vary depending on complexity of prototype and aims of testing
Import & storage	ZAR 20,000-30,000 (logistics & storage only)	ZAR 20,000-40,000 (logistics & storage only)	• Excludes cost of prototype and cost of international shipping • Logistics for import, duties & taxes, local storage fees • Duties & taxes are prototype-dependent, see Chapter 5: Shipping and Logistics
Social assessment	ZAR 60,000-100,000	ZAR 70,000-110,000	• Baseline and final social assessments, preparation, reporting • May also include interim social assessment for longer testing periods

Project stage	Indicative costs for prototype at single household, 6 months of testing at steady state (total project period 12 months)	Indicative costs for prototype at community site, 6 months of testing at steady state (total project period 14 months)	Comments
Installation & commissioning	ZAR 40,000-200,000	ZAR 150,000-250,000	• Lowest costs if: front-end only being tested, installation is simple, no laboratory analysis, i.e. main costs are staff time and travel • Longer commissioning periods, e.g. for biological systems, significantly add to costs
Testing	ZAR 400,000-800,000	ZAR 700,000-1,500,000	• Based on six-month test period at steady state • Includes staff time, laboratory analysis, consumables, operation & maintenance, utilities, caretaker, security • Costs highly dependent on laboratory analyses required (25 to 50% of testing costs could be analysis) and whether an engineer is required full time on site
Decommissioning & site rehabilitation	ZAR 60,000-120,000	ZAR 50,000-150,000	• Costs lowest for front-end only prototypes that can be removed without rigging equipment
Final project reporting	ZAR 50,000-75,000	ZAR 50,000-100,000	• Time costs are significant for analysis of a six-month test period

Total Costs Associated with the Testing of Systems on the EFTP

The EFTP in eThekwini estimated that the cost of developing a new demonstration site and carrying out testing in a community for a single multi-user system with a high TRL was approximately ZAR 2.7 million (excluding VAT, contingency, the capital cost of the system and international shipping costs). This assumed a six-month test period (14-month total project period), that only one technology was tested at this site (i.e. no opportunity for cost sharing), and includes all staff time costs. The estimated cost for testing a single user system with a high TRL at a new household site, with the same exclusions, was ZAR 1.7 million. Between 50 and 60% of the costs were project staff time (project management, design engineers, prototype engineers, technicians, community engagement specialists and social scientists).

For comparison, the cost of testing a multi-user system for six months (at steady state) at an established testing site, shared with other prototypes was estimated to be around ZAR 2 million (with the same exclusions as listed above for the previous two cases). Savings arise from the possibility of sharing site resources, such as site office space, community liaison officer and security guard, lower design and construction costs, the existence of utility connections and other basic testing site services, and the more efficient use of personnel.

Increasing the steady state test period by a block of three months increased total costs of the project by an estimated 10 to 15%. As such, additional in-field testing can provide large benefits in terms of more extensive performance data for a relatively low additional cost.

It is important to note that:

- *The EFTP operated in a manner that supported experimentation with the prototypes tested: additional tests were added as the project progressed and modifications were made to the prototypes. This added to the overall cost of testing and might not be applicable to testing carried out under SASTEP, where there would be clearly defined timelines and objectives.*
- *Conversely, the EFTP provided opportunities for significant resource-sharing between the prototypes tested – for example, a site office facility was shared between three technology developers, as were the salaries for a security guard and a community liaison officer. This might not be possible under SASTEP if the demonstration is not carried out on an established platform. The total costs given above were estimated based on sites where no resource-sharing took place.*

2.7 Ethical clearance

All health-related biomedical and social research, research involving human subjects that is non-biomedical, and research that makes use of animal subjects is subject to ethical clearance. An independent South African based research ethics committee must review the ethical and scientific rigour of all such trials to be conducted in South Africa. This can be obtained through ethics boards within professional research councils (e.g. Human Sciences Research Council), or tertiary institutions that are registered with the National Health Research Ethics Council (NHREC) in South Africa. Even if a technology developer from outside of South Africa has ethical clearance from an Institutional Review Board (IRB) in their institution or country, they will still need to apply for ethical clearance in South Africa if their prototype is to be tested in a 'real world' environment in South Africa.

POPI Act (2013)

The Protection of Personal Information (POPI) Act ensures that all South African institutions conduct themselves in a responsible manner when collecting, processing, storing and sharing another entity's personal information by holding them accountable should they abuse or compromise your personal information in any way.

For more information on the POPI Act, visit https://www.gov.za/documents/protection-personal-information-act

Key requirements for an application to obtain ethical clearance include a gatekeeper's letter and letters of informed consent. A gatekeeper's letter provides the necessary permission for the work to be undertaken at the selected demonstration site. This can be from the local municipality or traditional authority leader if the testing is taking place within a community or household, or from the Department of Basic Education and school's head teacher or governing body if the study is taking place at a school. A template gatekeeper's letter is provided in Appendix 2.1.

Letters of informed consent must be signed by the people participating in the study stating that they understand what the demonstration aims to achieve, and that they are participating freely in the project and may choose to stop participating at any time without judgement. For household testing, it is common to ask every member of the household to sign a letter. Where there are children under the age of 18, the parent needs to sign an informed consent letter on their behalf. Where the testing is taking place in a community, it is generally sufficient to have implied consent. In other words, detailed information on the project is provided and people can choose to participate by making use of the facilities. Alternative facilities must be available should the person choose not to participate. A template informed consent letter is provided in Appendix 2.2.

Where interviews or surveys are being undertaken, these must also be submitted for review by the ethics board (see Section 11.5).

Ethical clearance granted for demonstration and testing

Ethics Committees at the University of KwaZulu-Natal

One of the partners of the EFTP is the PRG at UKZN and as such, all ethical clearance goes through UKZN's ethic committees. As most of the prototypes involves collecting, analysing and storing of faeces and urine, ethical clearance had to go through the Biomedical Research Ethics Committee. One of the objectives of field-testing is to collect user feedback on prototypes and assess the social impact of the technology. As such, ethical clearance from the Humanities and Social Sciences Research Ethics Committee had to be obtained for the social assessments undertaken for each prototype.

2.8 Environmental Approvals

In the South African context, certain regulations need to be met for waste management, effluent discharge, air emissions, and other pollutant mitigation.

When testing a prototype, some of these regulations may need to be considered. For example, if the prototype is processing waste then discharging it to a river, the requirements for general discharge, and possibly special limits, need to be met. Table 2.4 provides an overview of which regulations may be applicable, and it is up to the LTCP to check which are relevant for the field-testing and demonstration of their prototype.

Table 2.4 – South African legislation that may be relevant to a sanitation demonstration programme

Legislation	Possible relevant aspects
National Water Act 36 of 1998	• Application for a water use license or General Authorisations • Extracting water, storing water or reducing the flow of a water source • Discharging or disposing of waste or water into a water resource
National Environment Management Act 2008 (NEMA) No. 107 of 1998	• Conditions for undertaking an environmental impact assessment (EIA) • Duty of care
National Environmental Management: Waste Act (NEM:WA; no 59 of 2008)	• National Norms and Standards (2013) for the Storage of Waste; and Remediation of Contaminated Land • Waste activities that may require a licence
National Environmental Management Act: Air Quality Act 2004 (NEM:AQA no 39 of 2008)	• Activities that impact on air quality • Combustion of biomass • Disposal of hazardous or general waste

Relevant environmental approvals identified and granted

Chapter 2: What You Need to Know Before You Start – In Brief

- *The sanitation value chain covers each stage of the sanitation treatment process, from containment to reuse or disposal*
- *TRLs define the maturity of a particular technology*
- *South Africans are wipers not washers and sanitation systems for South Africa need to be designed to process toilet paper*
- *Load shedding will impact on demonstration of systems requiring electricity*
- *There is a clear process for applying for funding under SASTEP*
- *Stakeholders in a sanitation technology demonstration have different roles and responsibilities that need to be clarified up-front*
- *Timelines and costs for testing prototypes are influenced by where they are tested, the scope of the testing, the prototype's TRL, and the number of laboratory analyses required*
- *Ethical clearance is required for any sanitation demonstration that collects samples that include faeces or urine or ask users for feedback on a prototype*
- *Applications for ethical clearance can take a few months to process so should be started early*
- *Environmental approvals may be required and should also be investigated early to prevent delays*

Chapter 2: What You Need to Know Before You Start – Further Reading

For more on the sanitation value chain, see:

- *Bill & Melinda Gates Foundation Water Sanitation and Hygiene fact sheet: https://docs.gatesfoundation.org/documents/water-sanitation-hygiene-fact-sheet-2010.pdf*

For more on technology readiness levels, see:

- *NASA's summary of TRLs: https://www.nasa.gov/directorates/heo/scan/engineering/technology/txt_accordion1.html*
- *NASA's TRL definitions: https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf*

For more on ethical research, see:

- *National Health Research Ethics Council: http://nhrec.health.gov.za*
- *Human Sciences Research Council, Research Ethics Committee: http://www.hsrc.ac.za/en/about/research-ethics*
- *POPI Act: https://www.gov.za/documents/protection-personal-information-act*

For more on environmental legislation, see:

- *Full text of National Water Act: https://www.gov.za/documents/national-water-act*
- *Full text of National Environment Management Act (NEMA): https://www.gov.za/documents/national-environmental-management-act*
- *Full text of National Environment Management: Waste Act (NEM:WA): https://www.gov.za/documents/national-environmental-management-waste-act*
- *Full text of National Environmental Management: Air Quality Act (NEM:AQA): https://www.gov.za/documents/national-environment-management-air-quality-act*

Chapter 3: Planning for a Sanitation Prototype Demonstration

This chapter details what documents are needed to plan for field-testing and demonstration of a prototype and provides suggestions as to what test work the technology developer may wish to undertake prior to testing in a 'real world' environment. It also provides guidance on the various standards that may need to be met as an outcome of the field-testing and demonstration.

Technology developer, commercial partner, demonstration platform (if relevant)

1 to 2 months

Chapter 4: Site Identification and Selection; Chapter 6: Community Engagement; Chapter 9: Setting Performance Acceptance Criteria; Chapter 10: Technical Aspects of Testing; Chapter 11: Social Aspects of Testing

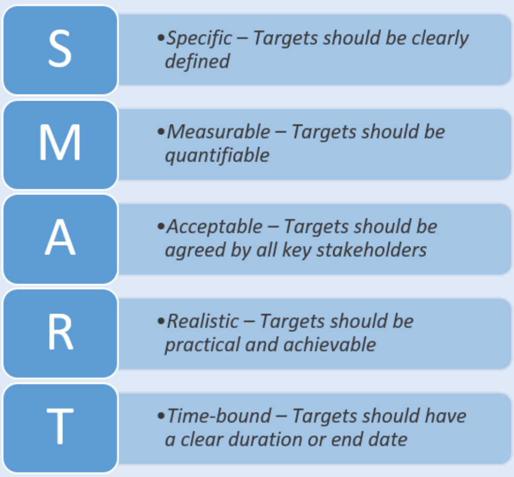
3.1 Understanding the Aim of Demonstration and Field-testing

Before undertaking the field-testing and demonstration of a prototype, it is important to be clear on the required outcomes in order to ensure that the relevant analyses and surveys are carried out. Aims could include:

- Proving compliance against standards (local, national and international) (see Chapter 10: Technical Aspects of Testing)
- Assessing user acceptance (see Chapter 11: Social Aspects of Testing)
- Identifying unit components that can be optimised before production (see Chapter 10: Technical Aspects of Testing)
- Assessing applicability in different situations (e.g. household, community, school) (see Chapter 4: Site Identification and Selection, Chapter 10: Technical Aspects of Testing and Chapter 11: Social Aspects of Testing)

SMART Targets

SMART targets have the following characteristics:



It is useful to describe the aims of testing using SMART targets, i.e. setting goals that are Specific, Measurable, Acceptable, Realistic, and Time-bound. This reduces vague thinking about what the field-testing and demonstration wants to achieve, and provides clear guidance on what needs to be measured and how it will be measured, what can realistically be achieved in the time allocated, and defines the duration of the project. At the planning stage, it is important to consult the municipality or regulator to ensure that the goals set are relevant to the local context.

The aims of testing will allow the development of relevant success/failure criteria for the demonstration and these should be written prior to the field-testing and demonstration (see Chapter 9: Setting Performance Acceptance Criteria).

Aim of testing and demonstration agreed by all stakeholders

3.2 Description of the Prototype or Product

When considering field-testing and demonstration, the technology would normally be at TRL 5 or higher. It should have already undergone the initial development stages, which would include the development of documentation such as a process description, process flow diagrams, initial testing results, health and safety documentation, and an initial assessment of production and running costs to determine feasibility.

To assess the requirements for demonstration of a prototype, the commercial partner or demonstration platform needs to have a full description of the prototype along with a brief description of how it functions. This should be provided in a short document describing the prototype and its operation, and providing sketches of the component(s).

The sketches do not need to be full draughted drawings of the prototype. However, as a minimum, scale drawings should be provided with details of the dimensions of the component(s) along with dimensions of any pipe connections, positions of any electrical/electronic connections, and materials of construction. Plan and side cross-sectional views are important as these will assist in determining the size of any enclosures necessary, and should a plinth be required (for example for a novel toilet with collection tanks below the pedestal), this should be included in the sketches. An example of such a sketch is provided in Figure 3.1. Another useful depiction is an isometric sketch (i.e. 3D depiction), or a computer-generated 3D image of the unit(s) drawn to scale. Photographs from laboratory testing may also be useful as an indicator of size and layout; however, without dimensions, they provide insufficient detail.

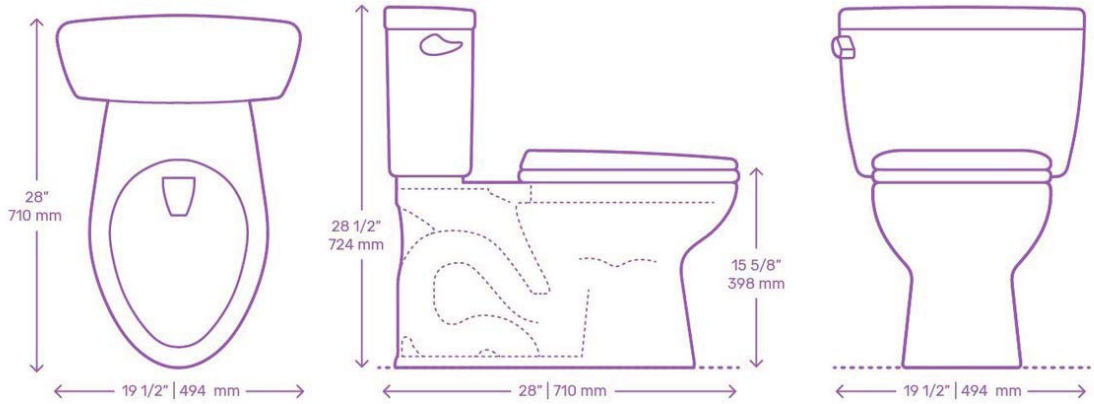


Figure 3.1 – An engineering sketch of a toilet pedestal showing dimensions; taken from dimensions.guide

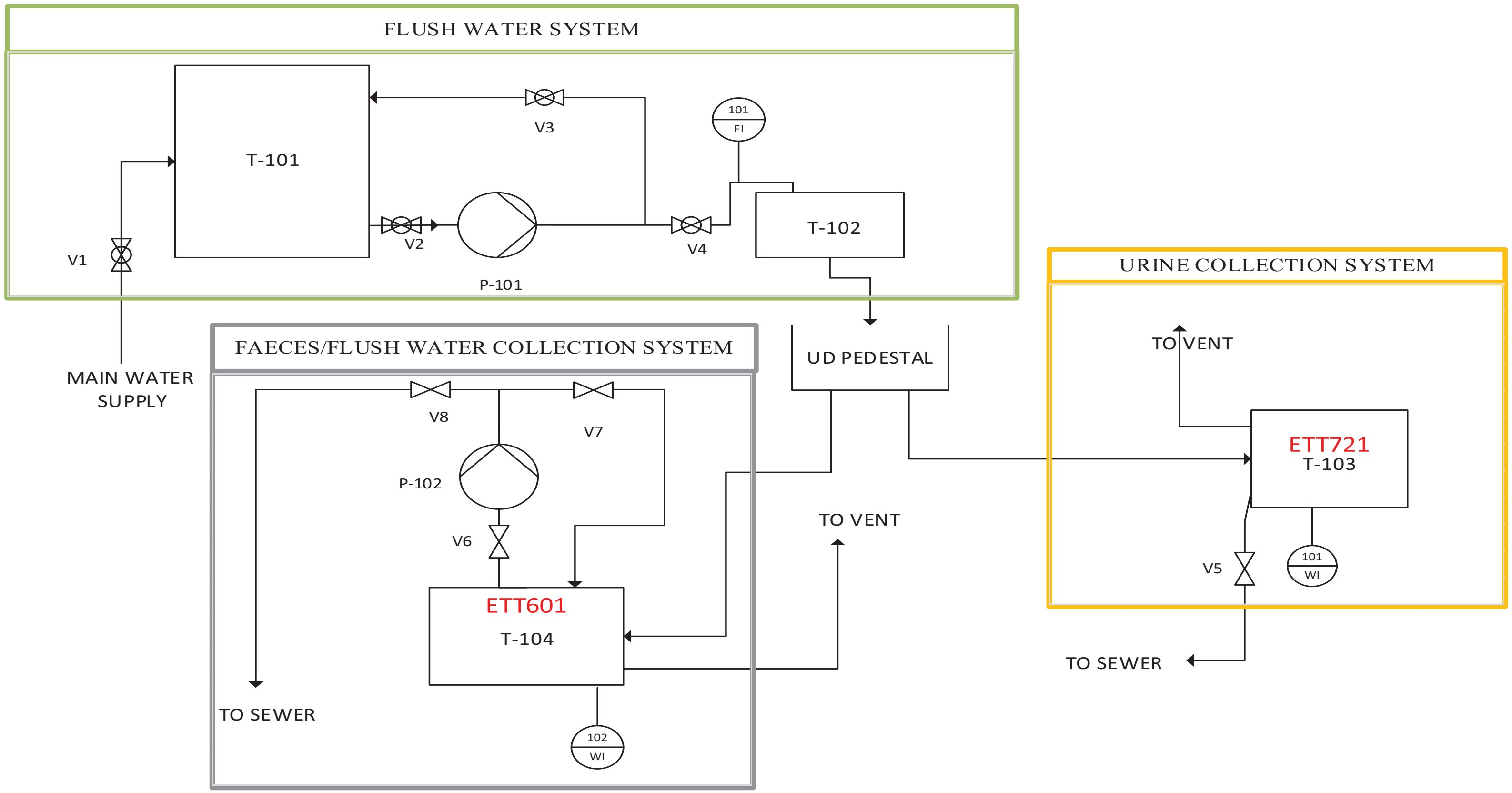
3.3 Overview of the Process

Where an integrated or back-end system is to be tested, a process description and a process flow diagram (PFD) should be included describing and showing the required process layout and any control systems/instrumentation requirements on the various flow lines. An example of a basic PFD is provided in Figure 3.2

The process description should be a summary of the process highlighting the functions of the different units, any temperature/pressure variations, and the flow of materials through the process. It is worthwhile developing this along with the PFD and referring to unit numbers and line numbers consistently. For example, line 1 may be a flow of urine from a urine diversion toilet (UDT1) into a fresh urine holding tank (T1). This would be stated in this way in the description and the same unit labels and line labels used in the PFD.

A PFD does not necessarily have to use specific symbols for the main units (blocks can be used in the simplest case); however, should there be multiple pumps and valves, it is worthwhile using a standard symbol for each, with unit labels which can then be listed separately with specifications of the pumps/valves. For example, if there are pumps between the holding tank and a membrane separation unit, with pumps for the separated streams, they can be labelled P1, P2, and P3 and a separate table detailing pump type, power, and flow requirements included for reference.

If the integrated or back-end system has been tested as a process in a laboratory, an isometric sketch (or 3D representation) of the process showing placement of the units is useful when determining the on-site layout for field testing (particularly if gravity flow is being used). It is valuable to mark valves, outlets, and access ports that will be used for sampling to check if they will be easy to access before the system is installed.



VALVE LIST	
Valve No.	**Description**
V1	Ball valve
V2	Ball valve
V3	Ball valve
V4	Ball valve
V5	Gate valve
V6	Gate valve
V7	Gate valve
V8	Gate valve

TANK LIST	
Tank No.	**Description**
T-101	Flush Water Tank
T-102	Cistern
T-103	Urine Tank
T-104	Faeces Tank

PUMP LIST	
Pump No.	**Description**
P-101	Flush Water Pump
P-102	Faeces Pump

INSTRUMENT LIST	
Instruments No.	**Description**
FI-101	Water Meter
WI-101	Urine Weightometer
WI-102	Faeces Weightometer

Figure 3.2 – Basic process flow diagram for a system to measure stream separation from a urine diversion pedestal, with equipment list, and sampling points indicated by red text

3.4 Health and Safety Aspects During Operation

During field-testing and demonstration, the prototype will normally be tested in a household, school or community environment. Thus, it is important to carry out a full risk assessment of the prototype, to ensure its safe operation by identifying any potential hazards that could arise should the process develop faults, and putting in place appropriate mitigation measures.

In process engineering, a HAZOP (Hazards and Operability) study would normally be carried out on each unit operation and line during the early design stages with subsequent risk assessments and hazard analyses carried out throughout the design process. Although most prototypes are on a smaller scale than a full process plant, it is still necessary to carry out an appraisal of the potential for hazards to arise during operation due to any fluctuations in the throughput or changes in the operating conditions.

HAZOP Study Guide Words and Variables

A HAZOP study uses a systematic approach to review a complex process to identify where problems may arise and the risks that those problems may present. The complex system is broken down into simpler section which are reviewed individually. Standardised prompts in the form of guide words and variables help to provide structure and direction to the thorough review of each section.

Guide words for deviations in a HAZOP study could include: no, more, less, as well as, part of, and other than (more possibilities are available depending upon your process). Variables could include liquid flow, solids content, temperature, pressure, trash and again, others depending upon the process.

For the purpose of planning for field-testing and demonstration, a basic HAZOP can be carried out by considering the stages of the process which may suffer failure due to fluctuations in the process. For example, if there is a stage in the process where pressure may build up if there is a blockage, what could be the consequences of a pressure build up? Would this be detected by instrumentation? If not, could a catastrophic failure take place (e.g. a rupture to a seal causing untreated effluent to leak from the prototype causing a health hazard)? A HAZOP should be undertaken by a team of people as it is a brainstorming exercise that allows the team to look at all possible deviations and determine potential consequences. A standard HAZOP table is provided in Appendix 2.3 which may be of use for the development of a risk assessment. After undertaking a HAZOP exercise, the potential operational risks can be identified and mitigated against. A template risk assessment is provided in Appendix 2.4.

3.5 Previous Testing Results

Prior to the start of field-testing and demonstration, it is important to have an understanding of the expected outcomes based on any previous testing that has been carried out. In particular, the effluents from the system need to be understood so that the performance of the prototype can be benchmarked against the expectations from laboratory trials, and to ensure that any effluents being released into the environment during the field-testing and demonstration are expected to be within allowable limits.

Although the testing carried out (and variables analysed) prior to field-testing and demonstration will vary according to the system, recommended flow rates of influent materials, and expected effluent qualities would normally be expected. For example, for a liquid effluent stream, variables such as COD, dissolved ions (e.g. nitrates, phosphates, potassium, and chlorides), turbidity, likely pathogen loads, and suspended solids content can assist with determining how to deal with the effluent (whether it can be discharged to the sewerage system, or would need further treatment prior to this happening).

Chapter 10: Technical Aspects of Testing contains details of what analyses are recommended for effluents from a variety of processes. This can be used to guide the analyses carried out during laboratory testing prior to field-testing and demonstration.

In addition, indications of the residence time distribution of the various components of the process are valuable as they allow an estimation to be made of the time needed to reach steady-state. Ideally, conserved tracer test results would be available, so that the flow configuration can be assessed to understand the mean residence time, degree of by-passing, back-mixing and dead space. This helps to establish the volume of influent that the prototype will process before steady-state is reached after the establishment of e.g. a biological system.

3.6 Previous User Acceptability Results

Although the prototype may only have been tested in a laboratory environment (and not as yet in a community, school, or household environment), any previous feedback collected from users of the system would be beneficial for guiding the design of social assessments during field-testing and demonstration. For example, if testing carried out during development of the prototype has been limited to use by male participants, or adults, there may be a need to determine whether it is suitable for use by all members of society during field-testing and demonstration. The inclusion of any prior end-user surveys in the documentation will assist in designing the initial stages of community engagement.

3.7 Production Costs and Estimated Running Costs

At the design stage, it is important to gain an initial idea of the prospective production costs for a system, as well as the operating costs that would be associated with it. For example, simple decisions such as materials of construction can have a great impact on production costs whilst simultaneously affecting the time that components will last without the need for replacement.

When producing documentation for a demonstration programme, an initial estimation of the production costs of the unit, as well as the required operating costs (per day per use) should be included. During field-testing and demonstration, actual operating costs can be estimated from the net utility usage required and compared to the estimated costs to determine where savings may be made. In addition, rigorous testing will indicate whether design decisions need to be made regarding any of the components due to wear, over-design or suitability issues which would alter the potential production costs.

In a similar manner to the provision of test data prior to field-testing and demonstration, the costing provides a baseline that can be used as a comparison during the demonstration programme.

3.8 Applicable Standards

This section provides an overview of standards applicable to non-sewered sanitation systems. If an outcome of the field-testing and demonstration is to meet local, national or international standards, it is important to have a clear understanding of what these standards are in order to ensure the relevant tests are conducted.

3.8.1 International Standards: ISO 30500 and ISO 31800

In 2015, TÜV SÜD Asia Pacific Pte Ltd in Singapore undertook a project funded by the Bill & Melinda Gates Foundation to develop and establish a voluntary international standard for safe and sustainable sanitation technologies for use by the poor in the developing world with a focus on Reinvented Toilets. The standard was published in October 2018 under the title "ISO 30500:2018 – Non-sewered sanitation systems – Prefabricated integrated treatment units – General safety and performance requirements for design and testing". The technical standard provides general safety and performance requirements for the product design and performance testing of prefabricated integrated treatment units that are not attached to a network sewer or drainage system as shown in Figure 3.3. This standard is for household scale systems.

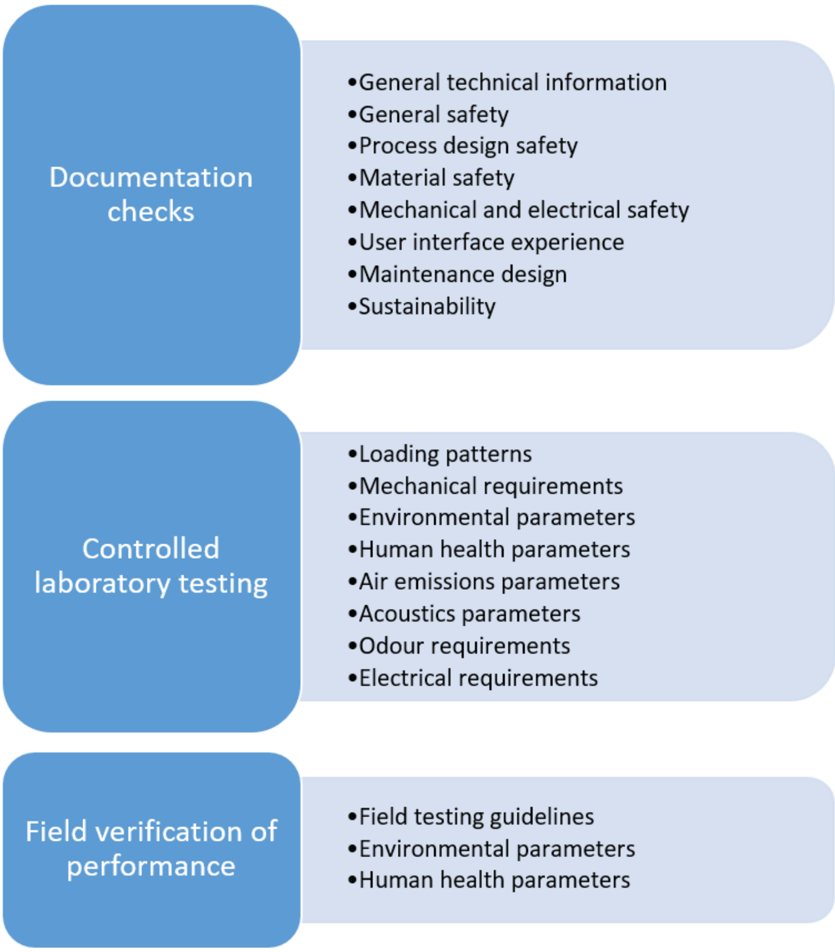


Figure 3.3 – General overview of content of ISO 30500

ISO Project Committee (PC) 318 for "ISO 31800: Community scale resource-oriented sanitation treatment systems", developed a voluntary, international product standard that focuses on faecal sludge treatment through the development of sanitation treatment units. These sanitation treatment units will treat waste at a community level even in areas where there are no suitable wastewater treatment systems in place as highlighted in Figure 3.4. This standard is for community scale treatment systems.

