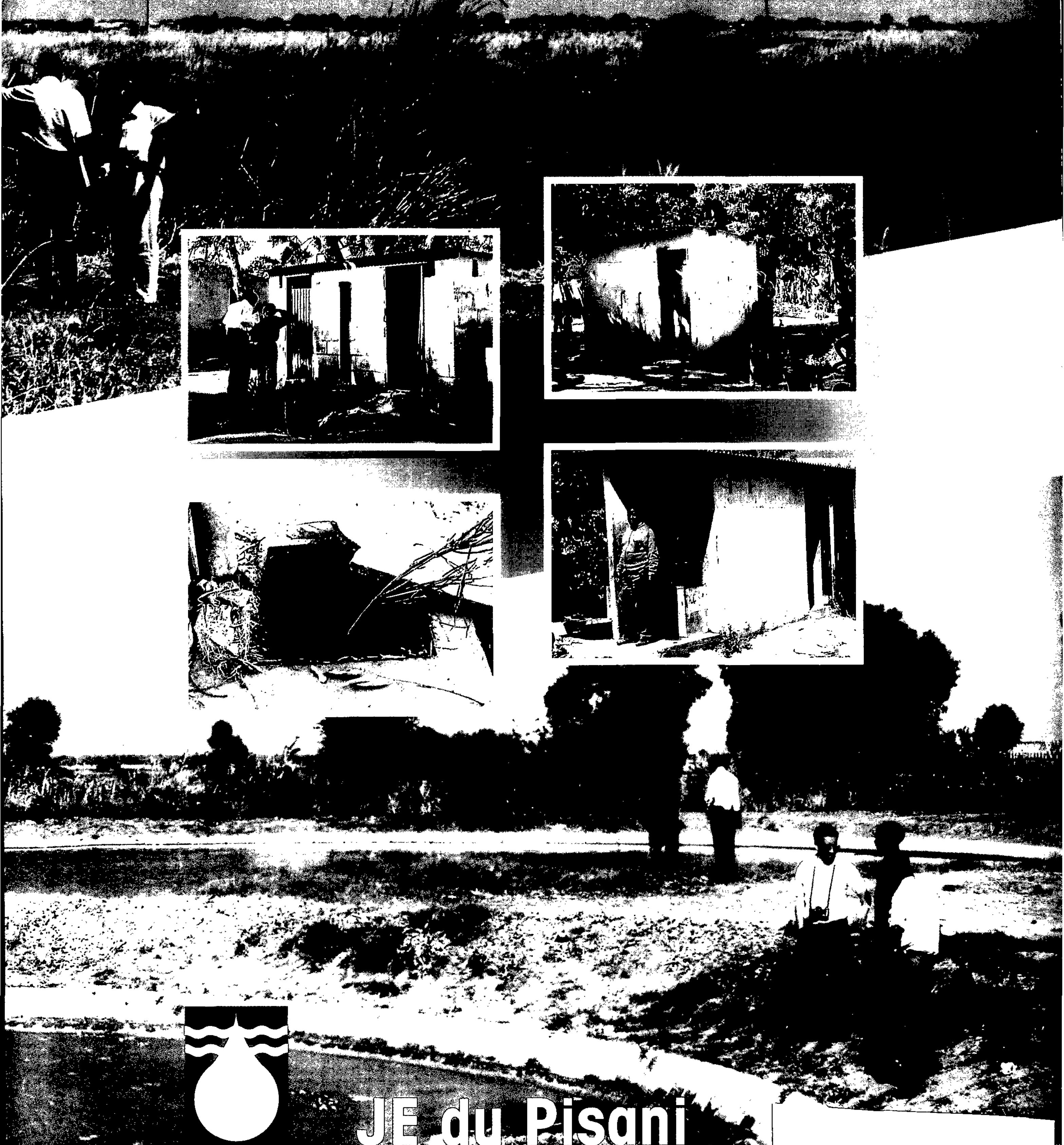
Operation and Maintenance of Solids-Free Sewer (SFS) Systems in South Africa:

GUIDELINES FOR ENGINEERS



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OPERATION AND MAINTENANCE OF SOLIDS-FREE SEWER (SFS) SYSTEMS IN SOUTH AFRICA: GUIDELINES FOR ENGINEERS

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This report forms the second in a set of three documents prepared for the Water Research Commission under Project K5/708: *Guidelines for the Operation and Maintenance of Septic Tank Effluent Drainage Systems by Communities in South Africa.* The full set of documents comprises:

1.	**The Operation and Maintenance of Settled Sewerage (SS) Systems in South Africa:** *Research Report*	The research findings are set out in this document, which includes, as Annexures A and B, reports on the field inspections carried out under the project.
3.	**Operation and Maintenance of Solids-free Sewer Systems in South Africa**: *Guidelines for Engineers*	Document provides background information on solids-free sewer systems and guidelines for operation and maintenance. Includes the requirements for an operation and maintenance manual.
2.	**Solids-free Sewer Systems in South Africa:** *A Community Leader's Guide*	A 16 page graphic document, using simple language, providing information on solids-free sewer systems.

