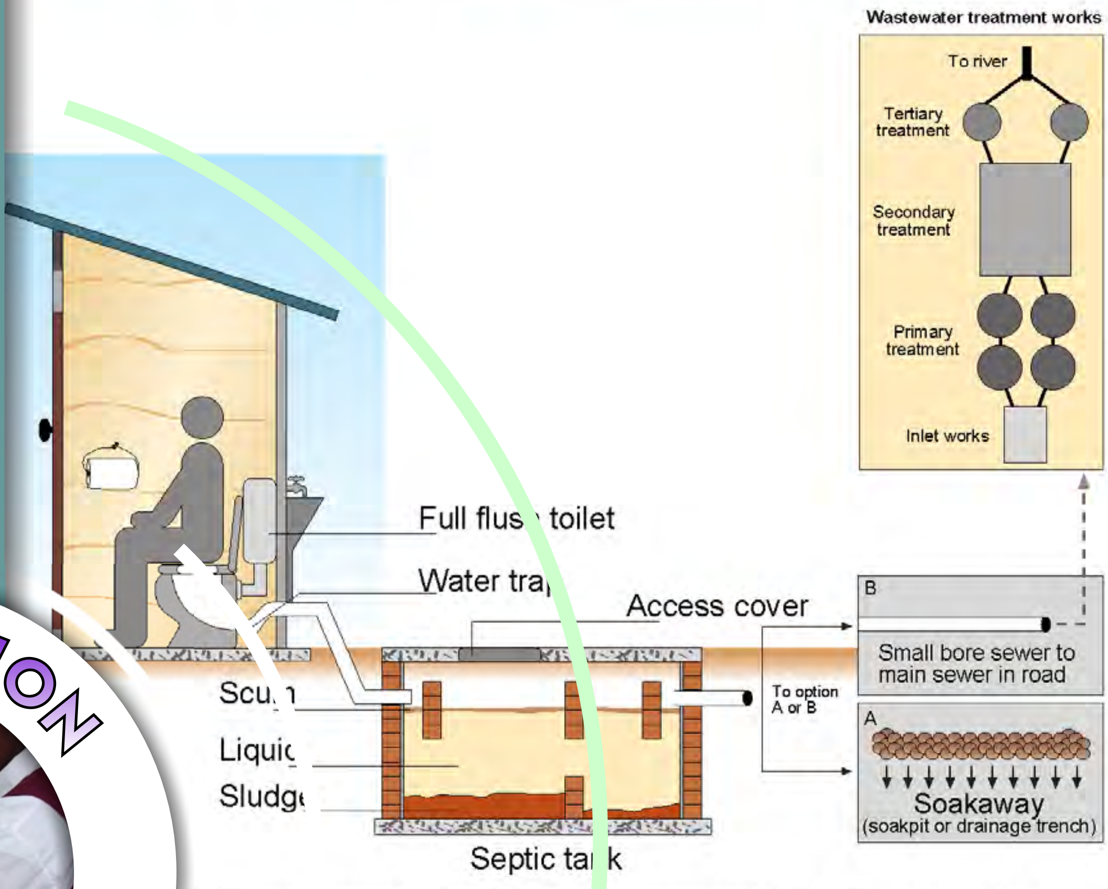
Septic tank and soakaway or small bore solid-free sewer



SANITATION TECHNOLOGY OPTIONS

water & forestry
Department:
Water Affairs and Forestry
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1. INTRODUCTION

The full range of technical options for providing adequate basic sanitation is still not widely known nor are the characteristics of the different options well understood. In particular, there is little appreciation of the long-term financial, environmental and institutional implications of operating and maintaining the various sanitation systems. As a result, in many cases communities and local governments are choosing technical options that, in the long term, are unaffordable and/or unsustainable.

Challenges arise from the wide range of options available and the differing environments and conditions to which each is suited. Experience shows that it is important to allow local involvement in the choice of solutions, but with a full grasp of the requirements of each option. The options include the ventilated improved pit toilet in all its variations, composting toilets, separation toilets, dehydration type toilets, on-site wet systems such as aquaprivies and septic tanks, and a range of full water borne systems.

The choice of technology is not only based on the technical aspects of each technology, but also on such factors as the permanence of the settlement, financial costs and affordability, design life, expectations and preferences, institutional capacity, the potential for job creation, and environmental considerations. This guideline will present the different technical, and to some extent financial, properties of the various technology options which have proved to be viable for large scale use within the South African context. The variety of proprietary systems are not named nor addressed individually, but usually can be classified as a member of one of the generic categories of sanitation systems addressed within this guideline.

In this document, you will read more about the various technical options that meet the requirements for the provision of basic sanitation and the operational and maintenance requirements of each of these options. Some of the sustainability requirements, e.g. affordability, operation and maintenance, and institutional responsibilities are also addressed. A brief technology choice guide is also provided, but should be subject to local assessment of sustainability and acceptability in each case.

The options are divided into two categories: Dry on-plot systems (that do not require water for operation) and wet systems (that do require water for operation). Within the wet systems there is a further division into those systems that are fully on-site, and those that have both an on-site and an off-site component. The following information is provided for each technical option described:

• A sketch drawing of the recommended option
• a description of the option
• an explanation of the principles of operation
• operational and maintenance requirements and responsibilities for households and institutions
• a summary of costs
• notes on previous user experiences and comments on these

It should be noted in the introduction that the drawings are not meant as technical specifications for each of the sanitation types, but to illustrate the basic features. Additional technical details can be obtained from technical specifications obtainable from DWAF, SABS, WRC and CSIR, as well as from other literature.

Please note: The capital and operating costs of a given technology may vary widely between locations - depending on locally available materials, construction method, extent of existing infrastructure, etc.

2. CONSTRUCTION REQUIREMENTS

There are a number of approaches to and requirements for the construction of the physical sanitation facilities that are not related to a specific technology choice. The approach adopted can lead to increased community participation and ownership, the enhancement of job creation and skills development, and contribute to the long-term sustainability of the facility. However the approach must not result in the construction of poor quality facilities that the households and communities find inferior or unacceptable. It is therefore important that no matter what technology is chosen, the construction be done in a way that both promotes community ownership and job creation, and a high quality product that people will be proud of and that will function effectively according to the design principles during its lifetime.

In South Africa the following minimum construction specifications have been adopted for domestic toilets:

- The superstructure must provide adequate privacy and be constructed with a floor, walls and a roof of material adequate for long-term low maintenance usage. The superstructure must be provided with an opening which will give natural lighting and ventilation and the area of such opening shall be not less than 0,2 m^2.

- A latrine shall be provided with a seat and pedestal at a height of between 350mm and 450mm and fitted with a fly-proof lid.

- No excavation for a latrine substructure (e.g. pit, digester or septic tank) shall be sited within 3 m of a building or of a boundary of the site on which it is located.

- For digesters and septic tanks the excavation should be such that the tank can be adequately covered. In the case of plastic digesters or septic tanks, these should be adequately anchored to prevent them floating when empty in the case of a high water table.

- Outside latrines should not be built under or near trees, and should be located so that a vacuum tanker is able to approach to within 30 m of the pit or digester with the difference in levels between the pit and the surface upon which the tanker stands being not more than 2,0 m;

- Pits in unstable soils shall be fully lined. Unlined pits should be circular and should not exceed 1,5 m in diameter.

- Measures should be taken to prevent rainwater, soil, rubbish and other foreign material from entering the system. Separate provisions shall be made for the disposal of grey-water and other household waste.

- Pits of pit latrines shall be ventilated with a ventilation pipe of nominal diameter at least 110 mm and screened with a non-corrosive material which is resistant to ultraviolet radiation to prevent insects from entering or from escaping from substructures. The vent pipe should be installed such that its height is at least 2,5 m above the ground level, and 500 mm above the highest point of the roof.

- The upper 500 mm of any pit should be impervious, with openings to be provided for seepage out the pit from 500 mm below ground.

3. SUSTAINABILITY OF SANITATION SYSTEMS

The sustainability of a sanitation system is usually the most important consideration when selecting a specific technology option for a community. Sustainability refers not only to measures to minimize breakdowns and costs in the operation of a scheme, but also refers to measures taken to maximize its positive social impact while minimizing any negative environmental impacts.

The following sections briefly outline some of the key requirements for promoting sustainability of sanitation systems and their relationship to choice of technology.

3.1 User education and participation in technology choice

3.1.1 It is imperative that representatives of the community for whom the sanitation project is to benefit be consulted and fully informed of the sanitation technology options that could be considered. The representatives must be part of the decision making process, and should in turn inform the residents of the options and choice.

3.1.2 It is the responsibility of the local authority to ensure that the necessary level of user education on the proper use, care and maintenance of the selected sanitation technology is provided; this will vary depending on the system to be installed.

3.1.3 As a general rule, the greater the household/community responsibility for operation and maintenance of the system, the more extensive must be the programme of user education, and the lower the tariffs and municipal O&M costs.

3.1.4 Conversely the greater the institutional responsibility for O&M, the greater the need for system monitoring by the local authority and effective cost-recovery from the users to provide the necessary resources for O&M.

Factors to be addressed by a programme of user education include:

- establishing structures in the community to facilitate and support effective O&M
- correct operation of the facility,
- the level of household/community responsibility for O&M of the proposed system,
- what to do when the pit is full or septic tank needs desludging,
- use of suitable/acceptable anal cleansing material,
- design life of the facility,
- implications of system failure (on personal health and on the environment),
- where to obtain assistance when problems are experienced,
- cost recovery awareness.