General safety and performance requirements for product design and performance of pre-fabricated community-scale resource recovery faecal sludge treatment units that serve 1,000 to 100,000 people	
Contains: Criteria for functionality, usability, reliability, maintainability, and safety	Excludes: Guidelines for selection, installation, operation and maintenance, and management of faecal sludge treatment units

Figure 3.4 – Summary of content of ISO 31800

3.8.2 National Standards and South Africa's Adoption of ISO 30500

In South Africa, the development of innovative sanitation solution standards is a national priority according to the Industrial Policy Action Plan and the National Development Plan 2030. Non-sewered sanitation systems are included in the Water and Sanitation Master Plan. In 2019, South Africa became the first nation in the world to adopt ISO 30500:2018, in the form of the SANS 30500:2019 standard.

It should be noted that any system that is discharging into municipal sewers or into the receiving environment (land, freshwater or coastal) must adhere to the relevant national and local guidelines for discharge. This must be discussed with the municipality or regulator responsible for the area where the system is being tested. For more information on emissions and effluent standards in South Africa, see Section 2.8.

3.8.3 Water Recycling Standards

There is currently no official legislation in South Africa that speaks directly to the recycling of water from sanitation systems for reuse as flush water or hand washing water. The development of such a standard is currently being reviewed by the WRC.

Recycling standards are not universal across countries and therefore if the prototype is to be aimed at the international market, commercialisation partners should consider national or local regulations for all markets they intend to enter.

Relevant standards applicable to testing identified and agreed by all stakeholders

3.9 Developing a Test Plan

Once all the information on the prototype and results from previous testing have been collated, and there is an understanding of what standards need to be met, a test plan needs to be developed. This test plan should include the following:

- Phases of testing and goal of each phase
- Streams to be sampled in each phase
- Frequency of samples taken in each phase
- Analysis to be carried out on each sample

A template for a test plan can be found in Appendix 2.5.

Test plan agreed by all stakeholders

Water Recycling Standard for EFTP

Many of the prototypes tested on the EFTP in eThekwini aimed to recycle the treated wastewater as flush water. As no water recycling standard existed, the standard shown below was developed by the PRG in consultation with the Deputy Head of Scientific Services at eThekwini Water and Sanitation. It sets out the minimum water quality required for recycled water to be reused for flushing toilets and urinals. An average of three samples taken from the treated water holding tank that feeds toilet or urinals with flush water on consecutive weeks had to be below the average standard set out in the table below. In addition, no single sample could exceed the maximum stated in the table. If either the average of the three samples exceeded the average standard, or any sample exceeded the maximum standard, recycled water would be diverted to sewer.

	ISO 30500 Standard		EFTP Recycling Standard	
Parameter	Average	Maximum	Average	Maximum
Chemical				
COD (mg/L)	50	150	50	150
TSS (mg/L)	10	30	10	30
Turbidity (NTU)	-	-	5	10
pH	-	6-9	-	6-9
Free chlorine (mg/L)	-	-	>0.5	-
Biological				
E. coli (CFU/L)	-	100	10	100

3.10 Checklist of Documentation

Documentation that is useful prior to planning a field-testing and demonstration programme includes the following:

- Identification of the required outcomes of the testing
- A description of the prototype/product and the current TRL
- An overview of the process design
- Health and safety aspects that need consideration during operation
- Testing results from laboratory/pilot trials to date
- User acceptability results from any user testing carried out to date
- Production costs/estimated running costs for the prototype/process

A checklist of these documents is shown in Appendix 5.1. These documents along with an understanding of the applicable standards will assist in the development of a test plan.

All necessary documentation required prior to testing and demonstration collated

Chapter 3: Planning for a Sanitation Prototype Demonstration – In Brief

- *A clear understanding of the aims or outcomes of the testing (using SMART targets) is important to guide the planning of the field-testing and demonstration*
- *Important documentation includes a brief description of the system, engineering sketches and process flow diagrams*
- *Health and safety considerations related to the operation of the system should be provided up-front*
- *All previous test results should be provided, including any user surveys*
- *An understanding of the relevant standards is important to ensure that the relevant analyses are undertaken*

Chapter 3: Planning for a Sanitation Prototype Demonstration – Further Reading

For more on risk assessments and HAZOPs, many texts are available. A recommended guidebook is:

- *Crawley, F. and Tyler, B. (2015) "HAZOP – Guide to Best Practice" 3rd Edition, Elsevier.*

For an introduction to process design, flow-sheeting and costing, this book may be of interest (although it is aimed more towards large scale chemical engineering processes):

- *Sinnott, R and Towler, G. (2015) "Chemical Engineering Design" 5th Edition, Butterworth-Heinemann.*

For more on non-sewered sanitation ISO standards and their adoption in South Africa, see:

- *American National Standards Institute (ANSI)'s "What is ISO 30500?": https://sanitation.ansi.org/Standard/ISO30500*
- *American National Standards Institute (ANSI)'s "What is ISO PC 318?": https://sanitation.ansi.org/Standard/ISOPC318*
- *SANS 30500:2019 (for purchase): https://store.sabs.co.za/sans-30500-ed-1-00-1*

For more on the adoption of non-sewered sanitation into policy in South Africa, see:

- *Industrial Policy Action Plan: http://www.dti.gov.za/industrial_development/industrial_development.jsp*
- *National Development Plan 2030: https://www.gov.za/issues/national-development-plan-2030*
- *Water and Sanitation Master Plan: https://www.gov.za/documents/national-water-and-sanitation-master-plan-28-nov-2019-0000*

Chapter 4: Site Identification and Selection

This chapter describes issues to consider in relation to selecting suitable demonstration sites for off-grid sanitation systems. It covers identifying the required characteristics of a site, the practicalities of looking for suitable sites, and approaching local government and communities for approval to use the preferred site.

Technology developer, commercial partner, demonstration platform (if relevant), community engagement team, municipal management, municipal community liaison

2 weeks to 3 months

Chapter 2: What You Need to Know Before You Start; Chapter 6: Community Engagement

4.1 Defining the Required Characteristics of the Demonstration Site

The type of system to be tested and the specific aims of the field-testing and demonstration will guide what is required from the demonstration site. For example, a test of a front-end system at household level, where the primary aim of field-testing and demonstration is to gauge the user acceptability of the system, will require little supporting physical infrastructure and can probably be tested in an area where limited utilities (water, sewer, and electricity) are available.

The test plan (template given in Appendix 2.5) developed during the planning phase of the project will provide a guide to the requirements for the demonstration site(s). A detailed site selection criteria document should now be developed, reviewed and approved by all stakeholders. A template can be found in Appendix 2.6. It is important that the site selection criteria are written down and shared with all stakeholders, to make sure expectations are aligned from the start.

Table 4.1 lists the main items for possible inclusion in the site selection criteria – which ones are applicable will be dependent on the prototype being tested. It should be emphasised that strong support from the household or community is of the highest importance, and should be used as the deciding factor in choosing between sites. Technical issues can normally be resolved, but a lack of support for the project or complicated political dynamics will result in an extremely difficult working environment.

The site selection criteria document for a particular prototype is then used to identify possible sites and to create a shortlist of the preferred options.

Table 4.1 – Items to consider including in the site selection criteria

Item	Description	Details
Level of household, school or community support for the project	• Most critical element in site selection • Do not use the site if little support for the project from the household, school or local community	• Strong support and ownership of the project is key to security on site, obtaining good employees and reducing delays to the project • Ownership ensures that field-testing and demonstration is socially just and not imposed on communities
Political dynamics of the site and local area	• Stable political situation desired, with support at all levels for the project • Easy to contact those who have decision-making power	• Is there support at ward councillor level for the project? • Does the test site community support the local ward councillor? • Are there different political factions within the community who may use the project to further agendas, in the process delaying it?
Number of users for system and usage pattern	• Treatment capacity of the system must match the expected usage rate and pattern	• Take into account how many users are absent during the day at work/school and the impact on usage rate • School systems have particular usage patterns, with periods of zero inflow outside of school hours, weekends and school holidays • Buffer volume may be required to deal with uneven usage patterns
Travel time from office to testing site	• Impacts on staff time commitment, testing budget and safety measures required (more back-ups required if not possible for a staff member to get to site quickly)	
Water availability	• Is water available to supply the prototype as required – for commissioning,	• Supply pressure? • Limited daily volume available (e.g. if household on free basic water only)?

	normal operation and decommissioning? • Is a back-up supply required (rainwater, water tanker, etc.)	• Willingness of household, school or community to share water connection in return for compensation? • Frequency of water cuts?
Sewer connection availability	• Is a sewer available to divert emergency overflows to? • Otherwise, is a tank required and means to empty it?	• Having a sewer back-up is of greater importance for prototypes at lower TRLs due to the increased risk of breakdowns, leaks etc.
Electricity availability	• Is mains electricity required and available?	• Limit on current that can be drawn via an existing connection? • Willingness of household, school or community to share electricity connection in return for compensation? • Frequency of power cuts?
Space	• Is there sufficient open space to fit the prototype, auxiliary systems and working space around it?	
Level ground or level drop	• Can the levels on site be made to work for the prototype without excessive costs?	• Is level ground required? • Would a natural slope help, e.g. to avoid having to have steps up to the toilet door?
Level of site access required	• Will access for a crane or forklift be required? Will items be carried in by hand?	
Security	• Does the site look organised from a security perspective – is there fencing? A locked gate? Is a security guard required?	• Security can add a significant cost to the budget
Visibility of prototype from outside the site	• Will the prototype be fairly concealed from casual passers-by?	• High visibility of expensive and desirable equipment (e.g. solar panels) should be avoided

Languages spoken by users	• What will be the language of communication between the users and the field-based project team?	• Is there a need for a translator or do your field-based staff speak the same language as the intended users of the prototype?
Structural integrity of any existing structures to be used (e.g. existing toilet superstructure)	• State of concrete structures, doors, windows • Consider user experience as well as logistics of bolting on new system to existing structure	
Willingness to have testing staff working regularly in the household or community space	• Consider how this will work in practice – how will the team get access to site (will they have their own keys?), how will the project run without impinging excessively on the household's privacy?	
Proximity to potential manufacturers	• Are there other key manufacturers or sub-contractors in addition to the LCTP who will be accessing the site regularly?	
Specific requirements from SASTEP	• Does the LCTP's contract with SASTEP give any requirements for the testing site?	

Site requirements recorded in site selection criteria document

Overcoming Challenges During Site Selection

Once suitable sites have been identified based on the technical and infrastructure requirements, the selection of the sites needs to take place. This involves engaging with the relevant stakeholders, including political leadership, community committees, household owners and school governing bodies. Some of the challenges experienced in site selection during the EFTP include:

- *Identifying suitable sites, but not being able to use them for testing due to existing political conflict in the ward*
- *Obtaining permission from both the ward and proportional representation (PR) councillor to undertake the testing in the particular community*
- *Where a particular household is selected for testing, explaining to other households why they were not selected*
- *Obtaining buy-in from a community where there are two community committees with conflicting view points*
- *Where a school is involved, ensuring that permission is obtained from the Department of Basic Education, the school governing body and the head teacher*

Careful and continuous engagement with the relevant stakeholders by the municipal community liaison explaining the aims, benefits and outcomes of the testing programme, and the contribution that the community, household or school would be making to the selection of future sanitation solutions, assisted in overcoming these challenges.

4.2 Engagement with Regulator (Municipality or Other)

The relevant regulator(s) must be fully informed about the proposed field-testing and demonstration and give approval for it to happen, before any engagement can take place at potential sites. The test plan and site selection criteria document will form the basis of these discussions between the regulator and the LTCP or demonstration platform. The applicable regulator will depend on the type of site:

- Community or household sites: support from the municipal Water and Sanitation Unit is needed, particularly for prototypes that may require connection to municipal infrastructure such as sewerage networks or communal ablution facilities
- School sites: support from the provincial Department of Education is needed and it is advisable to liaise with any implementing partner that they have for water and sanitation provision at schools under their jurisdiction
- Municipal sites such as wastewater treatment plants: support from the municipal Water and Sanitation Unit is needed

The regulator should give written permission to access sites and to start identifying potential demonstration sites. It is advisable to engage with the municipal Water and Sanitation Unit about the project regardless of the type of site, as they may be potential buyers of the technology. In addition, it is valuable to inform other departments whose sphere of influence may benefit from or be affected by field-testing and demonstration. These departments could include:

- Electricity department: to provide support with electrical connections in areas where there is no electricity or illegal connections
- Development planning, environment and management unit: to provide support in issuing any required environmental licences or permits

4.3 Site Searches and Shortlisting

The initial search for potential sites will involve minimal (if any) engagement with the communities or households, to avoid creating expectations at sites that do not end up being used. Knowledge of possible sites from previous work in the area is invaluable, as this will provide an insight into the likely local political dynamics. This is particularly relevant when selecting informal settlement sites.

Tips for Identifying Suitable Sites

- *At a high level, specific wards can be ruled out if the political situation is known to be non-supportive*
- *Driving through an area is a practical way of identifying possible household sites*
- *For school sites, geographical location, quintile classification, number of learners and age-groups catered to provide an initial indication of their suitability for testing and need for improved sanitation*

4.4 Engagement with Local Government

Once a shortlist of possible sites has been identified, engagement with the applicable local government officials should take place. This engagement is dealt with in more detail in Chapter 6: Community Engagement and includes:

- Ward councillor: to inform them about the project and gain permission to test within the ward
- Proportional representation (PR) councillors: to inform them about the project and gain their support. This is particularly important where the community at the test site may support the political party of the PR councillor, and not the ward councillor
- Traditional leaders: to inform about the project and gain permission to test within their area of influence

The following factors can impact on engagement with local government:

- The timing of local and national elections
- Shifting ward boundaries around elections
- Political dynamics between ward and PR councillors and the communities they serve
- The availability of key decision-makers
- The level of involvement that local government officials wish to have with the testing activities

Test plan approved by regulator and local government

4.5 Engagement with Communities and/or Households

Once permission for testing has been granted by the regulator and local government, engagement with shortlisted communities and households can start. The aims should be to:

- Inform the community or household of the potential project and provide basic information and pictures
- Understand the political dynamics at play within the community or household
- Gauge the likely level of support for the project
- Understand the technical suitability of the site and estimate the costs of site preparation

The importance of having skilled community engagement staff on the project team cannot be over-emphasised. The community engagement process, particularly for informal settlement sites, may take several weeks or even months to run its course due to the difficulties of bringing decision-makers together. Community committee members are often only available in the evenings or at weekends and political dynamics may cause people to delay decisions or to not attend meetings. Community engagement is dealt with in more detail in Chapter 6: Community Engagement.

4.6 Final Decision on Demonstration Site

It should be decided in advance who will be part of making the decision about the final choice of demonstration site. This should be decided during the planning stages, as outlined in Chapter 2: What You Need to Know Before You Start. The decision should be communicated in writing to all those who were part of the site selection process. If possible, a back-up site should also be chosen by the project team.

Testing and demonstration site agreed by all stakeholders

Chapter 4: Site Identification and Selection – In Brief

- *The criteria for a demonstration site must be developed up-front to enable suitable sites to be identified*
- *There are a number of key criteria to consider for site selection, in particular the scale of testing (community/household/school), the political climate in the area, and most importantly, the level of household, school or community support for the project*
- *Engagement needs to happen on a number of different levels – municipal (e.g. Ward and PR councillors), traditional authority (where relevant), school (e.g. Department of Basic Education and school governing body), community (e.g. community committee) and individual (e.g. household residents)*
- *Community engagement can take from one month to several months*

Chapter 4: Site Identification and Selection – Further Reading

For more on site selection for sanitation field-testing and demonstration, see:

- *STeP (India) guidance on site selection: https://stepsforsanitation.org/2020/01/reinvented-toilet-pilot-playbook-streamlined-guidance-for-technology-and-commercial-partners/*

Chapter 5: Shipping and Logistics

This chapter provides a guide to shipping and logistics considerations that are specific to the field-testing and demonstration of non-sewered sanitation systems. It is not intended to be a comprehensive guide to these topics as it is assumed that commercial partners already have substantial experience of these activities.

Topics covered in this chapter are import and export of sanitation systems, local transportation and storage, insurance considerations, and spare parts.

Technology developer, commercial partner, demonstration platform (if relevant), community engagement team, municipal management, municipal community liaison, prototype engineer, engineering contractors, shipping firm, clearing agent, SARS

Refer to Table 5.1

Chapter 3: Planning for a Sanitation Prototype Demonstration

5.1 Import and Export of Systems

This section provides guidance on the international shipping of non-sewered sanitation prototypes. Table 5.1 lists considerations for the organisation acting as the importer of such prototypes to South Africa.

Table 5.1 – Guidance for the import and export of sanitation system prototypes

Item	Description	Details
Registration with SARS as an importer	• LCTP will need to register with SARS as an importer-exporter • Timeline: 2 weeks	
Packing the shipment (single or multi-piece shipment)	• Consider the costs/benefits of shipping the system as a single containerized unit versus shipping individual unit modules and procuring a superstructure for the unit in South Africa. • Timeline: 2 days to 2 weeks depending on shipment size	• Shipping a containerised system: ○ Pros: ▪ Unit well protected for shipment ▪ Faster installation on site ○ Cons: ▪ Higher shipping costs ▪ Difficult to get large containers onto sites with constrained space and access ▪ Expensive rigging equipment required at multiple times • Shipping system as modules: ○ Pros: ▪ No expensive rigging required to unload and transport ▪ Superstructure can be easily tailored to local requirements (e.g. security features) ○ Cons: ▪ Higher potential for damage in transit ▪ More assembly required on site
Incoterms/ Delivery terms	• DAP – Delivered at Place • DDP – Delivered Duty Paid • DAP leaves the responsibility for unloading and payment of import taxes and duties with the	• Explanation of incoterms: https://www.incotermsexplained.com/the-incoterms-rules/the-eleven-rules-in-brief/delivered-place/

Item	Description	Details
	buyer/importer; thus budget needs to be allowed for these activities if the agreed delivery term is DAP	
Shipping timelines (indicative)	• Sea freight: 4 to 6 weeks, plus 2 to 7 days for clearing Customs • Air freight: 2 to 3 days in transit, plus 2 to 7 days for clearing Customs	
Clearing shipment through Customs	• Importer will complete customs clearing instructions	• Confirm beforehand who will appoint the clearing agent (shipping company or importer) • Specify on the clearing instructions if a minimum notice period is required prior to delivery, so that rigging equipment can be arranged if required
Import goods classification and duties	• Applicable import duties will depend on what goods category the shipment falls under	• Prototypes that fall under the category of 'Machinery; for filtering or purifying water' are assigned HS code 842121 and this code currently attracts zero import duties in South Africa • Searchable full list of HS codes: https://www.foreign-trade.com/reference/hscode.htm?cat=13
Import VAT	• VAT applies to goods imported into South Africa at 15% of 110% of the shipment value. • VAT-registered importers can claim this VAT back on their VAT return; sufficient cash flow is needed to cover the initial VAT payment but should not be a final cost to the project	
Information to provide to seller	• Information the importer will provide to the seller (technology developer) pre-shipment	• SARS importer number • VAT number • Contact details for two people who can receive the shipment

Item	Description	Details
		• Delivery address
Information required from seller	• Information required when planning shipment and after dispatch	• Pre-shipment: ○ Confirm delivery terms ○ Confirm packing list and mass/volume of each package ○ Confirm storage requirements for shipment ○ Confirm arrangement for appointment of clearing agent ○ Confirm expected shipment value and goods classification, to estimate import duties and VAT • After shipping: ○ Final packing list ○ Commercial invoice ○ Waybill number

5.2 Local Transportation and Storage

It is advisable to have prototypes delivered to a secure storage site, rather than directly to the demonstration site. This provides an opportunity to unpack the prototype, check for any damage that may have occurred in transit and to carry out some assembly and pre-commissioning tasks in a convenient and secure location. Table 5.2 summarises considerations for LCTPs in relation to local transport and storage of prototypes.

Table 5.2 – Guidance for local transportation and storage of sanitation system prototypes

Item	Description	Details
Make-up of shipment (single or multi-piece shipment)	• Single piece containerised shipments will normally require a crane or forklift to unload – rigging equipment and suitable access required	
Size of container	• Containers over 6 m length require much longer transport with larger turning radius – access to storage and demonstration sites needs to be adequate	
Rigging activities	• Competent rigging company needed to deal with hazards typical of demonstration sites	• Informal settlement sites may have narrow road access, constrained space to manoeuvre, overhead power cables, poor road surface particularly in wet weather
Storage site characteristics	• Good security (24 h guard preferable) • Lock up storage for components when unpacked • Protection from rain and sun • Facilities for pre-commissioning activities (e.g. water supply and sewer access for leak tests, electricity supply)	• Hired shipping containers are cost-effective secure storage, but get very hot inside
Temperature sensitive equipment	• Equipment such as batteries and chemicals may require separate storage	
Waste management	• Disposal route for significant quantities of packing material	
Equipment inventory	• Advisable when equipment is being stored/operated at multiple sites	

5.3 Insurance

Field-testing and demonstration of non-sewered sanitation prototypes requires suitable public liability insurance to be in place. Depending on the risk level of the demonstration site and the value of the prototype, theft and damage insurance may also be advisable.

5.3.1 Public Liability Insurance

Prior to a test plan being developed, a risk assessment of the prototype (HAZOP Stage 3 or other assessment suitable to the level of development of the system) must be carried out and risk mitigation measures put in place (see Chapter 3: Planning for a Sanitation Prototype Demonstration).

Public liability insurance will always be required for the period that the prototype is at the demonstration site, in case of any injury to the public caused by the operation or malfunction of the prototype (e.g. fire, flood, environmental contamination, explosion, air pollution etc.).

Options for public liability insurance include:

- An addition to the LCTP's existing public liability insurance;
- If testing on a municipal site, adding the prototype to the municipality's asset register (e.g. via a temporary donation for the demonstration period) and being covered under the municipality's public liability insurance;
- Where a university is involved in the field-testing and demonstration, it may be possible for the demonstration site to be designated as a university research site and be covered under the university's public liability insurance.

5.3.2 Theft and Damage Insurance

The risk of theft and vandalism will be dependent on the demonstration site:

- Community informal settlement sites may be relatively low-risk sites if there is a cohesive community, a good Community Liaison Officer, good community engagement by the project team, and hence a sense of community ownership of the site and prototype
- The security of a school testing site will be dependent on the school infrastructure (fencing, security guard) and management, and the attitude of the surrounding community to the school – is it seen as a community asset or as a facility from which theft is an accepted norm?
- Household testing sites are often lowest risk, as with good community engagement there should be strong ownership of the prototype and interest in making the demonstration a success

If theft and damage insurance is taken out, it may still be worth keeping budget in reserve for carrying out urgent fixes to the prototype, whilst an insurance pay-out is being negotiated. This may prevent significant and costly standing time when no field-testing and demonstration can take place.

If ownership of the system still resides with an overseas technology developer, it may be difficult for the LCTP to insure the prototype locally. Prototype value for insurance purposes can also be difficult to prove.

Theft and Damage Insurance for Prototypes on the EFTP

The EFTP did not take out theft and damage insurance for any prototype tested on the platform. Prototypes which were added to the municipality's asset register would in theory have been covered by the municipality's insurance, but in practice the process of making a claim would have been too lengthy to provide pay-outs for urgent fixes. The EFTP did not own any of the prototypes being tested. Instead, both the EFTP and technology developers made allowance in their budgets for minor to medium expenses caused by theft or vandalism, and critical or likely-to-be-damaged spares (e.g. solar panels and pipe fittings) were kept in storage where possible.

Appropriate insurance put in place for testing and demonstration

5.4 Spare Parts

A critical element of achieving a successful sanitation prototype demonstration within budget is to reduce any standing time where the prototype cannot run according to design. It is therefore important to have an assured and prompt supply of spare parts when needed.

A critical spares list should be supplied by the technology developer well in advance of the prototype being installed on site. This lists all parts of the prototype where spares are likely to be required and assigns each of them a criticality score A or B as follows:

- A – Long lead item, critical for operation of the prototype
- B – Normally available or not critical for the operation of the prototype, or duplex system is available and installed

The list will detail the following:

- Item description
- Make
- Part number
- Criticality score
- Recommended quantity to have in stock at start of testing
- Unit price of spare
- Whether the part can only be obtained from the technology developer

A template for a critical spares list can be found in Appendix 2.7.

Typical parts might include:

- Custom-shape tanks
- Standard and custom-shape pipe adapters
- Valves and actuators (especially those specific to sludge or gas streams)

- Water meters
- Data logger components
- Instrumentation
- Batteries
- Door locks and keys
- Toilet flush mechanisms
- Taps
- Membrane modules
- Filter media
- Chemicals

The critical spares list will enable the LCTP to plan procurement of spares in advance, so that time is not lost when the prototype arrives on site. The following sub-sections consider procurement routes for spare parts.

5.4.1 Off-shelf Spares

The LCTP should review the critical spares list and understand to what extent they will be reliant on spares that can only be supplied by the technology developer and/or overseas suppliers.

The process for sourcing viable local replacements for these parts should start as early as possible, and it is advisable to identify several suppliers of parts that are locally available off the shelf.

5.4.2 Custom-made Parts

The nature of novel waste processing systems is that some parts will be non-standard and potentially currently only available from the technology developer or one overseas supplier. The following options should be considered, both to reduce reliance on one supply route for parts and to start the process of localising the manufacturing of the system:

- Local fabrication of custom parts: working with local manufacturers to develop techniques and build the capacity required
- 3D printing of parts by a sub-contractor

Critical spares documented and appropriate in-country suppliers found where possible

Chapter 5: Shipping and Logistics – In Brief

- *There are a number of steps required in order to ship systems in from outside South Africa and these need to be followed correctly to prevent delays*
- *Having a secure off-site area for the initial delivery, storage, unpacking and checking of equipment is recommended*
- *Public liability and insurance are required to protect the communities in which the prototypes are being tested, and to protect against damage and theft*
- *Compiling a list of critical spare parts prevents standing time once the prototype is at the demonstration site*
- *Local suppliers and manufacturers of critical spare parts should be Identified wherever possible to reduce reliance on overseas supply routes and to support localised manufacturing.*

Chapter 5: Shipping and Logistics – Further Reading

For more on import and delivery codes and terminology, see:

- *Explanation of incoterms: https://www.incotermsexplained.com/the-incoterms-rules/the-eleven-rules-in-brief/delivered-place/*
- *Searchable full list of HS codes: https://www.foreign-trade.com/reference/hscode.htm?cat=13*

Chapter 6: Community Engagement

The active involvement of communities in sanitation technology demonstrations is vital to the success of the project. This chapter covers the process for ongoing engagement, methods for raising awareness and educating communities about sanitation issues, the importance of managing expectations, and ensuring that the community are adequately compensated for their involvement.

Community engagement team, demonstration platform (if relevant), prototype engineer, engineering consultant, community liaison officer, municipal community liaison, councillors, traditional authority leadership (if relevant), community/school leadership, head of household (if relevant)

Duration of project – 3 to 18 months

Chapter 11: Social Aspects of Testing

6.1 Legal Requirement for Community Engagement

South Africa is a participatory democracy. The active involvement and participation of the citizenry (or communities) in public and private decision-making is enshrined in the South African Constitution (Act 106, 1996) and legislated in the National Environmental Management Act (NEMA, Act 107, 1998), amongst others.

Feeling Seen

One advantage for communities of being part of a demonstration project is the feeling that the municipality knows that 'they are there' and will respond to housing and service-related issues.

The provision of sanitation is both a public and private issue:

- Public – responsibility for provision of services lies with the local water authority
- Private – water and sanitation services are used in the private and community domain

Community engagement or public participation is the ongoing process of ensuring the community is informed about and included in the multiple aspects of any sanitation prototype demonstration taking place in their community.

6.2 Roles and Responsibilities in Community Engagement

Identifying who is responsible for establishing and maintaining social networks and relationships in a demonstration project is important. There needs to be a group of people working together to engage with the community and the roles and responsibilities within the team need to be agreed upon at the start of the process, as discussed in Section 2.4.

Community engagement is characterised by a two-way exchange of information between communities (including various leadership structures) and the demonstration project team. It is an ongoing, open, transparent, and transformative process that needs to be initiated at the outset of a sanitation technology demonstration, from site selection through to the end of the decommissioning phase. A deliberate and inclusive approach should be taken to engaging with any individual or group that will have an influence on or will be affected by the field-testing and demonstration.

