A Study into the Provision of Sustainable Toilets in Remote Rural Locations

Submitted to

Forth Valley and Lomond LEADER Local Action Group
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Scottish Natural Heritage
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The Scottish Government

LEADER
FORTH VALLEY & LOMOND

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1. Introduction

Living Water was commissioned in January 2010 to prepare a report on the provision of sustainable toilets in remote rural locations for the Forth Valley and Lomond LEADER Local Action Group.

The whole report, including case studies is available on the Forth Valley and Lomond LEADER website: www.fvl.org.uk

The proximity of the rural Forth Valley and Lomond area to urban conurbations and the ever increasing numbers who seek to benefit from the outstanding natural resources of the region put great pressure on the area's visitor management infrastructure.

A significant task is the provision and maintenance of adequate toilet facilities. In rural areas, the usual support infrastructure – from mains water to lighting – is often absent and yet many visitors expect to use standard flush toilet facilities, and also expect that someone else will clear up any mess they make.

The purpose of this study is to research and present a comprehensive range of options for any organisation considering installing a sustainable toilet in a rural area. The study also addresses the wider issues of drainage and disposal.

Case studies review a number of facilities where different toilet systems have been installed and operated over a period of time. We include feedback from staff who have experience of maintaining these systems, and add our own comments.

A glossary of unfamiliar terms is included at the end of the report.

1.1 The importance of effective sanitation

The subject of sanitation tends to be avoided and it is assumed – wrongly - that the industrialised world now manages its waste appropriately. A salutary lesson was hopefully learned in 2003 when faulty plumbing in a Hong Kong apartment block led to a four month outbreak of SARS (Severe Acute Respiratory Syndrome), 8,422 reported cases, 926 deaths, and the spread of SARS to China, Singapore and Canada [R: George, 2008]. Good sanitation can never be taken for granted.

"More than 1 in four people have faecal matter on their hands! Britain's 12 million cases of norovirus, gastroenteritis, MRSA, E-Coli and now Swine Flu infections are mainly down to dirty hands. Wash it off!" (London School of Hygiene and Tropical Medicine).

'Europe's sanitation problem' was addressed at the World Water Week Seminar in Stockholm in August 2008 [R] where it was reported that there are more than 20 million European citizens in rural areas who do not have access to safe sanitation. The World Health Organisation figures indicate that 150 million Europeans use some sort of decentralised sanitation, often without any treatment of the faeces.

"Even in the 21st century, children are still at risk from dying from waste water related diseases in the European Union. The common system of pit latrines, especially in rural Eastern Europe is a cause of groundwater pollution in many villages which depend on wells for drinking water. The unsafe water and sanitation situation adversely affects public health and thus hinders the economic development in the region." (WHO).

"We shall not finally defeat AIDS, tuberculosis, malaria, or any of the other infectious diseases that plague the developing world until we have also won the battle for safe drinking water, sanitation and basic health care." (Kofi Annan, UN Secretary-General).

The relevance and value of this study can be seen set in a worldwide context where there is an urgent need to provide effective and safe sanitation. “Sanitation is first and foremost an issue of basic dignity and human rights.”

1.2 What is a sustainable toilet?

‘Sustainability’ is the capacity to endure without significant degradation. In ecology the concept encapsulates how biological systems remain diverse, productive and functional over time. In the human context, ‘sustainability’ implies the long term maintenance of wellbeing, which in turn depends on the wellbeing of the natural world and the responsible use of natural resources.

The study looks at the practicalities of installing toilets in rural areas and the need for toilets to endure in difficult and sensitive human and natural environments. A sustainable toilet is one that has been designed to endure, to be easy to manage, and to have a minimum impact on the environment.

The human environment includes the unfortunate reality that a fraction of visitors to the countryside will not behave responsibly and a smaller fraction will actively behave irresponsibly and anti-socially. To have any hope of endurance, therefore, public toilet facilities need to be well designed, clean and highly managed.

Water flush toilets are the standard offering that the public finds most comfortable, that contractors and regulatory authorities understand, and know how to manage. This standard then needs to be balanced with the needs of the natural environment: water-based toilets pollute large volumes of clean water which then need to be cleansed before being returned to nature. The nutrients that remain in faeces are wasted and typically released into the atmosphere as greenhouse gases that may also be malodorous.

The design of sustainable toilets and drainage should ensure that waste and wastewater is recovered, treated or disposed of without endangering human health or harming the environment, and in particular without risk to water, air, soils, plants or animals. Toilets should not cause a nuisance through noise or odours and toilet buildings should integrate sympathetically with their surroundings.

Wastewater arising from water-based systems can be treated by wetland plants creating valuable wetland habitat and also be used to grow useful plants and trees for non human consumption, habitat creation and for bio-fuels.

Since each site, location, number of visitors and context will be different, it is necessary to find the most suitable design for a particular site that can achieve as many of the sustainable aims as possible.

This study will help the reader to understand the wider issues, the range of options, and the practical and technical basis on which to make decisions.

2. Summary

This summary serves as an entry point into the study. We note the issues we feel need to be taken into consideration when planning a toilet installation, together with links to sections of the study that explore these issues in greater depth.

Sections of the study referred to for further information are marked as [Section number]. Elements elaborated in the Glossary are marked [G]; References are marked [R].

- **COST AND REALITY CHECK**
- **SITE**
- **BUILDINGS**
- **FOOTFALL**
- **TOILET PROVISION**
- **URINE AND LEACHATE MANAGEMENT**
- **WET TOILETS**
- **DRY TOILETS**
- **REGULATIONS**

COST AND REALITY CHECK

The installation of a toilet may at first sight seem a simple operation. However, when all the issues are taken into account - the expense, the difficulties of managing human waste, public safety, maintenance, and seeking approval from the regulatory authorities – the cost and effort involved can be considerable. For a toilet installation at a public car parking site, a budget of £50,000 (2010 prices) plus significant time and energy seems to us a minimum starting point.

If connection to a mains sewer is possible, this will be obligatory in most cases.

If there are existing toilet facilities that are either inadequate or failing, it is usually cheaper to fix the faults than build anew.

Sometimes older public conveniences may need a new, larger septic tank or mechanical treatment plant to treat the sewage if the number of visitors has increased since the facilities were installed. In other cases, a system that can improve the quality of the discharge, such as a constructed wetland which can provide tertiary treatment quality discharge, will enable existing facilities to remain operational.

Even where a toilet seems a necessity, it is worth considering other options first. Could an arrangement be made with a local hotel or bar to make use of their toilets? [Section 8.1]

At an early stage, it will be necessary to speak with the Planning Authority to determine their position on the proposed toilet facility. The project can only proceed once planning permission is obtained. [Section 9.1].

SITE

- Light
- Warmth
- Ventilation
- Height
- Access
- Surface and ground water

The site should be chosen to maximise the potential for natural illumination and natural heating, through a southern exposure to daylight, and an open setting to promote good ventilation.

Locating the construction on the highest possible point improves the chances of propelling all waste flows by gravity. Whenever possible gravity should be used instead of pumps in order to reduce energy requirements and minimise the possibility of equipment failure.

Location on a slope can help in the construction of basement areas, if they are required. Public entry can be on one level while maintenance entry can be on a basement level. Construction may be hampered by the presence of bedrock, a high water table, and constrained by protected areas such as SSSI woodland [G].

Issues of access need to be considered carefully to ease DDA-compliance [G], and facilitate the management of the toilet system, while at the same time limiting abuse by, for example, camper vans that discharge chemical waste into the facilities.

Surface water needs to be managed to avoid the flooding of facilities and to avoid heavy footfall turning the access area into a quagmire. Roof and surface water should be managed separately and not mixed with sewage.

Construction in areas with a high water table or in a flood plain should be avoided. Tests will be required to evaluate the likelihood of flooding or ground water problems. Ground water pressure can eject septic tanks and leachfields [G], and ground water is vulnerable to pollution by treatment systems.

BUILDINGS

- Materials
- Insulation
- Lighting
- Ventilation
- Power
- Health and safety
- Vandalism
- Hand washing facilities
- DDA compliance
- Combination with other infrastructure
- Urinals
- Secure storage
- Signage
- Maintenance

Buildings should be located no closer than 10 metres to a road, watercourse or water body. Toilet facilities should be clean, dry, bright and safe, and the design should complement the surroundings.

If a composting or dry toilet is to be installed, considerable space will be needed underneath the toilet pedestal to house the collection vessel. Raising the floor level introduces accessibility problems and the building may need to be located on a slope in order to give access at two levels, or a ramp provided for disabled access.

The building materials used should be environmentally sound, and locally sourced. The building should be constructed from highly insulating materials to retain heat and help create a naturally warm ambience. Resinous woods have a natural capacity to absorb and mask odour. Cleaning materials should be chosen so as not to affect the waste treatment systems nor add pollution themselves.

Powered lighting and ventilation should be provided at all times. Energy should be generated from renewable sources. LED lighting, low powered fans and solar panels are now readily available technologies. Timers can be installed to limit energy waste. Building Control will require powered lighting and ventilation for public toilets, buildings or rooms above a certain size and for any with opening hours during darkness.