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GLOSSARY OF TERMS

Ablution unit	A room or a building housing toilets, and/or baths or showers.
Access eye	An access hole at a bend in a drain pipe, ordinarily covered by a metal plate wedged or bolted over it, which enables the pipe to be rodded (see *rodding*) (Scott & Smith, 1980).
Access chamber	A chamber constructed in the sewer line allowing for access of a person. Also termed *manhole.*
Anaerobiosis	Life in the absence of free or dissolved oxygen, typically resulting in the production of methane, ammonia, nitrogen, hydrogen sulphide and carbon dioxide (Scott & Smith, 1980).
Anal cleansing material	Material used to clean excreta off the anal area after defecating, eg: toilet paper, maize cobs, stones, newspaper, leaves, sand, water, etc.
Aqua-privy	A sanitation system which does not need a p-trap, but rather uses a section of pipe to connect the toilet to a septic tank, usually positioned beneath the ablution unit. The pipe extends below the water level in the septic tank, thus providing a seal against odours and ingress of insects.
Attenuate	Reduce the intensity or rate of flow.
Bacteria	Single-celled microscopic organisms that multiply rapidly by splitting in two. They are fundamental to the purification of sewage in sludge digestion. Some cause illness in man (Scott & Smith, 1980).
Blackwater	Water from flush toilet bowls, so called to distinguish it from sullage or "greywater" (Scott & Smith, 1980).
BOD	Biochemical oxygen demand. A measure of the amount of pollution by organic substances in water. It is expressed as the number of milligrams of oxygen per litre of water required by the micro-organisms to oxidise the organics. (Scott & Smith, 1980)
CED	Common effluent drain. Solids-free sewers in Australia.
Cistern	A tank containing water. When related to toilets the cistern is a small tank, containing about 9 to 13 ℓ which discharges into the toilet bowl.
Cleaning eye	See *access eye.*
Cleanouts	See *access eye.*

GLOSSARY CONTINUED

COD	Chemical oxygen demand. A measure of the amount of pollution by both organic and inorganic substances in water. It is expressed as the number of milligrams of oxygen per litre of water required by the micro-organisms to oxidise the organics plus the amount of oxygen required for chemical oxidation of inorganic substances (Scott & Smith, 1980).
Communal drainfield	A soakaway serving several homes (i.e. a community) and septic tanks.
Construction tolerance	The deviation allowed from the design levels, positions or size. When the tolerances are exceeded the work may be rejected.
Corrosion	Attack on the surface of materials. In water or sewage there are three main causes : (1) scouring, (2) presence of dissimilar metals close to each other, (3) chemical or biochemical attack (Scott & Smith, 1980).
Curvilinear	In a curved line. The use of the term implies that sharp changes in direction are excluded.
Densification	The process of increasing the number of residents per square metre of land.
Design criteria	The accepted minimum standards of performance assumed during design. These standards have developed over time by observation of systems that work well, or as the result of experimentation.
Digested sludge	Sewage sludge which has undergone anaerobic digestion or passed through an aerobic digester should have a fibrous structure and a peaty smell, which is not unpleasant, unlike raw sludge, but may still contain organisms that cause disease (Scott & Smith, 1980).
Effluent	That which flows out.
Erf	Proclaimed property with a single or corporate owner.
Excreta	Solid and liquid waste matter excreted from the bodies of humans and other animal species.
Faeces	Solid waste matter from the human body. Also see *excreta.*
Greywater	Water from basins, baths and sinks. Excludes water from flush toilets.
HDPE	High density polyethylene.
Hydraulic head	The energy in water that enables it to do mechanical work. It is the sum of (1) elevation head (i.e. physical height), (2) pressure head (i.e. the height to which a static column of water can be carried by pressure at that point), (3) velocity head (i.e. the energy due to the movement of the water) (Scott & Smith, 1980).
Hygiene	The science and practice of keeping the person and the environment clean.

GLOSSARY CONTINUED

Level	The vertical position above a given datum.
Level of service	The comfort, convenience and cost-effectiveness provided.
Liquor	Liquid, comprising mostly water, in sewage treatment.
Maintenance	The actions required to reinstate a system that is malfunctioning, and the actions required to prevent malfunctioning.
Manhole	A chamber installed over a sewer to provide access. Large enough to accommodate a man.
Operation	The actions required on a continuous basis for a system to function.
Peak flow	The highest flow rate.
Primary treatment	The sedimentation in sewage treatment that releases the top water for biological treatment and removes organic solids as sludge.
Raw sewage conveyance systems	Sewers which convey solids such as faeces and paper, as well as liquids. The solids float in the liquid, or are forced down the sewer by the momentum of the liquid.
Retention period	The time during which sewage is kept in a tank, so as to enable it to undergo treatment. Theoretical retention time is the volume of the tank divided by the flow through it. The actual time may be considerably less, because of poor distribution or flow.
Reticulation	The network of pipes, usually referring to water supply pipes or sewage conveyance pipes.
Rodding	Clearing blockage by inserting steel rods into the sewer.
Sanitation	The science and practice of removing harmful substances from the environment, and/or treating them to render them harmless before releasing them into the environment. Refers particularly to removal and treatment of excreta.
Scouring velocity	Self-cleansing velocity. The rate of flow at which all solids are taken into suspension and the pipe is left clear of material.
Scum	Any material that floats on top of still water (Scott & Smith, 1980).
SDGS	Small-diameter gravity sewers. Solids-free sewers flowing only with gravity. An American term.
Septic tank	A tank in which anaerobic digestion takes place.
Service lateral	Sewer serving an individual property, connecting the septic tank to the collector sewer.