The members of the community engagement team need to work together, and may need to attend the same community meetings when required if multiple areas of responsibility or expertise need to be present. However, feedback from any community engagement meetings or events needs to be provided to all members of the community engagement team to ensure that the information and knowledge shared with communities is consistent, that the same approach is being followed by all members of the community engagement team, and that the social learning that takes place through the community engagement process is shared.

6.3 Community Engagement Process for Community Sites

The first point of contact in engaging communities draws on the Municipal Structures Act (Act 117, 1998), which states that the ward councillor and the ward committee act as the point of contact between communities and the municipality. The municipal community liaison makes first contact with the ward councillor, and where possible with the proportional representative (PR) councillors to inform them of the project and to obtain their feedback on site selection. In the case where the demonstration sites are located in Traditional Authority Areas, which are under dual governance, the ward councillor is required to inform the traditional leader (*Inkosi*) and should report back to the municipal community liaison that the *Inkosi* is aware and approves of the project. If the ward councillor is not on good terms with the *Inkosi*, it may be necessary for the community engagement team to inform the *Inkosi* directly.

Informing PR Councillors

In informal settlements where there is a high level of support for a political party that does not represent the ward, informing the PR councillor can be an important way to ensure that community members are supportive of (or at least not actively resistant to) the demonstration project.

The ward councillor and *Inkosi* will use existing communication and leadership structures (e.g. ward committees, or headmen – *Izindunas*) to inform the community leadership. They will then call a community meeting to discuss the possibility of new sanitation technologies being tested in the community. The meeting will be used to obtain community responses to the proposed idea and report back to the municipal community liaison, who may be invited to attend this first meeting. Once the community leadership has met with the community to propose the idea, and the community agrees to participate in the demonstration project, an information-sharing meeting with the community should be held. This meeting also serves as an introduction to the community engagement team. It is advisable that as well as representatives from the community engagement team, someone who can answer technical questions about the prototype should also be present at this meeting so that community members can raise questions about the demonstration project and what it may mean for their community. This process is illustrated in Figure 6.1.

A Community Liaison Officer (CLO) should be hired from the community to serve as the community-based contact/receiving person for the project team. This person will know the area well and can provide support to the community engagement and social assessment teams when they have to navigate the area to talk directly to community members. An appropriate candidate for the position of CLO should be identified through the community leadership structures.

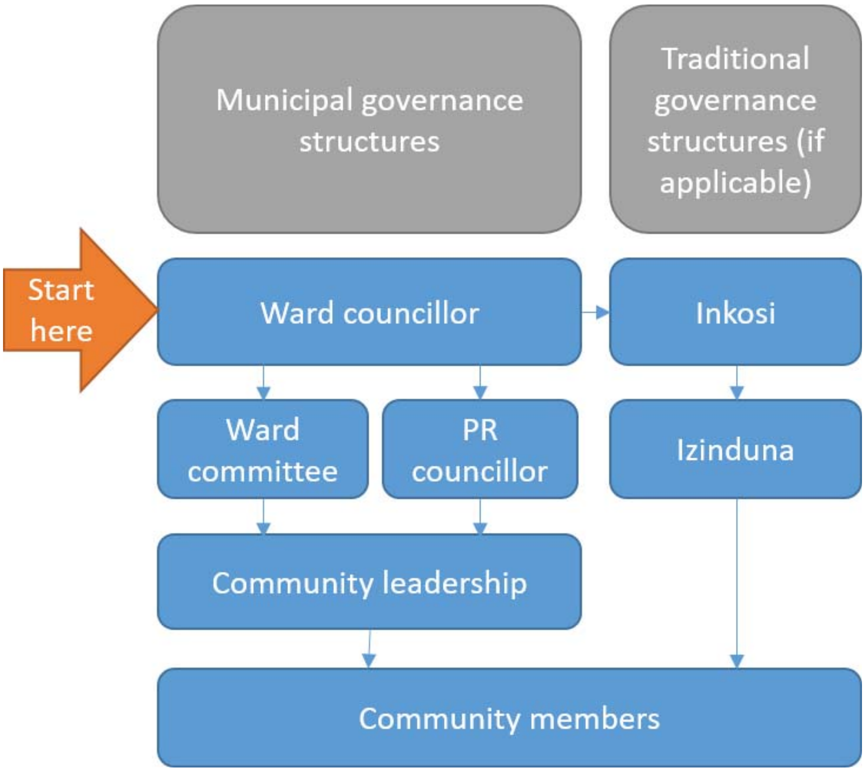


Figure 6.1 – Community engagement process for community sites

Community leadership and community members approve plan for testing and demonstration; Community Liaison Officer appointed for community site

Using Sanitation Demonstrations as an Opportunity to Promote Science

The community leadership in one informal settlement used as a demonstration site under the EFTP were keen to use the demonstration as an opportunity to promote science education amongst learners in the community. The prototype engineers based at the site carried out tours of the prototypes for high school learners to explain how the systems worked. They also arranged a laboratory tour where the learners carried out a filtration experiment to study how filtering through different materials changed water quality. This helped learners understand the prototypes in their community and showed them an example of science at work in a setting that was familiar to them.

6.4 Community Engagement Process for Households

As with communities, the first point of contact for household demonstration sites is the ward councillor. Where possible, the PR councillors should also be informed about the project. In the case where the demonstration site is located in a Traditional Authority Area, which is under dual governance, the *Inkosi* should also be made aware of and give approval for the project. Once project approval has been given by the ward councillor and, where necessary, the *Inkosi*, the community engagement team can then interact with the head of the household. After permission has been given by the head of the household to use the household as a demonstration site, interaction with all members of the household will be necessary. This process is illustrated in Figure 6.2.

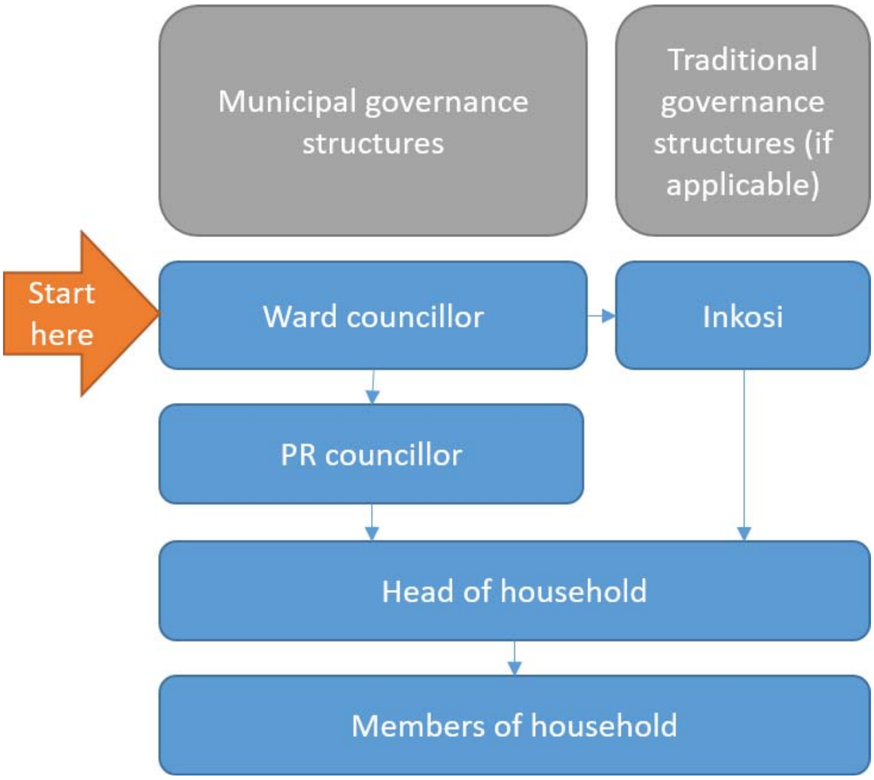


Figure 6.2 – Community engagement process for household sites

Household members approve plan for testing and demonstration

6.5 Community Engagement Process for Schools

Where field-testing and demonstration is taking place at a school, the Department of Basic Education (DBE) needs to be approached for approval for the demonstration project to take place. Once a school has been selected, further discussions will take place between the community engagement team, the school's governing body and the head teacher of the school. Both the DBE and the head teacher or school governing body must supply gatekeeper's letters to show that they are happy for the demonstration to take place at the school. This is important in order to apply for ethical clearance (see Section 0), particularly for social assessments (see Chapter 11: Social Aspects of Testing). Section 11.5 gives more guidance on social assessments in school settings as interviewing children raises ethical concerns. Once approval for use of the school as a demonstration site has been secured from the DBE, the governing body and the head teacher, the community engagement team can interact with the teaching staff and the school's caretaker.

Whilst permission for use of a school site is given by the DBE, it is useful to inform the ward councillor and the *Inkosi* (if the school falls within a Traditional Authority Area) that the sanitation demonstration will take place at the school, as it allows them to answer questions from the wider community (through local leadership structures) as necessary. This process is illustrated in Figure 6.3.

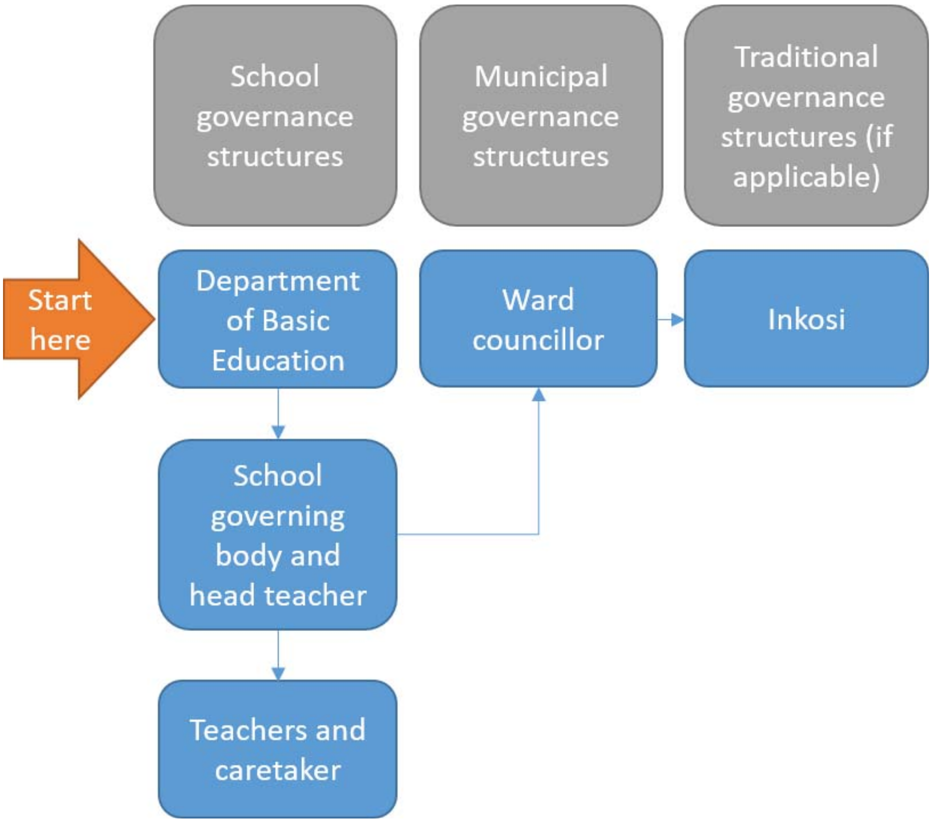


Figure 6.3 – Community engagement process for school sites

School governing body and head teacher approve plan for testing and demonstration

6.6 Methods for Community Engagement

A wide range of methods are used for community engagement and the choice of method is dependent on several factors. It can be useful to categorise stakeholders based on the level of power that they have over a project and the level of interest that they have in a project to determine the appropriate form of engagement. An influence-interest matrix can be useful for this process, which can also inform the development of a RACI matrix (see Section 2.4.1).

In addition, the following factors should be considered:

- Goal of the engagement – Is the aim to inform community members about a change, educate learners about a prototype, gather input on the best location for a prototype, understand concerns about a system's operation?
- Audience – Is the message aimed at school-age learners, adults, parents, community leadership? Is it aimed at a small group or a large number of people?
- Context of the demonstration site – What existing political or community concerns might affect how people respond to the messages being shared?
- Time during the project – Is this engagement taking place at the beginning of the project when people do not have a good understanding of the project or the community engagement team, or is it taking place later on when the project and team are well-known to the audience?
- Knowledge and expertise of community engagement team – Does the team have the skills to run street theatre or school learners' events?

Influence-interest Matrix

An influence-interest matrix considers how much influence stakeholders have over a project and how interested they are in the project. This can help to identify the level of communication needed with each stakeholder. The different approaches to communication are shown in the matrix below.

Influence \ Interest	Low	High
High	*Keep satisfied*	*Engage and consult*
Low	*Monitor*	*Keep informed*

Table 6.1 lists the various methods that can be used for community engagement, where they should be held and possible topics to be discussed. Not all members of the community engagement team need to be present at all of these meetings, and the decision as to who should represent the community engagement team will depend on the aim of the engagement.

Table 6.1 – Methods for community engagement; N.B.: members of the community engagement team should be present at all events

Method	Venue	People involved	Timing	Aims
Community leadership meetings	Community	• Municipal community liaison • Community committee	Start of project; regular updates during project	• Information sharing and consultation • Identifying location for prototypes • Project updates and concerns
Community meetings	Community	• Municipal community liaison • Community CLO • Community members	Start of project; during project	• Information sharing and consultation • Listening to concerns • Updates on progress
Site visits & informal discussions	Demonstration site	• Engineering consultants • Prototype engineer • Community CLO • Community members	As required	• Address specific concerns • Discuss each stage of the project • Obtain input from the community
Feedback meetings	Demonstration site or off-site (e.g. offices of demonstration platform)	• Municipal community liaison • Social assessment team • Community committee	Once or twice during project	• Information sharing, consultation and collaboration on progress • Feedback results of social assessments
Posters and media	Demonstration site	• Demonstration platform	At start of project	• Provide explanation of prototype
Learners events	Community, school or university	• Prototype engineer • Engineering consultants • Demonstration platform	As necessary to raise awareness	• Provides learners with information on science topics
Street theatre	Community	• Municipal community liaison • Community members	As required based on issues on site	• Addresses specific areas of concern such as hygiene, blockages etc.

Street Theatre as an Educational Tool

eThekwini Water and Sanitation has a councillor liaison and community education team that, amongst other methods, use street theatre as a way to educate communities about how to use and look after communal ablution blocks (CABs). After a number of challenges with the influent to back-end prototypes tested in one community under the EFTP, the community education team were asked to support with delivering messages about what can and cannot be put down drains and toilets. The street theatre was included as part of the community's Heritage Day celebrations and included questions to the audience and prizes (such as soap) for correct answers. The street theatre drew a larger crowd than had attended previous community meetings on the subject, and there were less issues with people disposing of food and household waste in the drains and toilets after the event.

6.7 Managing Community Expectations and Responses

Prototypes may be tested at a demonstration site for up to one year. This raises significant social issues as households, schools, or communities where new sanitation technologies are being tested usually have access to a sanitation system that has low levels of user satisfaction prior to the installation of the prototype, and which may be considered inferior to the prototype being tested. Household members, learners and communities therefore experience an improvement in technology during the demonstration, because the prototype offers improved features and because the prototype is carefully monitored and maintained by the prototype engineer during the demonstration. This creates a situation of exceptionalism where the prototype is fixed as soon as it fails, cleaning materials and toilet paper are provided, and the cleanliness of the toilets is ensured. The prototype engineer ensures good maintenance of the prototype and quick response times to users' concerns about faults and failures.

When the prototype is decommissioned, the household, school, or community loses the prototype which may have been a significant improvement on their existing sanitation system, and the focus of attention on water and sanitation maintenance in their area, as well as in some cases, improved security.

It is therefore critical in the community engagement process that household members, learners, and communities are continually reminded that the demonstration project is about testing and developing new technologies and that prototypes and infrastructure will be removed at the end of the project. In some cases, infrastructure that can continue to function under the existing systems can remain, such as a toilet block that can be re-routed to sewer. The social assessment process (see Chapter 11: Social Aspects of Testing) needs to address the impact on households, schools and communities by enabling them to voice their concerns, as in most cases the removal of the prototype is a significant loss and has social impacts.

Jealousy and suspicion in neighbourhoods must be recognised and managed through the community engagement process. Neighbours will ask why one community, school, or household was selected to obtain preferential treatment through their involvement in the field-testing and demonstration.

Household members and communities need to be able to report on this through the social assessment process. The community engagement team may need to address this by explaining to neighbours why a particular site was selected. In most cases, household members and communities relay this information to others by providing the information given to them by the community engagement team on the site selection process. It is also essential that undue attention through the media is not placed on the recipient communities as this can increase the response of "why there and not here?" from other communities. A transparent approach to dealing with media requests should be agreed upon by the project team in advance of the field-testing and demonstration (see Section 14.5.3).

Leaving Infrastructure Behind

One school where a stand-alone toilet block and associated treatment process was tested was selected as a demonstration site because there were insufficient toilets at the school. When the field-testing and demonstration ended, it was decided that the toilet block should be left in place and connected to sewer, while the treatment process was removed from site. This meant the number of toilets at the school was increased by involvement with the EFTP but the school was not left with the responsibility of operating and maintaining a novel wastewater treatment system. As such, the school benefited from involvement in the field-testing and demonstration, beyond the duration of the project itself.

6.8 Community Compensation or Appreciation Gesture

Testing a prototype in a household, community, or school involves users dedicating their time, voluntarily, to participate in the project. Demonstrating sanitation technologies involves being in private spaces in people's communities, schools and households, sometimes interfering with their sanitation practices and daily routines. It also takes time for users to participate in interviews, focus groups and surveys, and therefore, as an appreciation for their time and accommodation of the project, the communities at demonstration sites should be compensated in a communal manner. In places where demonstrations take place at the household level, tokens of appreciation must be carried out in a sensitive and open manner to ensure that all household members understand the short-term nature of the demonstration and any benefits that may come to the household hosting the technology. The following are possible ways to give back to communities, schools, and households:

- During the community engagement process make observations of what could support social development at the site. Discuss possible contributions with the community leadership structures to find out what the community needs within the limits of the project budget.
- Look out for possibilities of providing a playground or facilities for children, community garden tools, children's school uniforms, community crèches, community hall upgrades.
- Support community events and promote the project on national holidays.
- Look out for opportunities for capacity building through organising learners events (for a clearly defined age group) to educate learners about the project and other subjects such recycled water and the importance of proper sanitation and hygiene practices; to motivate learners towards different career paths (academic, vocational, entrepreneurial); and also to create awareness about the project and/or the progress of the project.

- At household level, the existing toilet structure could be improved through painting and fixing the door.

Appropriate compensation identified and agreed with stakeholders at testing and demonstration site

Chapter 6: Community Engagement – In Brief

- *The active involvement of citizens in decision-making is enshrined in the South African constitution*
- *Community engagement is an ongoing process and will continue from site selection through to the end of decommissioning*
- *For community or household sites, the first point of contact is always the ward councillor, and the Inkosi for areas under dual governance*
- *For community sites, a CLO should be hired to serve as a community-based contact person*
- *For school sites, the first point of contact is the Department of Basic Education, followed by the school governing body and the head teacher*
- *Methods for community engagement depend of the goal of the engagement, the audience and the context, and can include meetings, posters, educational events and street theatre*
- *Community expectations must be managed from the outset, and communities should be given an appropriate token of appreciation for their involvement in the project*

Chapter 6: Community Engagement – Further Reading

For more on the legislation that relates to the active involvement of communities in decision-making and the processes for achieving this, see:

- *Constitution of Republic of South Africa: https://www.gov.za/documents/constitution-republic-south-africa-1996*
- *Municipal Structures Act: https://www.gov.za/documents/local-government-municipal-structures-act*

For an overview of the importance of community engagement and social assessment in non-sewered sanitation research and development, see:

- *Raising People's Voices video: https://www.youtube.com/watch?v=BfHrMsmRcjc&t=6s*
- *Water and Sanitation for the Urban Poor Topic Brief: Getting Communities Engaged in Water and Sanitation Projects: Participatory Design and Consumer Feedback: http://www.bpdws.org/web/d/DOC_354.pdf?statsHandlerDone=1*

For an overview of the how the dual governance system in eThekwini operates, see:

- *Sutherland, C., Sim, V., Buthelezi, S., & Khumalo, D. (2016), Social constructions of environmental services in a rapidly densifying peri-urban area under dual governance in Durban, South Africa, Bothalia 46(2): https://doi.org/10.4102/abc.v46i2.2128*

For an introduction to methods for community engagement, see:

- *Community Planning Toolkit: Community Engagement: https://www.communityplanningtoolkit.org/sites/default/files/Engagement.pdf*

Chapter 7: Site Design and Preparation

This chapter describes how to develop a design basis for the demonstration site infrastructure, useful considerations for the site design process, the appointment of contractors, and the management of construction and equipment procurement for a typical demonstration site. Ideally, site design should only start once the site has been selected and agreed on by all stakeholders.

Technology developer, commercial partner, demonstration platform (if relevant), community engagement team, municipal management, municipal community liaison, prototype engineer, laboratory team, design engineers, engineering contractors, building contractors, rigging contractors, material and equipment suppliers, community liaison officer

1 to 3 months, may be longer if new utility connections are required

Chapter 3: Planning for a Sanitation Prototype Demonstration

7.1 Design Basis

The design basis document collates the detailed infrastructure requirements for the field-testing and demonstration of a specific non-sewered sanitation prototype at the chosen demonstration site. An example design basis document is included in Appendix 3.1. It includes:

- The design capacity of the system (average, minimum, and maximum influent flow rates)
- The influent streams required (mixed wastewater, black water only, grey water only, etc.)
- The safeguards to be put in place for emergency and out-of-service conditions (linked to the risk assessment)
- Water metering requirements
- Pre-treatment requirements or other components external to the containerized prototype, e.g. screens, driers
- The output streams
- Streams to be recycled
- The physical footprint of the prototype on site
- Any requirements relating to positioning, e.g. solar line of sight
- Requirements for a slab or plinths on which to place the prototype
- Mass of the prototype
- Utility (water, sewer, electricity) requirements
- Test duration
- Any other site requirements, e.g. office space

The design basis document, together with the PFD for the containerized prototype, should be used to create a PFD for the entire site. This will include all waste flows, overflows, metering, and other items not part of the prototype itself. More information on the PFD can be found in Chapter 3: Planning for a Sanitation Prototype Demonstration.

The design basis document and site PFD should be reviewed and approved by the technology developer, commercial partner, regulator, and any other relevant stakeholders.

Design basis document approved by relevant stakeholders

7.2 Site Design Process

Table 7.1 lists elements that should be considered in the design process for demonstration sites. A design pack including drawings, proposed equipment to be procured and tender specifications (if relevant) will be produced. The design pack should be reviewed by:

- Technology developer – to check the infrastructure proposed will be suitable for supporting the prototype
- Regulator – to check the infrastructure proposed is acceptable
- Community – elements of the site design, such as the general site layout, should be reviewed with the community to check there are no negative impacts on community life
- Prototype engineer and laboratory team – the infrastructure and process proposed for taking samples should be reviewed to check that the sampling procedure will conform to the standard methods

Once the design pack is approved by all stakeholders, contractors can be appointed and equipment procured.

Table 7.1 – Elements to consider when designing demonstration sites

Design element	Description
Underground services detection (electricity, water, sewer)	• As-built drawings of existing infrastructure may not be available for demonstration sites • Illegal water and electricity connections are common at informal settlement sites • Scanning for underground services is advisable for safety reasons – illegal services may need to be avoided, disconnected or relocated • Careful community engagement is needed when dealing with illegal services
Basic geotechnical (DCP tests)	• May be required depending on site conditions and size of structures to be built

Topographical surveys	• May be required depending on if the prototype to be installed is level-dependent, e.g. relies on gravity flow
Baseline social survey	• Ideally to be done during the design process, so that findings on the use of the space can be incorporated into the design of the testing site, e.g. information on the opening hours of shared toilet facilities, how the area around toilet blocks is used for other activities such as drying clothes (see Chapter 11: Social Aspects of Testing)
Pre-treatment – screens	• Screens must be designed so that (i) they effectively protect downstream equipment and (ii) they are easy to operate and maintain. The following should be considered: o Allow sufficient level drop across the screen to prevent backing up of flow down the inlet pipe o Direct influent flow vertically onto the screen to avoid head loss over concrete prior to the screen o Include overflow to sewer in case of screen blockage o Design for easy access to rake screenings off the screen and into a disposal container o Allow for measuring and recording quantities of screenings removed
Pre-treatment – buffer or equalisation tanks	• Tanks to receive incoming flows to even out peaks in influent flow and load and provide buffer volume prior to treatment system • Consider: o Ground conditions for installation of underground tanks o Depth of tank required to receive influent flows under gravity o Requirement for water to fill underground tank prior to backfilling
Scum removal from tanks	• Allow access for scum removal and a disposal route for scum
Pipework design – gravity pipework	• Include rodding eyes
Storm water management	• New infrastructure will create additional storm water – must be diverted and disposed of appropriately (difficult in constrained spaces)
Process safety	• Ensure all measures highlighted in the HAZOP (Section 3.4) are incorporated into the design including: o Overflows to sewer or storage tank from screens and tanks

	○ Facility to divert wastewater to sewer or storage tank if the system is unable to receive it ○ Duty/standby systems where required ○ Detection and warning systems for when the process is not functioning correctly
Sampling infrastructure	• Sample points for grab samples – liquid, sludge and gas, dependent on system, e.g. sampling valves, dipping tanks • Consider how to sample from streams containing large solids, e.g. fresh faeces, toilet paper, newspaper, to ensure sample is representative, i.e. not all liquid fraction or all solid fraction • Composite samples – purpose-built tank to collect wastewater for several hours before homogenising and sampling, e.g. for streams containing large solids, or facility to hook up an auto-sampler to the flow to be sampled
Roof tanks on existing structures (e.g. shipping containers)	• May require additional stand to support heavy tanks on roofs that were not originally designed for this
Electrical supply	• Where taking electrical supply from an existing building, existing electrical infrastructure must be compliant for a Certificate of Compliance to be issued for the new installation • Separate circuits for treatment process, plugs, lights • Allow spare breaker for later changes/upgrades to system
Earthing	• Metal superstructures will require an earth mat to protect against a live structure in case of electrical fault or lightning strike • Structures taking electrical feed from an existing building will require their own earthing
Security	• Fencing and gates • Specific measures for securing vulnerable pieces of equipment, e.g. solar panels (steel cables, padlocks), batteries (cabinets/cages), cables (conceal, encase aboveground terminals in concrete, locked electrical cabinets)

Design pack approved (including drawings and equipment list)

7.3 Appointment of Contractors

The following are useful to consider when appointing contractors to carry out construction and/or maintenance work at demonstration sites:

- The project team is likely to have a higher level of freedom to choose contractors and labour at household, school, office and municipal wastewater treatment plant sites than at community sites.
- At community sites (e.g. informal settlements), there may be strong pressure to use local contractors and labour for any work carried out on site. Where it is feasible to use local contractors, this is a good opportunity to support the community hosting the demonstration site. It is advisable to define pre-qualification criteria (e.g. minimum Construction Industry Development Board (CIDB) grading or experience of previous similar work) for contractors to submit quotes for work, and to make sure these criteria are communicated clearly to the local community. If it is not possible to use a local contractor for work on site, the reasons why should be communicated to the local community leadership and go-ahead obtained to use an outside contractor. Failure to be transparent in the contractor selection process and to keep the community informed is likely to result in the stoppage of work on site.
- Allow sufficient time in the programme for the appointment of contractors, particularly where it involves negotiation with local contractors; it could be as long as a month between starting the process and work starting on site.
- Any contractors or labour from outside the community should be formally introduced to the CLO and other key community members, prior to any work starting on site.
- In informal settlement communities with high unemployment rates, there is likely to be an expectation or requirement that contractors use local community members to carry out work wherever possible. Negotiation is likely to be required between the project team, community, and contractor to agree on where local labour will be used and where the contractor will use his own personnel. Agreement should be reached in advance of any work starting.
- Be aware of the gaps in experience of small, inexperienced contractors (e.g. shoring up deep excavations safely, laying gravity pipework with tight tolerances on levels). Construction must be supervised at the critical points and support provided where necessary.
- Designs for equipment at the field-testing and demonstration site frequently have to be modified during construction, due to unpredictable site conditions. It is useful to identify contractors who are good at problem-solving and can suggest practical solutions to issues on site.