Health issues need to be addressed through the provision of hand-cleaning facilities, whether water based (not recommended) or by gels. The toilet spaces themselves need to be well designed and easy to clean.

Safety and access issues will require attention to detail in respect of ramps, hand rails, easy-opening doors, safe locks, and a building design that limits the potential for squatters, anti-social behaviour and vandalism. The use of masonry paint helps discourage graffiti.

As most facilities will receive predominantly urine, the provision of urinals and low-flow self-stopping taps can reduce water use.

Secure storage for maintenance staff may be necessary to store toilet paper, cleaning materials and equipment, and protective clothing.

Signage needs to be clear, engaging and effective. Signage for public users should include detailed information as to how the toilet works, and make clear the responsibility of the users to help maintain the facilities provided.

Detailed Health & Safety instructions will be required for maintenance staff. All interventions by staff should be logged, reported and analysed at regular intervals.

Toilets may be just one component of a larger development, with other forms of sewage such as hand washing, kitchen and shower water also needing treatment. Provision of other facilities such as baby-changing areas may be considered desirable.

The cleaning and maintenance of public toilets are onerous and expensive tasks. Intervention may be needed every day at busy times. At some sites, the provision of rubbish bins is essential; at others, rubbish bins encourage dumping. Power supplies such as batteries will need to be monitored, maintained and recharged. Toilet supplies such as toilet paper and soap will need to be replenished. Vandalism and anti-social behaviour will need to be managed. The quality of maintenance will need to be monitored and verified, and these elements built into any maintenance contracts.

FOOTFALL

- Estimation of use
- Effect of presence of toilets
- Door counters

An essential component of the design process is the estimation of the likely number of users of differing types. Day visitors will predominantly urinate; campers may also use quantities of water for showering and washing clothes.

The very presence of new facilities will attract visitors in greater numbers, and the increased demand will need to be prepared for and future-proofed.

Monitoring use over time – through road pressure pads and door counters - will provide valuable information to help estimate likely use. The design of toilet systems based on footfall figures is covered in [Section 5.4].

TOILET PROVISION

- Wet or dry?
- Treatment of solid and liquid excreta

Water flush toilets are the standard offering that the public finds most comfortable, and that contractors and regulatory authorities understand and know how to manage. Unless the site or service provision precludes their use, the first choice should be the installation of a standard flush toilet, with measures taken to minimise water use and ensure adequate treatment of the effluent, solids and discharge arising from such a system.

When a water-based toilet is not possible, the alternative is the dry or composting toilet.

Whether wet or dry, both solids and liquids need to be treated. Urine is normally sterile but requires treatment prior to discharge to land or water due to its toxicity. Solid waste requires treatment to eliminate pathogens before it can be safely returned to the environment.

URINE AND LEACHATE MANAGEMENT

- Urine separation
- Low flush toilets and low flow taps
- Leachfield design and function
- Wetland design and function

To save water, urinals can be provided, or urine can be separated from solids in the toilet pedestal itself. There are arguments [Sections 4.2, 7.4] for and against urine separation and the provision of urinals. Water consumption can also be reduced through the provision of low-flow taps, and low-flush toilets.

Whether wet or dry, most toilets will produce a liquid discharge that requires to be treated. Liquid discharges from septic tanks and urinals are typically treated in a leachfield, which is essentially a drainage trench that relies on soil organisms to degrade the nutrients in the effluent stream. Leachfields may not be appropriate in soils that are insufficiently porous - for example in clay soils.

Leachfields need careful design and sensitive sites will require further treatment, typically through processing in a constructed wetland. A constructed wetland is a lined filter bed that is planted with suitable wetland plants. The ecosystem of the wetland processes the effluent stream, using the nutrients as a source of food.

WET TOILETS

- Septic tank design and function
- Mechanical treatment plants
- Liquid discharge

The standard rural toilet flushes the faeces into a septic tank. A septic tank is a large underground container with baffles that retain the solids and allow the liquid to pass through and discharge from the tank to the next stage of treatment. Very little degradation of the solids takes place in a British climate, and the solids retained by the tank need to be pumped out from time to time by a sewage tanker. The ecological footprint of tankers needs to be considered and their cost needs to be included in the pricing.

If power is available, a more efficient form of septic tank is the mechanical treatment plant (MTP). This is a septic tank with added aeration and mechanical stirring. An MTP is able to achieve a higher degree of processing, reducing the need for further treatment stages.

Various proprietary technologies, such as 'Biorock', add further elements to septic tank design and achieve higher standards of treatment.

This first stage of processing discharges into a secondary processing system, typically a constructed wetland or leachfield [Section 5].

DRY TOILETS

- Composting
- Total containment
- Drained storage
- Management

When a water-based toilet is not possible, the alternative is a dry toilet. The principal dry toilet design suitable for Scottish temperatures is the composting toilet. A composting toilet tries to create conditions so that the faeces decompose as in a garden compost heap, sterilising and stabilising the waste.

A standard design (Clivus) aims at total containment, with all solid and liquid wastes being retained and processed in the composter. Experience indicates significant risk of overflow with this design.

Other designs drain the liquid through the composting solids and discharge the liquid to exterior storage or a leachfield.

The management of composting toilets requires highly motivated staff. Composting toilets are unusual and their management requires a degree of experience. Motivated staff will learn the vagaries of each system and adapt to make the best use of them. Disinterested maintenance will run into and exacerbate problems. In all likelihood, the maintenance of a composting toilet will result in exposure to raw faeces, and the need for training, tolerance, and H&S vigilance will be significant.

REGULATIONS

Various regulatory bodies will need to be consulted and consent obtained before proceeding with installation. Planning and Building Control will make decisions about the site, the construction and the proposed treatment system. The Scottish Environment Protection Agency (SEPA) will need to approve the discharges to the environment, as may Scottish Natural Heritage (SNH), if the site is specially designated.

It will be valuable to arrange an initial meeting with these bodies to get an indication of the position they are likely to take. Thereafter, a formal application will need to be submitted, together with plans and details of the proposed installation and justifications for any unusual elements. Most Local Authorities take a positive view on rural toilet provision and decisions are usually made on a case by case basis.

3. Managing human waste

For most of us in the industrialised world, using a toilet is a matter of going to the loo, pulling the flush, washing our hands and walking away. It all seems so simple and yet hidden behind this apparent simplicity is a complex and expensive chain of consequences.

The bowl of the flush toilet – a porcelain pedestal – is no more than a recipient. Water flushes everything away to somewhere else, cleans up, and seals the join between the toilet and the outside world. Somewhere else – and after appropriate treatment – the liquid and solids are eventually returned to the natural environment.

In a rural location where the infrastructure necessary to handle all the behind-the-scenes processing is typically lacking, a sustainable toilet must act not only as a clean (and cleanable) recipient but also as an entire processing system, so that the material returned to nature is as clean and non-polluting as possible.

In the best-case scenario, services such as mains water and electricity are available, vehicle access is nearby, the surrounding area is not ecologically sensitive, and staff are available to carry out maintenance and handle problems.

In the worst case scenario, there are neither services nor access, there are no maintenance staff, and the area has sensitive surroundings and difficult ground conditions. One such example is the toilet system installed at Corrour bothy in the Lairig Ghru (Cairngorms), two or more hours walk from the nearest road [Case study 12.3].

3.1 Wet or dry? - Flush Toilets or Dry / Composting Toilets

96% of households in the UK are connected to mains sewers. Where it is possible to connect a rural toilet to a mains sewer, connection is likely to be mandatory and will provide the most manageable solution.

Where there is no mains sewage connection, but mains water is available, the standard choice (90%) is the septic tank and leachfield (soakaway) [G].

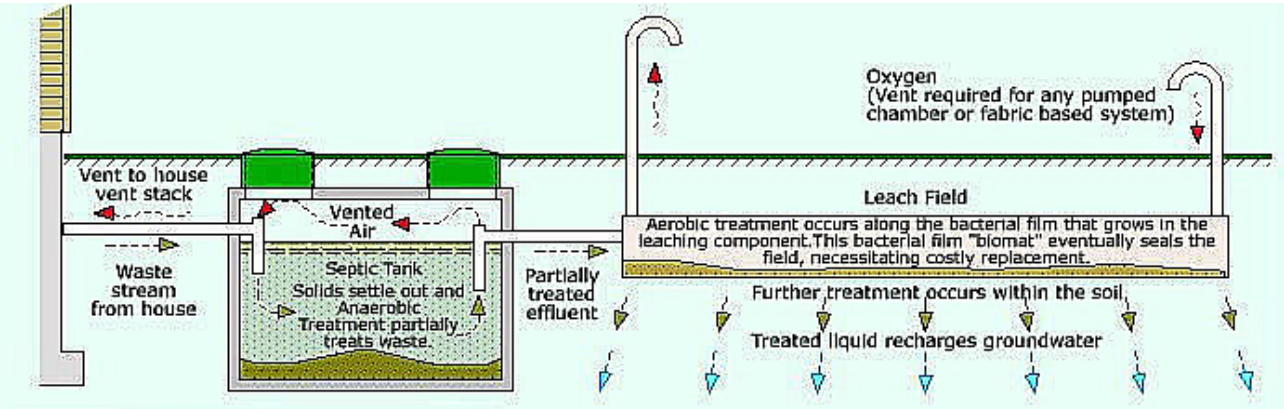


Image source: thecleansolution.com

Effluent from toilets, sinks, showers, baths, kitchens and washing machines is combined and passes into a septic tank, a large underground container with baffles that retain the solids. Very little degradation takes place in a British climate, and the solids retained by the tank need to be pumped out from time to time by a sewage tanker.