GLOSSARY CONTINUED

Sewer	A buried pipe that leads wastewater away for treatment and disposal (Scott & Smith, 1980).
Sewerage	A network of sewers (Scott & Smith, 1980).
Skilled work	Work requiring a knowledge of the materials and techniques to be used, and entailing training in these techniques.
Sludge	Solids settled out from water, but still containing 55% to 99% water (Scott & Smith, 1980).
Soakaway	A hole in the ground for disposal of rainwater, sullage or treated sewage effluent (Scott & Smith, 1980).
STEP	Septic tank effluent pumping system. Solids-free sewers operating under pressure supplied by pumping units.
Straightness	Lack of deviation from a straight line.
Sullage	Water from baths, wash-basins and sinks. Also termed greywater.
Surcharge	Put under pressure. A surcharge chamber is a tank which stores water until sufficient has been accumulated so that the pipes downstream will flow under pressure when the water is released into them.
Toilet	The unit which forms the seat. Squatting plates are included in this definition. In flush systems the toilet will also have a bowl as receptacle for excreta and urine. During flushing the bowl is emptied.
Uphill	From a lower to a higher geographical elevation.
uPVC	Unplasticised polyvinyl chloride.
Vent pipe	A pipe allowing escape of gases from a sewer or drain pipe, a pit or a tank. The vent pipe usually rises above the roof so that odours are dispersed by the wind.
VGS	Variable grade sewers. Solids-free sewers with sections flowing "uphill". An American term.

1. INTRODUCTION

1.1 Description of Solids-free Sewer Systems

A ***solids-free sewer*** (SFS) system is a system of effluent conveyance which uses an on-site tank to settle solids out of the sewage, and conveys the liquid effluent only to a central treatment and/or disposal point by means of a sewer network (sewerage). The liquid transported in the sewers is termed ***settled sewage.*** The solids remain in the tank, where they are acted upon by anaerobic bacteria and converted to carbon dioxide, ammonia, water and a residue, termed sludge. The volume of sludge accumulates in the tank and must be removed, usually by vacuum tanker, and transported to the treatment works.

SS systems have the following elements :

- A flush toilet, using either pour flush, sullage flush or cistern flush.
- An on-site container (septic tank) which receives flush water and human wastes from the toilet, and often sullage (kitchen and bath wastewater) as well. The addition of water is essential. The function of the tank is primarily to provide settlement of the solids in the toilet effluent, but a measure of anaerobic microbiological activity is also commonly required since this significantly reduces solids volume. When the liquid effluent portions are disposed of in drainfields located on the property, the system is termed a septic tank and drainfield system and is not classed as a ***solids-free sewer*** system.
- A mechanism for removing the sludge from the tank at periodic intervals.
- Sewers which convey only the liquid portion of the sewage from the tanks to a communal drainfield or treatment facility.

A diagram of an SS system is given in Figure 1.