Contractors appointed for site preparation

Identifying Appropriate Contractors on the EFTP

At one informal settlement site significant civil works and laying of pipework were required as part of the site preparation for the prototype being tested. The work involved fairly deep (over 3 m) excavations for underground tanks and the laying of gravity pipework with very low falls due to level restrictions on site. The community requested that the work be carried out by a business run by someone from the community. The EFTP agreed that local businesses would be given the first opportunity to quote, but that in order to submit a quote, the business would need to fulfil a minimum set of criteria that would demonstrate they had the necessary skills and experience to do the work. The EFTP team includes an engineering firm as one of its partners, who appoint and manage contractors during site preparation. The engineers running the tender process compiled the list of minimum requirements for contractors. The EFTP's community liaison specialist communicated, in writing, the list of minimum requirements for contractors to the ward councillor, with a deadline for contractors to submit their details. The ward councillor then communicated this to community leadership. Interested contractors then submitted their details.

The minimum requirements for contractors who were tendering for the work were stated to potential local contractors, in writing, as follows:

- *Shall be registered on the CIDB Register of Contractors, at Grade 1 or above, in the Civil Engineering (CE) class of works*
- *Shall be capable of carrying out the following work:*
    - *Laying concrete slab foundations, maximum size 10m x 4m*
    - *Excavation: 3m deep*
    - *Digging trenches for pipework*

It was also requested that any contractors that were proposed should submit a list of recent projects completed and references.

No names of contractors were submitted by the deadline. Three weeks later and after several follow-ups from the EFTP's community liaison specialist, the details of three contractors were submitted. Unfortunately, only one of them had the necessary CIDB grading and none had the necessary experience to carry out the work. This was communicated back to the ward councillor during a meeting with the ward councillor, PR councillors, community liaison specialist and engineer from the EFTP team. Go-ahead was then received from the ward councillor to use an outside contractor for the work. It is important to note that it took around four weeks to get the go-ahead to able to start the tender process for an external contractor. These processes need to be allowed for in the project timeline.

Appointment of Local Labour for Site Work on the EFTP

Local employment opportunities were created wherever possible during the work carried out by the EFTP. Where contractors were appointed to do significant work on site (e.g. civil works lasting for several weeks), it was a condition of contract that a certain number of local community members would be employed to carry out unskilled work (e.g. digging trenches). The daily labour rate to be used was also specified in the contract with the main contractor, having been previously communicated to the community leadership. The CLO was informed of the need for local labour several days before they were needed on site, and was in charge of finding community members to work. Where possible, the main contractor paid and supervised the local labour, thus taking responsibility for providing them with necessary protective clothing and equipment. Organising daily or weekly payment for local labour was also a time-consuming task for EFTP staff, and therefore better left to the contractor where possible.

There have been a number of community disputes over local labour issues, some causing site work to stop for several days. These arose either due to miscommunications, or often because the project was being used as a pretext for raising other community disputes, which were often politically motivated. The prompt and skilful intervention by the EFTP's community engagement specialist was key to the speedy resolution of disputes, and the only consequence was delays to work.

7.4 Equipment Specification and Procurement

The field testing of non-sewered sanitation systems requires test infrastructure to support the systems on site. Table 7.2 lists common items of equipment procured for testing sites, together with notes on their function and items to consider when procuring.

Table 7.2 – List of equipment frequently procured for demonstration sites

Equipment item	Notes
Custom-made tanks	• Tanks for solids collection and sampling often need to be sloped towards an outlet so that solids do not accumulate in the base of the tank. Tanks can be custom-made in PVC with pyramidal or conical bases. • Wide, flat tanks with custom inlets and outlets are frequently required to sit on scales and fit under equipment, to continuously weigh the quantity of product from the system.
Underground tanks	• Tanks may be required for buffering or equalising incoming flow. Off-shelf tanks can be used but check following items: ○ Where on the tank it is possible to add inlet pipes ○ The maximum depth the tank can be buried at (and does this work with the levels on site) – manhole extension necks may be used to increase this depth ○ Ground conditions required for installation and installation instructions
Macerator/chopper pumps	• Used to homogenise samples containing solids, e.g. faeces, toilet paper, prior to laboratory analysis. • May also be required to move fresh black water containing large solids from the system to a storage tank. • Different pumps may need to be trialled to achieve effective maceration and homogenisation.
Valves suitable for sludge streams or streams containing non-macerated solids	• Knife-gate valves are normally most suitable for this application. Frequently used in pairs on the feed to the system, to provide the option of taking wastewater to the treatment system or diverting it to sewer.
Flexible pan connectors for flow diversion without valves	• Used at Y junctions for streams containing solids where it is not possible to use a valved arrangement to divert flow one way or the other. Prevents solids from accumulating in a dead-end behind a closed valve.

Equipment item	Notes
Custom made screens and rakes	• To fit purpose-built screen chambers. Rakes need to match the screen so that prongs fit between the bars.
Air break and auto top-up system for municipal water supply feeding tanks that may also be filled with recycled water	• Municipal water may be used to top-up recycled water tanks if the prototype's treatment system is offline. No direct cross-connection is permitted between municipal water supply and recycled water so an air break is required between municipal water feed and the high level of the recycled water tank.
Water meters and data logger and/or smart water meters	• To log water consumption and recycled water generated. • To log the water consumption by fixture on site to understand usage patterns, e.g. toilets, hand wash basins, showers, laundry. Data collection intervals of at least one minute required to log times of individual flushes.
Scales	• For measuring masses of tanks, e.g. when testing the separation efficiency of a urine diversion toilet. • Choose appropriate resolution and capacity. Price increase sharply with increasing resolution. Some scales have in-built data logging facility (data stored on SD card).

7.5 Construction Management

Sufficient resources must be allocated to construction management during the site preparation phase. Timelines for site preparation, installation, and commissioning are often short. The following need to be considered when planning resources and programme during the construction phase:

- Multiple contractors are likely to be working on site at the same time in a constrained space:
  - Civils work (excavation for tanks, construction of slabs)
  - Rigging (placement of systems on site)
  - Plumbing (water and sewer pipework)
  - Electrical (electrical supply to the system, compliance with standards)
  - Earthing (installation of earth mats and linking system to them)
- Allow additional time when employing local community members on construction tasks – arranging labour, procuring PPE, training and dealing with any disputes that occur all take time
- Allow sufficient time and resources to make sure working conditions are safe – this is difficult when working in areas that the general public has access to, e.g. deep excavations next to public toilet facilities
- Allow sufficient time for community liaison specialists during the construction period – for negotiations with local labour, updates to community leadership and resolution of miscellaneous issues that arise

Construction Management Resources on the EFTP

The EFTP by its nature involves multiple sites and prototypes, and therefore at various points there has been construction occurring on several sites simultaneously. The EFTP includes an engineering consulting firm as one of its partners, who manages the design and construction process for the demonstration sites. The following team members were required during construction management, with an indication of the time commitment required per site during the main construction phase:

- *Project manager/Process engineer (1 to 1.5 days/week, depending on complexity of site)*
- *Civil engineer – construction supervision, drawing management, design changes (2 to 3 days/week)*
- *Administration and accounting support (0.5 days/month)*
- *Community engagement specialist (0.5 days/week, more if specific issues arose)*

Significant construction supervision was required on most sites. In some cases, this was because the contractor did not have much experience with specific aspects of the work (e.g. laying gravity pipework to specified levels or implementing proper shoring for deep excavations). In other cases, unpredictable site conditions (e.g. very rocky ground, underground pipework that was not known about) necessitated changes to the construction plan and site design. Frequent presence on site by the EFTP's civil engineer was also needed to make sure health and safety measures were enforced.

7.6 Documentation

Table 7.3 lists the documentation that should be produced at the end of the site preparation phase and a checklist is given in Appendix 5.2.

Table 7.3 – List of documentation for new testing site at end of site preparation phase

Document or drawing	Notes
General site layout (as-built)	
Site services drawing (as-built): pipework, electricity, earthing, other buried services	• Showing existing and newly installed pipework • Distinguish between gravity and pressure pipework
Structure drawings (slabs, chambers, screens etc.) (as-built)	
Electrical drawings	• Include simple schematic of distribution board (showing breaker sizes) and what it connects to on site, as well as standard electrical drawings
Earthing drawings	• Layout of earthing cables
Equipment list	• Including make, model number, number installed, installation date, supplier contact details
Critical spares list (updated)	• Critical spares list will be updated following installation and will continue to be updated through commissioning and testing period
PFD for site (as built)	

Relevant documentation for end of site preparation phase collated

Chapter 7: Site Design and Preparation – In Brief

- *A design basis document details all the necessary site infrastructure requirements for the testing of a prototype and together with process flow diagram of the prototype will enable a process flow diagram for the entire testing site to be prepared, including all auxiliary infrastructure such as utility supplies, emergency overflows and sampling points*
- *Site design should be developed by the commercial partner or whoever is carrying out the demonstration on their behalf, reviewed by the technology developer, the regulator, the community/household/school hosting the prototype, and the prototype engineer and laboratory that will be collecting and analysing the samples*
- *Sufficient time needs to be allowed for the process of appointing contractors and the possibility of recruiting local labour from the community*
- *There are additional considerations for the appointment of contractors and recruitment of labour in informal settlement contexts*
- *Changes to the design often need to made during construction due to unpredictable site conditions*
- *There are number of aspects to take into account when managing construction and these need to be considered during the planning of resources and time*
- *The site design should be documented in detail with as-built drawings of infrastructure, flow diagrams and equipment/spares lists*

Chapter 8: Installation and Commissioning

Before field-testing and demonstration of a prototype can start, the prototype must be installed on the site and commissioned. This chapter will cover the installation process, the technical process of commissioning, and initial tests and safety checks that should take place during this stage. The chapter will also consider the education and orientation of the users to ensure that they have sufficient knowledge to understand and use the prototype.

Prototype engineer, laboratory team, social acceptance team, community engagement team, technology developer, municipal management, engineering contractors, commercial partner, demonstration platform (if relevant), community liaison officer

1 week to 2 months

Chapter 6: Community Engagement

8.1 Pre-commissioning Off-site

A pre-commissioning stage off-site prior to installation at the demonstration site is advisable for more complex prototypes, where some pre-assembly of modules is required and/or where a sewer connection is not present at the demonstration site but is useful for start-up of the process. Pre-commissioning should take place at a secure site where there is access to utilities (water, sewer, electricity) and weatherproof secure storage for spare parts. The process may include:

- Checks for any damage to the prototype incurred during shipment.
- Assembly of any modules that can be transported pre-assembled to site, to reduce installation time on site and therefore security risks. A trade-off normally needs to be made between more complicated/expensive transport to site (and greater requirements for access to site) or pre-assembled modules and an easier/more secure installation process (see Section 8.3.2).
- A water leak test on the assembled system or individual modules.
- In some cases, pre-commissioning may include feeding the treatment system manually with feedstock, e.g. sludge from a wastewater treatment works, in order to be able to start up unit processes. This is particularly useful with biological systems, to reduce the commissioning time required at the demonstration site (and therefore to avoid having long periods when the prototype is on site but potentially not open for users). It is also of great use for prototypes that recycle treated water for other uses, e.g. toilet flushing, as the processing system can be left to run to sewer for several weeks whilst the treated water quality comes into specification. At demonstration sites without a sewer connection the period during which a normally-

recycling prototype runs to sewer has to be dealt with using temporary storage and tankering water to, and wastewater away from site.

8.2 Community Engagement Prior to Installation

The future users of the prototype and site leadership should be informed in advance of the installation and commissioning timeline for the prototype, including when it will actually open for use. A site meeting prior to installation is advisable to communicate clearly exactly how the installation process will impinge on normal daily life and if any special precautions need to be taken (see Chapter 6: Community Engagement).

8.3 Technical Aspects of Installation

8.3.1 Local Transport and Placement on Site

The prototype must be transported from the storage or pre-commissioning site to the demonstration site. A pre-assembled containerised system will probably require a crane truck for transport and sufficient access at the demonstration site to put the container in place. It is therefore critical to select the demonstration site with due consideration for access requirements during installation. Smaller prototypes, or those which will be assembled to some extent on site, may only require a regular pick-up truck to transport them. If no wheeled access is possible to the demonstration site, it is useful to limit the weight of each component to a weight that can be safely handled manually – the guidance for this is 25 kg per person when carrying the load close to the body at waist height. If wheeled access is possible trolleys or pallet jacks can be used for moving equipment.

8.3.2 Assembling Components On-site

It may be that the prototype can be partly assembled on-site. If system components can be easily carried and fitted together using hand tools or power tools, this may be a simpler approach than assembling the prototype off-site and moving it as a single entity. This decision should be taken in conjunction with the technology developer who will be able to advise on the tools, skillsets, and tolerances for variation required for on-site assembly. Detailed assembly plans should be produced showing the order of activities, the expected duration, and required resources, including personnel and equipment required. If changes are made to the plan during assembly, this should be recorded as it may impact on disassembly plans for the prototype or assembly plans for future installations.

8.3.3 Final Pipework and Utility Connections

All site pipework should have been checked to be clear from blockages and free from leaks in the week prior to installation, particularly if there was a long gap between completing construction on site and installation of the prototype.

8.3.3.1 Feed to System

The feed to the system will normally have been designed with a safety divert to sewer or storage tank in case the prototype is unable to receive influent at any point. The final feed pipework connection will be made to the prototype but the wastewater will remain diverted to sewer for now.

8.3.3.2 Treated Water

Treated water produced by the system will initially be connected to sewer or a temporary storage tank (that is easily accessible by a vacuum tanker or other means of tank emptying), even if the end goal is to recycle it for another use, e.g. toilet flushing.

8.3.3.3 Waste Liquid Streams and Overflows

Any waste liquid streams and overflows will be connected to sewer or temporary waste storage tanks.

8.3.3.4 Gas Streams

Final connections to exhaust pipes may be required for combustion processes – this may require welding on site. Connections to biogas storage for anaerobic processes may also be required.

8.3.3.5 Municipal Water Supply

A municipal water connection may be required to the system for a first fill, for providing service water, e.g. backwashing, for topping up recycled water tanks or for hand washing.

8.3.3.6 Electricity

The connection of the prototype to mains electricity will be carried out by a registered electrician and a Certificate of Electrical Compliance (COC) given for the finished installation. A UPS may be included for back-up electrical power during short outages, e.g. load shedding.

8.3.3.7 Internet

Internet connection for the prototype will normally be via mobile signal. A normal modem may be sufficient but a signal booster may be required if the router is located inside a metal container.

Prototype installed on-site and connected to all necessary utilities

8.3.4 System Electrical Earthing

Systems may require their own specific electrical earthing. Considerations include:

- If the system is housed in its own metal container, there is a possibility of the container itself becoming live if there is an electrical fault or a lightning strike
- Systems housed in their own containers separate to an existing building, but taking an electrical supply from the existing building, may require additional earthing to ensure that the path of least resistance to earth is close to the container

Metal shipping containers will normally require an earth ring or mat, consisting of copper conductor and rods joined to the container at one or various points and buried in the ground. The design of the earthing infrastructure is dependent on the prototype and the ground conditions on site. An electrical earthing specialist should design for the system and site, carry out the installation and issue a COC.

Installation of an earth mat can take several days, and should be carried out before the final electrical connection is made to the prototype.

8.3.5 Electrical Compliance of the Prototype

All electrical components of the system need to be durable, low maintenance, easily serviceable and be adequately protected from aggressive environments (see SANS 30500:2019, Section 5.6). Note that systems imported from other countries may not meet South African safety standards. Therefore, once the prototype is installed, a local electrician must inspect the prototype and provide a COC for all electrical components and connections.

Electrical Compliance Issues with an EFTP Prototype

One of the prototypes that was tested on the EFTP was installed on-site and inspected by the municipality and subsequently an electrical contractor. It was discovered that there were significant areas in which the system was not compliant with South African electrical regulations. These included: unshielded battery terminals, lack of earthing and lightning protection, incorrect or missing labelling, lack of electrical drawings, incorrect cable types used, and incorrect circuit breakers used. The costs of modifications to make the prototype compliant was around ZAR 100,000 and several weeks were required to complete the inspections and remedial work, before commissioning could take place.

Certificate of electrical compliance (COC) obtained for prototype

8.3.6 Mechanical and Process Modifications to the System

The installation process may highlight where mechanical or process changes are required to the prototype for safety reasons or ease of operation. The following are areas that should be considered:

- On-site modifications may be required when some parts have been procured locally and need to fit onto the imported prototype, e.g. special pipe adapters
- Ease of removing waste products from the system, e.g. full solids tanks
- Security of the system – are additional window bars, security gates, padlocks, etc. required? Is the processing area securely locked? Particular consideration should be given to securing of solar panels
- Padlocks should be weatherproof and it should be possible to make copies of the keys (for the multiple stakeholders who will require them), otherwise padlocks should be changed
- Toilet cubicle door locks or latches must be robust and ideally should be able to be opened from the outside using a screwdriver, otherwise consider changing the mechanism (particularly in a school context)
- Water isolation valves that are accessible to users should have valve locks on them to prevent tampering, e.g. on the water supply line to toilet cisterns
- Safe storage of consumables, particularly chemicals – are chemicals suitably packaged and separated from one another if necessary (if mutually incompatible for storage together)?

8.4 Technical Aspects of Commissioning

Once the prototype is in place on-site and has been connected to necessary utilities, it must be commissioned. Certain safety checks must take place prior to running the prototype.

8.4.1 Safety Checks During Commissioning

Any processing system should be leak-tested with water after installation so that leaks can be identified and fixed prior to filling the system with faecally-contaminated material. The system should be filled with clean water and left overnight to check for leaks. If feasible, clean water should also be pumped through the processing system at normal working pressure, under supervision.

Aeration systems can also be tested when vessels are filled with water for leak testing by visual inspection of whether bubbles are present in the correct vessels when aeration is turned on.

If the system has any vessel with a working gauge pressure of 50 kPa or higher, the South African Pressure Equipment Regulations (PER) requires that these are tested every three years. The pressure vessel testing should comprise an inspection and hydrostatic testing to check for leaks or cracks. A South African National Accreditation System (SANAS) approved Authorised Inspection Authority (AIA) should carry out the test and a test certificate should be issued. Prior to start-up of the prototype, documentation for any pressure vessels included should be checked and confirmed to be in order.

Fire safety aspects of the prototype should be checked prior to start up, and suitable fire extinguisher(s) kept on site.

All safety requirements met during commissioning phase

8.4.2 System Filling and Reaching Steady-state

The technology developer will provide guidance on the start-up procedure for the prototype. This could include filling the system with water before opening it to receive black water, or filling with black water from empty. Some processing systems, which have a biological treatment stage, may require “spiking” with a quantity of biologically active material, prior to opening the prototype to black water influent. Depending on the requirements of the technology developer, this could be animal-derived faecal material or primary sludge collected from a wastewater treatment works. It is important to understand if, and how much, spiking material is required in advance of installation and commissioning so that collection, transport and storage (if necessary) can be arranged without delaying the start-up of the prototype.

With some systems, technology developers will request a ramp-up approach to start the processing system. This requires the volume of influent to the system to be slowly increased over a number of days until the design flow is met. It is difficult to limit the number of users of a prototype during this time, unless there is a way to divert excess flow away from the prototype (e.g. to a sewer), and as such, it may be necessary to use an alternative influent during this ramp-up period. The technology developer should be consulted as to what alternative influents are appropriate for this, but the chosen influent should be as similar as possible to the black water the processing system is designed to treat.

During commissioning, the performance of the processing system should be monitored to ascertain when steady-state is reached. Steady-state is reached when the prototype is achieving consistent performance within its stated design parameters. The frequency at which the parameters are monitored depends on the type of processing system. For example, biological systems change relatively slowly, and therefore require less frequent monitoring than a thermal system that may reach steady-state quickly. The primary goal of each component should be determined and an appropriate parameter selected and measured before and after the component. Plotting these measurements against time will indicate when steady-state is reached. Suggested parameters are given in Table 8.1. Once steady-state has been reached, the testing phase begins. Details on how to take samples is provided in Section 10.6.

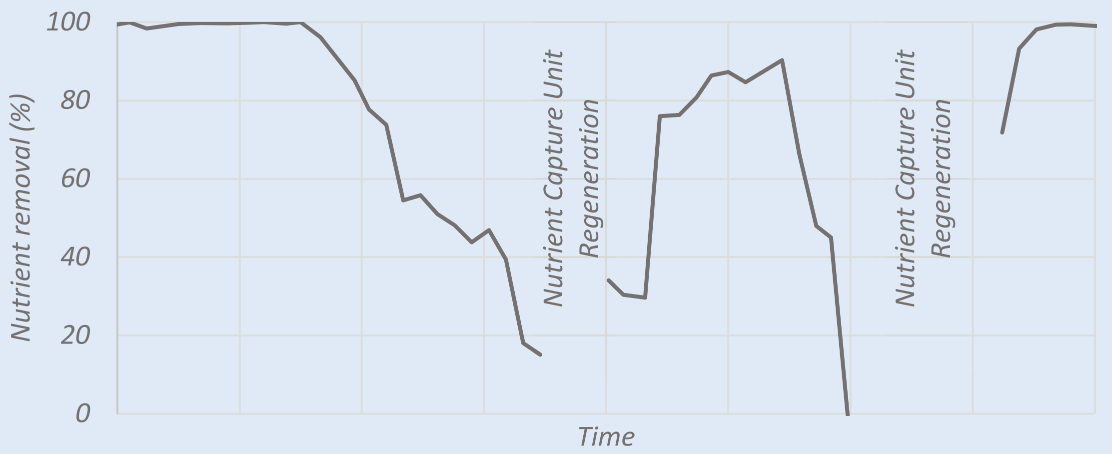
Table 8.1 – Suggested parameters for ascertaining steady-state

Purpose of component	Parameter for analysis
Solid-liquid separation	Total solids
Drying	Moisture content
Combustion	Ash content of residue
Mixing	Concentration of substance to be mixed in, in a series of samples taken from the mixed vessel
Filtration (for solids removal)	Total solids in filtrate
Nutrient removal	Phosphate and nitrate
Disinfection	*E. coli*
Chemical reaction	Concentration of compound produced in reaction
Membrane separation	Water flux
Biological treatment	Volatile solids
Energy generation	Voltage

Steady-state reached

Deviations from Steady-State to Identify the Need for Prototype Maintenance

As well as using key parameter measurements plotted against time to identify when steady-state is reached, tracking a parameter's deviation from steady-state can be used to identify when there is an issue with the performance of the prototype and when maintenance is required. The graph below shows how nutrient removal across a nutrient capture system that was tested under the EFTP started to drop rapidly as the material was spent. A regeneration process was used to restore the functionality of the unit.



8.4.3 Opening the System to Users

The start-up procedure for the prototype will determine at what point it should be opened to users. Ideally, this should happen as soon as the processing system is able to operate safely with human faecal influent. Before opening the prototype to users, user education and orientation should take place (Section 8.5).

8.4.4 Tests Carried out During Commissioning

If the processing system includes an electro-chemical cell for the generation of chlorine, a chlorine evolution rate (CER) test should be carried out at the beginning of the testing phase, after ramp-up, so that performance can be compared to the CER at the end of the testing phase. This allows the required frequency of electrode cleaning to be calculated. The method for CER testing is given in Appendix 4.1.

Any online instruments should be calibrated during the commissioning period and online readings compared to analysis results from samples.

8.5 User Education and Orientation

As the demonstration of a sanitation prototype relies on having members of the public use it, it must be made clear to users what is required of them before the prototype is opened for use. The users must be made aware of:

- How to use the prototype
- How the prototype works
- How to take care of the prototype

Any information shared with the users should ideally be shared in their first language.

8.5.1 Prototype Usage

Users should be shown the front-end of the prototype and the behaviour that is required from them should be explained. This should take into account the type of toilet they are accustomed to using. For example, if they regularly use a dry toilet, it may be necessary to explain dual-flush buttons on a flush pedestal. The explanation of the front-end of the prototype should be informative but not patronising and users should be allowed to ask questions. If the prototype is installed at a household, it may be possible to show all those who live in the house how the toilet operates. If the prototype is installed in a school or community setting, it may be necessary to arrange for small key groups to visit the prototype, such as community leaders or teachers at a school, and provide posters or photos to show to the wider audience at an opening event.

Where the prototype is a back-end system, which makes no changes to the existing front-end system, e.g. treating black water from a community ablution block, there may still be changes in behaviour that are required from the users of the front-end, such as changes to cleaning materials used in the toilets, not flushing certain waste materials, etc. All of these should be highlighted to users at the start of the testing phase, and it is useful for repeat training or information sessions to take place to remind users of the behaviours required during the course of the testing phase.

Changing Cleaning Materials at a Community Ablution Block

Community ablutions blocks (CAB) in informal settlements are managed by caretakers that are employed by EWS, and who are provided with cleaning materials for the washing of toilets, floors, showers, etc. Under the EFTP, two prototype systems were connected to a CAB, neither of which could treat the waste produced if the CAB was cleaned with the cleaning product usually provided by EWS as it caused excessive foaming in the treatment process. The cleaning product was therefore replaced with a 3% hydrogen peroxide solution which was provided by the EFTP for the duration of the demonstration. This highlights the importance of:

- *Understanding the cleaning materials used when connecting a prototype to existing toilet infrastructure to ensure that it does not impact the treatment process*
- *Providing the correct cleaning material to the caretaker or home owner to use with the prototype*
- *Providing clear instructions on how to use the cleaning materials*

8.5.2 Prototype Function

The users should also receive an explanation (and where possible, a tour) showing them how the back-end processing system works. This should include any health and safety features that ensure that recycled water (or other products) is safe for use or that heat-based treatments are not at risk of starting fires. This can help to give users confidence in the prototype and allows them to explain it to others. Users should be given the opportunity to ask questions about how the processing system works. A poster or leaflet (depending on the number of users at the demonstration site) that depicts and explains the process should be installed or left behind as a reminder to users of how the prototype works. This should be provided in both English and the home language of the users. An example of such a poster for a prototype tested on the EFTP is shown in Figure 8.1.

Figure 8.1 – Example posters explaining the operation of a hand washing station in English and isiZulu

8.5.3 Prototype Care

Whilst the users are unlikely to be the individuals who are operating and maintaining the processing system, they should be made clear on the “dos and don’ts” required to give the prototype the best chance of operational success. Again, this should be tailored to the existing behaviours of the users, and may include what items can and cannot be disposed of in the toilet and how to clean the toilet. Posters of “dos and don’ts” should be displayed in the toilet cubicle so that users are reminded of the required behaviour throughout the field-testing and demonstration. An example of such a poster for a prototype tested in a community on the EFTP is shown in Figure 8.2. This is also useful if people who were not at the initial information event use the toilets, such as house guests for household systems, children who missed a day of school in school settings, or newcomers, visitors or those who could not attend the information event in the case of communities.

Figure 8.2 – Example do's and don'ts poster for using a hand washing station

8.5.4 Informed Consent

Most ethics boards will require informed consent from participants in research, such as the prototype users during field-testing and demonstration. Informed consent requires users to sign a letter saying that they understand what the project aims to achieve, and that they are participating in the project freely and may choose to stop participating at any time without judgement. For household testing, it is common to ask every member of the household to sign an informed consent letter. Where there are children under the age of 18, the parent needs to sign an informed consent letter on their behalf. For community testing, this is cumbersome and often it is easier to display a sign that states that by using the facilities, users agree to participate in the field-testing and demonstration. If this is the case, there must be alternative sanitation facilities available for use should the user decided that they do now want to use the prototype. All informed consent letters need to be approved by an ethics board, and should be prepared in the home language of the users. Further information on how to apply for ethical clearance is provided in Section 2.7.

Users educated on prototype usage, function, and care; prototype opened for use

Chapter 8: Installation and Commissioning – In Brief

- *Certificate of electrical compliance (COC) for any electrical components and connections needs to be obtained prior to prototype start-up*
- *There is a trade-off between installing a pre-assembled unit on site (short installation period, fewer security concerns) against assembling the system on site (lower transport costs, feasible when limited site access exists)*
- *Systems must be leak and pressure tested prior to commissioning and relevant certification for pressure vessels provided*
- *Start-up may require dosing with faecal material and this must be arranged well in advance to minimise delays*
- *After start-up, the system should be monitored on a regular basis to determine when steady state is reached*
- *Tests may need to be conducted during commissioning depending on the type of system, e.g. chlorine evolution rate test*
- *Users need to be well informed of how to use the system and what precautions to take in terms of cleaning, disposing of other material, etc.*
- *Letters of informed consent need to signed by users, or implied consent letters posted at sites with a high number of users*

Chapter 8: Installation and Commissioning – Further Reading

For more on the legislation and standards relating to pressurised vessel and electrical safety, see:

- *Guidance on Pressure Equipment Regulations (PER), 2009: http://www.sagas.co.za/wp/wp-content/uploads/2019/01/Guidance-Notes-to-the-Pressure-Equipment-Regulations_Nov2017.pdf*
- *Guidance on Electrical Installation Regulations, 2009: https://www.gov.za/sites/default/files/gcis_document/201409/35180gen258.pdf*
- *SANS30500:2019 (for purchase): https://store.sabs.co.za/sans-30500-ed-1-00-1*

Chapter 9: Setting Performance Acceptance Criteria

Performance acceptance testing of a prototype is carried out to demonstrate whether or not the stated requirements of the prototype have been met.