Liquid passes through the tank and into a leachfield – the next stage of treatment. A leachfield consists of a series of perforated pipes that run in underground gravel trenches. The pipes distribute the liquid effluent into the ground where it is broken down by soil organisms. Leachfields are covered in more detail in Section 5.

Septic tank systems are well understood, contractors know how to install most elements. The public is familiar with flush toilets, and the regulatory authorities know how to evaluate and monitor them.

Careful design of these standard facilities can aid in reducing their impact on the environment. The use of low-flush cisterns and replacing water-based hand cleaning with sprays or gels are covered in Section 7.

Cesspools - storage vats that require regular emptying - are now illegal in Scotland.

In situations where there is a risk of water freezing in winter, or the local environment is not suited to the septic tank discharge - where the ground is a non-porous clay, or where there is a high water table - a dry toilet may be more suitable.

Where there is no water supply, a dry toilet is the only answer.

Dry toilets function without a water flush and waste is treated by composting (biological decomposition), evaporation, de-watering (powered dehydration and pasteurisation), or incineration. For the purposes of this study we relegate de-watering and incineration to the category of 'exotics' [Section 10] that we consider unsuitable in the context. We consider only composting toilets, and use the terms 'composting' and 'dry' interchangeably.

While a 'dry' toilet functions without a flush, there will still be a liquid component as a result of urination. Depending on the functioning of the toilet, this may be discharged as urine or as a 'leachate' [G].

The treatment of septic tank discharge and leachate from dry toilets is covered in Section 5.

3.2 Solids

The standard septic system comprising septic tank and leachfield or wetland treatment system can be very effective in managing sewage in a rural setting. The toilet flush and hand washing water dilutes the urine component and the physical barriers in the septic tank retain most of the solids so that they can be removed at a later date by a tanker.

The tanker takes the solids to a sewage treatment plant where bacteria are harnessed in specially designed vats to break down the solids into gases and mineral solutions. Once the treatment is deemed adequate, the end product is discharged back into the environment.

If power is available, the bacterial decomposition of solids can be accomplished on site in what is referred to as a ‘mechanical treatment plant’ (MTP). This is a settlement tank with the addition of combined aeration and mechanical mixing to create aerobic conditions, thereby activating the decomposition of the solid matter. The discharge from an MTP is of higher water quality than that of a septic tank. Stricter treatment standards in recent times have led to an increasing number of mechanical treatment plants being installed.

The outflow from septic tanks, MTPs and leachfields requires further treatment and is no longer permitted to discharge directly to a watercourse or water body, especially in sensitive environments. A final wetland treatment system [G] is often added to bring the water quality up to a sufficient standard.

The "Do" and "Don't" of Septic Tanks

Warning: Never enter a septic tank - toxic gases are produced by the natural treatment process. Ensure all main septic tank covers are kept locked at all times.

DO	DON'T
Have your septic tank system professionally fitted, following local guidelines and regulations.	Use boiling water or drain rods to open a blocked drain.
Run all wastewater from your home into the system.	Pour fat, oil or grease down the drain. Return it (when cool) to its original container and dispose of this carefully. Your local Council's Environmental Services Department can advise.
Have your system inspected regularly.	
De-sludge the tank regularly. Once a year should be sufficient if the tank has been correctly sized.	Pour paint, solvent or motor oil down the drain. Recycle or dispose of it carefully, following the instructions on the pack.
Act immediately if you find a blockage or any sign of a problem. If necessary, seek professional help (see 'Drain and Pipe Cleaning, Plumbers Merchants or Sewage Consultants' in the telephone directory).	Dispose of garden chemicals or pesticides into the septic tank. You will kill the organisms that make the tank work.
Keep a note of any maintenance work.	Empty chemical toilets or cat litter into drains or septic tanks.
Ensure all manhole covers are accessible and sound. They should not admit water.	Put nappies, sanitary items, cigarette butts, plastic or similar items into your toilet. Bag it and bin it.
Ensure that any air vents are not blocked.	Leave water running. Attend to any leaky taps.
Divert surface and roof water away from septic tank systems.	Dig or drive over the drainage field.
Know where your septic tank and drainage field are located. Keep the drainage field protected.	Cover the drainage field with a hard, watertight or airtight surface. It needs to breathe.
Wash dishes in a dishwasher whenever possible (fat is converted into soluble substances in a dishwasher).	Block air vents.
	Desludge your tank too often. Once a year should be sufficient.

3.3 Urine

Urine is the liquid that carries urea [G], salts and other waste products away from the body. It is sterile when released but it rapidly becomes contaminated by naturally-occurring bacteria. The bacteria rapidly decompose the urea into carbon dioxide and ammonia, the latter being the component primarily responsible for the smell emanating from stagnant urine.

Water-based ecologies have evolved in an environment with very low levels of ammoniacal nitrogen (henceforth referred to here as 'ammonia') [G]. This form of nitrogen is therefore toxic to aquatic organisms at very low levels; salmon, for example, stop laying eggs when the ammonia concentration is 0.5 mg/l. The concentration of ammonia in stagnant urine exceeds 8000 mg/l.

Soil-based ecologies are similarly intolerant of ammonia and will be harmed if urine is applied directly. While fungi and soil organisms are able to degrade ammonia if it is incorporated into humus or compost in a less concentrated form, if the ammonia level is too high, land plants' mechanisms for the uptake of nutrients and minerals are overwhelmed and will fail. Wetland plants used in ecological treatment systems (constructed wetlands) are harmed at ammonia concentrations above 4 mg/l.

Given the toxicity of ammonia to both soil and water flora and fauna, we recommend that urine is not discharged directly to land or water, even via a leachfield. This is especially important in sensitive environments with high water tables and close proximity to clean water; where there is a risk of serious contamination should the system fail.

Urine is best processed in a compost pile where its nutrient value can be properly utilised and incorporated prior to being spread to land. Composting enables the urine to be processed using organisms that have evolved to carry out that task.

3.4 Greywater

Facilities for hand-cleaning are a necessary component of a toilet. If mains water is available on site and flush toilets are used, efforts should be made to reduce the quantity of water required, through the use of low-flush toilet designs and low-flow and self-stopping taps.

Soapy water and water containing anti-bacterial gels from hand-washing (plus showers and kitchen facilities if present, for example in visitor centres) cannot be discharged into the environment untreated. Such 'greywater' typically joins the black water flowing into the septic tank.

Where a dry toilet is being used, it is best to provide hand-cleansing facilities that are not water-based (see Section 7). This avoids the need for a water supply and limits the volume of polluted material requiring treatment. In addition, a source of water is an invitation to users to wash themselves or their hair, clean the toilet, or pour water that has been used to clean floors, pans or equipment into the toilet vault. Any of these actions can easily flood a dry toilet.

When greywater is produced in a situation where there is no septic tank, it should be suitably treated by passing through a leachfield or wetland, before discharge to the environment.

3.5 Composting

Where a water-based system is not possible, the alternative is a 'dry' or 'composting' toilet. A dry toilet retains the solid component in a vault and attempts to create suitable conditions for composting of the solid material, just as in a garden compost heap.

Composting is the biological decomposition and stabilisation of biodegradable waste by fungi, bacteria and microorganisms [G] under controlled conditions.

Under ideal conditions, fungal and bacterial activity in a compost pile generates temperatures of up to 70º C, sterilising the material, killing pathogens and creating a soil-like end product.

Conditions for the production of high-quality compost include:

- volume of organic solids sufficient for heat retention.
- the correct ratio of carbon to nitrogen (30:1)
- access to air throughout the pile
- sufficient moisture (but not too much)
- temperatures above 10º C (the higher the temperature, the more active the bacteria)

Ideal conditions are unlikely to be produced in the low temperatures of the Scottish climate and consequently a 'mouldering' compost pile is the best one can hope to achieve. If solids are stored for at least a year in a composting toilet vault in conditions satisfying the above criteria but at a low temperature, most pathogens will have died and the solid mix will have been rendered relatively pleasant to manipulate.

The spreading of sewage sludge on land is common practice, and neither this nor the advice given to the public – to dispose of their faeces by burying in soil – stand up to scrutiny:

"Shallow burial of faeces, recommended to backcountry recreationists, does not result in quick destruction of intestinal pathogens. Samples of faeces inoculated with two bacteria, Escherichia coli and Salmonella typhimurium, were buried at two depths at four sites in Montana's Bridger Range, U.S.A. Both bacteria survived in large numbers during the summer and fall. Salmonella persisted over winter at all sites; Escherichia persisted at some sites. Depth of burial had no effect on persistence, and differences among sites were minor." Temple et al. 1982 [R]

Human faeces need to be properly treated to eliminate all possibility of health and pollution hazards.