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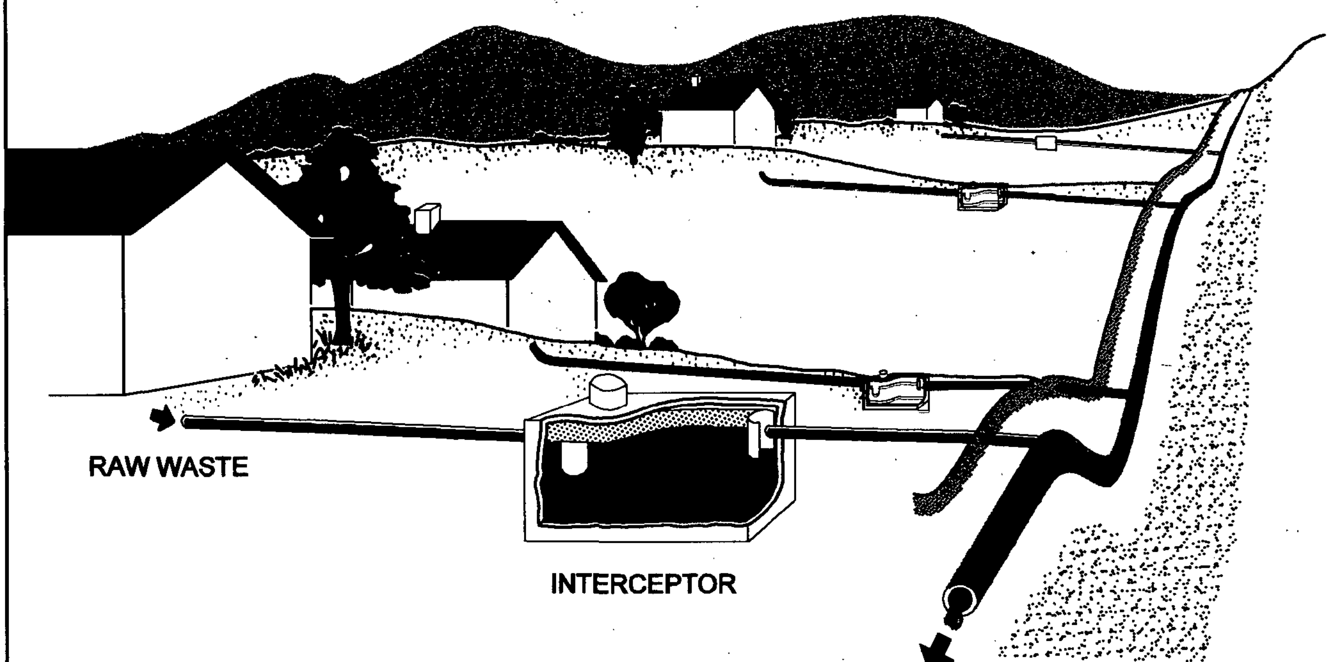

SOLIDS-FREE SEWER SYSTEMS

FIGURE 1

1.2 Advantages of Solids-free Sewer Systems

The advantages of SS systems are a direct function of the solids-free nature of the effluent transported in the sewers. The use of a settling tank on the property, however, also gives rise to the most costly aspect of the technology, due both to the capital cost of the tanks and to the operation and maintenance requirement that tanks be emptied at intervals.

The advantages resulting from having the tank on the property are:

- As solids do not have to be moved a great distance, low flush volumes can be used. The lower daily water consumption results in the use of smaller water reticulation pipes.
- Inappropriate anal cleansing materials or rubble and plastic dumped into the system are intercepted by the tank. Blockages due to these materials occur primarily in the tanks and directly affect the person who has caused the blockage. This situation can be used as an opportunity to educate the community.
- Where there are existing septic or conservancy tanks, considerable savings relative to conventional sewerage can be realised by using an SS system.
- Flow attenuation is provided by the tanks, resulting in a lower peak in the sewers and consequently smaller pipe diameters and pumps.
- Due to settlement digestion in the tank, smaller sewage works and simpler treatment processes can be utilized.
- Pumps do not require solids-handling capacity.

The advantages resulting from solids-free sewers are:

- Pipes can be sized according to hydraulic principles and designed to flow full, allowing for smaller pipes.
- As there is no transportation of solids, velocities can be lower.
- Slopes can be flatter due to the lower velocity requirements.
- Sections where flow is due to pressure head (as opposed to gravity) can be used.
- Horizontal alignment can be curvilinear.
- Manholes are not required, and are in fact not favoured, since they provide an entry point for soil, rubble, surface runoff and root intrusion.
- Construction is simpler and more rapid since horizontal and vertical tolerances are greater.

The cost advantages of SFS systems include the:

- Use of smaller diameter pipes, which reduces material costs.
- Reduction of excavation due to flatter gradients.
- Potential for deviating around obstacles rather than removing them.
- Exclusion of manholes.

- Reduction in operation and maintenance frequency and actions required
- Reduction in the size and complexity of the treatment works.
- Use of smaller, liquids-handling, pumps.
- Reduction in water use.
- Reduction in water reticulation size.
- Low operation and maintenance costs.

Solids-free sewer systems are particularly well suited to use where:

- Slopes are flat.
- Erf frontages are long.
- There is shallow rock; and/or
- There are existing septic or conservancy tank systems.

1.3 Health and Hygiene

Solids-free sewer systems meet hygiene, health and environmental criteria since

- A flush system must be used, thereby allowing for the use of a waterseal, which provides an effective barrier between excreta and the user. The flushing also makes the toilet easier to keep clean and limits odours, encouraging use.
- The waterseal and watertight septic tank and sewer network prevent conditions conducive to the breeding of vermin and contamination of the environment.
- Good lighting can be provided in the ablution unit without fear of attracting flies, making it more attractive for use.
- The ablution unit can be included in the house, making it more pleasant to use, particularly at night and in cold weather.