This chapter describes the criteria against which the results of a sanitation technology demonstration will be measured for performance of the prototype to be considered successful. This chapter links closely to the chapters on what the testing aims to achieve (Chapter 3: Planning for a Sanitation Prototype Demonstration), technical aspects of the testing phase (Chapter 10: Technical Aspects of Testing) and the reasons for the decommissioning (Chapter 12: Decommissioning and Site Rehabilitation).

Refer to sub-sections

Refer to sub-sections

Chapter 3: Planning for a Sanitation Prototype Demonstration; Chapter 10: Technical Aspects of Testing; Chapter 11: Social Aspects of Testing; Chapter 12: Decommissioning and Site Rehabilitation

The overall aim of all sanitation technology demonstrations under the SASTEP programme is to demonstrate that the prototype fulfils a particular set of requirements for SASTEP, for commercial partners or for potential buyers. The needs of target clients will thus dictate the aims that are set for field-testing. For example, does the client need a system that is compliant with SANS 30500:2019 standard and therefore is the aim of the field-testing and demonstration to show comprehensive compliance with all aspects of that standard? An alternative scenario might be that the system is successfully operating elsewhere in the world, and the aim is to show its suitability for the South African market. The aims of field-testing and demonstration will in turn inform what defines the prototype to have been a ‘success’ or a ‘failure’ at the end of the demonstration, i.e. the performance acceptance criteria.

It is important to understand that there can be no universal set of performance acceptance criteria that can be applied to all prototypes indiscriminately. The criteria are defined for each demonstration based on:

1. The specific aims of that demonstration (see Section 3.1), and
2. The particular characteristics of the prototype, technical and otherwise

The performance acceptance criteria will normally include elements relating to:

- The functionality of the sanitation technology – does it operate according to its design specification? Does it comply with specific standards?
- The actual operation and maintenance requirements – are they reasonable?
- The robustness and reliability of the sanitation technology – is it viable?
- The user acceptability and marketability of the sanitation technology – will people want to use it and want to buy it?
- The potential for further optimisation of the sanitation technology – have we shown that with modification of the prototype it could run more efficiently?
- The running costs of the sanitation technology – is the lifetime cost feasible?

The first section of this chapter summarises who is involved with setting the performance acceptance criteria and assessing prototype performance. The sections that follow give guidance for developing the criteria and how to run the performance acceptance testing.

9.1 Pre-Requisites for Starting Performance Acceptance Testing

Prior to starting performance acceptance testing, the system must be running at steady-state. Steady-state operation means that commissioning has been successfully completed and that the processing system is operating according to design in the mode of operation that it would operate in long-term, e.g. recycling treated water for toilet flushing. The prototype should operate within its influent design flow and loading range for the majority of the performance acceptance testing period.

The following documents are required to be in place prior to starting performance acceptance testing:

- Functional design specification (FDS) (describing how the system control is supposed to work, all control modes, all alarm functions, etc.)
- Operation and maintenance manual (draft is acceptable but must be understandable)
- Operation and maintenance schedule
- Process flow diagram
- Process and instrumentation diagram, if applicable

9.2 Roles When Setting the Performance Acceptance Criteria

See Table 9.1

1 week, depending on size and complexity of system and number of stakeholders

Performance acceptance criteria need to be developed and agreed on by all stakeholders before the field-testing and demonstration starts. Some or all of the following stakeholders may be involved:

- SASTEP
- Commercial partner
- Technology developer

- Potential buyer of the system, e.g. property developer, municipality, other regulator
- Independent technical reviewer, without vested interest in the success of the prototype or any of the other stakeholders

Table 9.1 indicates the roles that each stakeholder has in the development of the performance acceptance testing criteria.

Table 9.1 – Roles in setting acceptance criteria

Stakeholder	Role in developing performance acceptance criteria and implementing performance acceptance testing
SASTEP	• Have the final say on the content of the performance acceptance criteria ('client' role) • May also develop the performance acceptance criteria
Commercial partner	• Review the draft performance acceptance criteria and provide feedback • Implement the performance acceptance testing on site
Technology developer	• Review the draft performance acceptance criteria and provide feedback
Potential future buyer of the system	• Provide input on their requirements for the prototype, if they were to consider purchasing it • Performance acceptance criteria should then include items that demonstrate that these buyers' requirements can be met
Independent technical reviewer	• May develop the performance acceptance criteria on behalf of SASTEP, managing the liaison with all stakeholders (but SASTEP to still have final approval of the criteria) • Be an independent witness of the performance acceptance testing • Review the results of the performance acceptance testing and report to SASTEP and commercial partner as to whether the system has met the performance acceptance criteria or not

The performance acceptance criteria document should be signed off by all stakeholders prior to the start of the field testing.

Performance acceptance criteria document approved by all stakeholders prior to the start of field-testing and demonstration

9.3 Defining Criteria and Implementing Performance Acceptance Testing

Two stages of performance acceptance testing will normally be required to test against all the agreed criteria. These are:

1. Intensive functionality testing, and
2. Reliability testing

9.3.1 Intensive Functionality Testing

Commercial partner, prototype engineer, laboratory, SASTEP, independent technical reviewer (if relevant)

2 to 4 days, depending on size and complexity of system

The aim of intensive functionality testing is to systematically confirm that all aspects of the prototype operate according to the stated design specification. Functionality testing is a short-term test.

A system-specific performance acceptance testing record sheet should be created listing each part of the system and all the control and alarm functions applicable to each part. An example is shown in Appendix 3.2. This information should be available from the functional design specification (FDS) for the system. For example, a chemical dosing system might have several modes of control (e.g. time-based or flow-based dosing) and a number of alarm possibilities (e.g. pump failure to start, high flow, low flow). During the intensive functionality testing, the system should operate continuously and the person witnessing the test will request that each unit process is run in each of its control modes in turn. Alarm conditions also need be simulated in the system by changing alarm set-points so that each alarm is triggered in turn. Logs of process parameters monitored by online instruments as well as alarm logs should be reviewed by the person witnessing the test to confirm that the system responded according to design in each instance. Copies of charts logging process parameters and demonstrating compliance, as well as alarm logs should be included in the performance acceptance testing report.

A sampling schedule should also be created for the period of intensive functionality testing. An example is given in Appendix 3.3. This should typically plan for samples to be taken at the start and end of the process as well as intermediate points throughout it, to check on the performance of each unit process as well as the treatment performance of the system as a whole.

Table 9.2 and Table 9.3 summarise the parameters that should be considered for inclusion in intensive functionality testing and sampling schedule. Each system must then be considered individually and a tailored performance acceptance test sheet developed for it.

Table 9.2 – Parameters to consider for inclusion in intensive functionality testing

Category	Item	Details
Pre-requisite to test	Get the snag list of any outstanding work to be completed, before the test starts	• Check all snags are closed out and if there is anything outstanding then note why and what impact it has on the operation of the system
Pre-requisite to test	Prior to the start of testing, obtain record of ranges / values that operational set-points and alarms are set to	• Check these look realistic for long term operation • Agree any settings that need to be changed before testing commences • Alteration of set-points during testing should be recorded and agreed with the person witnessing the test
Pre-requisite to test	Check alarm log	• Any continually repeated alarms? • Reasonable number of alarms?
Pre-requisite to test	Any masked or inhibited alarms to be reactivated or permanently removed if not required	
Intensive functionality testing	Plant control functions	• Check off all process control functions on the system against the FDS requirements e.g. different backwash modes, recirculation/sleep modes etc. • Check off sections of the FDS as passed/failed and reasons why. Record the results on the test record sheet (see Appendix 3.2 for example sheet)
Intensive functionality testing	Check online monitoring data trends on control system (e.g. pH, flow)	• Agree pass/fail condition for each – how far is each parameter allowed to deviate from set-point? • Explanations for all failures should be recorded where possible • Where applicable cross-check with sample data

Category	Item	Details
Intensive functionality testing	Plant alarm conditions	• Check functionality alarms by changing the alarm set-point such that a fault condition is triggered (do this rather than simulating the process value and keeping the set-point the same)
Intensive functionality testing	Check alarm logs	• Check the alarms are as per design in the FDS • Agree pass/fail condition for each • Explanations for all failures should be recorded where possible • Check for: ○ Repetitive failure, indicating faulty unit (if a mixer/blower/valve etc.) or ineffective control (e.g. chlorination alarm) and if so what triggering? Is it always at a particular time etc.? ○ Is the alarm set-point appropriate? ○ If a pump fails, did the standby unit start correctly on failure of the duty?
Intensive functionality testing	Water quality parameters	• Specific sampling should be carried out during the functionality test to: ○ Compare instrument readings to sample data to check the instruments are functioning correctly ○ Check short-term performance of unit processes and system as a whole. See Appendix 3.3 for example sampling schedule for intensive functionality testing and Table 9.3 below, as well as Chapter 10: Technical Aspects of Testing. • Failure during the intensive functionality test indicates the plant is not ready for reliability testing
Intensive functionality testing	Motors – number of starts per hour	• Check that there are not excessive number of starts per hour occurring for pumps, blowers, actuated valves, etc., by checking trends or observing the system on-site

Category	Item	Details
		• Physical check of unit in question if a problem is indicated
Intensive functionality testing	Rotation of duty / standby plant if applicable	• Is this occurring as per FDS? • Has all standby equipment run for a reasonable duration?
Document to be reviewed	FDS for the system	• Document that describes in detail how the system is controlled, what different control modes there are, what set-points and alarms exist
Document to be reviewed	List of control set-points and their values at start of test	
Document to be reviewed	Alarm log for three days prior to test, alarm log for each day of test	
Document to be reviewed	All online monitoring data trends logged by control system throughout test	• Graphs of parameters logged by online instruments, e.g. level, flow, pH, etc.
Document to be reviewed	Water quality analysis data (from lab tests)	• To compare against online instrument readings taken during performance acceptance testing

Table 9.3 – Parameters to include in sampling schedule for intensive functionality testing (see Appendix 3.3 for example of sampling schedule for functionality testing)

Item	Description
Sampling point identification number	• Identifier for sampling point on site and samples sent to laboratories
Sampling point location	• For example, 'raw influent' or 'after sand filter'
On-site tests – parameters	• Parameters to be analysed, e.g. pH • On-site tests will normally be for parameters that can be checked easily with a portable monitor and which are more susceptible to change over time during sample storage and transport, e.g. pH and free chlorine
On-site tests – sample type	• Grab or composite sample • If composite, state number of hours composite is to be taken over
On-site tests – frequency of sampling	• In most cases daily during the intensive functionality testing • Note that frequency of sampling will normally decrease substantially for the longer-term reliability test
On-site tests – reason	• Reason for analysis – for example, to confirm that an online instrument is reading correctly
Off-site laboratory tests – parameters	• Parameters to be analysed, e.g. COD • Parameters which cannot be analysed on-site
Off-site tests – sample type	• Grab or composite sample • If composite, state number of hours composite is to be taken over
Off-site tests – frequency of sampling	• In most cases daily during the intensive functionality testing • Note that frequency of sampling will normally decrease substantially for the longer-term reliability test
Off-site tests – reason	• Reason for analysis – for example, to confirm the performance of a particular unit process in the system

9.3.2 Reliability Testing

Commercial partner, prototype engineer, laboratory, SASTEP, independent technical reviewer (if relevant), social assessment team

1 to 5 months, depending on system type, and the standard(s) against which the system is being tested

Meaningful compliance with the majority of the performance testing criteria can only be demonstrated through a longer-term test of the system. For example, it is of little significance that the product water from a system complies with the water quality standard on one occasion – it is only of interest if that treatment performance is consistently maintained over a significant period of time. This longer-term test is the reliability testing component of the performance acceptance testing.

Table 9.4 summarises the parameters that should be considered for inclusion in the performance acceptance criteria for the reliability testing period. Each system must be considered individually, with reference to the stated aims of the field-testing and demonstration, a test schedule developed, and pass/fail values agreed for each parameter. A new sampling schedule should also be developed for the reliability testing period. The same format of sampling schedule can be used as for the functionality test (see Table 9.3 and Appendix 3.3), but sampling frequencies will normally be lower. It should also be noted that the SANS 30500:2019 standard specifies values for various testing and sampling parameters, and these will apply if the system is being tested on SASTEP for compliance with the SANS standard.

The steps to define the performance acceptance criteria for reliability testing are:

1. Consider the aims of field-testing and demonstration and select the applicable parameters from Table 9.4 accordingly
2. Develop appropriate test record sheets for the reliability testing
3. Consider all applicable technical standards for the field-testing and demonstration, the system TRL and the level of risk acceptable to all stakeholders, then decide on the reasonable threshold values for compliance for each parameter measured
4. Develop an appropriate sampling schedule for the reliability testing period

Table 9.4 – Parameters for reliability testing; N.B.: not all performance parameters will be applicable to all prototypes and applicable parameters and values must be selected based on context

Performance parameter	Description	Guide value
Length of the reliability testing period	• Length of the test period to be agreed on by all stakeholders and will be dependent on the level of risk acceptable to SASTEP and potential buyers (longer test period = higher assurances about the system). Reliability test must only start when the system is running under steady-state conditions. • Longer test periods may be advisable for: systems which are more vulnerable to changes in operating conditions (e.g. many biological systems), multi-unit process systems, systems with complex system control, systems which are operating for the first time in the chosen test environment, systems at lower TRLs. • Shorter test periods may be justified for: single component processes, high TRL systems which have already operated in similar environments, unit processes that are less vulnerable to changes in operating conditions (some physicochemical processes). • Where a system is to be tested for SANS 30500:2019 compliance, the SABS standard defines the test period based on system type.	• **For SANS 30500:2019 testing:** ○ Class 1 systems: minimum of 30 days ○ Class 2 and 3 systems: minimum of 5 months • **For other testing:** ○ Where a shorter test period can be justified: run the system at steady-state for a minimum of three months, then implement a reliability testing period of 21 days ○ Longer test period: run the system at steady state for as long as demonstration time allows, then implement a reliability testing period of 3 months
System alarms/faults	• Review system alarm and fault logs weekly. Check for: the same alarm or fault recurring frequently; how many of the alarms/faults required operator intervention to resolve • Note: a lack of recurring alarms/faults is a pre-requisite to starting reliability testing	• Number of acceptable different recurring alarms/faults per week: 1 • Alarm/fault cause must be identified, reported and rectified within: 3 days, and • The system run continuously for a minimum period of 2 weeks without the same recurring

Performance parameter	Description	Guide value
		alarm/fault happening again (extending the test period if necessary to allow for this)
Water quality in final treated liquid effluent	• The standards that the treated liquid effluent have to comply with are discussed in Section 2.8 and Section 10.4 • These may include: ○ SANS 30500:2019 ○ Applicable local and national standards for discharge of treated water to the environment or reuse for specific purposes ○ Local regulator's standards for reuse of water for specific purposes (e.g. toilet flushing, irrigation) • The most stringent applicable standard for each water quality parameter takes precedence • A sampling schedule should be developed for the reliability testing period, with reference to applicable standards	• Refer to the SANS 30500:2019, Section 7.3: Field verification of performance • In summary: ○ At least 75% of test results for environmental parameters and 100% of all test results for maximum human health-related parameters shall satisfy the requirements detailed in the ISO 30500 standard. Results shall not be averaged. ○ SABS standard specifies required frequency of sampling • Refer to requirements of local and national standards for number of permissible failures in test results
Quality/composition of any other final products produced	• The standards that the final products have to comply with are covered in detail in Section 2.8 and Section 10.4 • These may include: ○ SANS 30500:2019 ○ Applicable local and national standards for discharge of treated water to the environment or reuse for specific purposes ○ Local regulator's standards for reuse of water for specific purposes (e.g. toilet flushing, irrigation)	• Refer to the SANS 30500:2019, Section 7.3: Field verification of performance • In summary: ○ At least 75% of test results for environmental parameters and 100% of all test results for maximum human health-related parameters shall satisfy the requirements detailed in the ISO

Performance parameter	Description	Guide value
	• The most stringent applicable standard for each water quality parameter takes precedence • A sampling schedule should be developed for the reliability testing period, with reference to applicable standards	30500 standard. Results shall not be averaged. ○ SABS standard specifies required frequency of sampling • Refer to requirements of local and national standards for number of permissible failures in test results
Operation and maintenance interventions	• An operation and maintenance schedule must be produced and signed off by the commercial partner and technology developer prior to starting reliability testing (see Section 10.8.1, and Appendix 2.10 for a template) • A log of operation and maintenance activities will be kept throughout the testing period (see Appendix 2.11 for template). Each entry will be categorised as planned (a routine activity detailed on the schedule) or unplanned (unexpected fault or breakdown) • The number of permissible unplanned O&M interventions needs to be decided based on the TRL of the system and the likely implementation scenario for the system (e.g. if targeted at remote off-grid locations, the figure will be lower)	• For high TRL systems (8 and 9), suggested number of permissible unplanned O&M interventions: maximum once/year • For lower TRL systems (5 to 7): acceptable frequency needs to be decided based on the aims of field-testing and demonstration
External energy supply	• The design specification for the system will specify the external energy required to operate the system, and on what basis • External electricity consumption will be metered. Supply of any other external energy source (e.g. supplementary fuel) will be logged.	• Suggested that actual consumption should not exceed the stated design requirement by more than 10%

Performance parameter	Description	Guide value
Energy recovery	• The design specification for the system will specify the expected energy recovery rate.	• Suggested that actual energy recovery should not fall below the stated design requirement by more than 10%
Water use (from a supply external to the system)	• The design specification for the system will specify the external water supply required to operate the system • External water consumption will be metered	• Suggested that actual consumption should not exceed the stated design requirement by more than 10%
Volume of liquid waste disposed of to on-site sewer or taken off-site for disposal	• The design specification for the system will specify the volume of liquid waste product to be produced for disposal, or the approximate proportion of influent flow that will end up in the waste stream • Volume of liquid waste disposed of (on-site to sewer or taken for off-site disposal) will be logged	• Suggested that actual waste effluent production (or the waste stream as a proportion of the influent stream) should not exceed the stated design requirement by more than 10%
Reuse of effluent	• The design specification shall indicate what proportion of the system's water requirements can be met by reusing treated effluent • The volume of effluent recycled will be logged	• Suggested no more than 5% reduction in proportion of water requirements met by reuse of treated effluent
Consumables use	• The operation and maintenance schedule will state expected use rate of consumables (e.g. chemicals, filter cartridges) • The operation and maintenance log kept throughout the testing period will record actual usage	• Consumables use over the test period should be reasonable and should be approximately in line with the operation and maintenance schedule • Acceptable reasons must be given for instances of high consumables use

Performance parameter	Description	Guide value
Running costs	• Detailed records of running costs will be kept through the testing period (see Section 10.9)	• Target running costs will be defined on a case-by-case basis, depending on the target market for the product and SASTEP requirements
Key process parameters which require long-term monitoring	• To be identified on a case-by-case basis and in most instances should be included in the operation and maintenance schedule. Examples include: ○ Membrane systems: membrane flux ○ Filtration systems: frequency of backwash required ○ Pumps: number of starts per hour	• System specific
User acceptance and potential marketability of product	• The social assessment survey should include questions to collect feedback on: ○ Frequency of use ○ Reasons for non-use ○ Acceptability by all target users (e.g. women, men, children) ○ Issues with use and functionality of the front-end of the prototype ○ Issues with noise, odour, smoke or fumes, particularly relating to the back-end of the prototype ○ Desire to have the prototype installed permanently	• Prototype should have been used more often than alternative sanitation systems available • Suggested that prototype should be viewed as acceptable by 80% of any target users • Suggested that no more than 30% of users should identify issues with use and functionality • Suggested that no more than 10% of users should identify issues with back-end system • Suggested that desire to have prototype installed permanently should be stated by 60% of targeted users

Chapter 9: Setting Performance Acceptance Criteria – In Brief

- *Performance acceptance criteria should be defined based on the specific aims of the field-testing and demonstration and the particular characteristics of the prototype*
- *The criteria will normally include functionality, operation and maintenance requirements, robustness and reliability, user acceptability and marketability, potential for further optimisation and running costs*
- *Criteria should be agreed by all stakeholders before the field-testing and demonstration starts*
- *Performance acceptance testing can only take place once the system is running at steady-state within its design parameters*
- *Performance acceptance testing consists of two parts: intensive functionality testing and reliability testing*
- *Separate record sheets and sampling schedules will need to be drawn up for each phase of performance acceptance testing based on the criteria agreed upon*

Chapter 9: Setting Performance Acceptance Criteria – Further Reading

For more on environmental legislation and standards for liquid, gas and solid emissions quality, see:

- *Full text of National Water Act: https://www.gov.za/documents/national-water-act*
- *Full text of National Environment Management Act (NEMA): https://www.gov.za/documents/national-environmental-management-act*
- *Full text of National Environment Management: Waste Act (NEM:WA): https://www.gov.za/documents/national-environmental-management-waste-act*
- *Full text of National Environmental Management: Air Quality Act (NEM:AQA): https://www.gov.za/documents/national-environment-management-air-quality-act*
- *SANS30500:2019 (for purchase): https://store.sabs.co.za/sans-30500-ed-1-00-1*

Chapter 10: Technical Aspects of Testing

This chapter draws on the extensive lessons learnt from the EFTP as well as making reference to the requirements of SANS 30500:2019. It outlines the aspects of the prototype which require analysis and how this analysis should be conducted. It highlights the various aspects of the process performance which requires assessment, health and safety considerations when testing the prototype, and the importance of understanding what users think of the prototype (with greater detail on this aspect of testing given in Chapter 11: Social Aspects of Testing). The costs of running the prototype in a non-testing environment should also be considered. Note that aspects to consider when developing success and failure criteria for a prototype undergoing field-testing and demonstration are provided in Chapter 9: Setting Performance Acceptance Criteria and the two chapters should be considered in conjunction with one another.

Prototype engineer, laboratory team, community engagement team, technology developer, community liaison officer, engineering consultant, demonstration platform (if relevant)

1 month to 1 year

Chapter 9: Setting Performance Acceptance Criteria; Chapter 11: Social Aspects of Testing

10.1 Structural and Mechanical Performance

For full details on the structural and mechanical performance assessment of a prototype, please refer to SANS 30500:2019 Sections 4.12.3 and 5.4, respectively. A summary is presented in the following sections.

> ***SANS 30500:2019***
>
> *South Africa is the one of the first countries to adopt the ISO 30500-2018 closed loop water/sanitation treatment standard for facility infrastructure. The standard specifies general safety and performance requirements for design and testing and is applicable to sanitation systems that are manufactured as one package, or manufactured as a set of prefabricated elements that are designed to be assembled in one location.*

10.1.1 Structural Safety

All components of the prototype must be able to withstand the static and dynamic pressures of expected operation.

10.1.2 Mechanical Safety

Pressurised equipment with a nominal operation gauge pressure > 50 kPa or vacuum equipment with a nominal operation pressure gauge < 50 kPa respectively must be able to withstand the mechanical loading pressure of the system during operation. Safety relief values must be installed for overpressure mitigation. Damage of pipes, hoses and tanks from heat or sharp surfaces must be prevented and these should be included in visual inspections to check regularly for damage or deterioration. Movable or rotating parts must be away from human contact (in protective devices) and must be prevented from blockages.

10.2 Visual Inspection

Regular visual inspections of the prototype help to ensure safe operation. A visual inspection template form is presented in Appendix 2.8. A visual inspection of the prototype should be carried out weekly, and more frequently if the process includes high risk components or processing systems that are in early development. In addition to regular inspections during the testing phase, visual inspections should be carried out before starting the processing system, and at the end of the testing phase before decommissioning takes place.

10.3 Process Performance Testing

The evaluation of process performance is one of two crucial components of the testing phase (with the other being user acceptability) and the specifics of the evaluation are dependent on the process under test. More information on identifying appropriate success/failure criteria for a prototype and planning the testing phase accordingly is given in Chapter 9: Setting Performance Acceptance Criteria. In addition to the requirements of performance testing, it is important that all solid, liquid, and gaseous effluents from the prototype that will be released to the environment should be analysed against the environmental emissions set out in Section 10.4.

10.3.1 Planning for Process Performance Testing

A sampling and analysis plan must be drafted by the project team with expert advice from the technology developer, laboratory team and, where necessary, external advisors who can support with research or technical expertise. The plan must take into account the objectives of the testing phase, and representative samples need to be collected that will assess the overall performance of the prototype or each component of the prototype. It is useful to have a PFD of the system (see Section 3.3) so that sampling points can be identified and easily communicated with other stakeholders. The schedule of testing should be agreed in advance with the laboratory team to ensure they can handle the workload in a timely fashion.

The following documents should be available at the start of testing:

- PFD including sampling points (see Section 3.3)
- Drawing or picture with overall system dimensions (see Section 3.3)
- Electrical compliance documents (see Section 8.3.5)
- Sampling and analysis plan detailing sampling points, frequency of sampling and analyses (see Section 3.9)
- Expected ranges for sample test parameters
- Critical spares list (see Section 5.4)
- Draft operation and maintenance schedule
- HAZOP study with mitigation measures (see Section 3.4)

The performance testing plan should also include what tests are required during commissioning and decommissioning of the system (see Sections 8.4.4 and 12.1.2) as these will add to the time and cost.

Planning should also include the measurement and recording of water and energy use, as well as any other outputs not related to the operation of the prototype (e.g. solids accumulation, scum, etc.) as this is important data for long-term monitoring and costing.

All necessary documents required at start of testing phase collated

10.3.2 Water Usage

All municipal water consumption during operation of the system must be recorded. At minimum, readings should be taken daily over the same 24-hour cycle (i.e. the meter should be read at the same time each day). A water meter with data logging capacity can allow for more comprehensive data collection on water usage rather than manual daily readings. The water usage for different activities such as top-up water or maintenance tasks should be measured and recorded separately. If there is recycled water generation, the volume produced must also be logged daily, over the same 24-hour cycle as the municipal water consumption. A water balance should be constructed of the system as this enables any variations in water use to be identified immediately and corrective action taken if required.

10.3.3 Energy Usage

Daily electrical use readings must be recorded over the same 24-hour cycle each day to indicate grid or municipal power usage. If possible, power usage per treatment stage should be recorded. If there is power generation, e.g. from solar panels, this must also be logged daily over the same 24-hour cycle as municipal power usage. Recording this data enables any variations to be identified immediately and the reasons for variations investigated.

10.3.4 Solids Removed from Processing System

If materials need to be removed to ensure the continued operation of the processing system (e.g. scum, sludge, or screenings), then the volume or weight removed must be recorded so that a mass balance across the prototype can be carried out. This information is also valuable to understand what maintenance is required and how often, and how these activities will affect the operational costs of the system. In the case of sludge, the dry solid content should be tested for pathogen content to determine if it meets the thresholds presented in Table 10.6.

10.3.5 Sludge Inventory

In holding tanks where sludge may accumulate, the volume accumulated must be measured at the end of the testing phase (see Section 12.1.2 for methods of sludge measurement). A sample should be taken, dried, and tested for pathogens to determine if the quality meets the thresholds presented in Table 10.6.

10.3.6 Influent Testing

In order for data collected on the output streams from the processing system to be meaningful and to allow benchmarking against other sanitation technologies, the influent stream should also be analysed for the parameters set out in Table 10.1.

Table 10.1 – Minimum analysis for system influent

Parameter	Frequency	Reason
Chemical oxygen demand (COD)	Weekly	Indicates organic content
Total solids (TS)	Weekly	Indicates solid content
Volatile solids (VS)	Weekly	Indicates organic solid content
Total nitrogen (TN)	Weekly	Indicates nutrient concentration
Total phosphorus (TP)	Weekly	Indicates nutrient concentration
pH and conductivity	Weekly	Indicates presence of dissolved ions
Alkalinity (see Note 1)	Weekly	Indicates the buffering capacity to changes in pH
Ammonium (see Note 2)	Weekly	Indicates organic nitrogen concentration
Ortho-phosphate (see Note 2)	Weekly	Indicates organic phosphorus concentration
CNS (see Note 3)	Weekly	Indicates total carbon, nitrogen and sulphur
Chloride (see Note 4)	Weekly	Can be used to form chlorine for disinfection

Notes:

- **Note 1** – only required if there is an anaerobic biological treatment process involved
- **Note 2** – only required for systems with solid-liquid separation and subsequent treatment of two streams
- **Note 3** – only required if there is a biological treatment process or combustion
- **Note 4** – only required if there is disinfection is carried out by chlorination

10.3.7 Evaluation Against Design

As well as the regulatory sampling and analysis requirements laid out in Section 10.4, the analyses listed in Table 10.2 (for liquids), Table 10.3 (for solids), and Table 10.4 (for air emissions) are recommended to assess the performance of different components of the processing system. The selection of these parameters is based on the experience of the EFTP.