3.2 Health and hygiene promotion

3.2.1 It is the responsibility of the local authority to ensure that a project implementation health awareness programme followed by an ongoing programme of health and hygiene promotion is established.

3.2.2 Any programme must focus on the particular needs of different communities, in line with the level of service to be developed.

3.2.3 Factors to be addressed by a programme of sanitation health and hygiene promotion should be formulated following a comprehensive participatory process (PHAST), and may include:

- safe disposal of urine and faeces including desiccated and composted wastes,
- good personal hygiene practices,
- importance of clean toilets,
- food hygiene,
- keeping stored water clean and hygienic,
- safe disposal of wastewater,
- implications of inappropriate hygiene practices and associated diseases.

3.3 Operation and maintenance tasks and plant& equipment availability

3.3.1 Households are responsible for the operation and maintenance of the sanitation system components located on their own erf, but the municipality may provide support for undertaking bigger tasks such as pit or septic tank emptying, moving top structures, or unblocking sewers.

3.3.2 It is the responsibility of the local authority to ensure that all transport, treatment and disposal facilities and equipment for handling sanitation wastes are appropriate to local conditions and of sufficient capacity to deal with the wastes associated with the level of service to be provided.

3.3.3 The operation and maintenance requirements of the transport, treatment and disposal facilities and equipment and all their associated costs must be planned for.

3.3.4 Back-up/emergency procedures are the responsibility of the local authority and must be addressed as part of the ongoing O&M requirements.

3.3.5 In the case of pit or tank emptying when the need for this has been established, particular factors to consider include:

- availability of suitable emptying equipment,
- accessibility of pit/tank for emptying equipment,
- proximity/access to local treatment facility or suitable disposal arrangements,
- suitability of emptying strategy (i.e. ad hoc, rotational, systematic),
- provision for recurrent expenditure.

3.3.6 The following are the general requirements for operation and maintenance of the various sanitation options. These should be fully assessed and detailed during the design stage of the specific projects:

Sanitation scheme	O&M tasks	Skills level	Time requirements	Equipment and materials	Comments
All latrines	Maintaining structure & pedestal	Maintenance skills	± 1 day per year	Some cement, paint, wood	May be done by home owner or small contractor
VIP Latrines	Cleaning vent pipe	None	1/2 hour per month		Undertaken by home owner
	Emptying pit	Brief training	1 day in 5 to 10 years	Vacuum tanker or hand equipment + roughage for composting sludge + safety clothing	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
UDS latrines	Emptying pit	None	1/2 day each year	None	Most activities can be undertaken by home owner
Aquaprivy	Removing sludge from tank	Brief training	± 1/4 day every 3 months	Vacuum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
	Maintaining soak pit	Brief training	Monthly for grease trap	None	Soak pit may need to be unblocked or moved every 5 to 10 years in some soils
Flush toilet with septic tank and adsorption trench	Repairs to pipes	Pipe skills	± 1 day every 5 years	Pipes and joints	May be done by home owner or small contractor
	Removing sludge from septic tank	Brief training	± 1/4 day every 3 years	Vacuum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
	Maintaining soil adsorption trench	Brief training	Monthly for grease trap	None	Soak pit may need to be unblocked or moved every 5 to 10 years in some soils
Flush toilet with septic tank, solids free sewer and pond treatment	Repairs to pipes	Pipe skills	± 1 day every 6 years	Pipes and joints	May be done by home owner or small contractor
	Removing sludge from septic tanks	Brief training	± 1/4 day every 3 years per household	Vacuum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
	Maintaining stabilization pond	Brief training	Daily	Minor tools	This can provide permanent job positions for 2 to 5 people.
Full waterborne sanitation	Repairs to pipes	Pipe skills	± 1 day every 6 months	Pipes and joints	May be done by home owner or small contractor (if on-site) or municipality (if off-site).
	Sewer blockages	Minor training	± 1 day per week	Rodding equipment + transport	May be done by municipality or small contractor
	Operating and maintaining wastewater treatment works	Full training to diploma level	Daily	Monitoring equipment + tools	Municipal responsibility providing permanent job positions for 4 to 10 people.
Sewage pump stations	Maintaining pumps, clearing screens and grit channels	Full training to certificate level	± 4 hours per week	Pump maintenance tools, safety clothing	Municipal responsibility but pump maintenance may be contracted in.

3.4 Cost recovery

3.4.1 It is the responsibility of the local authority to ensure that the recurrent costs of the level of service to be developed are identified in full during the planning stage.

3.4.2 Along with any user education programme, issues around cost recovery awareness and the implications of non-payment must be addressed on an ongoing basis; this in itself constitutes an O&M cost.

3.4.3 Factors to be considered include:

- affordability in the medium to long term,
- willingness to pay,
- interim and emergency sources of funding,
- subsidy policies (pensioners, disabled, etc.).
- availability of equitable share for subsidy of the poor

4. Sanitation technology choice

4.1 Options not recommended

The options below are not recommended for large-scale use since they do not meet the safety and environmental criteria for a basic level of service under general circumstances.

Unimproved pit toilet

This system is not recommended (subject to bad smells and insect infestation). Consists of a *top-structure around and /or over a pit, generally unlined where soil conditions allow, with a pedestal or squat-plate. There is no ventilation pipe*

Chemical toilet

This system is only suitable for short-term temporary use such as special functions (it is expensive and requires regular emptying). There are *various modern types. These utilise a water- diluted chemical in a receptacle below the toilet seat to render excreta harmless and odourless. These are generally standalone units.*

Bucket toilet

This system is not recommended due to the exposure of the bucket contents to insects and vermin that can spread disease both during use and when emptying. Consists of a *top-structure with the seat positioned above a bucket or other container located in a small compartment beneath.*

Communal toilets

This system should only be considered for temporary use where a high level of cleanliness and maintenance can be assured. Consists of *toilet "blocks", which may be based on dry or wet systems as outlined in the following descriptions.*

4.2 Factors to consider in the choice of a sanitation technology

The selection of an appropriate technology from a range of possibilities is the key to the successful and sustainable operation of any facility. Choice of technology is often considered a simple process, but is usually quite complex requiring careful assessment of factors, consultation with the beneficiaries and the operating authority, and an understanding of the integration of factors affecting the sustainability of a system.

The process of selecting an option for a particular application may follow a step-wise sequence as shown in the layout below.

Step 1: Confirm goal and objectives

What is to be achieved and why?
Is it a realistic goal and will it address the main problem(s)?
Are there sub-objectives that should be prioritized?

Step 2: Analysis of constraints and promoters

Social issues
Health issues
Technological issues
Economic issues
Financial issues
Institutional issues
Environmental issues

Step 3: Output

Selection of technology
Specification of implementation methodology
Plan for ongoing operation, maintenance and hygiene awareness
Economic plan including sustainability of jobs and financing of O&M

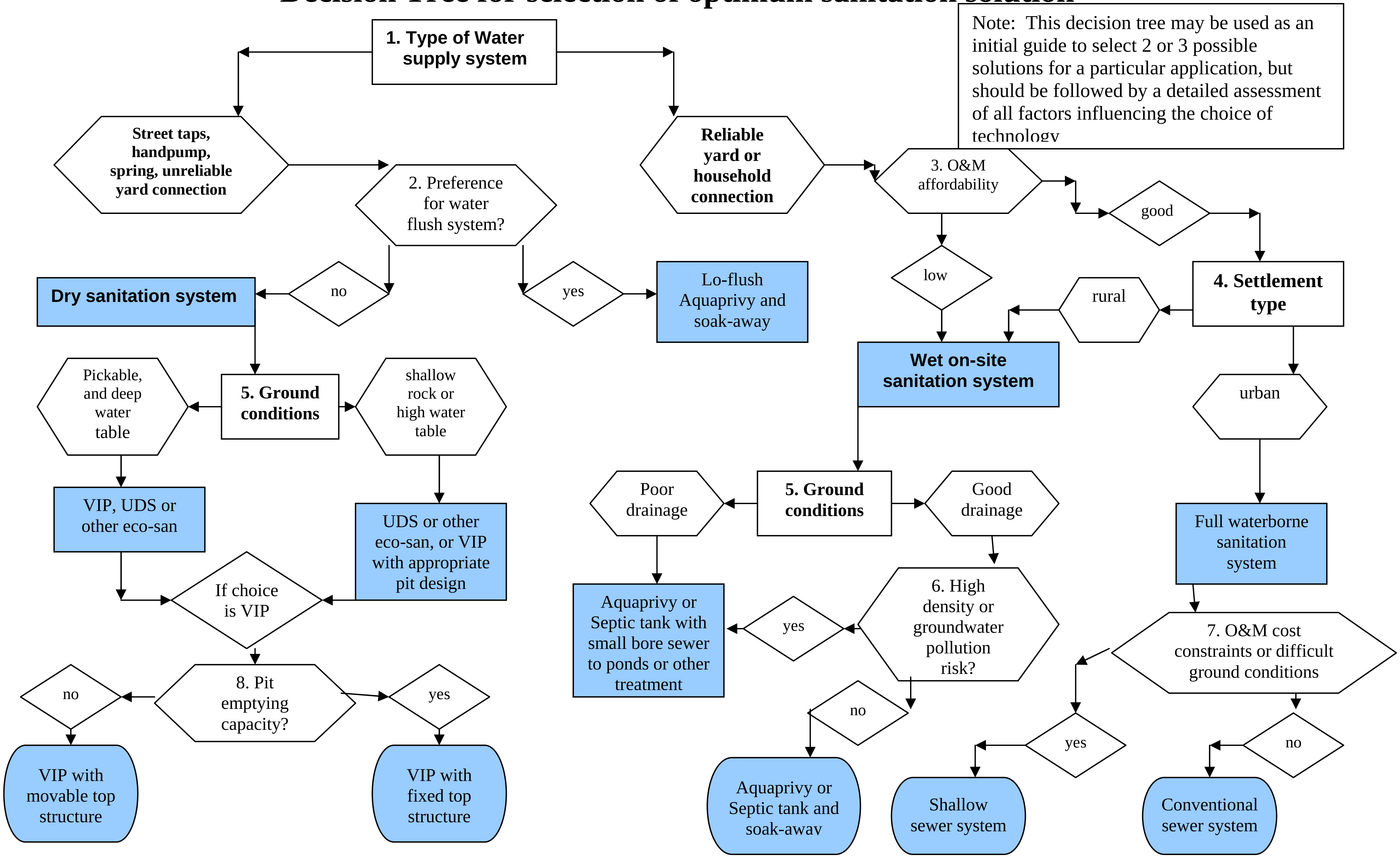
These three steps are illustrated in the following example framework:

Issue or factor	Effect or implication	Output or impact
Step 1: Goal and objectives		
Goal: Improve the health and dignity of residents	Minimum basic sanitation for settlement type and effective H&H education	
Objectives (e.g.): 1. Ensure acceptable sanitation service 2. Ensure affordable sanitation service 3. Maximise social benefits 4. Protect the environment	1. consult with residents prior to selecting technology option 2. assess operation and maintenance costs at planning stage 3. assess potential for job creation and skills development 4. assess environmental impact through application of Groundwater Protocol	1. residents are informed and participate in decision making 2. financial requirements and tariffs are known beforehand 3. local employment is maximized 4. environmental impacts are well managed
Step 2: Analysis of constraints and promoters	• Capital costs • Recurrent costs • Job creation potential • Availability and reliability of water • Ground conditions (construction and/or drainage aspects) • Operational requirements • Environmental protection • Settlement location and layout • Past experience and preferences • Existing infrastructure	• Ensure affordability of capital and O&M costs • Maximize employment benefits for local residents • Ensure ongoing operational viability • Prevent pollution of surface or ground water • Ensure appropriate level of service for each community • Maximise links to existing infrastructure and services.
Step 3: Output Selection of technology Specification of	• All stakeholders involved in technology selection • Technology is most appropriate	• Acceptable sanitation solution • Sustainable sanitation systems

Issue or factor	Effect or implication	Output or impact
implementation methodology Plan for ongoing operation, maintenance and hygiene awareness Economic plan including sustainability of jobs and financing of O&M	for specific application • Implementation approach ensures participation and maximizes local benefits including job creation, support local material suppliers, strengthens local management capacity. • Ongoing sustainability ensured • Health benefits maximized	• Short and longer term local employment creation • Local skills development • Reduction in sanitation related illness

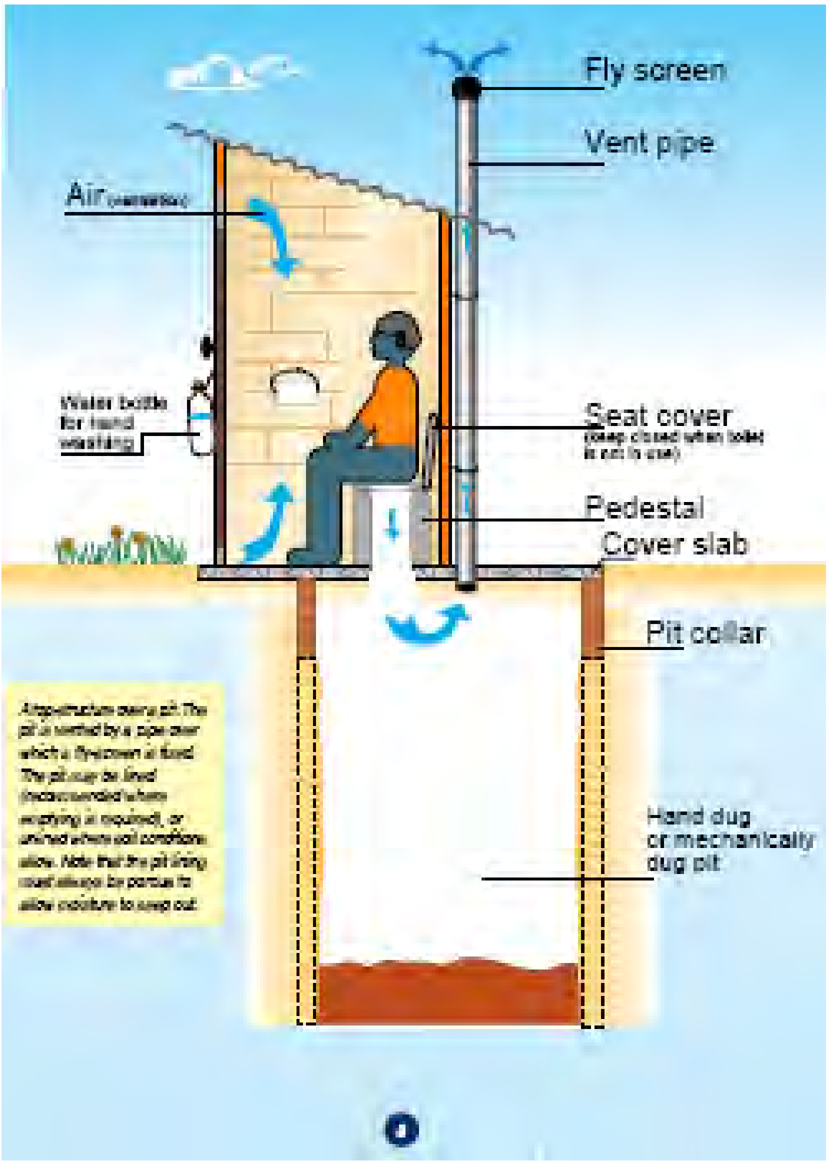
The following technology decision tree is provided as a support in the initial screening of technology options for a particular application. However, a thorough feasibility study should be undertaken before finalizing the selection:

Decision Tree for selection of optimum sanitation solution



5. RECOMMENDED SANITATION TECHNOLOGY OPTIONS

5.1 Dry on-plot systems - Ventilated Improved Pit (VIP) toilet



5.1.1 Fixed Top Structure – pit emptied

1. Principles of operation

Waste drops into the pit where the organic material decomposes and excess liquids percolate into the surrounding soil. Natural airflow through the top-structure and moving across the top of the vent pipe removes smells and vents gases from the pit to the atmosphere. A darkened interior is maintained causing insects entering the pit to be attracted towards the light at the top of the vent pipe and trapped by the fly screen. A separate hand washing facility is required.

2. Operational and institutional requirements

The VIP should be located to prevent ingress of storm water to pit, as well as to prevent the contamination of local groundwater that is used for drinking. The system cannot accept domestic wastewater, nor can it be installed inside the house. Ensure that there is access to the pit for mechanical pit-emptying equipment, and availability of facilities for sludge treatment and disposal. Repair or replace damaged or worn materials to ensure the proper functioning of the toilet.

3. Costs

Capital: May range from R3,000 – R4,500, depending on location, choice of materials and other specific project requirements.
Maintenance: R80 to R200 per year if emptied once in 5 years, or R30 to R70 per year if emptied once in 15 years. The pit emptying frequency depends on the pit volume and number of users in the household. An average pit emptying frequency of 8 years is generally accepted for planning purposes.
Operating: Household cleansing materials, water for hand washing

4. Experience and Comment

VIPs are widely used internationally and in rural and peri-urban areas of South Africa. These systems are most successful in water-scarce and less densely populated environments. Failures are generally due to inadequate user education and/or poor design and construction. The system has been found to be robust, not prone to negative impacts due to the failure of other services, and widely affordable even to the poorest. Minor adaptations to the pit can be made where shallow rock or high groundwater tables occur.

5. O&M requirements and responsibilities

5.1. On-site components (usually responsibility of household)

Maintaining as dark an interior as is acceptable and taking precautions to restrict the exit of flies from the pit into the toilet superstructure (e.g. by lowering the seat cover when not in use). Repair/replacement of damaged or worn out materials (e.g. vent pipe, fly screen) to ensure optimal functioning of the ventilation system. Daily cleaning of the pedestal and interior of the toilet, and maintaining the hand-washing facility.

5.2. Off-site components (usually responsibility of the local authority)

The O&M and institutional responsibilities include:
- Management and supervision arrangements for mechanical pit -emptying, sludge transfer, treatment and disposal
- Plant, equipment and vehicle O&M .
- Ongoing user education and health and hygiene promotion

6. Other construction and operational considerations

The following questions need to be answered to understand the construction and operational challenges involved with operating this technical option:

Is pit substructure stable enough to ensure no risk of collapse on emptying?
Are pits accessible for emptying?
What options are available for sludge treatment and disposal?
Are there objects being thrown into the pits that may block the suction pipe (cans, bottles, rags)
Are locally manufactured materials of adequate quality for the intended lifespan of the system?

7. Upgrading Options

VIP toilets can be upgraded to other sanitation technology types. This will usually mean closure of the pit and reuse of the top structure, with removal of the pedestal and refitting with a flush-type pedestal. Additional plumbing and the downstream drainage system and facilities for the treatment and disposal of wastes will need to be installed. One alternative option is to install a urine diversion pedestal and continue to use the pit for the disposal of the solids, while the urine is diverted to an alternative disposal system.