2. INSTITUTIONAL ASPECTS

2.1 Community Participation

The community should be involved in

- **The choice of a solids-free sewer system.** The acceptance of the system by the community is particularly important in the case of solids-free sewer systems because the on-site septic tank is highly accessible to individuals, and therefore particularly susceptible to misuse, vandalism or sabotage. Since the effective operation of the tank is essential to the effective operation of the sewerage system and the treatment works, vandalism, abuse or sabotage will have far-reaching cost implications.
- **Determining the affordability of the system.** Where communities cannot afford to have tanks desludged, local health hazards and/or blockages downstream can result.
- **The choice of fittings and fixtures.** Solids-free sewer systems allow for as great a range of fittings and fixtures as raw sewage conveyance systems, and the choices should be made available, albeit at a cost to the homeowner.
- **The location of the ablution unit.** As flush toilets are required for effective functioning of the septic tank, it is possible to provide ablution units attached to the house, and this choice should be offered, albeit at a cost to the homeowner.
- **The location of the septic tank.** The tanks should ideally be close to vehicle access, and sited to suit slopes from the ablution unit to the collector sewer. However, since the position of the tank can affect the development of the erf, the homeowner should have an input regarding the siting of the tank within these limitations.

2.2 Organizational Arrangements

The requirements for operating and maintaining a solids-free sewer system depend on the size of the system. Small systems may require only a maintenance man and a treasurer, both part-time.

The functions of the treasurer in relation to the operation and maintenance of solids-free sewer systems are to:

- determine the rates and tariffs payable by the residents for operation and maintenance, based on the costs of delivering these services and local government guidelines
- issue accounts and collect payments from homeowners
- disburse sums for equipment, fuel, salaries and other costs, and

- keep a set of accounts of income and expenditure and to render these to the council, the auditor-general and/or the homeowners, as required.

In smaller communities the maintenance department may be staffed by one part-time maintenance person, assisted where necessary by casual unskilled labourers. The maintenance person should be literate and numerate, have some basic plumbing skills and, where a vehicle is to be used to transport equipment, have a driver's licence. In larger local authorities the maintenance division may employ drivers, engineers, trained technicians, plumbers, unskilled labour, etc. Personnel who will be responsible for dealing directly with the public should have good communication skills.

The functions of the maintenance department are to:

- deal with blockages and other problems in septic tanks and sewer pipelines
- inspect and monitor the operation of the septic tanks, sewers, pump-stations, attenuation and surcharge tanks, treatment works, etc.
- monitor sludge levels in the septic tanks
- inspect construction of new tanks, new connections, etc.
- maintain records of all callouts, causes of problems and work executed
- maintain files on each property, pump-station, surcharge and attenuation chambers and the treatment works, and
- do, or arrange for, the desludging of tanks.

Where the local authority operates the sewage tanker used for desludging the septic tanks, the function of the driver is usually separate from that of the maintenance person. The driver may require an unskilled assistant where tank covers are heavy, long sections of hose are required, etc.

2.3 The Responsibility of the Local Authority

Several models of responsibility for various elements of the solids-free sewer system are in use, as shown in Table 1. Models 1 and 2 accept the financial responsibility of the homeowner to pay for construction of the system, while models 3 and 4 accept that the capital costs are financed or subsidized by government or by cross-subsidization within the local authority. All models accept the financial responsibility of the user to pay for operation and maintenance, usually through monthly rates.

In models 1 and 3 the responsibility for implementing operation and maintenance of all elements of the system that are not in common use (e.g. ablution unit, drains, septic tank, and service lateral) lies with the homeowner. Responsibility for implementing operation and maintenance actions for all elements in common use (e.g. collector sewers, outfall sewers, pump-stations, rising mains and treatment works) is the responsibility of the local authority. Models 2 and 4 allocate the responsibility for implementing operation and maintenance of the septic tank to the local authority.

Models 2 and 4 are the recommended models, since effective operation of the septic tanks is essential to the successful operation of solids-free sewer systems.

Table 1 : Models of responsibility for elements in SFS systems

Activity / Item	Responsibility			
	Model 1	Model 2	Model 3	Model 4
Supply and install - Pipework from house to tank	User	User	User	Local authority
Supply and install - Tank	User	User	Local authority / govt subsidy	Local authority / govt subsidy
Supply and install - Pipework from tank to collector main	User	User	Local authority / govt subsidy	Local authority / govt subsidy
Operate and maintain all pipework on erf	User	User	User	Local authority
Operate and maintain tank	User	Local authority	User	Local authority
Bear costs of clearing all blockages in pipework on erf	User	User	User	User
Bear costs of clearing tank blockages	User	Local authority	User	Local authority
Arrange for and bear cost of emptying the tank	User	Local Authority	User	Local authority
Pay cost of installation of collector mains	User (proportionately)	User (proportionately)	Local authority / govt subsidy	Local authority / govt subsidy
Pay monthly amount to cover the operation and maintenance cost of collector sewers and treatment works	User	User	User	User
Execute operation and maintenance of collector sewers	Local authority	Local authority	Local authority	Local authority
Operate and maintain treatment works	Local authority	Local authority	Local authority	Local authority

2.4 Financing Operation and Maintenance

In terms of the National Policy on Sanitation (draft White Paper, June 1996), the user must pay for operation and maintenance. Where the user cannot afford this, a lifeline tariff will be applicable for the basic minimum level of service.