Because the solids removed from a dry toilet are unlikely to be fully composted, we recommend secondary batch treatment in a purpose-designed composting facility. Depending on quantity, this may involve a garden sized compost heap, windrows (long piles of compost) [G] or forced-air composting [G].

The composting standard PAS100 [R] provides an approved methodology and standards for the composting of green and food waste in the UK. To be used for non-agricultural applications, the end product derived from the composting of solid wastes from dry toilets would not have to meet the full suite of standards. However, the methodology and general quality standards set out in PAS100 should be the target for any composting operation.

3.6 Summary of treatment criteria

The following summarises the criteria that we feel that should be considered when designing and installing toilets and drainage.

- The quality of air, soil or water should not be diminished or polluted by any of the discharges. In practice, all gaseous products are vented to the air, and in a rural setting it is assumed that air pollution is of minimal risk.

- All discharges from septic tanks and mechanical treatment plants should be treated to secondary and preferably tertiary treatment standards [G]. Tertiary treatment standards must be met when discharging to either groundwater or watercourses.

- Untreated urine leaching into the soil or ground and surface water is detrimental to life and its nutrient value is mostly wasted. Urine is more valuable and less noxious if incorporated into humus through composting.

- Water collected from roof and surfaces should be managed separately and not mixed with sewage.

- We take the position that commercially-available 'composting toilets' do not work well at typical U.K. temperatures**,** and very little composting occurs. The storage vessels act primarily as holding tanks and therefore provision must be made for further processing of the accumulating solids. If there is no outlet on a composting unit, allowing liquid to drain, the vessel risks turning into a cesspool [G], which is illegal in Scotland

- Human waste (urine, faeces, sewage), composted or not, must not be spread on land growing food crops or trees bearing fruit that humans will eat.

- Animal, garden and kitchen wastes should be processed separately from human waste. Human waste is poor in nutrients and has little value for the land. Sewage can also contain harmful metals, toxins, hormones and pharmaceuticals. Mixing organic and human waste contaminates the more valuable organic waste and renders its disposal problematic.

4. Dry toilets

Dry toilets function without a water flush and the waste is treated by composting (biological decomposition), de-watering (dehydration and pasteurisation), or incineration. For the purposes of this study we relegate de-watering and incineration to the category of 'exotics' (section 13). We consider only composting toilets and use the terms 'composting' and 'dry' interchangeably.

Composting toilets are typically chosen:

- to alleviate the need for water to flush toilets
- to avoid discharging nutrients, toxins and pathogens into sensitive environments
- to capture nutrients in human faeces

Composting toilets work through the **managed** aerobic decomposition of human waste.

Composting toilets should not be confused with pit latrines, which are typically little more than a hole in the ground. Pit latrines rely on **unmanaged** decomposition by organisms already present in the faeces and by organisms in the soil. Pit latrines often do not protect ground water from contamination nor provide optimal nutrient recycling. Pit latrines are also temporary, with the upper structure needing to be moved when the pit becomes full.

Conditions for the production of high-quality compost include:

- a volume of organic solids sufficient for heat retention.
- the correct ratio of carbon to nitrogen (30:1).
- access to oxygen throughout the pile.
- sufficient moisture (but not too much).
- temperatures above 10º C (the higher the temperature, the more active the bacteria).

Composition

To obtain optimal conditions for composting, there needs to be a sufficient volume of material to retain heat, and a suitable mixture of nutrients - primarily nitrogen and carbon.

When urine and faeces are composted together, their combined nitrogen content is too high to create ideal composting conditions and a carbon-rich bulking material (‘soak’) needs to be added after each bowel movement. A typical soak is pine shavings, which perform better than sawdust or wood chips or bark in that they help create open spaces within the compost pile, promoting aeration.

If a soak is provided, the general public tends to add far too much, wasting the soak and drying out the composting material. If staffing permits, it is better to have the maintenance crew add the soak on each visit.

Ventilation

To maintain the public-facing toilet space odour-free, powered ventilation needs to be provided to create a downward draft of air in the toilet pedestal.

The ventilation will also pull air through the composting chamber, helping maintain aerobic conditions throughout the pile.

For the venting to be effective, the toilet seat must be closed after each use, and sealed well against the pedestal. Equally, the chambers and vent pipe joints need to be well-sealed. Experience indicates that ventilation failure is common and that cheap fans do not survive for long in this moist environment.

The vertical vent pipe should extend well above the roof level to take advantage of wind extraction and minimise exterior odours. A cowl can be placed on the vent pipe to aid ventilation.

Moisture content

The moisture content of the material to be composted needs to be carefully controlled: too dry and the mass decomposes slowly or not at all; too wet and anaerobic organisms thrive, creating undesirable odours.

Source liquid separation, through the use of low-flush male urinals or urine separating pedestals, can also be used to control the amount of liquid entering the composting chamber.

The rate of diffusion of oxygen through water is 10,000 times slower than through air. Excess moisture therefore significantly decreases the rate of oxygen transfer to bacteria, encouraging anaerobic conditions. Stagnant urine rapidly develops an offensive odour and encourages bacterial growth. Consequently, excess liquid or 'leachate' should be evacuated via a separate drain at the bottom of the composting chamber.

In urine separating systems, where the problem can be lack of moisture, recirculating the urine or a source of water via misting spray heads controlled by a digital timer is a common feature.

Another problem, especially in cold climates, is the build-up of condensation in the exhaust vents. This liquid can then re-enter the composting chamber and reduce its temperature, affecting the composting process. One solution is the inclusion of a T-bend section in the exhaust vent to catch this condensation.

Temperature

Under ideal conditions, aerobic composting proceeds rapidly, with thermophilic bacteria - those that thrive at high temperatures 40 to 85 ºC (104 to 185 ºF) – breaking down the waste into its components, some of which are consumed in the process, reducing volume, and eliminating potential pathogens. The heat generated internally drives off moisture and can even lead to fire hazards if there is insufficient mass to contain these internal temperatures.

Under less ideal conditions or without a properly formed compost pile, and in a British climate, thermophilic composting is hard to achieve, and other bacteria (mesophilic) - operating at up to 35ºC - decompose the material slowly in a process referred to as 'mouldering'. Insulation of the building and of the composting vaults, and background heating systems can be used to increase the rate of decomposition, with the rate typically doubling with every 10ºC increase. Increasing the ambient air temperature, will also aid in evaporating excess liquid. At temperatures below 10° C, the average temperature of lowland Scotland, bacterial activity slows significantly.

To increase the initial rate of decomposition, adding (or leaving) previously decomposed material to the composting chamber will introduce beneficial micro-organisms already suited to the material. A significant barrier to elevated pile temperatures in cold climates is the heat lost to evaporative cooling, with as much as 90% being lost, again emphasizing the importance of good drainage.

Management

Most commercial units require manual methods for periodic aeration of the solid mass, such as rotating a drum inside the unit or working an "aerator rake" through the mass. The frequency of emptying will depend on the speed of the decomposition process and capacity, from a few months (thermophilic composting) to years (mouldering composting). Under ideal conditions, a very small volume (about 10% of inputs) of a humus-like material results.

Another issue, often overlooked in the site selection of a facility, is the disposal of the composted material. The sensitivity of some sites makes re-use inappropriate, whilst the difficulty of removal from remote sites can be onerous.

Care is needed in selecting products for hand washing and cleaning. Anti-bacterial and strong cleaning chemicals can be harmful to compost. Baking soda or a dilute mixture of vinegar and water are recommended.

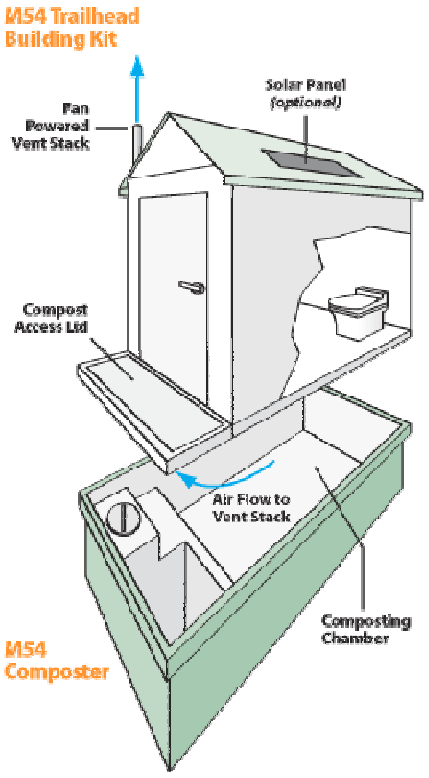
Site

An important element in ensuring a composting toilet installation will operate effectively is to select an appropriate site.