5.1.2 Movable Top Structure – pit not emptied

1. Principles of operation

As for fixed top structure above

2. Operational and institutional requirements

As for fixed top structure above. There should also be land available to dig a new pit and move the top structure when the pit is full.

3. Costs

Capital: May range from R3,000 – R4,500, depending on householder input and choice of materials and cost.
Maintenance: Additional capital costs incurred every 5 to 15 years when old pit is full. With fully movable top structures the main costs will be for the new pit, Where the superstructure must also be rebuilt, there may be some savings from re-use of materials.
Operating: Household cleansing materials, water for hand washing

4. Experience and Comment

VIPS that are not emptied are widely used in South Africa and other developing countries. When the pit is full, the household will dig another pit and transfer the superstructure to the new pit. The old pit should be covered with soil at least 0.5m deep to prevent possible contact with gardening and other surface level activities.

5. O&M requirements and responsibilities

5.1. On-site components (usually responsibility of household)

As for fixed top structure above

In addition when the pit is full, the following is required:
• digging of new pit
• relocating/rebuilding top structure
• backfilling and safe sealing of full pit

5.2. Off-site components (usually responsibility of the local authority)

The local authority is responsible for:
• Ongoing user education and health and hygiene promotion

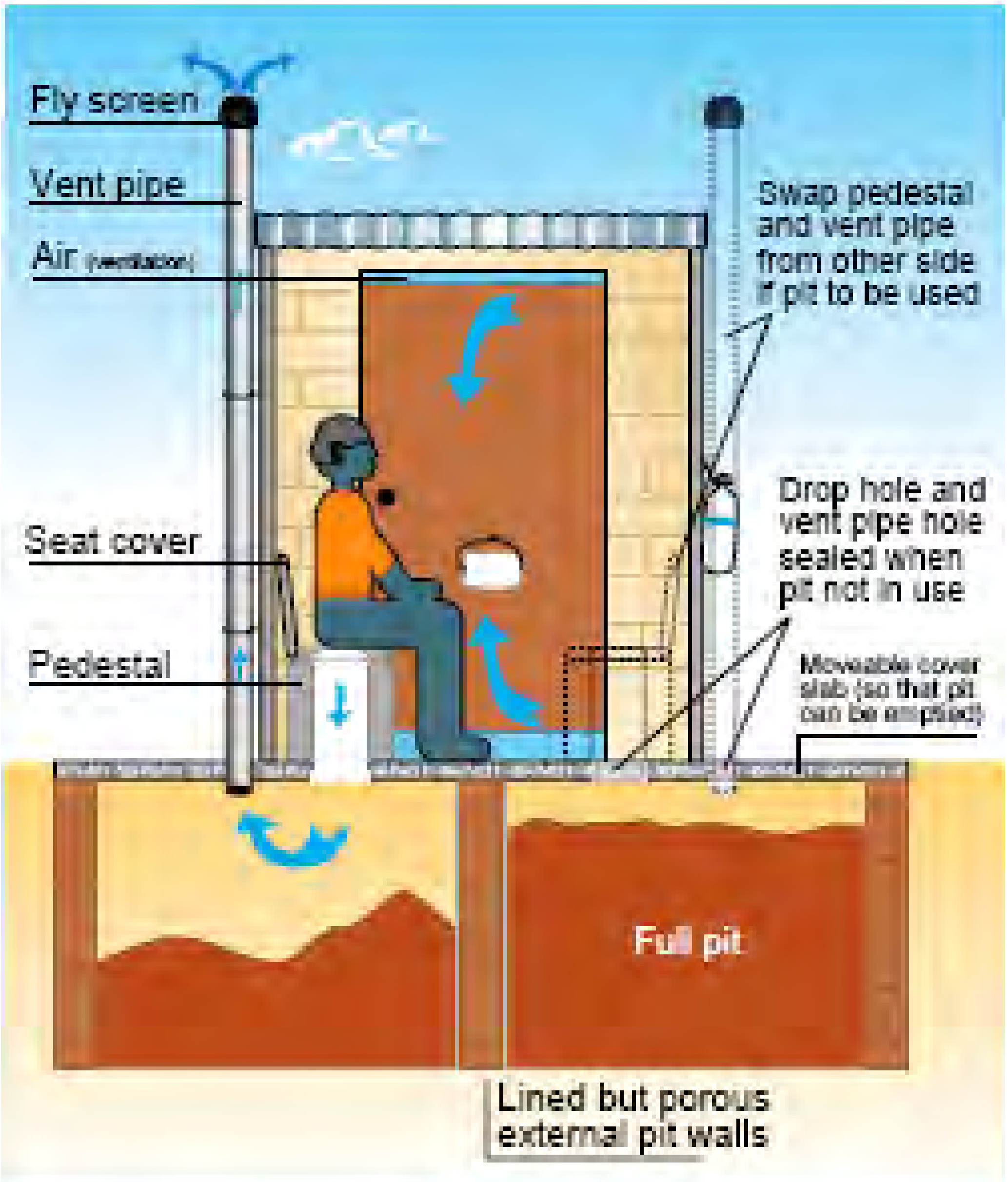
6. Other construction and operational considerations

The following questions need to be answered to understand the construction and operational challenges involved with operating this technical option:

Is pit superstructure stable enough to be able to move when the pit is full?
Is there a need for special equipment to move top structures?
Are locally manufactured materials of adequate quality for the intended moving of the top structure?

7. Upgrading Options (as for fixed top structure above)

5.2 Dry on-plot system - Ventilated Improved Double Pit (VIDP) toilet



A single top-structure over 2 shallow pits, side by side. Only one pit - vented by a pipe protected with a fly screen - is in use at any time. Generally lined and the central wall fully sealed to ensure isolation of one pit from the other.

1. Principles of operation

The principles of operation are the same as for the VIP toilet. One pit is used until filled to within about half a meter of the top. The pedestal and vent pipe holes are to be completely sealed before the other pit is used. The contents of the first pit are dug out after a period of at least two years, once the contents have become less harmful. The first pit can then be reused when the second pit is full, while the second pit is allowed to stand and be emptied after 2 to 3 years.

2. Operational and institutional requirements

The operational and institutional requirements are similar to that for the VIP toilet, except that promotion of manual emptying by the householder is required, and the safe use of the decomposed waste as a soil conditioner on the plot is possible. A suitable disposal site for the sludge should be available close to the structure.

3. Costs

Capital: May range from R3,500 – R6,000, depending on householder input and choice of materials and cost.
Maintenance: R35-R135 every 2 to 3 years depending on house-holder willingness to handle wastes, availability of local contractors, and the location of disposal site.
Operating: Household cleansing materials, water for hand washing

4. Experience and Comment

Resistance to handle decomposed waste and the timely changeover of pits by householders has often been overcome through education and demonstration. This VIP alternative is often applicable where rocky or groundwater conditions prohibit deep excavation.

However it has also been found that even with a water-tight wall between the pits, there is still moisture that seeps from the pit in use to the pit that is decomposing, and hence the contents of the decomposing pit does not dry out.

5. O&M requirements and responsibilities

5.1. On-site components (usually responsibility of household)

Communities or households are responsible for the:
• manual emptying of full pit after at least 2 years of decomposition
• disposal of decomposed sludge
• repair/replacement of damaged/worn out materials

Maintaining as dark an interior as is acceptable or restricting egress of flies from the pit into the toilet top-structure (e.g. by lowering the seat cover). Daily cleaning of pedestal and interior is recommended. A hand washing facility is required.

5.2. Off-site components (usually responsibility of the local authority)

The local authority is responsible for:
• user education
• health and hygiene promotion

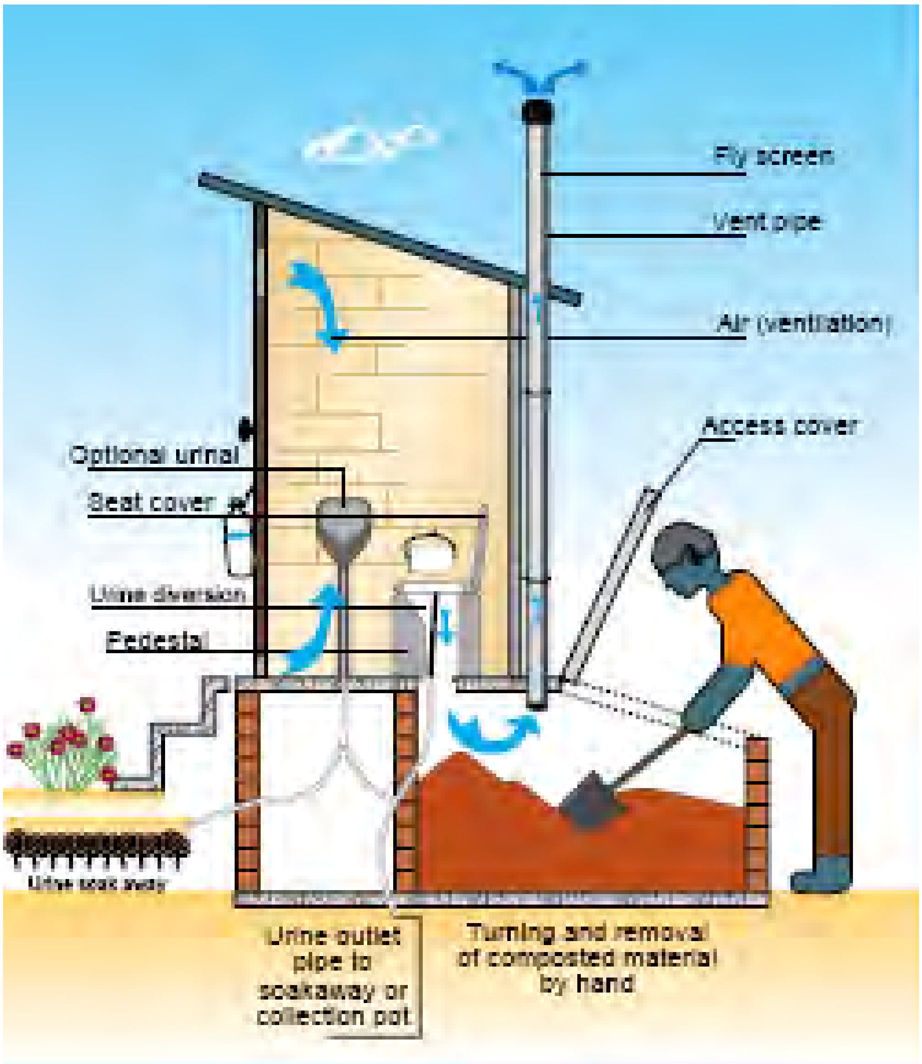
6. Other construction and operational considerations