Rates applied should be calculated to cover the costs of:

- personnel employed, including the sewage tanker driver
- purchase of and repairs to equipment, including an allowance for depreciation
- purchasing the sewage tanker
- fuel, servicing, parts and maintenance of the sewage tanker and attached suction pump
- pipes, fittings and fixtures required for replacement, repairs and maintenance
- depreciation of the system and the septic tanks, to allow for eventual replacement at the end of the design life
- operation, maintenance, repairs and depreciation of the treatment works or ponds
- electricity or fuel costs for running of plant and equipment at the treatment works
- operation, servicing, parts, maintenance, repairs and depreciation of equipment in the pump-station
- electricity or fuel costs for running the pumps
- ongoing education and training, and
- overhead costs (e.g. treasury, secretariat).

2.5 Education and Training

The SFS system must be well understood, particularly the manner in which it differs from systems with which users are familiar. Good user education is therefore a vital aspect of the SFS system, as it is for raw water conveyance systems. Users and operators should also be informed of where the responsibility for operation and maintenance lies, and what the cost recovery mechanism is. The education needs identified during discussions with both the users and the operating personnel include:

- health and hygiene
- sanitation technologies and SFS system components / technology
- costs of services
- operation and maintenance of SFS system
- trouble-shooting
- responsibility for components of the system.

3. DESIGN GUIDELINES FOR SIMPLIFIED OPERATION AND MAINTENANCE

3.1 Ablution Unit, Toilet and Drains

The design options available should allow the homeowner as much choice as possible with respect to the size, finishes, fixtures and fittings and siting, albeit at a cost to the homeowner.

All flush toilet types are suitable for use with solids-free sewer systems, with the exception of 750 mℓ and 1 ℓ flush systems. Current research (Batchelor, 1997) indicates that bacterial activity in the tank is severely limited with the latter volumes, and further research is needed to determine whether the addition of sullage water makes the use of these systems more viable. Consideration should be given to providing a waterseal in the toilets, although toilets that do not include a waterseal can be used.

3.2 Septic Tank

Septic tank design should be in terms of conventional standards (De Villiers, 1987) and should also include:

- A baffled inlet and a suitable length-to-depth ratio to assure quiescent conditions to allow for settling out of solids.
- A baffled outlet to prevent entry of solids into the sewers. Where a tee-piece is used, a minimum of eight openings, with a minimum diameter of 12 mm each, should be provided in the vertical leg of the tee to allow for movement of liquid from the tank to the outlet since the bottom of the vertical leg can easily become blocked by floating matter.
- Inspection ports above both inlet and outlet.
- Access for the suction hose during desludging operations.
- A manhole, or preferably a removable section of slab, to allow access into the tank for repair work.
- Nearby vehicular access, to allow for desludging.
- A cap on top of the inlet tee-piece to prevent odours entering the ablution unit via the drains.

One-chamber tanks have been used very successfully in most septic-tank schemes both internationally and in South Africa. Two-chamber tanks will, however, reduce the potential for blockages of the outlet tee-piece and provide a safety barrier against entry of solids into the line.

3.3 Service Laterals, Sewers and Appurtenant Structures

The service laterals, which run from the septic tank to the common collection sewers, represent the first line ot defence against solids entering the sewers. It is recommended that:

- the service laterals should be of smaller diameter than the collector sewers, since solids that can pass through the smaller pipes will be less likely to block the larger pipes
- cleaning eyes be provided at all bends in the service lateral, and at the junction with the collector sewer
- consideration be given to providing a small trap with an inspection cover upstream of the junction between the service lateral and the collector sewer, to intercept solids that may have entered the sewer, and
- consideration be given to installing a "sieve", with a minimum of eight openings of at least 12 mm diameter, in the service lateral directly upstream of its junction with the collector sewer and directly downstream of the solids trap.

Recommendations in respect of design standards which will ensure simplified maintenance on the collector and outfall sewers are:

- Manholes should be excluded as far as possible, since they provide entry points for surface runoff, rubble, soil and roots, and are not necessary for the maintenance of the sewers.
- Access to the sewers should be provided via cleaning eyes, provided at all bends and junctions. The latter should be sealed and buried.
- Consideration should be given to installing solids traps at various points in the sewers to intercept solids that may enter the lines.
- Consideration should be given to providing surcharge chambers to ensure minimum scouring velocities in sections with low flow, or where sections operating under pressure head are used.
- Consideration should be given to installing flushing chambers in line, which can be filled with water and used to flush to lines at will.
- All manholes, pits, chambers, pipework and fittings should be protected against the highly corrosive septic environment.
- All manholes, septic tanks, chambers and cleaning eyes should be sealed against the escape of odorous gases.
- Consideration should be given to providing monitoring points in the network, which may comprise a section of clear pipe in a chamber, allowing a visual inspection of flow conditions in a section. Sampling points for abstraction of liquid should also be provided.