Most composting toilets need to be located in a basement (1 to 2 m depth) and the composting chamber needs to be accessible for maintenance. Locating the building on a slope and avoiding shallow rock will make the installation of such toilets much easier and cheaper.

It is important to maximise solar benefits and minimise heat loss. A site with an open southerly aspect is best. It should be free of shade for as long as possible during the day, especially during the winter; it should be protected from prevailing winds and should not be located in a valley. The building should be constructed from highly insulating materials.

4.1 Dry toilet systems – Clivus systems



Clivus Multrum Toilets are manufactured in the U.S.A. The original Clivus Multrum composter was developed in 1939 by Rikard Lindstrom, a Swedish engineer.

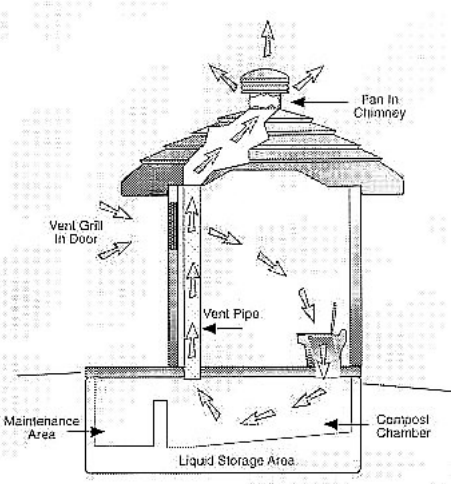
Description of the toilet and principles of functioning

The name Clivus Multrum means “sloping chamber”, which describes the functioning - waste drops onto a sloping floor and slides slowly down, decomposing and draining. Ventilation assures a downward draft in the toilet pedestal, keeping the public space odour-free, and promoting the aeration of the accumulating solids.

Clivus Multrum composting toilet systems require an accessible lower space beneath the toilet fixtures. North American homes are typically built with a basement, giving sufficient space to install a composting vault.

For remote locations such as parks and golf courses, Clivus supplies the “M54 Trailhead”, pictured on the right. This model includes a grill in the sloping floor that allows the liquid to drain through into a lower chamber.

Kingsley Plastics U.K. used to supply a Clivus model that appears to be based on the M54 Trailhead. Kingsley is no longer supplying Clivus toilets and Clivus does not appear to have a distributor in Europe.



Clivus Model M54 Trailhead

The Kingsley Clivus design is the model installed at a number of locations around the U.K. Other than the toilets installed at Loch Garten [Case study 12.10], the management of all Kingsley Clivus toilets we have encountered has been problematic.

At Linn of Dee [Case study 12.2], the solids do not decompose as advertised and access for maintenance via the toilet floor is difficult. The Yorkshire Dales National Park Authority is removing (2008) a Kingsley Clivus compost system and constructing a “new environmentally friendly on-site treatment plant” [Case study 12.12]. A Kingsley Clivus system installed at Loch Ossian Youth Hostel has overflowed with excess water and cleaning fluids. At Allean [Case study 12.9], the Forestry Commission modified the design to add an overflow. The toilet project at Inverlochlarig [Case study 12.8] has foundered, partly due to lack of support from the suppliers.

The U.S.A. National Park Service began an active research program in the mid 1980s that investigated nine Clivus Multrum composting systems and a dehydrating toilet installed at several remote national park sites that lack power, water, soil depth and vehicle access. The report states that “All the compost toilets were found to require a liquid disposal system. None of the ventilation systems were operating as designed. None of the units demonstrated the sliding of the solid material on the inclined bottom of the tank.” The dehydrating toilet investigated “required modifications to provide satisfactory performance, since drying the large accumulation of solids was not successful.” (Jensen 1984).

Cost
Kingsley is no longer supplying Clivus toilets and Clivus does not appear to have a distributor in Europe.

Contact
www.clivus.com

Our comments

The Kingsley Clivus system is the best known compost toilet system and installations have been in existence for some time. The problems encountered are to some degree inherent in the high degree of management required for composting toilets. However, there are also fundamental problems with the Kingsley Clivus design.

Although the sloping floor of the Clivus Multrum is supposed to encourage waste to slide while decomposing, in reality, new waste is being added continually and this tends to slide over the previous contributions, leaving the old behind and propelling the new down the slope. Old material tends to accumulate at the back, and new at the front. The old material is impossible to remove without contamination with the new, and the old material becomes covered and sealed, limiting its aeration. Experiments confirm that 'first in' is not 'first out'.

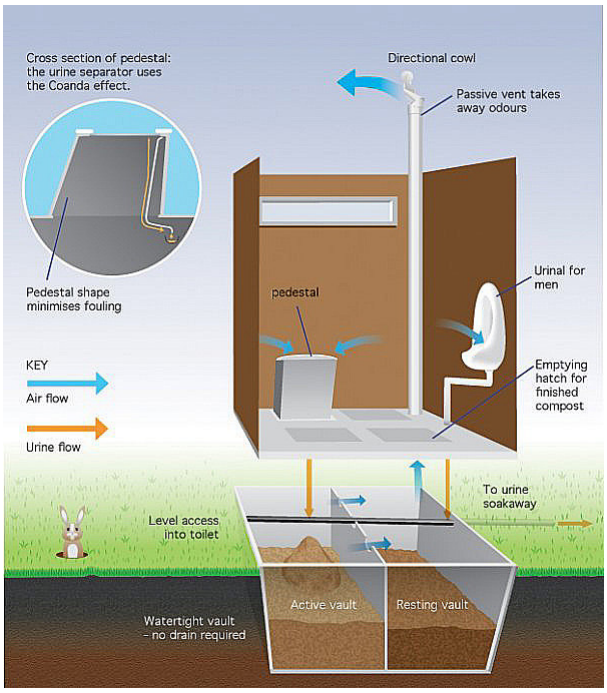
Waste tends to build up below the toilet pedestal and is difficult to reach with rakes due to the problems of accessing the composting chambers. Removal of the solid material is not easy.

Liquid collects in the base of the tank, creating anaerobic conditions, odour, dripping wet sludge, and unpleasant maintenance. The tank is vulnerable to overflow and usually has to be emptied by tanker.

In a few cases, improvements made by the owners of failing systems have overcome the worst of the problems encountered.

The exception to difficulties with Kingsley Clivus systems is Loch Garten [Case study 12.10], where leaving the composter to rest over the winter period together with choosing a large enough composting vault has proved successful.

4.2 Dry toilet systems - NatSol



The NatSol composing toilet is manufactured in Wales and has been supplied to many sites without mains services around the UK. It has found particular favour for allotments.

In Scotland, Sunart Oak Woodlands, Salen [Case study 12.7] and Sandown allotments, Nairn use NatSol toilets. Case study [12.5] reports on a NatSol system installed by Eden Rivers Trust.

Description of the toilet and principles of functioning

The NatSol vault is constructed from Glass Reinforced Concrete. The upper structure is available in wood or metal. No electricity, water or sewage connection is required.

A urinal is provided and the novel pedestal is urine-separating: urine clings to a steel plate and is led away to join the discharge from the urinal. This design avoids the problems usually associated with urine separation mechanisms which tend to be easily fouled by faeces.

Urine is discharged to a leachfield behind the building.

Soak is provided and one handful is added after each defecation.

Two floor hatches allow for the displacement of the pedestal, meaning that one vault can be put to rest while the other is activated. Two further floor hatches allow access to the vaults for maintenance and removal of the solid waste.

A cowled chimney provides passive ventilation.

The NatSol management document with photographs is available here: www.natsol.co.uk/manage.html

Cost

The capital cost for a toilet with a building is currently £5800 + VAT plus installation and delivery, which normally takes a day to a day and a half. Without a building, the cost of the toilet is £3600 + VAT etc.

Contact

Andrew Warren BSc ARCS
Managing Director
NatSol Ltd
20 Bethel Street
Llanidloes, Powys
Wales, SY18 6BS
http://www.natsol.co.uk/

Our comments

This design is very straightforward and can offer a suitable solution to toilet needs in a managed environment with low use, such as an allotment.

The vaults are relatively shallow (1 metre), allowing for simple installation with DDA-compliant access on a flat site without the need to create a basement area or access ramping.

On a less managed site, the lack of any drain to the vaults means it would be easy to flood and overflow the vaults if used incorrectly – by urination into the toilet, by cleaning or by running water into the toilet**.**

The combination of urine diversion - removing the principal source of nitrogen, the lack of provision for anything other than manual management of the moisture content of the solid waste and the low UK temperatures leave us doubting that suitable conditions for adequate composting of the solids in the vaults are created.

As a toilet for the general public, any rubbish disposed of in the toilet would either have to be removed through the forward hatches and the toilet floor cleansed, or just left in the vaults and removed later.

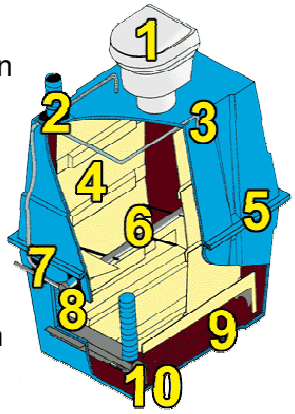
The problems of maintenance through the floor access hatches again suggest this design is best used on a managed site where staff can minimise misuse. Various elements would need to be made more robust for a less managed public toilet, and a vault overflow added.