The following questions need to be answered to understand the operational and construction challenges involved with operating this technical option:

Is there user acceptance of handling decomposed waste?
Is suitable land available nearby for disposal of decomposed waste?
Are there sludge disposal arrangements available in the case where handling of waste at household level is unacceptable?

7. Upgrading Options (as for fixed top structure VIP above)

5.3 Dry on-plot system Composting or desiccating (e.g. urine diversion system - UDS) toilets



A single top-structure over a sealed container, which could be one of two chambers side by side (as for the VIDP), with access for the removal of decomposed waste. A vent pipe may be installed to encourage drying of the waste.

1. Principles of operation

Waste is deposited in the chamber below the pedestal. For composting toilets, dry absorbent organic material, such as wood ash, straw or vegetable matter is added after each use to absorb odours, control moisture and facilitate biological breakdown (composting). In desiccating toilets, the solid wastes dry out rapidly through enhanced airflow or with the help of additional dry material like wood or coal ash. In these cases the urine may be separated from the solids to improve the rate of drying of the faeces. The urine is separated or diverted through the use of specially adapted pedestals. The urine may be collected and used as a fertilizer, or drained to a soak pit where it will seep into the soil. In desiccation systems, ventilation systems are often enhanced to facilitate the rapid evaporation of moisture.

2. Operational and institutional requirements

Composting or desiccating toilets do not accept domestic wastewater. It is important to teach and train the householder how to operate the toilet properly by for example manual 'turning' of compost and removal of composted or desiccated material when required. A suitable disposal site or area for the desiccated or composted dry wastes is required, usually a garden compost heap or a pit where it can be buried.

3. Costs

Capital: (variable depending on system and householder input): R 3 500 for community contractor built systems up to R7 500 for some commercial systems.

Maintenance: R45 – R650 per annum, depending on local government involvement and householder willingness to handle waste, taking into account different disposal options.

Operating: Cleansing materials, soap and water for hand washing

4. Experience and Comment

Control of moisture content is vital for proper operation of the composting or desiccating toilet. Contents may become too wet if not used properly, making the vault contents malodorous and difficult and unhygienic to empty. Urine diversion systems are still being pioneered and monitored in South Africa, but they are being widely accepted by certain municipalities and communities where it is working without significant problems. The burning of compost prior to removal is also being tested in South Africa.

Proprietary systems have been piloted in South Africa, generally with inconclusive results as to their likely success on a large scale and under varying conditions.

User educational requirements and continuous input is significant for proper operation in terms of the composting and desiccating processes.

5. O&M requirements and responsibilities

5.1. On-site components (usually responsibility of household)

Communities and households are responsible for the:

- repair/replacement of damaged/worn out materials
- disposal of composted sludge
- application of ash and/or vegetable matter after use
- control of urine diversion system and emptying of containers when or where required
- manual raking and emptying of the dried or composted contents of the chamber

5.2. Off-site components (usually responsibility of the local authority)

The local authority is responsible for:

- user education
- health and hygiene promotion
- Monitoring the proper use and management of the systems at households

6. Other construction and operational considerations

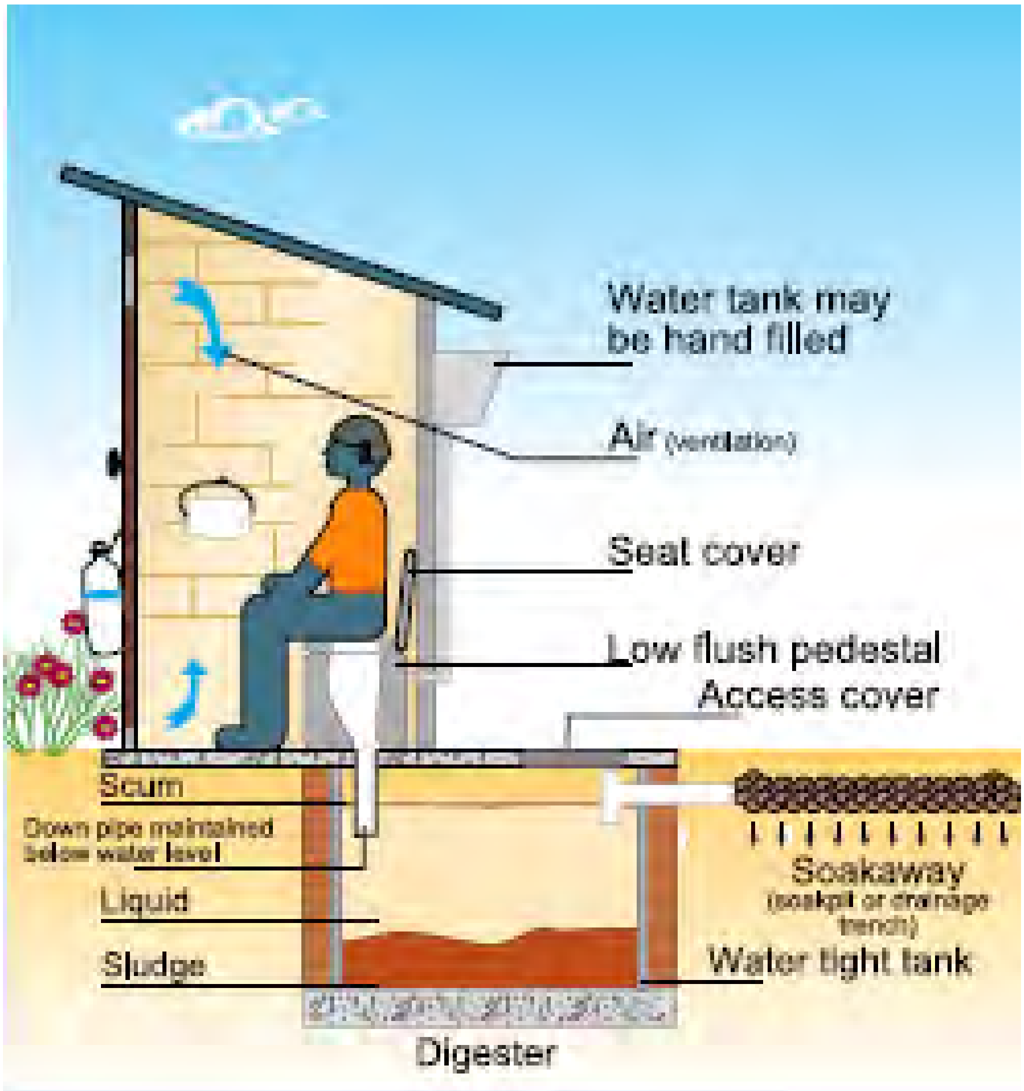
The following questions need to be answered to understand the institutional challenges involved with operating this technical option:

- Is there user acceptance of handling composted waste?
- Is suitable anal cleansing material that will readily decompose being used?
- Is suitable land available nearby for disposal of composted waste, or can the wastes be buried or placed on a compost heap for future use in the household garden?

7. **Upgrading Options** (as for fixed top structure VIP above)

5.4 Wet on-plot system

Loflos or aquaprivy toilet with soakaway



A toilet with a water-seal arrangement: a straight or curved chute running from the seat to below the water level with some form of waste collection and disposal system.

1. Principles of operation

After use, the toilet pan or pedestal may be flushed with one to two litres of water. Some pans have a tipping flap at the bottom of the pan that holds a small amount of water, opening when flushed. This flap acts as a seal between the pedestal and the digester. The wastes from the pan drop into a digester directly underneath the toilet, or just offset from the toilet structure.

An aqua-privy requires an initial filling of the digester with water for the effective digestion of wastes and to keep the end of the pedestal chute submerged, and thus forms a “rough water seal” between the pan and the digester contents. The solid portion of the waste partly decomposes within the digester, while the liquids are displaced with each use. The displaced liquids flow to a soak-away. The digester requires desludging from time to time (usually between one and three years, depending on the volume of the digester).

2. Operational and institutional requirements

The aqua-privy is appropriate where a flush type latrine is desired but only small volumes of water are available, usually carried by hand from a street or yard tap. The system can also accept domestic wastewater provided the soak-away is sized accordingly.