Trouble-free operation of the solids-free sewer system is dependent on good quality control during construction, which requires the preparation of clear specifications setting out tolerances and suitable test methods for the construction of the sewers, as well as adequate (preferably full-time) site supervision.

4. OPERATION AND MAINTENANCE REQUIREMENTS OF THE SOLIDS-FREE SEWER SYSTEM

The operation and maintenance requirements of solids-free sewer systems have been found to be generally less costly and less extensive than those of raw sewage conveyance systems.

4.1 Ablution Unit, Toilet and Drains

The maintenance of the ablution unit, toilet and drain from the toilet to the septic tank is the responsibility of the homeowner. However, if training is not provided in the basic actions required and in problem-solving techniques, the local authority may find that it has numerous call-outs relating to these aspects. A monthly inspection of toilets in the first year, with a reduction to quarterly and then annual inspection, may obviate many call-outs and reduce the cost to the local authority.

Typical operation and maintenance requirements of these elements are:

- **Flushing of the toilet after each use.** If this is not done the toilet may block. Furthermore, reduced flushing frequency may result in insufficient water entering the tank for effective operation as a settling unit or as a primary digester.
- **Cleaning of the toilet** (and in the case of aqua-privies, the downpipe) when it becomes soiled. Failure to do this will increase the risk of disease and make the unit unpleasant to use, leading to a return to defecating outdoors.
- **Clearing of blockages in the toilet, bath or kitchen sink.** These may be due to blockages in the p-trap or downpipe, drains or septic tank. Standard plumbing equipment such as rods and plungers are used to either force the matter causing the blockage forward to a point where it can be removed, or to break it up so that it can be flushed into the tank.
- **Clearing of blockages in the drains or the septic tank inlet tee-piece**. Again standard plumbing equipment and procedures are used. Should blockages be due to fat, consideration should be given to installing a fat-trap. Entry of fat and grease into the solids-free sewers will have far-reaching maintenance implications since flushing of the sewers may not remove the accumulated fat deposits in the pipes.

4.2 Septic Tank

Effective operation of solids-free sewer system depends on timeous desludging of the septic tanks. This should be done before the sludge has accumulated to the level of the bottom of the outlet tee-piece, at which stage the whole septic tank should be emptied, flushed out and inspected for structural integrity. Any repairs required should be made before the tank is put into use again. It is recommended that the septic tank be refilled with water up to the outlet tee-piece before it is put back into use, since this:

- ensures sufficient water for immediate recommencement of biological activity, particularly in low-volume flush systems;
- ensures that there is adequate water for settling out of solids; and
- serves an educational purpose for both users and operators, since many do not grasp the concept that the normal operating level is at the outlet level, and may request the tank to be emptied unnecessarily.

Other tasks relating to the operation and maintenance of the septic tanks are:

- Monitoring of sludge levels in the tanks (initially recommended at six-month intervals until the behaviour of the tanks under local conditions is established, thereafter at annual intervals). Institutional users, particularly hotels, fast-food outlets, service stations, etc., should be initially monitored monthly.
- Monitoring of the condition of tanks and tank covers.
- Monitoring for infiltration through the tanks and tank covers.
- Monitoring for materials (e.g. plastics) that may block the outlet, as well as for build-up of fatty deposits on the sieve protecting the outlet.
- Inspection and approval of new tanks under construction.
- Monitoring pre-fabricated tanks for deformation or collapse, and ensuring proper fitting of manhole covers in such tanks.

4.3 Service Laterals, Sewers and Appurtenant Structures

Operation and maintenance activities required on service laterals, collector and outfall sewers are the monitoring of:

- sections of sewer for, and dealing with, blockages
- solids-traps for accumulated matter
- sludge levels in attenuation and surcharge chambers

- slime build-up in the lines, particularly in smaller lines with low flows, and annual flushing of drains to remove slimes, and
- manholes for rubble, grit or root intrusion and desludging of manholes, solids-traps, attenuation and surcharge chambers.

4.4 Pump-stations

Operation and maintenance actions at pump-stations are as for raw sewage pump-stations, and usually require a fully detailed manual dealing with individual elements. The same process should be followed for solids-free sewage pump-stations, although actions relating to clearing of grit screens and blockages caused by solids are not required. Additional actions required for solids-free sewage pump-stations are:

- monitoring for solids in the sump
- monitoring of the sludge level in the sump, and desludging of the sump if necessary
- monitoring for corrosion of fittings, fixtures and pumps, and
- monitoring for odour and dealing with odour problems.

The operation and maintenance of pump-stations requires skilled personnel trained in the specific equipment in the pump-station. Smaller local authorities may choose to use local electrical contractors to deal with operation and maintenance of the switching and electrical works in the pump-station, and local pump suppliers to deal with the pumps.