In sensitive environments and as stricter regulations come into force, it is unlikely that running untreated urine into a soakaway will be considered acceptable practice. Treatment of the urine prior to discharge to either land or water would need to be provided.

NatSol mention that their composting process works in low temperatures. However, the mesophilic bacteria involved in biodegradation are active at temperatures of 15°– 40°C, which are rarely achieved in the Scottish climate without additional heating. The quality of the resulting solid waste, whether it actually degrades, and whether it is safe to handle remain unknown.

See also the manufacturer's answers to our questions [Section 13; Appendix].

4.3 Dry toilet systems - Phoenix



The Phoenix Composting Toilet is manufactured in the U.S.A. and will soon be available in the U.K. through a new supplier based in Wales.

Many Phoenix toilet systems have been installed in environmentally sensitive areas of the U.S.A. and they are widely used as public facilities in the National Parks where they have been approved by all Federal Agencies.

In the U.K., the sole installation is located in the FVL study area on Inchcailloch Island in Loch Lomond [Case study 12.1].

Description of the toilet and its principles of functioning

The body of the Phoenix toilet is constructed from polyethylene. This material gives a degree of insulation to aid composting and helps prevent the contents freezing. Various access panels and controls are easily accessible on the rear facade. The model shown above (lower photo) requires 1.9 m of vertical clearance.

The base of the unit [8] is initially filled with peat or a bulking agent (wood shavings) that acts as an absorbent bed and filter. The liquid component of the waste from the toilet drains through this bed into a storage tank [10].

The upper section of the toilet vault acts as composting chamber for the solid waste. Contributions from the user fall down a 30cm chute leading from the toilet pedestal [1] into the composting chamber and the solids tend to accumulate on a horizontal shaft with tines [6]. This shaft can be rotated by the maintenance crew via an external handle, which serves to knock down the peak, mix the solid material (faeces plus soak), aerate it, and encourage its descent into the lower section of the vault.

Clean water or the liquid collected in the base can be re-circulated and sprayed onto the upper material either automatically via an electronic timer, or manually via an external switch. This recycling of liquid serves to keep the upper composting mass moist.

A lower second or third horizontal shaft further controls the descent and aeration of the solids. This arrangement, together with aeration baffles in the walls appears to retain the solids suspended ‘in mid air’, thereby aiding the aeration of the mass.

When the vaults are to be emptied, the lowest of the shafts is rotated to propel the mass to the bottom of the chambers so that it can be removed.

Upper panels (black in the second image) allow access to view the upper contents and remove rubbish. Lower panels allow for the removal of the solid material.

Excess liquid overflows the storage tank at the base and can be treated by any of the standard methods or can be evaporated if the provision of power permits.

A 5 watt fan draws air into the chamber from the rear facade, across the surface of the liquid at the base to encourage evaporation, and up through the wall baffles and composting vault. The fan also creates a negative air pressure at the toilet pedestal, keeping smells to a minimum. Ventilation is provided through the top of the unit.

Cost

The Phoenix costs for two No 201's (as installed at Inchcailloch [Case study 12.1]) would be 2@ £4,793 = £9,586 plus delivery per unit of £950 plus Customs duty of 6.5%. These costs are based on an exchange rate of $1.53 to the pound sterling. The installation cost of each Phoenix is £550 giving a total cost of approximately £13,209.

Contact

David Beechey and Richard Beechey
Phoenix Composting Toilets UK Ltd.
Regent House, 32 Princes Street
Southport, PR8 1EQ
www.phoenixcompostingtoilet.co.uk

Our comments

The Phoenix is the only composting system we have seen that takes the composting phase seriously - the design tries to create the best possible conditions for composting of the solid material to take place. The vault is insulated; the solid mass is aerated; and the solids are both drained and sprayed in an attempt to create suitable moisture content.

The literature supplied is also very honest about the likelihood of the solid material actually composting, and graphs of toilet capacity against temperature are provided. At ambient temperatures below 10 degrees C, they confirm that little composting will take place.

Due to the recirculation of the urine that drains to the base of the unit, the liquid discharged from the unit may possibly be lower in volume and concentration of urea and ammonia than that of a urine separating toilet. As the liquid has re-circulated through faeces, however, it will no longer be sterile and will have accumulated a significant bacterial content.

The horizontal stirring rods are easily fouled with rubbish, and the need to remove rubbish is a drawback of the complexity of the Phoenix.

See also the manufacturer's answers to our questions [Section 13; Appendix].

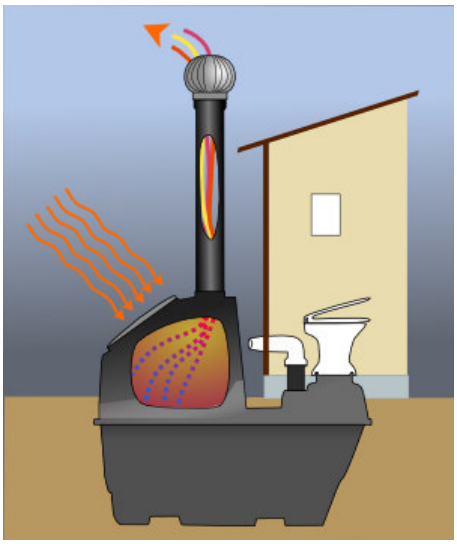
4.4 Dry toilet systems - Evaporating toilets

Evaporating toilets are designed to warm and evaporate the moisture from excreta and encourage the decomposition of the solids.

Solar dehydration has been investigated as a potential rural sanitation method by the U.S.A. Forest and Park Services. It has been used with varying success on Mt. Whitney in California and in Mt. Rainier National Park in Washington. The surface water runoff from the dehydrating toilet at Mt. Rainier has been tested and no contamination found. However, the dehydrated end product from these toilets is often “high in pathogens, difficult to handle and cannot be disposed of on-site”. (See Backcountry Sanitation, Lachapelle)

U.S.A. National Park Service investigations noted: “The dehydrating toilet investigated required modifications to provide satisfactory performance, since drying the large accumulation of solids was not successful.” (Jensen 1984).

4.4.1 The Kazuba Composting Toilet

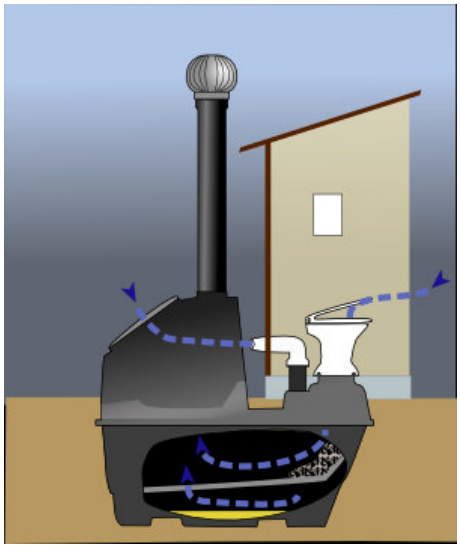


Kazuba toilets are based around the Enviroloo, a dry toilet system which uses sunlight and wind to dry human waste.

The Enviroloo first separates the liquid from the solids - waste falls directly from the toilet bowl onto a drying plate, the upper section of which is perforated. The liquid drains to the bottom of the container, evaporates, and is vented to the atmosphere.

Manufactured from black polyethylene, the rear of the Enviroloo heats up in the sun (even when there is no direct sunlight), causing the internal temperature to rise.

The prevailing wind turns the extractor at the top of the chimney and together with the radiant heat pulls air through the system, stimulating aerobic decomposition and deodorising the waste.



Fresh air enters via the ventilation tube, and passes through the drying plate and over the liquid. Fresh air also enters via the toilet bowl, passing directly over the solid matter. Liquids are evaporated and the solids, which are also partially composted, are dehydrated.

The solid waste dries and decomposes into a compost-like material, roughly 5 to 10% of its original mass. Once dried, the waste inside an Enviroloo becomes a safe, neutral, odourless material which can be handled with the minimum of fuss.

Cost

Kazuba RRP (*ex-VAT)*
KL1 (inc. Enviro Loo) £2,870
KL2 (inc. Enviro Loo) £5,420
KL2 prm (inc. Enviro Loo) £6,070

Contact
Joel Cormack
Kazuba UK
Unit 343
Camberwell Business Centre
99-103 Lomond Grove
Camberwell
London SE5 7HN
www.kazuba.eu

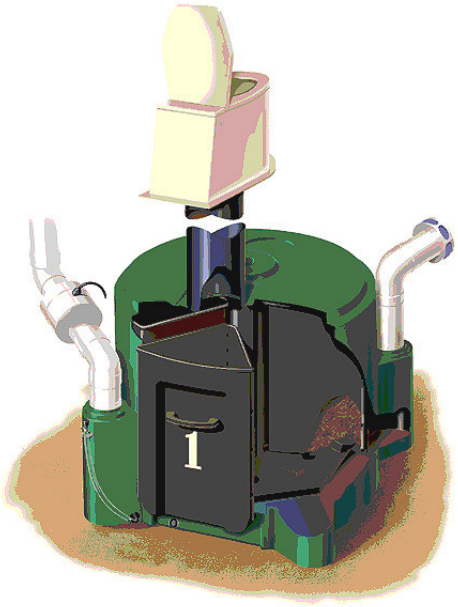
Our comments

The study team has no experience of the Kazuba system nor of evaporating toilets.