For proper operation of the system ensure access to the digester cover by mechanical equipment for the emptying of digester waste. In addition it is necessary to provide an acceptable subsoil drainage system for excess liquids and the availability of sludge treatment and disposal facilities within the proximity of the settlement.

3. Costs

Capital: R3 200-R5 500 which can increase where soils not well suited to drainage.
Maintenance: R195-R390 per annum where subsoil drainage is available.
Operation: Water for initial filling of digester, and ongoing for flushing (up to 20 litres per day), as well as cleaning materials and soap and water for hand washing.

4. Experience and Comment

The system is internationally accepted. Blockages may occur through use of inappropriate anal cleansing material.

Experience in South Africa has seen varied success, with failures through lack of user education and/or poor design and construction. The problem of carrying water to be able to flush the toilet has been problematic in some situations. The requirement of an effective and affordable sludge emptying service has also resulted in poor performance in some cases.

5. O&M requirements and responsibilities

5.1. On-site components (usually responsibility of household)

Communities and households are responsible for the:
- transporting of water to the system
- repair/ replacement of damaged/worn out materials
- sustaining the “rough” water seal (i.e. ensuring the digester remains full of water)

5.2. Off-site components (usually responsibility of the local authority)

The off-site O&M requirements (usually local authority is responsibility) include:
- mechanical emptying of digester,
- sludge transfer, treatment and disposal
- maintenance of treatment plant, equipment and vehicles
- cost recovery
- user education
- health and hygiene promotion

6. Other institutional considerations

The following questions need to be answered to understand the institutional challenges involved with operating this technical option:

- Is suitable anal cleansing material being used?
- Is suitable land and space available for soak-away?
- Is there access for desludging of digester/tank.
- What options are available for sludge treatment and disposal. Keep in mind this is dependent on the type of sludge, the availability of land and the capacity of existing treatment facilities?
- Is the integrity of tank and installation procedure ensured?

7. Upgrading Options

The aquaprivy or LoFlos toilet can be upgraded in either or both of two methods:

7.1 Conversion to full-flush toilet

In this case the pedestal is replaced with a full-flush pedestal and appropriate plumbing. The existing digester may be retained if the upgrade includes an on-site digester, or may need to be replaced if the upgrade is for conventional sewers or if the existing digester is unsuitable for a full-flush system.

7.2 Conversion to off-site transport of liquid wastes

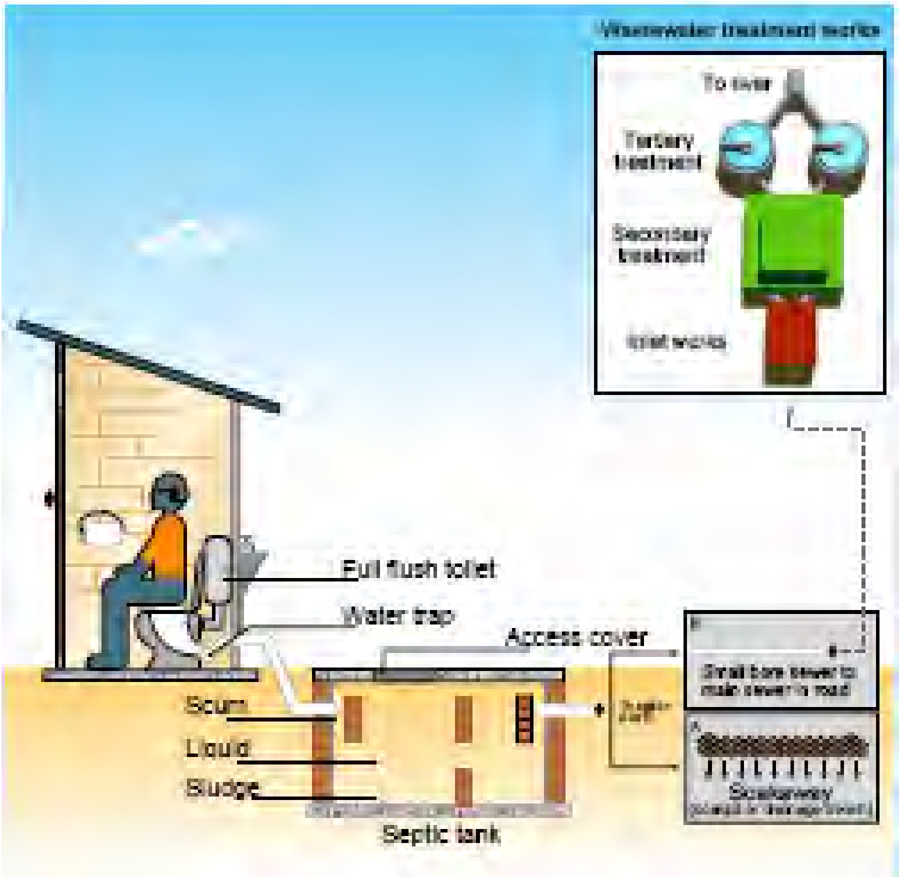
In this case the digester outlet may be connected to a small-bore sewer system and the liquid wastes transported to a suitable treatment facility. This upgrade would then replace on-site soak-aways.

7.3 Conversion to full flush and small-bore sewer

In this case both the above upgrades are instituted, with a full flush pedestal flushing into the digester, and the liquid wastes transported in a small-bore sewer to a suitable treatment facility.

5.5 Wet on- or off-plot systems

Septic tank and soak-away



Septic tank and soakaway: *An in-house full flush-toilet connected via pipe and plumbing fixtures to an underground watertight settling chamber (the 'digester') with a liquids outlet to a subsoil drainage/soakaway system.*

1. Principles of operation

Human wastes from the toilet is flushed into a septic tank that acts as a settling chamber for the solids. The liquid is retained in the septic tank for at least 24 hours, but may be up to 10 days. Domestic wastewater may also be drained into the septic tank, or alternatively directly into the soak-away. In the septic tank solids settle out to the bottom where they undergo biological digestion.

The liquids pass out of the tank and into a subsoil drainage system (soak-away). Digested sludge gradually builds up in the tank and requires eventual removal by tanker.

2. Operational and institutional requirements

The septic tank and soak-away system requires a reliable household water connection. Specific design criteria must be applied to the settlement tank and soak-away system. This option is applicable only in areas of low settlement density and where soils have a high ability to drain effluent away. For the optimal functioning of the system, ensure access for the emptying of tanks by vacuum tanker, and the availability of sludge treatment facilities.

3. Costs

Capital: R9 100 - R11 050.
Maintenance: R300 to R600 to empty the septic tank of sludge, approximately every 3 years.
Operating: Water for ongoing flushing (up to 60 litres per day), as well as cleaning materials and soap and water for hand washing.

4. Experience and Comment

The system is widely used by formal rural households, recreation resorts, remote clinics, and farming areas, where reliable water supply is available. The septic tank and soak-away provides a high level of service and user convenience. Failures in the operation of the system are experienced due to poor design and construction, and use of inappropriate anal cleansing material. The soak-away system is particularly prone to clogging in the long-term if not designed according to detailed soil testing, or if the septic tank is not desludged at regular intervals (to prevent solids being carried into the soak-away). In some cases soak-aways are allowed to dry out from time to time through having a dual system. In some cases the large amount of water disposed of in the soak-away results in the contamination of the local groundwater resource.

5. O&M requirements and responsibilities

5.3. On-site components (usually responsibility of household)

Communities and households are responsible for the repair/ replacement of damaged/worn out on-site materials. Households are also responsible for clearing pipe blockages, maintaining the soak-away, and requesting emptying of the sludge from the septic tank when necessary.

5.4. Off-site components (usually responsibility of the local authority)

The local authority is responsible for the management and facilitation of:

- mechanical emptying of digesters,
- sludge transfer, treatment and disposal plant,
- Maintenance of equipment and vehicles
- cost recovery
- user education
- health and hygiene promotion

6. Other institutional considerations

The following questions need to be answered to understand the institutional challenges involved with operating this technical option:

- Is there the necessary reliable household water connection?
- Is there access to septic tanks for desludging of tanks when required?
- Are local water resources unaffected or protected from the seepage from the soak-aways?
- Is suitable land and space available for the soak-away?
- What options are available for sludge treatment and disposal. Keep in mind it is dependent on the type of sludge, availability of land and the capacity of existing treatment facilities?

7. Upgrading Options

The full flush toilet with septic tank and soak-away can be upgraded as follows:

7.1 Conversion to small bore sewered system

In this case the outlet of the septic tanks are linked to a small-bore sewer system, and transported to a treatment facility. This would then bypass all on-site soak-aways.