4.5 Treatment Works

Operation and maintenance at treatment works and ponds should be dealt with as for raw sewage works, and usually requires a fully detailed manual dealing with individual elements. Actions relating to clearing of grit channels and trash screens, which are daily operation tasks for raw sewage pump-stations, are not required in solids-free sewage pump-stations.

The operation and maintenance of sophisticated treatment works requires skilled personnel trained in the processes and equipment used in the works. Smaller local authorities may choose to use consultants, local electrical and mechanical contractors and/or chemical laboratories to deal with specific aspects of operation and maintenance at the works. Pond systems are generally much simpler, and can be run with very little attention by a suitably trained worker.

5. PREPARATION OF AN OPERATION AND MAINTENANCE MANUAL FOR THE SOLIDS-FREE SEWER SYSTEM

Although no South African solids-free sewer schemes have an operation and maintenance manual, it is strongly recommended that one be prepared, particularly in view of the problems encountered in Zambian systems, where all knowledge of the system, the technology and the operation and maintenance requirements has been lost with successive staff changes. This section, based on the United States Environmental Protection Agency manual *Alternative Wastewater Collection Systems* (Browne et al, 1991), provides guidelines for the contents of such a manual.

The manual should provide a quick and portable reference for operation and maintenance personnel in the field, as well as a comprehensive summary for office personnel. The format should therefore be no larger than A3, but preferably A4. The Manual should not include background information or information on techniques unless these differ from standard practice, since it is not intended to be a training manual.

As the Manual is intended for use by communities, it is recommended that simplified technical drawing conventions be used where drawings are required, and that suitable training in reading and understanding the drawings be provided to the relevant community member responsible for operation and maintenance.

5.1 System Description

The system description should be placed at the front of the manual and include a layout of the system, with all elements numbered. Where operation and maintenance is to be done by the community a graphic representation of the element (e.g. a pump-station with an illustration of a pump, etc.) should be used. A list and description of the elements should be given on the page facing the chart, with the graphic repeated next to the description.

A more detailed description, with suitable drawings and details of each component (pipes, pumps, septic tanks, chambers, manholes, cleaning eyes, etc.) should follow, covering:

- functions
- limitations
- a description of normal operation
- typical performance characteristics

- the influence of adjacent components on the performance of the component under discussion
- the influence of the component on adjacent components
- design data (slope, flow volume, electrical rate, volumes, levels, etc.)
- drawings of the component, or standard detail drawings where applicable
- a plan showing the location or route of the component
- shop drawings (where relevant)
- profiles (alternatively slope, diameter, flow volumes, etc., can be shown on the layout), and
- a detailed drawing of the location of the element relative to the service marker.

5.2 Process Description of Normal Operation of the System

This section should contain a broad description of the criteria which determine normal operation. Suitable sensory (visual, odours) indicators of normal operation and typical problems should be described, e.g. give the anticipated range of flow depths in a section of pipe, or explain that the septic tank will always be full of liquid.

5.3 System Testing, Inspection and Monitoring

This section should cover the purpose of the tests, inspections and monitoring, with descriptions of the manner in which they are to be executed, as well as the skills required. A schedule of testing, inspections and monitoring (daily, weekly, monthly, quarterly), should be provided.

5.4 Typical Problems and Problem Identification

A flow chart for problem identification, based on the disruption or malfunction which is evident, must be provided, with suitable solutions. Where non-standard solution procedures are called for, the techniques required should be described.

5.5 Safety

General safety practices should be described, with appropriate protective wear and equipment specified. The health dangers of seepage and sewage, as well the dangers of gases such as hydrogen sulphide and methane, should be explained. Actions to be taken in the event of mishaps should be detailed. This section should be located at the back of the manual for easy access in emergencies.

5.6 Skills and Training Requirements for O&M Personnel

A short section listing the personnel required for efficient operation of the system, with abbreviated job descriptions, skills and training requirements, should be provided. This section should specifically be tailored to suit the organizational structure of the relevant local authority.

5.7 Equipment Requirements

A list of all equipment and plant requirements for operation and maintenance is required, with shop drawings, manuals for use and maintenance schedules tasks. Basic items such as spades, picks and protective clothing should be included.

This section should include a suggested list of spare parts to be kept in stock.

5.8 Monitoring and Record Sheets

Sheets for recording monitoring, inspection and testing activities, as well as for recording maintenance tasks, should be included in the manual. In this way it can be ensured that necessary information is recorded in a format that allows for easy interpretation and tracking of repetitive problems.

5.9 Costs

The manual should provide a method for determining the cost of operation and maintenance and for calculating the rates required for cost recovery. The methods and items should suit the organizational structure of the specific local authority. A schedule of predicted plant and material replacement costs at the end of the design life should also be included.

5.10 Useful Contact Numbers

The following numbers should be provided on the cover of the manual :

- emergency service
- pump manufacturer / supplier
- electrical equipment supplier
- chemical testing laboratory
- septic tank manufacturer / supplier
- works contractor

- works superintendent
- sewage tanker contractor / supervisor
- mayor
- town engineer.

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