Table 10.2 – Minimum testing requirements – liquids / effluent; F = Filtration; S = Sedimentation; M = Membrane; Fl = Flotation; IE = Ion Exchange; Ad = Adsorption; C = Chlorination; O = Ozonation; Ae = Aerobic; An = Anaerobic

KEY		
	X	Analysis required
	O	Analysis preferred (if prototype has high TRL or determinand is present in influent)

	Solid liquid separation			Nutrient capture		Disinfection			Biological		Water for recycling
Test	**F**	**S**	**M**	**Fl**	**IE**	**Ad**	**C**	**O**	**Ae**	**An**	
Organics and Solids											
COD	X	X	X	X	X	X	X	X	X	X	X
TS	X	X		X					X	X	
VS	X	X		X					X	X	
TSS			X								X
Nutrients											
TN			X		X	X			X		X
Ammonium									X		
TP			X		X	X			X		X
Ortho-phosphate									X		
Potassium			X						X		X
Physicochemical											
pH			X		X	X	X	X	X	X	X
Conductivity			X								X
Alkalinity										X	
Turbidity	O	O									X
Colour	O	O			O	X	X	X			X
Calorific											
Total and free chlorine							X				X
Chloride					X	X	X				
Metals											O
CNS									X	X	
Pathogens											
E. coli			X		O	X	X	X			X
Total coliforms			X		O	X	X	X			X

Table 10.3 – Minimum testing requirements for solids

KEY	X	Analysis required

Test	Solid separation	Drying	Combustion
Organics and Solids			
COD	X	X	
TS	X	X	X
VS	X	X	
Nutrients			
TN	X		X
Ammonium	X		
TP	X		X
Ortho-phosphate	X		
Potassium	X		X
Physicochemical			
Colour			X
Calorific	X	X	
Metals			X
CNS			X
Pathogens			
E. coli		X	X
Total coliforms		X	X

Table 10.4 – Minimum testing requirements for gases

KEY	X	Analysis required

Test	Biogas	Combustion exhaust
Gas		
CH_4	X	
CO		X
NO_x	X	X
SO_x	X	X

10.4 Compliance with Environmental Emissions Standards and Regulations

10.4.1 Liquids

For liquid effluents from the processing system that will be reused or discharged to surface water, compliance with discharge or reuse limits needs to be met. Some municipalities will have local regulations and where these exist, they should be adhered to. Where that is not the case, the South African discharge limits as specified by the Revision of General Authorisations in Terms of Section 39 of the National Water Act 36 of 1998 (Act No. 36 of 1998) should be met for liquid streams that will be discharged to the environment and the SAN 30500:2019 reuse and discharge limits may be applicable if meeting this standard forms part of the aims of the field-testing and demonstration. These discharge and reuse limits are presented in Table 10.5. Note that for discharge of treated effluent to surface waters, the national standards are more stringent that the SANS 30500:2019 limits and should take precedence.

Table 10.5 – Effluent quality limits as per SANS 30500:2019 (Section 7.2.9.4) and the South African National Water Act

Determinant	SANS 30500 limit for reuse or discharge	National Water Act limit for discharge
Organics Concentration	mg/L	mg/L
COD	≤ 50 (reuse); ≤ 150 (discharge)	≤ 75
TSS	≤ 10 (reuse); ≤ 30 (discharge)	≤ 25
Nutrient Reduction	%	Nutrient concentration
Total N	≥ 70	6 mg/L as NH_4-N; 15 mg/L as NO_3-N
Total P	≥ 80	10 mg/L as PO_4-P
pH	6-9	5-9
Pathogens		
Bacterial pathogens (*E. coli*)	100 CFU/L	100 CFU/mL
Viruses (MS2 Coliphage)	10 PFU/L	
Helminths (*Ascaris suum* viable ova)	< 1	
Protozoa (Clostridium perfringens spores)	< 1 CFU/L	

Discharge Standards

It is important to work with the local municipality/regulator to determine relevant standards for discharge or reuse as these may differ from provincial and national limits depending on the context in which the prototype is being operated.

10.4.2 Solids

10.4.2.1 Ash and Solid Outputs

If there are solid outputs, including ash, generated from the process, the pathogen content in the dry solids should be determined to ensure it is safe for reuse or disposal. Some municipalities will have local regulations and where these exist, they should be adhered to but where that is not the case, the SAN 30500:2019 limits may be applicable if meeting this standard forms part of the aims of the field-testing and demonstration. These threshold limits are presented in Table 10.6.

Table 10.6 – Safe pathogen content of solid outputs as per SANS 30500:2019 (Section 7.2.9.3)

Pathogen	SANS 30500 Limit
Bacterial pathogens (*E. coli*)	100 CFU/g dry solid
Viruses (MS2 Coliphage)	10 PFU/g dry solid
Helminths (*Ascaris suum* viable ova)	< 1
Protozoa (Clostridium perfringens spores)	< 1

10.4.3 Gases

Air emissions from the system during operation are classified as either pollutants or explosive gases. Some municipalities will have local regulations and where these exist, they should be adhered to but where that is not the case, the SAN 30500:2019 limits may be applicable if meeting this standard forms part of the aims of the field-testing and demonstration. The indoor or outdoor thresholds from the standard are given in Table 10.7.

Table 10.7 – Air emission thresholds for system during operation as per SANS 30500:2019 (Section 7.2.9.7)

Parameter	Emission threshold	
	Indoor (1 hour average except H_2S = 30 min)	Outdoor (1 hour average)
CO	28 ppmv	80 ppmv
NO_x	99 ppbv	68 ppmv
SO_2	6,8 ppbv	195 ppmv
CO_2	1000 ppmv	12 ppmv
H_2S	4.6 ppbv	1.9 ppmv
VOCs	187 ppbv	0.001 ppmv
$PM_{2,5}$	25 µg/m^3	10 mg/m^3
NH_3	25 ppmv	50 ppmv

ppmv = parts per million by volume; ppbv = parts per billion by volume

10.5 Helminth Testing

Soil transmitted helminths (STHs) require a period of egg or larval development in the environment to become infective. The eggs of one particular STH, *Ascaris lumbricoides*, are very hardy and are thus used as an indicator organism in sanitation. It is considered that if a system can kill or inactivate *Ascaris* eggs, then other viruses and bacteria will also have died.

The Cost of Pathogen Testing

Pathogen testing is expensive and time consuming. Guidance should be obtained from SASTEP as to whether testing for helminths, viruses or protozoa is necessary during field-testing and demonstration of a prototype.

Due to ethical and logistical considerations, it is not possible to obtain large numbers of *A. lumbricoides* eggs for research purposes, thus eggs of the morphologically identical pig roundworm, *A. suum* are used as a surrogate.

Helminth testing of a prototype involves spiking the influent to the processing system with a known concentration of *A. suum* eggs (hereafter termed '*Ascaris*') and sampling all effluent streams to identify if eggs that entered the processing system were inactivated and in which effluent streams they appear. Subsequent analysis of samples needs to be carried out by an experienced laboratory as the viability of *Ascaris* eggs must be determined microscopically and this is difficult for the 'untrained eye'.

In order to test for helminths in effluent streams, a known concentration of *Ascaris* eggs must be spiked into the influent to the processing system. The SOP for helminth spiking is shown in Appendix 4.2. As there is no way to differentiate between *Ascaris* eggs added during spiking and those already present in the influent stream, it is important that the influent is tested for helminths before spiking with *Ascaris* eggs takes place. Ideally, helminth testing should take place when the system is being used by people who are known to be uninfected. If this is not feasible, it is better to use a faecal simulant to ensure that helminths are not present in the influent. Recipes for faecal simulants can be found in Velkushanova et.al (2020).

Samples of the effluent should be taken from the spiked processing system for a sufficient duration such that all eggs can be accounted for in the various effluent streams. This includes sludge that accumulates within the system and may be disposed of at a later date.

Where possible, *Ascaris* egg spiking and sampling of all effluent streams should be repeated three times to ensure that the results are reproducible. Due to the intensive nature of the helminth testing, this should only be carried out after other results have shown that the processing system is working well.

Helminth Testing of a Urine Treatment System

A prototype tested on the EFTP uses microbial fuel cells (MFCs) to produce electricity from urine. Two systems were tested in eThekwini, one in the laboratory and one in a community. Both were fed with urine from urinals in a communal ablution block. An experiment was carried out on the laboratory-based system to investigate whether helminths would be inactivated in the MFCs. The system in the laboratory was used for this test as there was a reduced risk of infecting community members. The testing was carried out just before decommissioning when normal testing was complete. The feed urine stream was spiked with a known volume of eggs and fed into the MFCs each day for three days. Samples were taken at the outlet of each MFC over the same three days and at the end of the test, the system was flushed with clean water and this was also tested for helminths. The helminth testing showed that approximately 40% of the spiked helminth eggs accumulated within the system. Most of the eggs that left the MFCs were viable and so, if the outlet from the MFCs is to be applied to fields, additional treatment would be necessary to make it safe.

10.6 Sampling

This section provides guidance on how to undertake sampling of the prototype's processing system, how to transport the samples to the laboratory, and how to store them prior to analysis.

10.6.1 Sampling Technique

Representative samples must be collected in order for the data on the performance of the prototype to be reliable, as unrepresentative samples can skew performance data and give either a falsely positive or falsely negative view of the processing system's performance. SOPs for sampling from tanks, pipes and channels are provided in Appendix 4.3. The SOPs aim to ensure that samples are representative and maintain the chemical and physical integrity of the sample. However, the variety of conditions across prototypes means that some degree of judgement on the part of the sampler will be required. The following points should be considered when planning for sampling:

- Sampling locations – Sampling locations should be selected in order to satisfy the project objectives. As a minimum, the influent to a prototype and all effluent streams should be sampled. In addition, extra samples may be required before and after a particular system component to assess performance of that component.

- Special handling requirements for certain pollutants – Sampling for pathogens requires sterile sample bottles and sampling methods to prevent cross-contamination. Certain samples may require a preservative to prevent the deterioration of the sample before it is received by the laboratory. This information can be checked with the laboratory.
- Grab samples vs. composite samples – Grab samples are a single discrete sample that is representative of the conditions in the pipe, channel, or tank at the time of sampling. Composite samples are collected over time and require multiple discrete samples taken at different time points to be mixed. They represent the average characteristics in the pipe, channel, or tank over the period of compositing. For most purposes, grab samples are sufficient but it can be beneficial to take grab samples at different times of day or week to ensure that samples reflect the variation in system performance over the course of a day or week, e.g. due to high influent concentration at weekends or early in the morning when more users are using the toilets in a CAB.
- Operation of the system – Batch and continuous systems may require different sampling regimes. If the duration of the batch reaction is long, then the sampling visit must coincide with the end of the batch to prevent the sampler from waiting for long periods on site.
- Mixing – Wherever possible, samples should be collected where flow is well mixed, often near the centre of the pipe, channel, or tank. Skimming the surface of the water or dragging along the bottom of the channel or tank will result in the collection of scum or settled solids which are unlikely to be representative of the main flow. If composite samples are collected, individual samples should be thoroughly mixed before pouring the aliquots together to form the composite sample.
- Accessibility – Sampling points must be easily and safely accessible by the sampler and if samples need to be taken from a sample location that is not easy and safe to reach, changes to the system may be required, e.g. addition of a sampling tap on a pipe or tank.

10.6.2 Transporting and Storing Samples

Sample containers should be fitted with tight-fitting lids before they are removed from site and should be kept upright. Samples should be kept in a cool box or cool bag during transportation from site to the laboratory, both for sample preservation and to prevent spillages in the vehicle. All samples must be labelled with the sample location, sampler’s name, and time and date of sampling. If samples must be stored before analysis, they should be stored at 4 °C. Storage time should be kept to a minimum.

What's in a Sampling Box?

A sampling box contains essential sampling and safety consumables and tools. The following items are recommended to be included but will vary based on the types of samples to be collected:

A first aid kit	*Safety glasses*	*Square sampling containers*
70% ethanol	*Dust masks*	*500 mL clear plastic buckets*
1 L disinfectant container	*Half mask respirators*	*Small plastic scoop*
Latex gloves	*Paper towel*	*Markers, pens and labels*
Plastic elbow length gloves	*Plastic refuse bags*	*A long-handled shovel*

10.7 Health and Safety Considerations

10.7.1 Risk Assessments

The technology developer should provide a HAZOP study, which can form the basis of risk assessments for the operation and maintenance of the prototype. All standard operational and maintenance tasks should have a SOP and a risk assessment drafted in advance of the task. A risk assessment template is provided in Appendix 2.4 and a template for an SOP is provided in Appendix 2.9. These documents identify the steps needed to carry out a task, the hazards associated with each task, who is at risk from the identified hazards and the controls that can be implemented to mitigate the risks. The hierarchy of controls shown in Figure 10.1 should be considered when developing safe working practices.

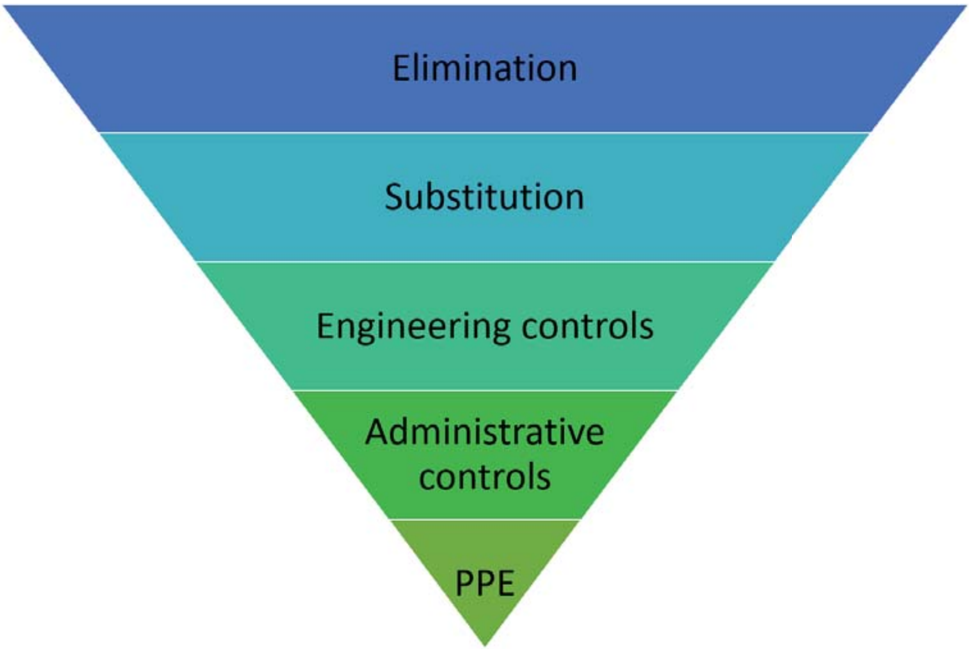


Figure 10.1 – Hierarchy of controls

The preferred controls are those closer to the top of the inverted pyramid. For example, a manual handling task could make use of a trolley to eliminate the risk of injury from incorrect lifting techniques. Similarly, a cleaning task that uses hazardous chemicals could be substituted for a cleaning task that uses less hazardous chemicals. Ventilation systems are engineering controls that reduce the risks associated with inhalation of fumes and dust. Administrative controls such as procedures designed to keep workspaces clean and free from contamination will form a key part of the standard operating procedures. The last line of hazard control is personal protective equipment (PPE) which should be used only after other controls have been implemented. However, when dealing with pathogenic samples, it is unavoidable that laboratory coats or overalls, closed footwear, nitrile gloves, and goggles will form part of the necessary safe working wear. Additionally, PPE may be required based on the specific task; the appropriate PPE can be determined by carrying out a risk assessment.

PPE for Site Work and the Laboratory

The following PPE for working with faecal sludge on-site is recommended:

- *Safety boots*
- *Overalls*
- *A half mask respirator*
- *Safety glasses*
- *Elbow length gloves*

The following PPE is recommended for working in the laboratory:

- *A lab coat and long pants to make sure that the entire body is covered*
- *Safety boots*
- *Latex gloves*
- *A face mask*
- *Safety goggles*

The PPE selected for any work should be based on the risks identified in the risk assessment for the activity. It is important that appropriate and well-fitting PPE is selected so that it does not hinder the wearer from carrying out their task or increase the risk that they face.

For non-standard operation and maintenance, a dynamic risk assessment should be completed on-site before the task is started to ensure that the logical order of steps has been considered along with their associated risks. If appropriate mitigations cannot be put in place at that time to minimise these risks, the task should be delayed until it is possible to complete the work safely.

In general, the following risks should be considered at all times:

- Safe access to site – Prototype engineers should only work during daylight hours and should not be alone on site. A vehicle should be present on-site for emergencies at all times when a prototype engineer is present, and the engineer should have a charged mobile phone, call credit and emergency contacts saved. The CLO should be contacted prior to visiting the site to ensure it is safe to do so.
- Faecal contamination – As prototypes contain and process faecal waste, it should be assumed that everything in test areas is contaminated and prototype engineers and visitors should

behave accordingly. Hands should be washed and disinfected after completing tasks, before leaving site and before eating, drinking or smoking. Spillages should be cleaned up immediately and the area sprayed with disinfectant. Waste material should be disposed of as hazardous waste. Prototype engineers should receive vaccinations for Hepatitis A and B, typhoid and tetanus before commencing work with faecally-contaminated material.

- Housekeeping – Work areas should be kept tidy, particularly where users are able to access sites. At the end of each day or if the prototype engineer has to leave, the site should be made safe with equipment and materials locked in secure storage or taken off-site. Access to groundworks or high-risk areas should be barricaded off. This prevents users from accessing unsafe areas. The safety of users and the community should be made a priority.
- Chemicals and spillages – Material Safety Data Sheets (MSDS) for all chemicals should be kept on-site. Chemicals for operation or maintenance tasks should be labelled with the substance and concentration, and any necessary warning symbols. Hazardous chemicals should be stored in accordance with the MSDS. Spillages must be cleaned up immediately and waste material disposed of safely.
- Moving parts – Movable or rotating parts must be away from human contact (in protective devices) and easily accessible emergency stops should be in place. Loose clothing or hair should be secured so that they cannot tangle around moving parts during operation and maintenance tasks and where possible, moving parts should be stopped before these tasks are carried out.
- Heat treatment processes – If the prototype makes use of heat treatment, hot surfaces should be insulated to prevent contact burns. Pipes or tanks carrying hot liquid or gas streams should be clearly marked.

Risk assessments for all activities relating to operation and maintenance of the prototype drafted and available for updating as necessary during testing phase

10.7.2 Standard Operating Procedures

If an operating manual and service and repair manual are not provided by the technology developer, the prototype engineer should develop SOPs for all regularly scheduled tasks relating to the prototype. A template for a SOP is given in Appendix 2.9. Aspects to consider when putting a SOP together include:

- The title of the activity
- A SOP reference number
- Publication date and revision number
- Names of organisation / division etc. that the SOP applies to
- Names and signatures of people responsible for developing and approving the SOP
- Scope of the SOP
- Equipment required
- Methods to be followed
- Potential hazards and safety precautions

Standard operating procedures for all regularly scheduled activities relating to operation and maintenance of the prototype drafted and available for updating as necessary during testing phase

10.8 Operation and Maintenance

An operations and maintenance (O&M) manual should be drafted by the technology developer and should include the details of all SOPs and necessary maintenance tasks. This manual should be updated by the prototype engineer during the testing phase if necessary to ensure its accuracy.

10.8.1 Maintenance Schedule

A list of all maintenance tasks must be recorded, and the skills required to undertake these tasks noted by the prototype engineer during the testing phase. A template is provided in Appendix 2.10. A list of critical spares should be requested from the technology developer and modified, if necessary, by the prototype engineer, to ensure that it represents the longevity of components in the context of the demonstration site.

Maintenance schedule for the prototype drafted and available for updating as necessary during testing phase

10.8.2 Fault Logging

The operator should keep a log of all actions they take to operate and maintain the prototype during the testing phase. In particular, faults with the system must be logged as well as the action taken to fix the issue. This information can contribute to updating the maintenance schedule, the critical spares list, and can allow the reliability of the prototype to be better understood. Templates for operator logs and fault logs are provided in Appendix 2.11 and 2.12 respectively.

10.9 Estimating Future System Running Costs Post-Commercialisation

The demonstration of the system in a 'real world' environment will provide data on costs that can be used to inform an estimate of the likely installation and operational costs of the system post-commercialisation. This information is obviously of critical interest to potential buyers, and therefore detailed record-keeping of costs during the installation, commissioning and testing phases is advisable. This section provides guidance on the tasks for which costs should be recorded and how they might inform an estimate of the running costs of the prototype in a normal operational environment.

Table 10.8 lists the types of costs that should be recorded. Costs will clearly be system-dependent and this is not intended to be an exhaustive list.

Table 10.8 – Costs to be recorded during the a sanitation prototype demonstration

Cost category	Tasks associated with costs
Site preparation	• Surveys and underground services detection • Site design work • Civil works • Plumbing • Electrical • Utilities connections • Project and construction management • Testing equipment procurement • Community engagement costs • Community liaison officer salary • Security
Taxes and duties	• Import duties • Import VAT • Clearing charges
Transport and rigging	• International shipping • Local transport to storage site • Rigging and unpacking • Storage fees • Local transport to demonstration site • Rigging for installation
Installation and commissioning	• Installation and commissioning engineers • Community engagement • Community liaison officer salary • Water and/or sludge for first fill • Utilities – water, sewer, electricity • Modifications to prototype
Testing	• Personnel: management, system engineer, plumbing/electrical support, caretaker, project manager • Sampling and analysis costs • Community liaison officer salary • Toilet paper • Cleaning materials • Disposal of waste (material from screens, sludge, etc.) • Utilities – water, sewer, electricity • Internet data charges • Chemicals for system process • Replacement parts

Cost category	Tasks associated with costs
	• System-specific maintenance tasks, e.g. screen cleaning, sludge removal, cleaning cycles • Caretaker salary • Security
Decommissioning	• Removal of prototype from site including rigging and transport • Storage and/or scrapping charges • Rehabilitation of site • Personnel time and costs • Appreciation gesture to hosts at demonstration site

An operation and maintenance schedule should be developed during the testing phase. The schedule should distinguish between tasks that are only carried out because the prototype is under test, and those tasks that would be part of the normal functioning of the system in a normal operational environment. It is useful to keep detailed timesheets for staff working on the prototype, to refer back to for estimates of task times when developing the operation and maintenance schedule.

An analysis is carried out of all the costs recorded during the field-testing and demonstration, and decisions or estimates made as to what costs were only applicable because the system was under test, and what costs would still apply for long-term operation. For example, the schedule of sampling and analysis under normal operation would be expected to be significantly reduced from that carried out during field-testing and demonstration.

Long-term system running costs post-commercialisation can then be calculated in two ways:

- Based on the ongoing running costs only (utilities, consumables, routine replacement of parts that wear out and occasional repairs), and excluding capital cost and other once-off costs such as installation, commissioning, and decommissioning at end of life.
- Incorporating entire life-cycle costs of the sanitation technology by calculating cash flows for the technology across its assumed lifespan. This accounts for both the ongoing running costs and the capital costs, the cost of servicing debt for the initial purchase, depreciation, installation and commissioning costs, decommissioning costs, and scrap value.

Metrics of interest to potential buyers include:

- Cost per use, incorporating entire life-cycle costs
    - The sum of the discounted costs per year from the cash flow calculation over the lifespan of the sanitation technology, divided by the estimated number of sanitation technology uses over its lifespan.
- Cost per kL of treated or recycled water (if the sanitation technology operates with a water flush), incorporating entire lifecycle costs
    - The sum of the discounted costs per year from the cash flow calculation over the lifespan of the sanitation technology, divided by the estimated total volume of water treated over its lifespan

- Monthly staff time inputs required to operate and maintain the sanitation technology, including on-site staff and engineering or management inputs
- Monthly cost of sanitation technology, based on ongoing running costs only

> ***Installation and operational costs of the system post-commercialisation estimated based on experience from the testing phase***

10.10 Social Assessment

An essential part of field-testing and demonstration of a prototype is undertaking a social assessment (see Chapter 11: Social Aspects of Testing). As a minimum, social assessments should be conducted with the user(s) before the testing phase begins and at the end of the testing phase. If the testing phase is going to be long (e.g. 1 year), it can be useful to carry out an interim assessment halfway through the testing phase. This allows the LTCP to address challenges associated with user acceptability before the end of field-testing and demonstration. These could include, but are not limited to, cultural and gender preferences relating to the design of the front-end, odour emissions and noise associated with the operation of the prototype.

10.11 Gateways to Higher Technology Readiness Levels

The concept of TRLs was introduced in Section 2.2. Most prototypes demonstrated under SASTEP are between TRL 5 and TRL 7.

Before a TRL 5 technology can progress to TRL 6, engineering validation is carried out by the technology developer in collaboration with either a commercial partner or a demonstration platform. The prototype must be evaluated against the performance specification for the system in a relevant environment and any remaining technical issues must be identified and a feasible action plan to overcome them put in place.

Before a TRL 6 technology can progress to TRL 7, design validation is carried out by the commercial partner or a demonstration platform with support from the technology developer only if necessary. Between one and thirty prototype units should be tested in a range of relevant operating environments and a full design package must be finalised. The number of prototypes to be tested is based on the type of system, with a small number of units tested if the system is community-scale and a larger number of units tested if the system is household-scale. The list of items required in the design package is provided as Appendix 5.5.

> ***Engineering validation or design validation completed if aim of testing is to move prototype to higher TRL***

10.12 Reporting on the Testing Phase

The various templates referred to in this chapter that can be used for day-to-day data logging will form the basis of data collection relating to the prototype field-testing and demonstration. To facilitate the reporting of this data to a wider audience, report templates for monthly reports and final testing reports are given in Appendix 2.13 and 2.14 respectively.

Chapter 10: Technical Aspects of Testing – In Brief

- *The testing phase takes between one month and one year depending on the type and size of the prototype, and the required outcomes of the testing phase*
- *A sampling and analysis plan should be drawn up and agreed prior to the start of the testing phase*
- *Water and energy consumption needs to be recorded at the same time each day*
- *Analysis of the influent as well as the liquid, solid and gas outputs from the prototype is required*
- *Local and national regulations as well as national and international standards may provide the criteria for performance of a prototype depending on the goal of the field-testing and demonstration*
- *Risk assessments and standard operating procedures help to ensure that health and safety considerations are met during operation and maintenance of a prototype*
- *Development of an operations and maintenance manual, as well as logging all faults and interventions is important*
- *Records of all costs should be kept in order to inform an estimate of the likely installation and operational costs of the system post-commercialisation*

Chapter 10: Technical Aspects of Testing – Further Reading

For more on legislation and standards for liquid, gas and solid emissions quality, see:

- *Full text of National Water Act: https://www.gov.za/documents/national-water-act*
- *SANS30500:2019 (for purchase): https://store.sabs.co.za/sans-30500-ed-1-00-1*

For more on laboratory analysis methods, see:

- *Velkushanova, K., Strande, L., Ronteltap. M., Koottatep, T., Brdjanovic, D., and Buckley, C. Editors (2020). Methods for Faecal Sludge Analysis: https://www.iwapublishing.com/books/9781780409115/methods-faecal-sludge-analysis*

For more on health and safety when working with faecal sludge, see:

- *Safer Sanitation for All video: https://www.youtube.com/watch?v=XwCD4TUsacU&t=94s*

Chapter 11: Social Aspects of Testing

Social assessment is one of two crucial components of the testing phase (with the other being process performance) and the specifics of the social assessment are dependent on the prototype and the location of the demonstration site. This chapter covers the process for carrying out a social assessment, the tools to be used, and the importance of including a diverse cross-section of the community.

Social assessment team, technology developer, commercial partner, demonstration platform (if relevant), community engagement team, community liaison officer, municipal community liaison, councillors, traditional authority leadership (if relevant), community/school leadership, head of household (if relevant)

Data collection – 1 day to 2 weeks; reporting – 1 to 2 months

Chapter 6: Community Engagement; Chapter 9: Setting Performance Acceptance Criteria

11.1 Social Assessment Aims

The involvement of citizens, and the co-production of knowledge through participatory processes, in the field-testing and demonstration of innovative non-sewered sanitation is essential if future sanitation technologies are to be socially just, sustainable, transformative and equitable.

Social assessment has a number of aims including:

- Identification and understanding of the context within which field-testing and demonstration will take place
- Evaluation of community perceptions, attitudes, experiences of, and responses to new sanitation technologies, and their acceptability
- Inclusion and acknowledgement of community's voices in sanitation technology design and improvement through the co-production of knowledge
- Reporting of context specific evidence of what works and what does not work for communities in relation to new sanitation technologies

Aim of social assessments agreed by all stakeholders

Community Feedback Impacting Design

After testing a pedestal prototype at multiple household sites in eThekwini on the EFTP, the technology developer was able to use the feedback from users to improve the design of the pedestal. Some of the changes that were made included:

- *Increasing the depth of the bowl so that human waste was less close to the user*
- *Integrating an automatic spray of lubricant into the bowl before use to prevent faeces sticking to the bowl*
- *Increasing the size of the dry swipe used to "flush" the toilet to reduce fouling of the bowl*
- *Changing the material of the bowl to reduce fouling of the bowl*

This resulted in a pedestal that users were more likely to consider as clean and comfortable to use.