7.2 Conversion of septic tank into a treatment unit

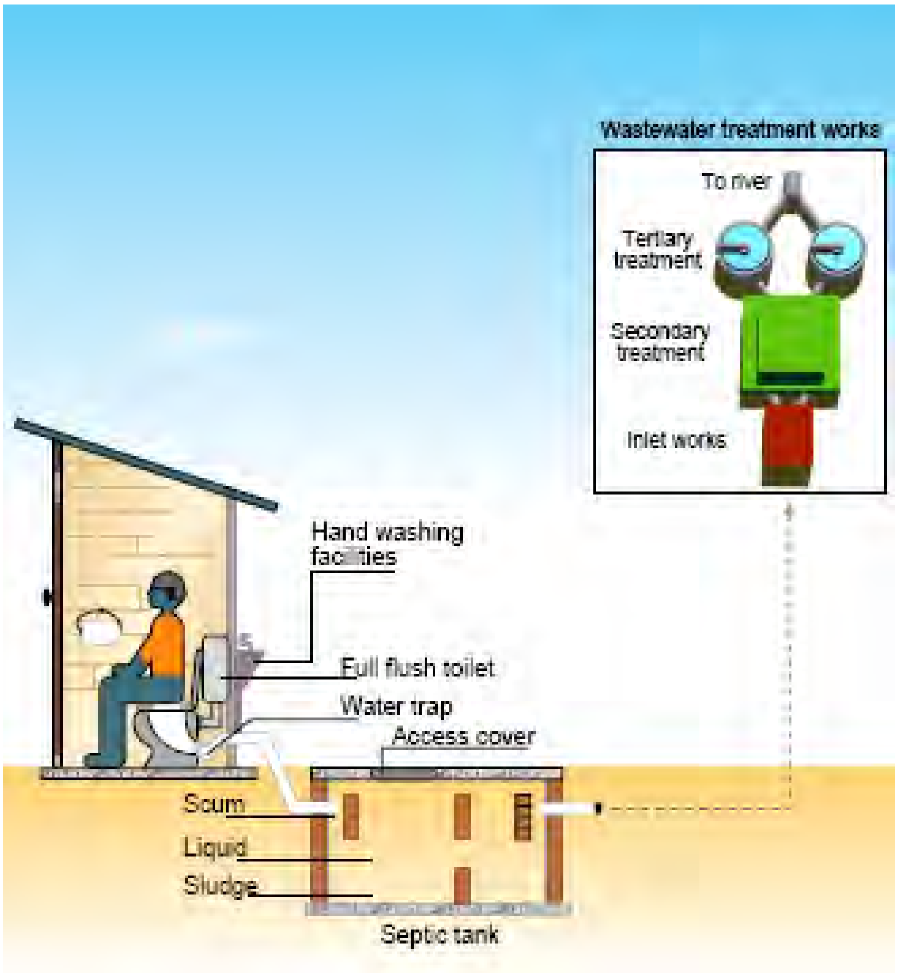
The septic tank can be converted into a small on-site activated sludge type treatment unit, providing a much higher quality effluent for possible limited re-use.

7.3 Installation of household level package treatment plant

A household level package treatment plant may be installed to treat the septic tank effluent, rendering it safe to reuse e.g. for irrigation purposes.

5.6 Wet off-plot systems

Small bore solids-free sewer



1. Principles of operation

The principles of operation are the same as for the septic tank and soak-away, except that the liquid effluent is conveyed by a system of small-diameter pipes to a wastewater treatment system (which may be located close to the community, or linked to the municipal works via existing sewerage pipelines).

2. Operational and institutional requirements

As for a septic tank and soak-away system, a reliable household water connection is needed. For optimal functioning ensure access for emptying of the septic tank, and the availability of sludge treatment and disposal. Routine maintenance of the pipe network is essential.

3. Costs

Capital:	R7 050 - R12 000 per household.
Maintenance:	R300 to R600 to empty the septic tank of sludge, approximately every 3 years, plus R100 to R300 per household per annum for the maintenance of the sewers and treatment facility.
Operating:	Water for ongoing flushing (up to 60 litres per day), as well as cleaning materials and soap and water for hand washing.

4. Experience and Comment

The system is not widely used in South Africa, except where existing septic tank and soak-away systems have been converted for convenience and/or environmental reasons. Failures experienced are as for septic tanks, but problems with soak-aways are avoided. Some problems may occur due to the lack of maintenance of the pipe network.

5. O&M requirements and responsibilities

5.1. On-site components (usually responsibility of household)

Communities and households are responsible for the repair/ replacement of damaged/worn out on-site materials. Households are also responsible for clearing pipe blockages and requesting emptying of the sludge from the septic tank when necessary.

5.2. Off-site components (usually responsibility of the local authority)

The local authority is responsible for the management and supervision arrangements for:

- sewer pipe lines and treatment plant
- mechanical emptying of septic tanks,
- sludge transfer, treatment and disposal plant,
- maintenance of equipment and vehicles
- cost recovery
- user education
- health and hygiene promotion

6. Other institutional considerations

The following questions need to be answered to understand the institutional challenges involved with operating this technical option:

- Is there the necessary reliable household water connection?
- Is there access for vehicles for desludging of septic tanks?
- What options are available for sludge treatment and disposal. Keep in mind it is dependent on the type of sludge, availability of land and the capacity of existing treatment facilities.

7. Upgrading Options

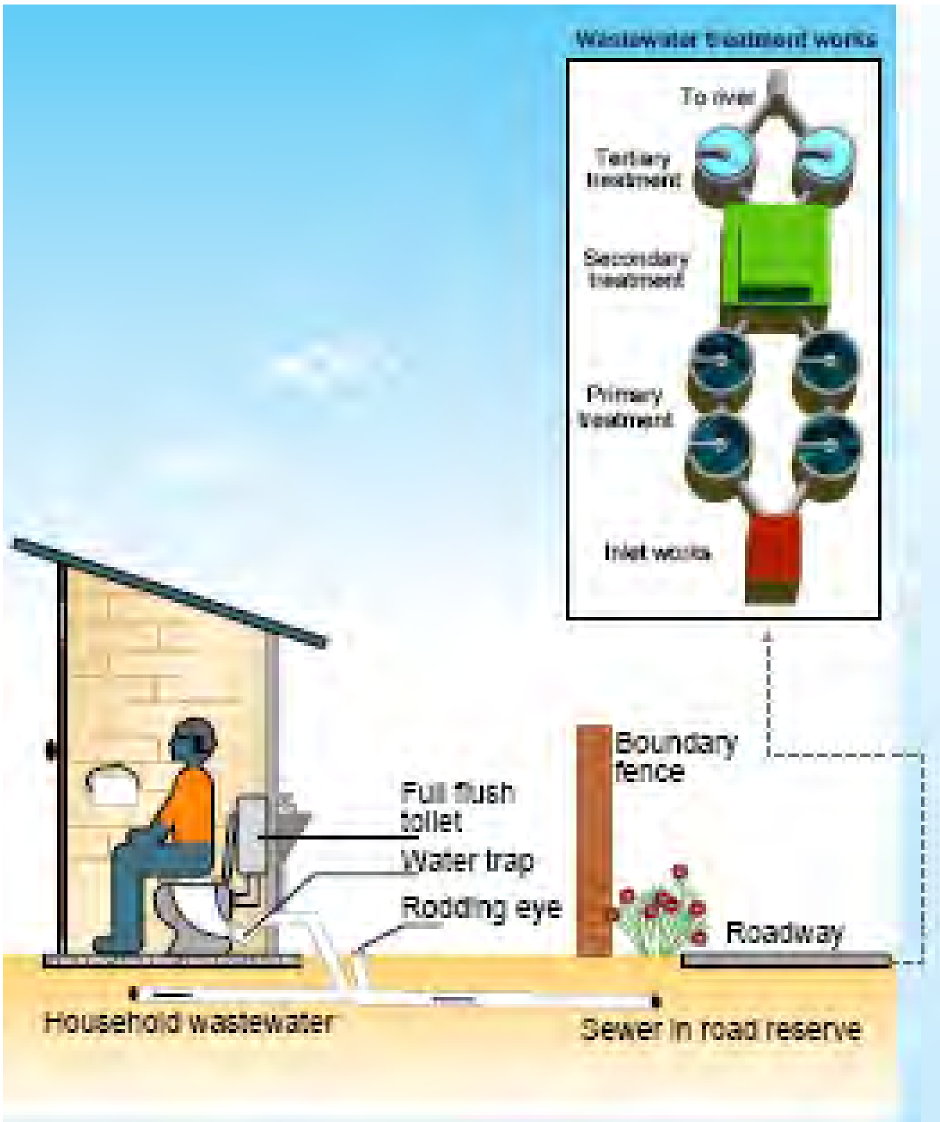
The full flush toilet with septic tank and small-bore sewer can be upgraded as follows:

7.1 Conversion to conventional sewerage system

In this case the existing septic tanks will be by-passes or discarded, and all wastes will be transported in a conventional sewer network. The small bore sewer system will also need to be replaced with a conventional sewer. The advantage would be that septic tanks will not need to be desludged.

5.7 Wet off-plot systems

Full or conventional waterborne sewerage



An in-house full-flush toilet connected to a sewer (pipe) network which drains to a wastewater treatment facility.

1. Principles of operation

Waste from the toilet is flushed, using between 6 and 13 litres of water per flush, into the sewer system for removal to a central treatment facility. A clean water seal is maintained in the toilet pan after each flush. Domestic wastewater is also drained into the sewers.

The sewer system may require pump stations if the topography is not suitable for gravity transport of all the sewerage within the communities. There are several types of wastewater treatment facilities that treat the wastes to a suitable quality prior to discharge into a stream or for re-use in municipal parks and gardens.

2. Operational and institutional requirements

The operation of full or conventional waterborne sewerage requires a reliable and uninterrupted household water connection and spatially regular permanent settlements.

Stringent design criteria must be applied throughout the sewerage network to ensure the uninterrupted flow of wastes to the treatment works. Skilled, organised and effective operation and maintenance capability is required for sewers and the full functioning of wastewater treatment facilities.

3. Costs

Capital: R8,000 - R15,000 per household including the on-site facilities and the sewer mains and sewerage treatment facilities.

Maintenance: R 250 – R 500 per household per annum for maintenance of sewers, pumps, and treatment facilities

Operating: R300-R1,000 per household per annum (depending on the complexity of the treatment facility and pump station requirements.