We believe it unlikely that significant evaporation would occur at Scottish temperatures. The exposed rear for sunlight capture would be hard to make vandal-proof. The design would appear to suffer from the same disadvantages as the Kingsley Clivus.

See also the manufacturer's answers to our questions [Section 13; Appendix].

4.4.2 The Rota-Loo Composting Toilet



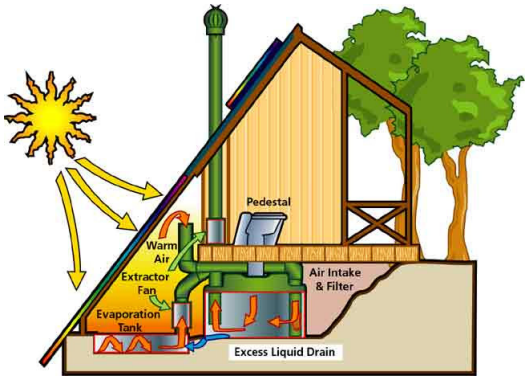
Rota-Loo toilets are an Australian system. A number of Rota-Loos have been installed in private houses in England, Spain and France, and at allotments in London and Hastings.

A turntable structure is located directly beneath the toilet pedestal and houses a number of removable composting bins. Only one bin is in use at any one time, and waste falls directly into the active bin.

Each bin has a series of drain holes and air holes located in its base. Inside each bin is a filter material made from geotextile. The geotextile allows liquids to drain through while allowing air to penetrate the pile from the base. Liquid that drains from the bin is stored in the base of the outer container.

The separation of liquids from solids ensures that the pile remains aerobic and reduces the possibility of odours. The design of the bins allows for an easily manageable amount of waste material to be collected. Once the initial bin is full, the turntable is simply rotated to allow a new bin to receive the waste. The previously active bin remains inside the system and continues to decompose without any fresh material being added.

Once all the bins have been filled and the first bin has returned to the active position, it can be removed and stored. An empty bin is added to replace it, and the cycle continues.



The Soltran building is an integral part of the Rota-Loo concept. The Soltran design incorporates a 10mm twin-wall polycarbonate glazing placed at a 60º angle facing south at the rear of the building. The area under the glazing is insulated and almost airtight except for a few bleeder holes allowing new air into the chamber. The air inside the Soltran is heated by the sun and drawn into the Rota-Loo via the air inlet and through the system by a fan.

Cost

£6,600+VAT and delivery

Contact
Jonathan Cooke
Dragon Contracts
Saffron Walden CB10 2SS
www.rotaloo.co.uk

Our comments

The study team has no experience of the Rota-Loo system or of evaporating toilets.

The rotating bin system appears to offer a low-profile containerisation of waste, and the removable bins offer an easily managed solution to the problems of removing rubbish and emptying the solids. The bins could use a geotextile bag [Case study 12.3] to further ease the removal of the solid waste. The drainage provision could be used to discharge the leachate to an external processing system.

As regards the Soltran building, we believe it unlikely that significant evaporation would occur at Scottish temperatures. The exposed rear plate for sunlight capture would be hard to make vandal-proof. The design would appear to suffer from the same disadvantages as the Kingsley Clivus.

See also the manufacturer's answers to our questions [Section 13; Appendix].

5. Drainage and secondary water treatment systems

5.1 Treatment of septic tank discharge, greywater and compost leachate

Septic tanks provide 'primary' treatment of sewage, separating the solids from the liquid. Little if any degradation of the sewage is achieved at British temperatures. The solids are removed by tanker and processed elsewhere. The liquid discharge from a septic tank requires further treatment before it can safely be released back into the environment.

Secondary treatment acts on the liquid discharge from primary treatment and removes most of the remaining organic material and suspended solids. This is known as 'biological treatment' since it depends on micro-organisms breaking down the organic material in the sewage. Secondary treatment is achieved in a sewage treatment plant by trickling the liquid through bacterial beds. Sewage treatment plants typically discharge secondary quality water.

In a rural setting, secondary treatment is typically achieved by discharging into a leachfield or constructed wetland.

Greywater (water from baths, showers, sinks, washing machines, kitchens), leachate from compost toilets, and the discharge from urinals should all be treated to a minimum of secondary standards before release into the environment.

Tertiary treatment is required for environmentally-sensitive sites and refers to the removal of further organic material, the removal of nutrients such as nitrogen and phosphorus, and the removal of pathogenic organisms such as *E coli* [G]. This is achieved through further biological, physical or chemical processing.

5.2 *Leachfields (soakaways)*

A leachfield consists of a series of perforated pipes embedded in gravel that run in underground trenches. The pipes distribute the effluent into the ground and treatment relies on soil organisms to degrade the nutrients in the effluent stream.

If well designed, leachfields can provide good treatment for most parameters as long there are suitable soil and ground conditions. The exception is nitrates, whose concentration tends to increase as a result of the degradation of urea and ammonia. Even for small systems, the concentrated urine and leachate can lead to pollution of ground or surface water and must be treated.

The effectiveness of leachfields can be enhanced by planting out with nutrient and moisture loving land and wetland plants or trees, although tree root systems can interfere with the piping.

Fissures in the ground or the proximity of land drains can allow leachfield effluent to reach groundwater or watercourses. This risk can be limited by lining the trenches with an impervious material, but eventually the effluent is discharged to ground.

Although a lined leachfield can help to protect the groundwater from pollution, the leachfield is more likely to flood and cause anaerobic conditions in the soil, preventing the soil organisms and the leachfield from functioning properly. The overland surface flow could still cause water pollution.

SEPA and EA guidelines state that rainwater and surface water must be kept separate from sewage, urine and faeces. All new buildings and developments require separate management of rainwater and surface water.

To ensure a well functioning leachfield, surface water should be excluded.

Leachfields are not suitable in clay soils or shallow soil on bedrock, or if the water table risks rising higher than one metre below the bottom of the trench. A leachfield should be located not less than ten metres from a watercourse or water body.

Leachfields are underground systems and are therefore difficult to monitor. If a leachfield fails, contamination of ground water is always possible, and goes unnoticed. If untreated prior to discharge, ammonia, nitrate and phosphorus can cause eutrophication [G] (abnormally nutrient-rich water) and trigger algal blooms [G].

We feel the risk of contamination by a malfunctioning leachfield is high, and that leachfields should be avoided in sensitive environments. Here, the water quality prior to discharge to a leachfield or watercourse should be treated to tertiary standard [G]. A lined aquatic plant treatment system - a constructed wetland - can achieve these standards and in sensitive environments can be used prior to, or as a replacement for a leachfield.

The effectiveness of leachfields can also be enhanced by the use of plants and trees – once the ammonia is broken down into nitrate and hydrogen by bacteria and fungi, the nutrients become available for uptake by vegetation as a food source.

5.3 Wetlands

Wetlands in nature perform a task similar to that of a liver in a human being. Their main function is water purification, through the trapping and transforming of sediments, nutrients and toxins. They are also significant hydrological regulators, providing flood control through the moderation of storm flows.

The term ‘reed bed’ is often used for an aquatic plant treatment system. A reed bed is one type of the larger category of complex environments known as wetlands. We use the term wetland to describe a complex aquatic plant ecology. Wetland plants have evolved unique symbioses with a wide range of bacteria and invertebrates that enable them to survive in harsh and wet environments. This symbiosis consists of the plants providing a safe habitat and oxygen to the bacteria and invertebrates, in return for attracting and transforming water-soluble nutrients and minerals into a form that can be utilised by other life.

A constructed wetland uses these characteristics to treat effluent to secondary or tertiary standards. The wetland beds are typically lined to eliminate the risk of contaminating ground water, and are designed so as to pull air into the beds, creating aerobic conditions for efficient degradation of the waste stream. The complex ecological relationships that evolve create a ‘food web’ that enables waste products to be efficiently transformed into plant and animal biomass.

Wetland plants are perennial (live throughout the year) and therefore can work and treat effluent throughout the winter months. It is best to plant native species that are already adapted to the Scottish winter climate.

A wetland is an ecological system of beauty that also attracts and nourishes a range of fauna. Wetlands naturally complement sensitive water environments.

5.4 Footfall calculations and sizing

For a water based toilet installation, the septic tank, constructed wetlands and leachfield systems need to be sized to be capable of treating the organic matter, the urine, and the suspended solids arising. The calculations need to take account of peak loadings as well as average loadings.