11.2 Social Assessment Stakeholders

Social assessment of sanitation technologies builds on the community engagement process (see Chapter 6: Community Engagement). The existing community engagement structures that are in place for field-testing and demonstration should be used to inform community leaders and the community about the social assessment work that will take place.

It is valuable for the social assessment team to be formally introduced to the stakeholders identified in Table 11.1 in order to facilitate their work. This introduction should be carried out by the municipal community liaison or the community engagement team before social assessment starts.

Table 11.1 – Stakeholders who should be introduced to the social assessment team

In a community	At a school	At a household
Community leadership	School governing body	Head of household
Community liaison officer	Head teacher	Household members
Community members	Teachers	

Social assessment team introduced to all relevant stakeholders at testing and demonstration site

11.3 Social Assessment Process

The social assessment process follows the steps described below and in Figure 11.1:

1. Social assessment team engages with the technology developer and commercial partner to understand the prototype and what information would be useful to them
2. Social assessment team engages with the leadership structures at the demonstration site to understand the context of the demonstration
3. Social assessment team determines which social assessment methodology is most suited to the situation (see Section 11.4)
4. Social assessment team identifies appropriate questions for surveys or interviews
5. Social assessment team obtains ethical approval prior to undertaking assessments (see Section 2.7)
6. Social assessment team carries out social assessment at the demonstration site
7. Social assessment team reports on social assessment results to community at demonstration site
8. Social assessment team reports on results within the context of the demonstration site to project team

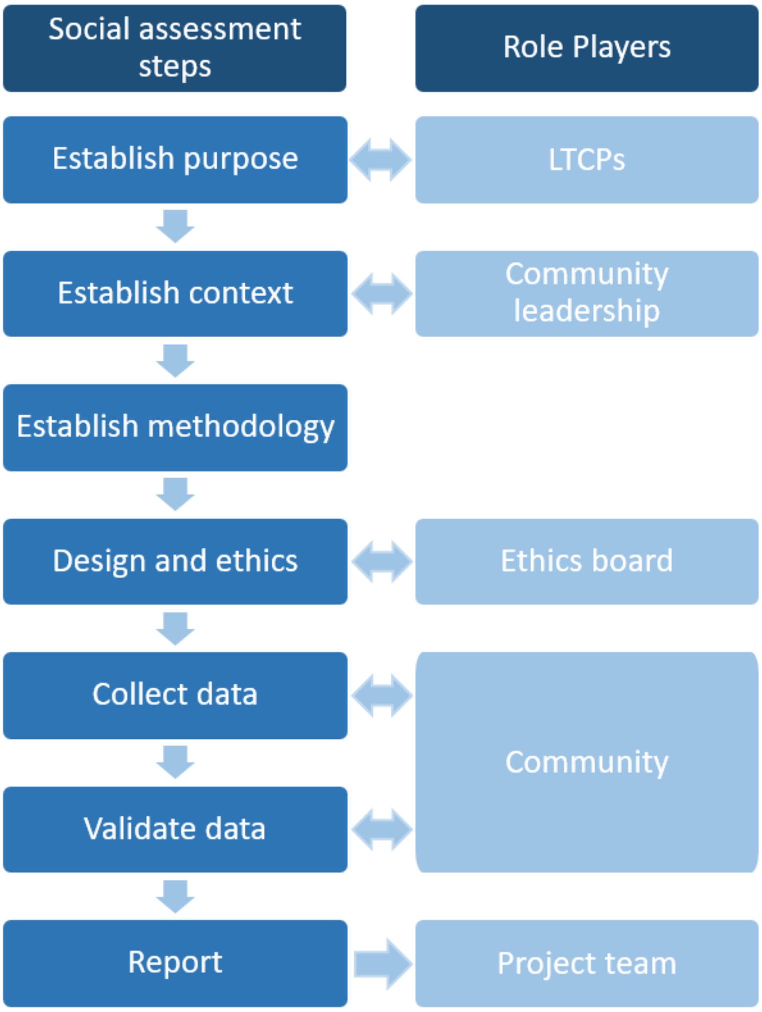


Figure 11.1 – Social assessment process

11.3.1 Stages of Social Assessment

The three main stages to a social assessment study are described in Table 11.2.

Table 11.2 – Stages and aims of a social assessment

Stage	Type of assessment	Aim
Baseline or pre-installation	• Surveys • Household interviews • Focus group discussions • Key stakeholder interviews • Transect walks and observations	• To determine the demographics of the demonstration site, socio-cultural practices and beliefs related to water and sanitation • To determine the level of sanitation at the demonstration site and the need for improvement • To assess people's experiences of and responses to their current water and sanitation situation prior to the installation of the prototype
Mid-demonstration	• As for baseline assessment but on a smaller scale	• Only necessary if testing period is longer than approximately six months • To determine the individual or community response to the prototype while it is being used
Post-demonstration	• As for baseline assessment	• To assess people's experiences and responses to the prototype once it has been decommissioned • To determine if there was any improvement in sanitation use and experience • To evaluate the effectiveness and social acceptance of the prototype • To document user perceptions and experiences of and responses to the prototype and broader social processes triggered by the demonstration

Why Bother with a Baseline Study?

A baseline study is important as the way in which people assess technical functionality and social acceptance of prototypes is shaped by their experiences and knowledge of previous sanitation systems. For example, someone who has previously used a pit latrine including for the disposal of nappies, may be disappointed that a dry toilet with a flushing mechanism cannot be used in this way.

Baseline social assessment carried out before prototype is opened for use

11.4 Social Assessment Methods

Table 11.3 provides an overview of the various methods that can be used to collect social assessment data. The selection of a method is dependent on the following factors:

- Type of prototype – users interact more with front-end systems, but there may be user concerns regarding odour, noise, emissions and the repurposing of space for back-end systems
- Aims of demonstration – the aims of field-testing and demonstration determined in Section 3.1 will provide an understanding of what data is of interest
- Number of users affected by field-testing and demonstration – interviews are feasible when the number of users of a system is small whilst surveys are more suitable for larger numbers of users
- Type of demonstration site – household sites are characterized by a small number of users, whilst schools and communities have a greater number of users, and a greater variety of users at a community site
- Resource constraints of social assessment team – it is important to balance the quantity of data collected (every user vs. a sub-set of the users) against the time and cost associated with the data collection process

Table 11.3 – Social assessment methodologies

Social assessment methodology	Description
Surveys	• Contain open and closed ended questions • Sample size determined by the size of the community and the resources for the study • Generally, between 50 to 100 surveys are undertaken • Clustered, systematic random sampling method is used
Household interviews	• Semi-structured interview • Conducted in the household • Only adults (over 18 years old) can be interviewed • Home language of the household used • Feedback on reports produced provided to the households for verification
Focus group discussions	• 8 to 12 adults (over 18 years old) • Conducted in community halls, households or at school with teachers • Comprised of men, women or mixed gender

Social assessment methodology	Description
	• Gender composition determined by nature of questions asked • 8 to 12 questions are asked and probed for more in-depth information • Conducted in the home language of the participants • Recorded and transcribed
Key stakeholder interviews	• Semi-structured interview • Conducted with community leaders or others who can give overview of impact on the site • Only adults (over 18 years old) can be interviewed • Home language of the interviewee used • Feedback on reports produced provided to the interviewees for verification

Templates for interviews, surveys and focus group meeting questions are provided in Appendix 2.15 to 2.20. These can be adapted or added to as necessary based on the aims of the social assessment.

Front-end vs. Back-end

Assessing the impact of a front-end pedestal on users is easier than assessing the impact of a back-end technology. For back-end systems, the social assessment should focus on broader sanitation experiences for the users and how the sanitation technology has impacted on individual and school or community life.

Social assessment interview, survey and focus group questions agreed by commercial partner, technology developer and SASTEP

11.5 Ethical Clearance for Social Assessments

Ethical clearance must be obtained before any form of data can be collected at an individual or community level from informed adults who have consented to participate in the study. Section 0 provides more detail on the process of obtaining ethical clearance. Information that needs to be provided includes the submission of a proposal for the study (literature review, aims, objectives, methodology, data analysis, data management) as well as the necessary documentation including a gatekeeper’s letter (usually provided by the municipality and the Councillor/Traditional Authority leader, or if the study involves a school, the DBE and the head teacher), as well as informed consent forms in English and the home language of the participants in the social assessment.

In South Africa, engaging with children under 18 years of age in social assessment studies requires a full ethical clearance application and evaluation, which is time consuming and complex; hence, unless it is essential, children are not included in the social assessment but their response to the prototype is evaluated through the knowledge of their parents or teachers.

Ethical clearance obtained for social assessment studies

11.6 Planning for Social Assessments

11.6.1 Principles for Social Assessments

A one-size fits all approach cannot be applied to social assessment, and social assessments should be adjusted based on the context of the demonstration site. The skills and experience of the social assessment team are important to ensure that the approaches used are sensitive, responsive, and adapted to each context. However, certain principles will apply regardless of context:

- Communities should be empowered and should engage in social learning through the social assessment process
- Social assessment should ensure the co-production of knowledge around social responses to new sanitation technologies
- Social and human capital should be built through the social assessment process, mainly through social learning and sharing
- Local and indigenous knowledge should be respected and this knowledge and local culture should be included in prototype design and improvement
- Social assessment must ensure that communities are not negatively impacted by field-testing and demonstration
- Social assessment should develop an understanding of the impact of the removal of the prototype after the demonstration so that the impacts of the loss of improved sanitation can be mitigated
- Communities must be empowered to make decisions about the value, and costs and benefits of sanitation technology demonstrations taking place in their community
- The voice of communities must be heard and included in by field-testing and demonstration processes and prototype design
- Knowledge and data collected in communities must be reported back to communities to be verified and accepted as accurate reflections of their views
- Communities and the settlements they live in must not be treated as laboratories, where science and society only interact around a particular technology. Instead, the everyday lived worlds of community members and the impact of all aspects of field-testing and demonstration on these experiences must be recognised, respected and acknowledged

11.6.2 Gender Intentionality and Diversity

A number of cross-cutting issues need to be taken into account when conducting social assessments of sanitation technology demonstrations. These include poverty, inequality, vulnerability, environmental risk and gender, all of which influence social assessment aims, methods, and design. Of particular interest is the aspect of gender issues where gender inequality persists in access to, and control over, safe sanitation, with women and girls experiencing significant disproportional impacts, particularly in terms of safety, hygiene, privacy, and dignity.

Social assessment methods should include questions on gender, including female and male responses to the field-testing and demonstration of the prototype and to sanitation experiences. The responses of participants can then be analysed using male and female variables to determine how gender impacts on water and sanitation experiences and responses. However, greater emphasis in social assessment must be placed on understanding how innovation in water and sanitation technology, and field-testing and demonstration can contribute to greater gender equality.

11.6.3 Social Assessment Team

The social assessment team must be trained in the various methods of undertaking surveys or interviews and how to collect this data in an ethical manner. Where community engagement at demonstration sites also aims to build the data collection capacity of community members, they can be included in the social assessment team. This supports social and human development at the demonstration site.

Community Inclusion in Social Assessment at an Informal Settlement Site

At one informal settlement site, community members were trained as data collectors to assess feedback to an innovative hand washing station. The data collectors carried out two main activities:

- *Carrying out a user count over a number of days to assess how often the hand washing station was used*
- *Carrying out questionnaires with users and non-users to assess perceptions and acceptability of the hand washing station*

This helped develop the skills of the data collectors and provided short-term employment within the community, as well as supporting the project by collecting valuable data on how the hand washing station could be improved from the point of view of users.

11.6.4 Safety During Social Assessments

It is important that the social assessment team are safe when they move around the community to carry out their work. Ensuring that the community leaders and the community members are aware in advance that the social assessment team are coming to the community and the work that they will be doing acts as an important safety net for the team. In addition, the social assessment team should be accompanied by a community member at all times. This could be the CLO or another person well-known to community members. This person acts as a guarantor for the team when they meet with community members, and should be able to provide guidance on areas that are considered unsafe. All of the social assessment team should be briefed on how to stay safe as they carry out their work and a “zero tolerance” approach to risk should be applied – if team members feel unsafe or unsure about their safety, work should be halted until the issue has been addressed. Briefings at the start of each day of data collection should highlight safe working practices and debriefs at the end of each day should reflect on any safety concerns.

11.7 Carrying out Data Collection for Social Assessments

The data collection method will guide how data collection is carried out. The following points should be considered when planning the data collection:

- Number of surveys or interviews required – In a school or household setting, it may be possible to interview every adult user. However, in communities, this would be time-consuming. The number of surveys or interviews carried out must be sufficient to give a good understanding of the variety of responses across different cross-sections of the community, but also take into account the limited time and resources available for the task. Experienced social assessment teams will be able to provide guidance on how many surveys or interviews are needed. This number will be smaller if the initial data collection shows repeated similar experiences, and will be larger if initial data collection shows many varied responses to the questions asked.
- Selecting households for surveys – The most common method for selecting households to include in a community survey is systematic sampling where every n^{th} house is included in the sample. If there are additional criteria for selecting respondents, e.g. must have children living in the house, these criteria should be checked at the start and if the household does not meet the criteria, the social assessment team will move to the next household.
- Navigating communities – It is valuable for the social assessment team to have maps of the area which they can break down into sub-sections and identify routes through these sub-section areas. This can help to ensure a good cross-section of the community with regards to location are involved in the social assessment. In addition, having a member of the community with the social assessment team will help them to navigate in areas that are not clearly mapped.
- Documents required by the social assessment team – The social assessment team must have copies of the map of the area where they are working, sufficient copies of the questionnaire or survey to complete with each interviewee, and sufficient copies of the informed consent form for interviewees to complete.
- Briefings and debriefings – At the beginning of each day of data collection, the social assessment team should meet with the CLO and any other community members accompanying them to discuss the plan for the day and any concerns, particularly with regards to safety. Similarly, at the end of each day, a debriefing should be held to discuss progress, and any new information that has arisen that may impact data collection in the future.

Final social assessment study carried out after prototype has been decommissioned

11.8 Reporting Social Assessment Results

After data collection is completed, the social assessment team will analyse the data to identify the main themes in people's responses. It is useful to present the outcomes to the household, school or community in order to validate that their views have been accurately represented. This can take place via a meeting or presentation and discussion. After this validation has been carried out, the results of the work can be written up into a formal report on the social assessment and presented to the technology developer and commercial partner so that user feedback can be incorporated into the design of the prototype as necessary.

Report of social assessment studies validated by household, school or community and shared with commercial partner, technology developer and SASTEP

Chapter 11: Social Aspects of Testing – In Brief

- *The aims of social assessment include understanding the context of a sanitation demonstration, evaluating community perceptions of new sanitation technologies, and including user feedback in design processes*
- *The social assessment team should work closely with the community engagement team*
- *Social assessments should be carried out before a prototype is installed to collect baseline data, at the end of the demonstration, and if the demonstration period is longer than six months, in the middle of the demonstration*
- *The method selected for social assessment will depend on the aim of the demonstration, the number of users and the type of demonstration site and can include surveys, interviews and focus group discussions*
- *Ethical clearance must be obtained for the social assessment and all participants must give informed consent*
- *A cross-section of the community must be included in the social assessment, including people of different genders, age brackets and incomes*
- *Safety of the social assessment team must be a priority and this can be achieved by working closely with community members*
- *Collected data should be reported back to the participants of the social assessment for validation before it is reported to technology developers and commercial partners*

Chapter 11: Social Aspects of Testing – Further Reading

For an overview of the importance of community engagement and social assessment in non-sewered sanitation research and development, see:

- *Raising People's Voices video: https://www.youtube.com/watch?v=BfHrMsmRcjc&t=6s*

For more on ethical research, see:

- *National Health Research Ethics Council: http://nhrec.health.gov.za*
- *Human Sciences Research Council, Research Ethics Committee: http://www.hsrc.ac.za/en/about/research-ethics*
- *POPI Act: https://www.gov.za/documents/protection-personal-information-act*

For more on gender intentionality, see:

- *Gates Foundation Gender Equality Toolbox: https://www.gatesgenderequalitytoolbox.org/*

Chapter 12: Decommissioning and Site Rehabilitation

At the end of testing, the prototype must be decommissioned and the site made good. This chapter will cover the technical process of decommissioning, the rehabilitation of the site, disposal or reuse of the unit or components, and the community close-out meeting.

Prototype engineer, laboratory team, social assessment team, community engagement team, technology developer, municipal management, municipal community liaison, engineering contractors

1 to 2 months

Chapter 9: Setting Performance Acceptance Criteria; Chapter 10: Technical Aspects of Testing; Chapter 11: Social Aspects of Testing;

12.1 Prototype Decommissioning

12.1.1 Decision to Decommission

There are several reasons why a prototype may be decommissioned, which will be determined by the success/failure criteria. These include:

- End of planned testing period and completion of testing
- Prototype not well suited to operation in selected environment
- Prototype failing to achieve required aims and no clear plan to address this
- Testing results show success and will move onto the next phase of product development

The decision to decommission should include the commercial partner and technology developer, the prototype engineer, a municipal management representative, and a representative of any demonstration platform which is supporting the field-testing and demonstration. The discussion and decision should be recorded. The results of the testing phase should be made clear to all stakeholders and the following options may be considered:

- Decommission prototype and remove from site
- Remove from site and test elsewhere
- Continue to operate prototype under control of commercial partner, as ongoing operation rather than testing
- Continue to operate prototype under control of municipality or Department of Basic Education, as ongoing operation rather than testing

The outcome of the decommissioning decision will allow further decisions about the decommissioning and site rehabilitation process to be made.

Decision to decommission agreed and communicated to all stakeholders

Reasons for Decommissioning

During the EFTP, testing of some prototype components were carried out in phases. The first phase of the testing for each component was to test at University of KwaZulu-Natal for functionality and reliability. The second phase of testing was to test at rural households for user acceptability. In the first phase of testing, the prototype engineer could easily make changes to the component under test to find optimal operating conditions and identify design improvements. The front-end of one system was tested in the laboratory and continued to testing in households. It was tested in multiple households and was decommissioned after it reached the end of the planned testing period. The separation unit was tested in the laboratory and did not achieve the required separation of solids and liquids, despite numerous attempts to adjust and improve its performance. It was decommissioned because there were no clear plans to address these failures and it needed to be redesigned before testing could proceed.

12.1.2 Tests Carried Out During Decommissioning

There are some tests that should be carried out after the testing phase has been completed, during the decommissioning stage.

Sludge layer measurements should be taken in any tanks where sludge accumulation is likely to occur before emptying and dismantling the system. If sludge blanket sensors are not part of the prototype, this can be done using the wine thief method or the light and ruler method for small tanks (depending on the material of the tank) or using a water core sampler (such as the Hach Sludge Judge) or portable sludge blanket sensor for larger tanks. The methods for sludge layer measurements in small tanks (as developed by Dr. Brian Hawkins of Duke Center for WaSH-AID) are shown in Appendix 4.4.

If the system includes an electro-chemical cell for the generation of chlorine, a chlorine evolution rate (CER) test should be carried out at the end of the testing phase so that performance can be compared to the CER at the start of the testing phase. This allows the required frequency of electrode cleaning to be calculated. The method for the CER test is shown in Appendix 4.1.

Relevant tests carried out during decommissioning

12.1.3 Disassembly of Prototype

In some cases, the prototype may be disassembled on-site rather than removing it from the site as a single unit. This will depend on the future of the prototype (refer to Section 12.4). Before disassembly begins, a disassembly plan should be drawn up showing the order of activities, the expected duration, and required resources, including personnel and equipment required. During disassembly, a log should be kept of how many person-hours are spent on the disassembly process. If changes are made to the disassembly plan because tasks take longer or require additional people or equipment, this should be recorded so future testing timelines can be adapted accordingly.

Decommissioning Process for a Prototype with Settlement and Electro-chlorination

On the EFTP, the decommissioning of a back-end process that included settlement tanks and electro-chlorination for the treatment of flush water included the following activities:

- *CER tests – These were carried out at the start and end of the testing phase to evaluate the change in performance of the electro-chlorination reactor plates over time*
- *Sludge layer measurements in the settlement tanks – These measurements showed the amount of sludge that had been deposited in the tanks during operation, which helps to understand settling efficiency and determine an appropriate maintenance schedule for emptying tanks*
- *Disassembly of equipment on-site – Equipment was disassembled on-site to make it easier to remove without the need for a rigger*
- *Organisation of equipment for shipping, scrapping and salvaging – Some high-value components were shipped back to the technology developer at the end of testing in eThekwini, while others needed to be cleaned before they could be scrapped or salvaged for use by the demonstration platform to support testing of other prototypes*

12.2 Site Rehabilitation

It is not considered acceptable to leave a prototype at the demonstration site after field-testing and demonstration is complete unless there is a contract in place to roll out the system in the area without changes. Leaving such 'legacy' systems in place is a burden on the community or local municipality who have to operate and maintain the prototype if it is to remain functional. Often, municipalities do not have the internal processes or staff to maintain one-off prototypes and so there is a high chance that the prototype will be neglected. This leaves communities without access to services, and reflects poorly on the technology developer, the commercial partner, and the demonstration platform.

Site rehabilitation aims to restore the site to the same quality, or better, than it was before field-testing and demonstration. This includes removing the prototype and making the site safe. Excavations should be filled in, water or electrical connections must be disconnected and left safe, and the whole area should be left tidy.

Only after the prototype has been removed from site and the site rehabilitated should the final social assessment be carried out.

If possible, the site should be left in a better state than it was found. Through consultation with the community, it is possible to identify small changes to the site that improve the area for community members as a gesture of appreciation for their involvement in the testing of the prototype. Such changes could be:

- Emptying existing pit latrines or urine diversion toilet (UDT) vaults
- Improving existing toilet blocks by fixing or replacing damaged parts or painting
- Installing washing lines or a structure that can be used by the community on hard standing or ground that was levelled for the installation of the prototype
- Installing play park or outdoor gym equipment in the community

In all cases, it is important that before the community decides on an appropriate gesture of appreciation, they understand that the upgrade is a one-off and that they will be responsible for the maintenance of any installation in the future.

Prototype removed from site and site left in as good or better state than before testing and demonstration

Play Parks and Other Appreciation Gestures

When testing takes place in an informal settlement, appreciation or compensation must take into account the whole of the community. In two settlements where the EFTP was testing sanitation prototypes, the community requested a safe area that children could play. A suitable area to install a play park was decided with the community leadership and it was made clear that the upkeep of the play park would be the responsibility of the community.

At household sites that participated in the EFTP, appreciation gestures on this scale were not possible or proportional. Instead, upgrades to the existing toilet are more suitable. These upgrades included emptying pit latrine or UDT vaults, painting toilet structures or replacing damaged doors or toilet components.

12.3 Community Close-Out Meeting

A community meeting should be held after decommissioning and site rehabilitation to give final feedback to the community and thank them for their role in the project. This meeting should cover:

- Providing a summary of the results from the field-testing and demonstration
- Outlining the next steps for the commercialisation of the sanitation technology
- Thanking the community for their involvement in the field-testing and demonstration
- Highlighting any improvements made to the site as a gesture of appreciation
- Giving the community the opportunity to ask any questions they may have about the field-testing and demonstration or the improvements made on site

A post-demonstration social assessment should be scheduled for the household, community, or school by the social acceptance team as described in Chapter 11: Social Aspects of Testing.

Community close-out meeting held to give feedback to community

12.4 Disposal or Reuse of Unit and Components

After decommissioning the prototype, all components must be disposed of or reused as appropriate. It can be useful to consider three disposal or reuse routes, as defined below:

- Ship – Components that the technology developer has requested be returned to them or shipped to another site
- Scrap – Components that must be destroyed because of intellectual property (IP) issues or will be scrapped because they are not wanted by either the technology developer or the commercial partner
- Salvage – Components that will be cleaned and reused by the demonstration platform with permission of the technology developer or the commercial partner

If items are to be reused, it should be assumed that they are contaminated with faecal material and possibly chemicals and therefore must be washed and sterilised before they are transported or reused. This can be done by soaking parts in a weak bleach solution. If parts are sensitive, they should be rinsed with clean water and sprayed with ethanol.

Chapter 12: Decommissioning and Site Rehabilitation – In Brief

- *Decision to decommission must be made by all relevant stakeholders*
- *The site must be returned to its original, or preferably better, state*
- *Reasons for decommissioning are linked to the success/failure criteria*
- *Planning for decommissioning is essential to ensure a smooth process*
- *Decisions must be made regarding which equipment to ship, reuse or scrap*
- *It is important to identify an appropriate gesture of appreciation to thank the community, household or school for hosting the demonstration site*

Chapter 13: Specific Guidance for Laboratories

The purpose of this chapter is to provide guidance for new or established laboratories who wish to support SASTEP by conducting analyses on faecal sludge and other samples associated with sanitation technologies. It gives guidance on how faecal sludge laboratories need to be set up (either as new laboratories or retrofitted into existing spaces) for ease of workflow, the test methods for faecal sludge, and laboratory certification and accreditation processes.

Laboratory team

3 years from setting up to accreditation

Chapter 10: Technical Aspects of Testing

13.1 Setting Up a Laboratory for Faecal Sludge Analysis

Setting up a faecal sludge laboratory begins with a business plan highlighting the background and need for establishing a laboratory. The organisation description and goals are important in determining the laboratory outcomes in terms of it being a research or commercial facility.

The options for setting up a laboratory depend on the available space and budget, and the objectives of the research or commercial laboratory. For a faecal sludge laboratory, health and safety must be prioritised due to the biological hazards associated with handling faecal samples. To create a safe environment for faecal sludge analysis, a strategic workflow, laboratory layout, health and safety procedures, and appropriate management systems must be considered. The hierarchy of controls (Figure 10.1) should be considered when developing safe working practices. As much as possible, direct exposure to faecal sludge should be minimised during handling and analysis.

13.1.1 Laboratory Layout

A well-planned laboratory layout leads to an efficient workflow of samples through the laboratory. Segregated areas for sample receipt, preparation, analysis, and reporting should be considered during the design and set-up. The layout, like any other laboratory, should consider utility connections (water, gas, electricity) and emergency safety protocols. A sophisticated drainage and extraction system is imperative for the safe handling and disposal of biohazardous samples.

13.1.2 Equipment

The choice of methods for faecal sludge testing will depend on:

- Available budget
- Available time

- Experience of staff
- Accuracy of results required
- Whether qualitative or quantitative results are required
- Whether testing needs to take place on-site or in the laboratory
- Sample matrix

Faecal sludge tests include chemical, physicochemical and bacterial parameters with the test strips and colorimeters being the cheapest options, inductively coupled plasma – mass spectroscopy (ICP-MS) the most sophisticated and expensive option and spectrophotometers sitting somewhere between these two extremes. Table 13.1 provides an overview of which methods can be used for the basic faecal sludge analyses.

Table 13.1 – Overview of applicable faecal sludge analyses equipment

Equipment	**Test Strips**	**Handheld Meters**	**Colorimeters**	**Spectrophotometer**	**ICP-MS**	**Filtration**	**Colilert**	**Oven/Furnace**
Test parameter								
pH	X	X	X					
Conductivity		X						
Chlorine	X	X	X	X				
Turbidity		X		X				
Colour			X					
Metals				X	X			
Ions			X	X				
E. coli						X	X	
Total and volatile solids								X
Total suspended solids		X				X		

13.1.3 Health and Safety

Setting up a faecal sludge laboratory requires special attention to certain aspects because of the biological hazards associated with the samples handled. When working with faecal sludge, a carrier of numerous human pathogens, health and safety is of the highest priority. Training on health and safety protocols, and awareness of risk assessments that highlight all hazardous elements for any tasks and their possible control and elimination are of great importance. PPE plays an important role as a barrier against pathogens and harsh chemicals. General aspects of health and safety, including the use of PPE are described in Section 10.7.

13.1.4 Training

Through training and workshop sessions, staff can be equipped to handle hazardous biological agents and to develop basic laboratory and health and safety skills.

Setting up Faecal Sludge Laboratories in Other Countries

The PRG has provided advice and support to many affiliated laboratories. The focus was on establishing laboratory management systems, health and safety protocols and standard operating procedures in these laboratories. Some required planning and designing of laboratories while others required modifications of existing work spaces. Support was also provided through training on sample preparation, testing and reporting of data. Laboratory set-up, designs and training have been provided in the following countries: India (New Delhi and Bangalore), Thailand, Kenya, Tanzania, Malawi (Lilongwe and Blantyre) and Netherlands.