4. Experience and Comment

The system is widely used and generally the level of service aspired by most South Africans. Where the systems are poorly maintained, or if there are frequent water supply interruptions, the result is a poor level of service where the facility may not be usable for a number of days, and may pose a serious threat to the environment. Appropriate anal cleansing material is required to prevent pipeline blockages.

The health risks in the event of failure are severe in comparison to onsite, dry sanitation systems.

Problems have been experienced with leaking and blocked sewers that may not be repaired timeously, inadequate treatment due to overloading or poor operation, and difficulties with cost recovery.

5. O&M requirements and responsibilities

5.3. On-site components (usually responsibility of household)

Communities and households are responsible for the repair/replacement of damaged or worn out on-site materials, and for clearing any blockages that may occur on the home-owners own property.

5.4. Off-site components (usually responsibility of the local authority)

The local authority is responsible for the management arrangements for:

- O&M of sewage reticulation system
- O&M of the wastewater treatment facility
- leak and blockage detection and monitoring
- emergency contingencies
- cost recovery
- user education
- health and hygiene promotion

6. Other institutional considerations

The following questions need to be answered to understand the institutional challenges involved with operating this technical option:

- Is there the necessary household water connection?
- Is the water supply reliable at all times?
- Is there access to an adequate sewage treatment facility with sufficient capacity?
- Is suitable anal cleansing material being used?
- Is sufficient capacity available in terms of human resources and skills to operate and maintain the system?

7. Upgrading or Conversion Options

Should an existing full waterborne sewage system not be able to function properly due to one of the failure possibilities mentioned above (lack of water, lack of O&M capacity, poor cost recovery), it is possible to convert the system to an alternative, at least until such time as the cause of failure can be addressed:

7.1 Conversion to solids interceptor system

In this case a septic tank or digester is installed at each household to capture the solids, allowing only liquid wastes to be transported to the treatment facility. This will greatly reduce sewer blockages and treatment requirements.

3.7 Conversion to low flush toilet pedestals

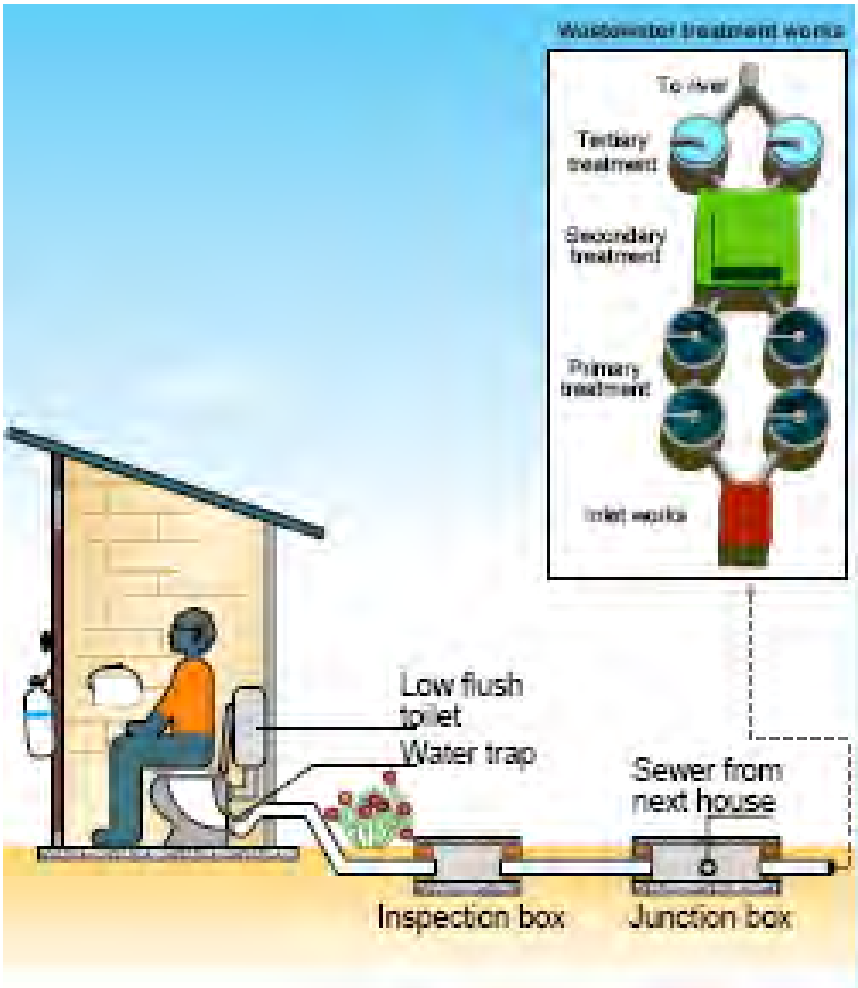
In this case the flush systems (and if necessary the pedestals) are replaced with low flush systems (2 to 6 liters per flush), saving considerably on water use, and hence also treatment requirements. Care must be taken to ensure that there remains sufficient water to transport the solids in the sewer network.

3.8 Conversion to low flush toilets with on-site solids interception

This would be the application of both the above conversions, saving considerably on water use, sewer blockages and pumping, and treatment requirements.

5.8 Wet off-plot system

Conventional waterborne system with shallow sewerage



A toilet, usually in-house, flushed using lower volumes of water than either conventional sewerage or septic tanks, to smaller diameter sewers laid at flatter gradients and shallower depths between dwellings on a block. On-site shallow inspection chambers are provided.

1. Principles of operation

Waste from the toilet, and usually also domestic wastewater, is flushed into a sewer system, with an option of using low flush pedestals to reduce the amount of water that is flushed. The internal sewer network is laid at a shallow depth (1 – 1.5m) with a flatter gradient, within the property of homeowners rather than in the street reserve. Householders accept responsibility for maintaining the sewers that run through their properties, and are supported by making accessible pipe clearing rods which people are trained to use when required.

The bulk sewers are as for conventional sewer systems, and the treatment of the wastes is as for conventional sewerage.

2. Operational and institutional requirements

The conventional waterborne system with shallow sewerage requires a reliable and uninterrupted household water connection. The sewer lines can, however, be laid out in a less formal or spatially regular pattern, and are thus suitable for less formal or more dense settlements.

Less stringent design criteria may be applied, but organised and effective operation and maintenance capacity within the community is required. This can be delegated to residents for the on-site portion of the sewers. Significant user education and acceptance of shared management of the system is critical

Skilled, organised and effective operation and maintenance capability is required for the functioning of the bulk sewers and the wastewater treatment facilities.

3. Costs

Capital: R 5,000 to R 9,000 per household -savings of up to 50% over conventional sewerage capital costs.

Maintenance: R 150 – R 200 per household per annum, assuming that all on-site (block sewer) maintenance is undertaken by the households themselves.

Operating: R 150 – R 300 per household per annum (depending on the complexity of the treatment facility and any pump station requirements.

4. Experience and Comment

The system has not been used widely in South Africa although it has been applied, with reported success, under a wide range of conditions in a number of South American countries, Ghana, Pakistan and Greece.

Pilot projects have been completed in Gauteng, Durban and Free State, with ongoing monitoring to determine overall success and sustainability. These currently indicate savings of up to 50% over conventional sewerage capital costs.

5. O&M requirements and responsibilities

5.1. On-site components (usually responsibility of household)

Communities and households are responsible for the:

- repair/ replacement of damaged/worn out on-site components
- operation and maintenance of mid-block collector sewers and associated access chambers, to agreed household/ community boundary.

5.2. Off-site components (usually responsibility of the local authority)

The local authority is responsible for the management arrangements for:

- O&M of bulk sewer system and internal sewers from agreed community boundary.
- leak and blockage detection/monitoring
- emergency contingencies
- cost recovery
- user education
- health and hygiene promotion

6. Other institutional considerations

The following questions need to be answered to understand the institutional challenges involved with operating this technical option:

- Is there the necessary household water connection?
- Is the water supply reliable at all times?
- Is there an agreed allocation of responsibility shared between householder and local authority?
- Is access to sufficient sewage treatment capacity available?
- Is sufficient capacity available in terms of human resources and skills to operate and maintain the system?

7. Upgrading Options

The full flush toilet with shallow sewers can be upgraded as follows:

7.1 Conversion to conventional sewerage system

In this case the existing shallow mid-block sewers would be removed or discarded, and all wastes will be transported in a conventional sewer network outside of the property boundaries. The municipality would then take full responsibility for the maintenance of the sewer network.

6. NOTE ON PROPRIETARY (COMMERCIAL) SANITATION SYSTEMS

A number of commercial sanitation systems have been developed and are offered as solutions to household sanitation challenges. These generally fall within one of the types of sanitation systems described in section 5 above. Many of these are of a good design and are fully acceptable systems, meeting the requirements of the specific type of technology. The factory assembly of these units ensures consistency of the units, ensuring they meet the design requirements of the particular type of sanitation system.

The precautions that need to be taken when adopting a commercial system is that it is to ensure that it is the most appropriate solution for the particular application, and that it has been tested within the environment for which it is proposed for use.

Although commercial proprietary systems may result in less local employment creation during the implementation of a project, they may be preferred by residents due to their appearance and functional characteristics, and hence should not be set aside on the basis of reduced employment creation only. In many cases commercial enterprises are able to set up manufacturing yards within the district where the projects are to be implemented provided a sufficient number of units are to be ordered. This will result in local longer-term job creation at those sites.

It is recommended that all commercial unit suppliers ensure that their units have been certified by the Agremont Board for “fitness for use” for the particular application they are intended. Agremont are located at the CSIR in Pretoria.

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