13.2 Laboratory Systems

Management of samples from collection and analysis, to data capturing and sample disposal is the key to providing reliable and accurate data. This allows for efficient workflows and accurate control of the analysis process. A process flow of the laboratory system used in the PRG laboratories is given in Figure 13.1.

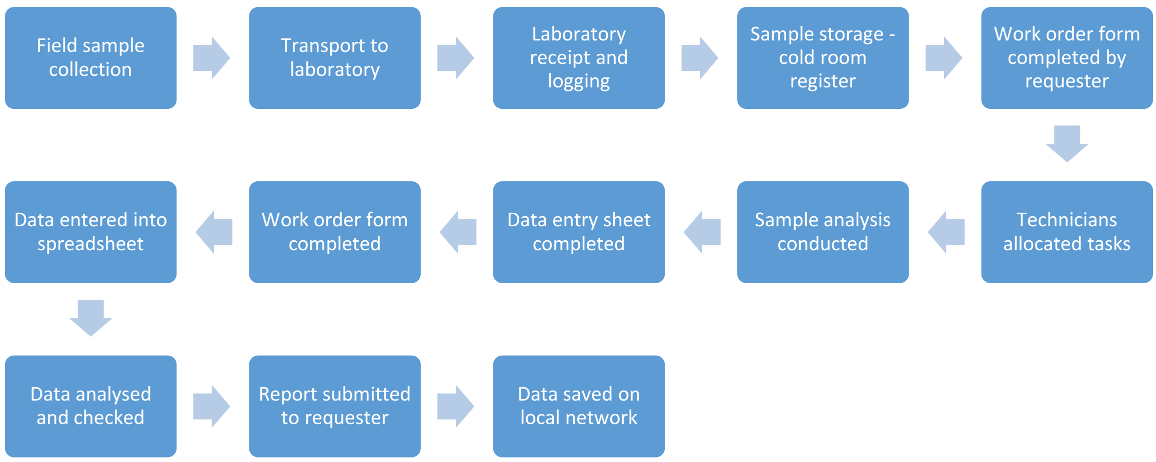


Figure 13.1 – Laboratory process flow for sample collection and analysis in the PRG laboratories

13.2.1 Work Order Form

A work order form provides information on the job tracking number, requestor's details, sample details, tests required, method reference, testing volume, and cost per sample. Replicates are required to check the accuracy of the results. A high standard deviation is often experienced with faecal sludge samples due to the presence of contaminants in the sample. It is recommended that faecal sludge samples be tested in triplicates or more to improve the measurement of variation. A work order form template is provided in Appendix 2.21.

13.2.2 Data Sharing for Better Results

In order to understand the data generated from analysis of samples collected from a prototype, it is valuable for the laboratory to have access to:

- Schematic of the prototype to understand the process flow
- Detailed pictures of the sampling points to ensure samples are representative
- Information about the maintenance of the prototype which provides information on process deviations and changes to sample characteristics over time
- Description of samples which provides information on sample content to help identify correct analysis protocols
- List of analyses per sampling point for costing and laboratory management

In addition, the laboratory should record the method and instruments used for sample analysis, for data traceability and quality assurance. A reporting format that enables further data analysis should be agreed upon between the laboratory and the client in advance. A standard template for laboratory reporting of data from faecal sludge analysis is given in Appendix 2.22. This is only a guide and can be modified as required.

13.2.3 Data Analysis and Reporting

Proper data management is key to effective data sharing. An organised sequence of steps is required to minimise laboratory analysis and data capturing errors. The most common errors arise from the lack of sample observation logging and from manual data entry. The following steps give some guidance for data checking:

- Correct sample receiving procedure
- Correct sample preparation and testing method
- Correct capturing of testing results into software
- Correct formulas and calculations
- Checking for outliers
- Correct fractions for parameters
- Correct plotting of graphs and correlation

The data reported should be in a format that is detailed but simple enough to interpret and reuse. The following should be considered:

- How can information be standardised across reports?
- What file format will be accessible for clients?
- Where will the data be stored?
- Who owns the data and who has access to the data?

13.3 Quality Assurance

The laboratory should take all steps to ensure that the data produced is valid and reliable by proving that the staff are competent at carrying out the analyses, ensuring that the correct SOPs and methods are followed, equipment is serviced, calibrated and in good working order, and that correct documenting and reporting protocols are followed. The following points can be used as a checklist for developing a quality assurance system:

- Is the technician trained in the analysis?
- Did the technician pass the competency test?
- Was there any cross-contamination during analysis?
- Was the equipment serviced?
- Was the equipment calibrated?
- Were the consumables checked for reliability?
- Were the samples stored correctly?
- Were the samples labelled correctly?
- Were the samples logged correctly?
- Were the correct methods followed?
- Did samples of known concentration give accurate results?
- Was there internal agreement between results from different technicians?
- Is there testing traceability?
- Is there data storage traceability?

13.4 Faecal Sludge Analysis Methods

The lack of standardised methods pertaining to the sampling, collection, and analysis of faecal sludge means that characterisation is often variable. Accurate faecal sludge characterisation is important in the design of appropriate treatment technologies. A consolidation of standardised methods for faecal sludge collection and analysis, based on lessons learnt in South Africa and from other global partners is available in Velkushanova et al. (2020).

13.5 Certification

Certification and accreditation for a faecal sludge laboratory is advantageous, though it may not be compulsory, depending on the business plan for the laboratory. It is a means to determine the technical competence of laboratories to perform specific roles. It is important to note that laboratories can be accredited for specific analyses, ranges and uncertainties, so it is worth investigating which analyses within the laboratory are applicable for accreditation, rather than attempting to obtain accreditation for the entire laboratory.

Establishing a quality assurance programme to ensure that all laboratory analyses are performed according to the Good Lab Practice (GLP) principles and the Occupational Health and Safety Act (OSH Act) is recommended. For quality management, ISO 9001 certification is appropriate. Depending on timelines, budget, and level of customer satisfaction, a laboratory can become accredited for ISO 9001:2015 and thereafter ISO 9001:17025.

Although both ISO 9001:2015 and ISO 17025:2017 are quality management systems applicable to any industry, their scope is different. ISO 17025 is only for calibration and testing laboratories whereas ISO 9001 can be applied to any organisation.

In South Africa, the accreditation body is the South African Bureau of Standards (SABS) and South African National Accreditation System (SANAS).

Faecal sludge samples have a high potential to contain pathogens, which pose a health risk to handlers and the environment. As such, the OSH Act classifies faecal sludge laboratories as Biosafety Level 2 laboratories. Following the Biosafety Level 2 protocols enforces the safety rules and provides security and confidence for a safe working environment. For Biosafety level 2 accreditation, The South African Department of Agriculture, Forestry, and Fisheries assesses laboratories based on the Occupational Health and Safety Act 85 of 1993 and The National Health Act, 2003 (Act No 61 of 2003).

Chapter 13: Specific Guidance for Laboratories – In Brief

- *Developing a laboratory system will assist in streamlining the laboratory process*
- *Obtaining detailed information on the prototype being sampled and the sampling points will assist in interpreting the data*
- *Developing templates for work orders, recording of data and reporting will ensure all information is recorded accurately and consistently*
- *Quality assurance is important to ensure high quality of analysis and data*
- *Certification is not essential for a faecal sludge laboratory, but laboratory testing should be performed according to the Good Lab Practice (GLP) principles and the Occupational Health and Safety Act (OSH Act)*

Chapter 13: Specific Guidance for Laboratories – Further Reading

For more on setting up faecal sludge laboratories, see:

- *Zikalala. T., and Reddy, M., (2018). Setting up and operating faecal sludge laboratories: three case studies from developing countries: https://repository.lboro.ac.uk/articles/Setting_up_and_operating_faecal_sludge_laboratories_three_case_studies_from_developing_countries/9593030*

For more on laboratory analysis methods, see:

- *Velkushanova, K., Strande, L., Ronteltap. M., Koottatep, T., Brdjanovic, D., and Buckley, C. Editors (2020). Methods for Faecal Sludge Analysis: https://www.iwapublishing.com/books/9781780409115/methods-faecal-sludge-analysis*

For health and safety legislation in South Africa, see:

- *Full text of Occupational Health and Safety Act: https://www.gov.za/documents/occupational-health-and-safety-act*
- *Full text of National Health Act: https://www.gov.za/documents/national-health-act*

For more on health and safety when working with faecal sludge, see:

- *Safer Sanitation for All video: https://www.youtube.com/watch?v=XwCD4TUsacU&t=94s*
- *Zikalala. T., and Reddy, M., (2018). Health and safety: handling faecal sludge in the Pollution Research Group's laboratory facilities: https://repository.lboro.ac.uk/articles/Health_and_safety_handling_faecal_sludge_in_the_Pollution_Research_Group_s_laboratory_facilities/9592613/1*

For guidance on good laboratory practice and standards for laboratory certification, see:

- *Good Lab Practice Handbook: https://www.oecd.org/chemicalsafety/testing/overview-of-good-laboratory-practice.htm*
- *ISO 17025:2017: https://www.iso.org/standard/66912.html*
- *ISO 9001:2015: https://www.iso.org/standard/62085.html*

Chapter 14: Specific Guidance for Regulators or Municipalities

Cities globally continue to experience growing challenges related to water and sanitation. Over the years, municipalities have grappled with the rising demand for basic service delivery that often outstrips adequate supply. Innovative and emerging non-sewered sanitation technologies have become potential sanitation solutions that most cities are willing to explore and invest in.

This chapter provides guidelines for municipal or regulatory partners on how to effectively and efficiently support the field-testing and demonstration of innovative sanitation technologies under SASTEP and the benefit to their involvement.

Municipal management, municipal community liaison

Chapter 2: What You Need to Know Before You Start; Chapter 6: Community Engagement; Chapter 9: Setting Performance Acceptance Criteria

14.1 The Value of Involvement in SASTEP

Municipal or regulatory institutions hold significant influence over the success or failure of sanitation technology demonstrations. The active participation of municipal/regulatory partners brings valuable benefits, not only to the sanitation technology demonstration, but also to the municipality, in the form of:

- Elimination of the risks associated with giving judgment and/or accreditation to technologies that have not yet undergone field-testing and demonstration
- Early adoption of innovative sanitation technologies with high levels of user acceptance
- Development of local sanitation service providers who can bid for work within the procurement terms and standards of the municipality
- Creation of jobs, capacity-building and learning opportunities for skills enhancement relating to sanitation for both municipal officials and community residents
- Exploration of innovative service or business models
- Development of new standards that support innovative non-sewered sanitation technologies
- Greater understanding of the sanitation value chain and how it contributes to a broader circular economy
- Strengthening of transdisciplinary research collaborations which allow the co-generation of knowledge beneficial to the municipality with experts from academia, the private sector, and communities

Benefits of the EFTP to EWS

By being a partner in the EFTP, EWS realised the following benefits:

- *Exposure to innovative sanitation technologies in their early stages of development*
- *Increased knowledge of operations and maintenance staff through exposure to innovative sanitation technologies*
- *Detailed insight into user perceptions around sanitation*
- *Collaboration with wide range of stakeholders to gain a broader perspective of sanitation*

14.2 Key Roles to be Undertaken to Support SASTEP

The municipal or regulatory partner has an overarching responsibility to ensure that communities involved in field-testing and demonstration of sanitation technologies are treated fairly and protected from unjust practices and as such, they must be in a position to support any process that requires effective community engagement and participation. This makes them the first point of contact for field-testing and demonstration. There are several distinct roles that municipalities and regulators should consider to efficiently support the field-testing and demonstration of sanitation technologies. The roles include but are not limited to:

- Facilitate access to suitable sites for field-testing and demonstration.
- Lead and coordinate the introduction of the project team to communities and vice versa – The municipality has well-established relations and understanding of the socio-cultural, political, economic, and environmental dynamics of different local communities within their jurisdiction.
- Act as a mediator between stakeholders during the field-testing and demonstration – The municipality's role is to protect local communities from exploitation. It is also to ensure that communities are integrated and represented in the planning and design phases of the demonstration project in a fair manner. Important stakeholders include the demonstration project team, local governance, and communities.
- Act as a 'watch-dog' for the duration of the field-testing and demonstration – The municipality provides clear direction and guidance for what can and cannot be done when demonstrating technologies at community sites. For example, they may determine locally relevant limits for water quality before it can be recycled or discharged to the environment, or they may stipulate certain characteristics of the front-end of the system, to ensure that facilities are accessible to all residents. Again, the main requirement of this guidance is to protect residents.
- Facilitate education and awareness programmes within local communities – This will allow people to understand the importance of saving water and taking good care of the sanitation facilities that have been provided and are being demonstrated in their communities. Some members of the community might have not have been previously exposed to these types of facilities and therefore may need guidance on how to use and care for them.

- Foster relations between service providers and those who they serve – This allows communities to better understand why a differentiated approach to sanitation service delivery is necessary.
- Foster an enabling environment for innovative non-sewered sanitation technologies to be demonstrated – One way to do this is to ensure that tenders allow for innovative solutions so that proven innovative sanitation technologies can be rolled out at scale (see Section 14.6).

Selection of Communities for Sanitation Prototype Testing on the EFTP

For the EFTP, selection of a community or household for the demonstration of a prototype was more than just finding a location that meets the spatial or infrastructure specifications. It also depends very much on the political environment and securing approval from ward councillors and committees, traditional leadership, and community leadership structures. EWS plays a critical role in interfacing between the various levels of both political and community leadership and the EFTP in order to identify and facilitate access to suitable sites for field-testing and demonstration.

14.3 Providing Practical Support for Field-testing and Demonstration

Practical assistance from the municipality or regulator in the form of institutional, technical or community engagement support can enable efficient field-testing and demonstration. The type and level of support will vary between municipalities based on their different contexts and capacity. The following sections give guidance on the types of support that may be valuable to field-testing and demonstration projects.

14.3.1 Community Engagement Support

Community engagement is a crucial element of demonstrating sanitation technologies at household, school, or community sites (see Chapter 6: Community Engagement). It is important that the municipality is involved in the community engagement for field-testing and demonstration, as any work related to sanitation will reflect to some degree on them as the service provider. Furthermore, the municipality often has a good understanding of the context and socio-political dynamics of communities within their jurisdiction. Thus, the municipality can play a beneficial role in supporting field-testing and demonstration through community engagement support. Some options for providing this support are given below:

- Recognise the role of communities in co-production of knowledge – Avoid prescribing solutions that are thought to be best for communities without proper engagement and understanding of their needs. Regulators need to ensure that field-testing and demonstration follows the maxim “nothing for the community without the community”, and that the community need to be part of the process throughout the project.
- Engage with communities to assess the situation prior to selecting a field-testing and demonstration site – Context, language, and existing cultural and traditional practices must all be understood before determining if a site is suitable.

- Be cautious about when the project is introduced to a community or a prototype commissioned – Starting projects in parallel with elections might be viewed as a way to garner support for a particular political party.
- Be open about the objectives of the demonstration – This avoids creating unrealistic expectations about the outcomes of the project. Participants at the demonstration sites should understand the benefits and limitations of the project.
- Encourage the creation of low-skill employment opportunities for local communities related to the demonstration project – These roles can include caretakers, CLOs, or manual labourers for construction work. This provides short-term employment and training for community residents.
- Ensure that updates about the project are provided to participants regularly and that there is an opportunity for feedback – There should be a constant flow of information and feedback about the project scope and objectives, including its benefits and opportunities for the local communities, with ample opportunity for them to raise questions, concerns, and have their views taken into account.
- Engage with all sectors of a community – User feedback needs to take into account a cross-section of users, including women, children, elders, and the disabled, from an early stage in the demonstration.
- Work in conjunction with project stakeholders who are engaging with communities to ensure that messages are consistent.
- Provide relevant information about field-testing and demonstration that can be shared publicly and used in public relations material – Providing relevant material for media minimises the risk that they will approach community members directly for information, which is an infringement on community life and can result in the sharing of inaccurate information. Be considerate of any IP issues relating to the sanitation technologies.

14.3.2 Technical Support

Some of the sanitation technologies that will be demonstrated will require connection to existing municipal assets such as water, electricity or sewerage networks, or to existing sanitation and ablution facilities provided by the municipality. Therefore, there is a need for technical staff who are in a position to maintain general municipal assets at demonstration sites. Funding for this should be considered, along with adopting relevant key performance indicators for these staff so that they are able to meet these requirements alongside the day-to-day commitments of their role. It should be made clear prior to installation and commissioning who is responsible for different areas of the site and their up-keep and maintenance. Technical support from the municipality is highly dependent on the type of prototype and how it fits within the municipality’s existing technical framework, including relevant municipal sanitation standards, bylaws, and policies.

There needs to be a clear agreement of whether the prototype will be donated to the municipality or shipped back to its developer after the field-testing and demonstration is completed. If the prototype is donated, all relevant documents (e.g. drawings, manuals, SOPs) must be provided in English so that technical staff have the documentation required to operate and maintain the system. It is beneficial for staff to receive training on the system from the technology developer before the system is handed over to the municipality or regulator.

14.3.3 Institutional Support

At an institutional level, there are many ways that the municipality or regulator can support field-testing and demonstration. These approaches are often more complex than providing direct community engagement or technical support to the project but can provide far-reaching benefits to the provision of sanitation services in the longer-term. These include:

- Identify one or more staff members to provide strategic input to the field-testing and demonstration – These should be high-level staff who can attend strategic meetings and make decisions to ensure that the outcomes of the demonstration are of value to the municipality.
- Identify a 'champion' who can drive the political will to support emerging and innovative technologies – Lack of support and acceptance by municipal leadership will stifle the progress of technologies that have the potential to provide sustainable sanitation solutions at scale.
- Be willing to take risks – Accept and embrace the possibility of failure at some stages of field-testing and demonstration. Understand that it is a progressive process and that some systems will show more positive results sooner than others will.
- Encourage internal collaborations between municipal units – Provide intra-structural support and involve relevant municipal units (e.g. Human Settlements, Research and Policy Advocacy, Engineering, Development Planning, Environment, and Management) that stand to benefit from field-testing and demonstration and to reduce 'silo thinking' within the municipality. This in turn helps to build social and technical competencies in the municipality.
- Be willing to form partnerships with other local and international stakeholders – These could include academic institutions, NGOs, and the private sector. This can foster transdisciplinary collaborations between key stakeholders and service providers.
- Be open to innovative and emerging development trends that have the potential to offer service provision solutions that can be applied at large-scale.
- Understand and support all aspects of the sanitation value chain (Section 2.1).

Research Collaboration Between EWS and PRG

EWS and the PRG have a long-standing research relationship in order to provide scientific support to water and sanitation services in eThekwini Municipality. This started in 2000 when the municipal boundaries were extended and over a million people without access to safe sanitation were incorporated into the municipal area. It would have been prohibitively expensive to provide sewered sanitation for all of these residents and EWS realised that an alternative approach was required to serve these new customers. PRG were asked to provide applied research support to the municipality to identify innovative solutions that could provide affordable safe sanitation. PRG benefits from the partnership through access to communities, wastewater treatment facilities and effluents, and EWS benefits from having the skills and capacity to carry out research on the challenges they face in sanitation service delivery. In addition, the collaboration allows municipal staff to engage in research relevant to their work as part of their continued education and professional development.

14.4 Time and Resources Required to Support Field-Testing and Demonstration

It is important to identify and define the time and resources that the technology will require once it is commissioned on-site from the point of view of the municipality or regulator.

14.4.1 Time Allocation

It is difficult to estimate the amount of time required prior to field testing a system as it is highly dependent on the type of technology and resources the technology requires to function efficiently. The municipality should:

- Attend regular strategic meetings and workshops for the field-testing and demonstration programme.
- Provide support in the vetting of any imported technologies – This is to check that all components are compliant with municipal and national standards, policies, and bylaws.
- Provide support and advice on site layout and construction during the site preparation phase.
- Address any major technical issues on-site that fall under municipal responsibility – Examples include fixing leaking pipes or toilets in a CAB, attending to water supply issues, resolving sewer blockages, etc. Clear boundaries of responsibilities must be agreed upon before the prototype is installed on-site.
- Provide advice to prototype engineers when experiencing complex technical issues if they are likely to have an impact on municipal assets.

EWS Support for the EFTP

The EFTP would not have been possible without the support of EWS. Essential support offered by EWS included:

- *Continuous community engagement at all levels*
- *Site identification and selection*
- *Providing insight into the political environment of wards where potential sites were identified*
- *Running awareness programmes and street theatre performances using existing education teams*
- *Employment of caretakers where a toilet block was installed as part of a prototype*
- *Training of caretakers when there were specific cleaning instructions*
- *Maintenance support for municipal infrastructure connected to the prototypes (e.g. fixing toilet leaks in CABs, clearing blockages etc.)*
- *Communicating with other municipal departments as required (e.g. electricity department)*
- *Providing seed sludge and water tankers at no cost*
- *Providing free storage or testing space at three municipal sites*

14.4.2 Resource Allocation

The people required to support field-testing and demonstration will depend on the context and the prototype. Some roles are essential whilst others are an advantage, but not vital as shown in Table 14.1.

Table 14.1 – Role of municipal actors in SASTEP

	Representative	Role
Essential	Project champion	Leads the project from within the municipality and provides authorisation for the project
	Community liaison	Engagement with councillors, traditional leaders and communities/households
	Maintenance engineer	Maintenance of municipal infrastructure linked to the prototype
Nice to have	Caretaker	Cleans communal toilet facilities linked to a prototype
	Civil engineer	Advises on integration of the prototype within a municipal or public site
	Electrical engineer	Advises on the electrical function of the prototype if necessary
	Electronic engineer	Advises on integration of the prototype into existing SCADA systems if adopted

The provision of non-human resources for field-testing and demonstration should also be taken into account during planning. These resources may include:

- General equipment such as tools required for maintenance of municipal infrastructure linked to the prototype
- Sanitation consumables such as toilet paper and cleaning products for communal toilet facilities linked to a prototype

It is worth noting that within municipalities, no budget is set aside to fix damages or faults, or to carry out routine maintenance of any technology that is not listed as a municipal asset. Therefore, it is the responsibility of the demonstration project team to ensure that these needs are covered in their budget.

14.5 Key Ways to Communicate with the Project Stakeholders

Good communication is an important factor for any field-testing and demonstration and different communication strategies will be required based on the needs of different stakeholders. Guidance on communication with some of the key stakeholders is given in this section.

14.5.1 Project Team

It is important that the project team hold regular meetings. The frequency of these meetings is dictated by the project timeline and may vary depending on the stage of the project. The aim of these meetings is to provide updates on progress and to highlight any issues that have been experienced. At least one representative from the municipality should be present at these meetings to address issues related to community needs, or any O&M issues related to municipal infrastructure. In addition, these meetings provide an opportunity for the municipality to obtain in-depth information on the operation and performance of the prototype which can inform the viability of the system as a long-term solution for sanitation service delivery.

14.5.2 Communities

Chapter 6: Community Engagement provides guidance on the role of the municipality in engaging with communities, households, or schools, and the community engagement process that needs to be followed. The municipality may also offer education and awareness programmes to communities in which demonstration is taking place, with a focus on issues such as the importance of saving water, taking good care of the sanitation facilities that have been provided by the municipality, or how to use sanitation facilities which are being demonstrated in their communities.

14.5.3 Wider Public

Field-testing and demonstration of innovative non-sewered sanitation systems is of great interest to the public and the media, particularly in light of the South African President's commitment to provide safe sanitation systems to schools under the Sanitation Appropriate for Education (SAFE) initiative. For this reason, the municipality must establish a clear and consistent approach to enquiries from the media and the wider public about the field-testing and demonstration of such systems. It is best to approach this with caution as over-exposure can be detrimental in a number of ways, including:

- Raising the expectations of the community or household hosting the demonstration site
- Exposing communities at the demonstration site to visits from the media without prior consent from the community, household or school, resulting in disruption and possibly mistrust of the project team
- Misinterpretation of the aims of the demonstration by the media, leading to misinformation being provided to the wider public
- Publication of information on prototypes installed in one community or household may lead to jealousy from other communities or households and queries as to why they were selected to host a demonstration site

Thus, a clear communication strategy needs to be developed by the municipality, which balances the need for accurate information to be shared with the media and the wider public against the risks stated above. Ideally, there should be a single point of contact for enquiries, so that messages are consistent. It is useful to prepare a media statement that can be issued should enquiries be made.

14.6 Providing an Enabling Environment for Rolling Out Innovative Sanitation Technologies at Scale

If a prototype performs well during field-testing and demonstration, municipalities may want to consider how the technology could be rolled out at scale to address sanitation service delivery within their jurisdiction. A vital part of successful implementation at scale is an effective procurement process. There are multiple aspects to this, which are outside the scope of these guidelines, including:

- The need for a common policy on procurement and tender criteria for innovative non-sewered sanitation systems between all institutions involved, including municipalities, Cooperative Governance and Traditional Affairs (COGTA), the Department of Water and Sanitation, and the Treasury.
- The need for updates to be made to guidance on sanitation in existing documents, such as the Guidelines for Human Settlement Planning and Design (the Red Book), so that these documents reflect the option of installing innovative non-sewered sanitation systems.
- Recognition that suppliers of non-sewered sanitation systems are all offering different products which are suitable for different contexts. Municipalities at times need the ability to select and procure a product from a specific supplier because that supplier is the sole supplier of a product suitable for their context. There needs to be a mechanism for this to happen, whilst at the same time clearly guarding against corruption.
- Potentially the unsolicited bid route should be considered for new sanitation technology products coming onto the market, which might not fit the specifications of tenders issued.

Tender documents inviting bids for the provision of non-sewered sanitation technologies for thousands of households must be written such that they achieve their purpose. This includes the following considerations:

- The tender pre-qualification criteria must ensure that the suppliers of innovative non-sewered sanitation systems are able to qualify to submit bids – It is recognised that the roll-out of new sanitation involves more than just the technology purchase, and that significant civils or building work may also be required. However, it is advisable that the technology suppliers submit the bids, as opposed to building contractors, as the sanitation technology is the core of the work and should be the basis for comparing bids. Pre-qualification criteria therefore need to be written differently to sanitation tenders of the past – for example, it does not make sense for a certain Construction Industry Development Board (CIDB) grading to be a pre-requisite for companies tendering for the work as this is meaningless for technology companies that supply non-sewered sanitation systems.
- The tender specifications must be written appropriately – The main focus must be on the functional requirements of the sanitation technology, as the core of the product being rolled out. The functional requirements need to be appropriate to the intended context for the roll-out of the systems. If several contexts are listed, several sets of functional requirement specifications will probably be required, and tenderers may only be able to bid for one specific context to which their product is appropriate. This option should be allowed for.
- It is important to give appropriate specifications for all parts of the system that will be supplied and installed, e.g. top structures, but previous tender documents have focused on these ‘standard’ items to the exclusion of the sanitation technology itself, in many cases because the tender was modelled on previous documents dealing with the procurement of pit-type toilets.

- The tender specifications need to reference specific performance standards for non-sewered sanitation systems (including items such as the ranges for influent parameters, product composition, water use, energy use, recycled water production efficiency, expected lifespan, etc.). They must require detailed performance test records (including laboratory analysis results) to be submitted as part of the bid to allow proper tender evaluation to take place. See Chapter 9: Setting Performance Acceptance Criteria for more on appropriate criteria.

Chapter 14: Specific Guidance for Municipalities or Regulators – In Brief

- *Municipalities and regulators can benefit from sanitation demonstration programmes which allow them to identify and adopt innovative sanitation technologies with high levels of user acceptance that are specific to their context*
- *The municipality has responsibility for protecting communities from unjust practices during field-testing and demonstration and should be involved in site selection and community engagement throughout the project*
- *Depending on the prototype and context, they may also wish to provide technical support (particularly where prototypes are linked to existing municipal assets) and institutional support*
- *The time and resources allocated to the project should include high-level staff who can attend strategic meetings to guide the project, technical staff who can address issues with municipal assets on-site such as sewer blockages, and community liaison staff who can support with community engagement*
- *It is important to determine a communication strategy to ensure that accurate messages about field-testing and demonstration are conveyed to the media and the wider public.*
- *Tender documents for the roll-out of non-sewered sanitation technologies should be fit for purpose and this requires significant changes to existing tender document templates.*

Chapter 14: Specific Guidance for Municipalities or Regulators – Further Reading

For an overview of how eThekwini Municipality works closely with the Pollution Research Group at University of KwaZulu-Natal to provide innovative solutions to service delivery challenges, see:

- *Good Science Makes Good Policy video: https://www.youtube.com/watch?v=ioZf8TFdARY&t=1s*
- *Sanitation for the Future video: https://www.youtube.com/watch?v=kkdQ7hr90q8*

For more on the SAFE initiative, see:

- *Sanitation Appropriate for Education Initiative: https://www.education.gov.za/SAFE.aspx*

DEVELOPMENT OF

THE SASTEP FIELD TESTING GUIDELINE

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SASTEP

South African Sanitation Technology Enterprise Programme

WATER RESEARCH COMMISSION