Similar calculations are also necessary when designing a dry toilet facility. There will always be a urine and leachate component to be treated and, if water for hand washing is to be provided, this will also require treatment. Dry systems will use less water, resulting in less volume, but higher concentrations of contaminants. The leachfield calculations below can be used to estimate the size of treatment system required for the liquid effluent discharged by a dry toilet. The compost arising from a dry toilet will also need to be processed.

Most of the documents produced by SEPA are based on flush toilet systems. As dry toilets differ from model to model, the manufacturer's literature should be consulted for sizing calculations.

Most failures of public toilets and treatment systems are due to under-estimating the number of users and, as a result, under-estimating the number of toilets and the treatment facilities required.

In order to size a treatment system, it is necessary to estimate the volume and loading generated by residents and visitors. To help to estimate the usage and size of public toilet facilities required, some useful procedures are set out below.

Guidelines for estimating usage levels:

- Obtain visitation records (e.g. admission ticket sales, etc.) for the area that the toilet facility will serve. (This is the most reliable method for estimating how many uses the toilet may have to accommodate).

- If records are not available, estimate visitation based upon information such as number of parking spaces, number of bus-loads, or foot traffic.

- Estimate the weekday, weekend and peak attendance levels. Account for seasonal variations, holidays, periods of closure, etc. and for duplication of peak days *vs.* weekday or weekend.

- Estimate the average length of stay at the site.

- Calculate the annual number of uses of the toilet facility based on an average of three uses per person per eight hour stay or five per 24 hour period.

Based on the footfall estimates and the type of visitor to a site, the size of the required treatment system can be calculated from the British Water / SEPA / Environment Agency Code of Practice:

www.britishwater.co.uk/Document/Download.aspx?uid=3d63842c-eb86-48b1-be17-12eebf7487a5

Tables give typical effluent values at the point of discharge from the septic tank. The figures most relevant to a rural parking area, for example, are the following:

	Volume in litres	BOD (g)	Ammonia (g)
Toilet (WC) (per use)	10	12	2.5
Toilet (Urinal) (per use)	5	12	2.5
Tent sites (per person / day)	75	44	8

The 'volume' is the typical volume of water used, 'BOD' [G] is a measure of the loading (the amount of oxygen required to remove the impact of the sewage when discharged to either water or land) and 'ammonia' is a measure of the urine (nitrogen) to be treated. The figure for toilet flush volume can be reduced if low flush toilets are used (2 to 6 litres per flush), but a significant safety margin should be allowed.

The effluent discharging from the septic tank into the leachfield will carry the typical values given in the table above.

Example

Taking the example of a proposed toilet installation at the Sallochy parking area / campsite on the eastern shore of Loch Lomond [Case study 12.11], the estimated visitor numbers in the summer months are 300 vehicle tents per month and 200 car visitors per day.

Assuming that, of the 200 car visitors, men will use the urinal twice, and 50% will also use the toilet, the daily loading due to these visitors is:

Visitors: per day	Volume in litres	BOD (g)	Ammonia (g)
100 uses of WC	1000	1200	250
200 uses of urinal	1000	2400	500

It is important to take into account peak loadings. Car park visitors can be provided with hand washing sprays or gels to reduce water consumption but campsites usually provide sinks with running water for hand washing, cooking and cleaning. Campers will tend to use such facilities at similar times - in the morning and evenings. These are times of peak loading on a treatment system and need to be included in the calculations to avoid overloading.

On weekends with good weather there may be as many as 25 4-person tents in the camping area. To accommodate such peak loading, we take the maximum number of camper uses to be 100 per day.

The daily loading due to campers is then:

Tent visitors: per day	Volume in litres	BOD (g)	Ammonia (g)
100 uses by campers	7,500	4,400	800
100 uses of urinal	500	1,200	800

Such figures are usually expressed in terms of "population equivalent" (pe), being a comparison with the loading resulting from typical residential use:

	Volume in litres	BOD (g)	Ammonia (g)
Standard residential	200	60	8

The loading to be treated at the site is therefore estimated at:

Total loading per day	Volume	BOD	Ammonia
	10,000 litres	9,200 grams	2,350 grams
Concentration		920 mg / litre	235 mg / litre
Population equivalent	50 pe	153 pe	294 pe

These figures make it clear that the urine (ammonia) content arising from a parking area is very high (294 pe) relative to the volume of water used (50 pe) - had this been a typical residential site, the ammonia and volume 'pe' would (by definition) be the same. This realisation emphasises the need for the adequate treatment of high concentrations of urine.

For a public toilet facility that is using flush toilets and a water based treatment system such as a septic tank or a mechanical treatment plant (MTP)[G], the volume of the tank will need to be sized based on the estimated volume loading and the leachfield sized on the basis of the volume and the estimated BOD and ammonia loadings.

Septic tank or mechanical treatment plant (MTP) design considerations

For sites with an electricity supply, or which may have protected or limited land available for a treatment system, or where greater use is projected in the future, it is best to consider using a mechanical treatment plant (MTP)[G]. An MTP will achieve a higher quality of treatment than a septic tank, but in sensitive environments, its discharge will still need further treatment in a wetland system. However, a MTP does not work well when there are variable loadings and flow rates, so a balancing tank may be required to even-out the flows.

Both septic tanks and MTPs should be sized based on the loading criteria above.

Septic tank or mechanical treatment plant (MTP) sizing

The size of the septic tank or MTP required is determined by taking the estimated daily volume as the size of the tank, adding a margin, and rounding up to the nearest available commercial size. For the example camping site, the required 10,000 litre capacity can be rounded up to 12,000 litres. A larger volume can be rounded up to the nearest 5000 litres.

Maintenance and emptying of septic tanks and MTPs

Septic tank and MTPs must be emptied as per the manufacturer's instructions to ensure that there is no discharge of solids. Most suppliers recommend that the solids / sludge of an MTP be emptied at least twice a year. Suppliers may also offer an emptying and maintenance contract.

The rates supplied by Scottish Water for septic tankers in 2008-9 were as follows:

- Commercial: £214 for the first 9m^3 plus £13.40 per m^3 in excess of that.
- Domestic: Approximately £143 for the first 9m^3 (no rate given for additional volumes).

Sizing of leachfield / wetlands for secondary / tertiary treatment of sewage effluent

For the example camping site, a suitable treatment system requires a septic tank or MTP of volume 12,000 litres and a leachfield / wetland design capable of treating 50 pe volume, 153 pe BOD and 294 pe ammonia.

The Royal Commission Standard for effluent quality from sewage treatment systems in the UK is 20:30:20 (BOD: Suspended Solids: Ammonia) [G] - all in mg / litre. These figures are an older standard for acceptable discharge to the environment. In a sensitive lochside environment, more appropriate figures would be the lower values of 5:5:5, tending towards 0:0:0.

Although the British Water / SEPA Code of Practice (above) does not give typical effluent figures for suspended solids, these also need to be removed before discharge to the environment to prevent pollution of watercourses or clogging of leachfields.

To put these figure into context, residential septic tank effluent is around 120:180:80 and distilled water is 0:0:0.

For Sallochy, secondary treatment therefore needs to process the outflow from the septic tank at 920:1380:235 and reduce these levels to 5:5:5 (the 1380 SS figure is extrapolated from residential figures).

Sizing of leachfields

Leachfields are normally sized on the ability of the soil to filter and treat the nutrient load before it reaches the ground water or watercourse. Each soil type has different characteristics and its capacity to filter, drain and treat differs.

Due to the pollution of groundwater and watercourses caused by the traditional practice of discharging septic tank effluent to leachfields, this is no longer allowed in sensitive environments. Under current legislative guidelines, effluent should be treated to tertiary standards prior to discharge to either land or watercourse.

In order to determine whether or not a leachfield discharge is an option and to determine a suitable size, a percolation test will be required. The results should be sent to both SEPA and Building Control for their approval for a discharge to land and to SEPA (only) for a discharge to watercourse.

We have set out below [Section 5.5] the methodology and typical submission form for a percolation test to determine whether a given site is suitable for a discharge to a leachfield, and the required size.

Sizing of wetlands

Wetland and reedbed systems (constructed wetlands)[G] are used to treat discharges from septic tanks, MTP or greywater to achieve secondary and tertiary standards. Constructed wetland systems need to be designed and engineered (normally by specialists) on a case by case basis because each site and location is different.

Wetlands are designed to treat the total volume and loading discharged from either a septic tank or MTP in any one day, taking into account periods of peak loading. As a rule of thumb, if the wetland is sized to treat the BOD and ammonia, it will also be sufficiently large to manage the volume.

For sewage, the treatment capacity of a wetland is taken to be 20 grams BOD / ammonia removed per m^2. In the example of Sallochy, we add the 9,200 grams BOD to the 2,350 grams of ammonia needing to be treated and obtain a wetland surface area of (9200 + 2350) / 20 = 578 m^2.

Due to the sensitivity of the site at Sallochy in combination with high visitor numbers, and high BOD and ammonia loading, we would recommend that a MTP would be used to reduce the effluent loading so that the area required to treat the discharge to tertiary standards is smaller.

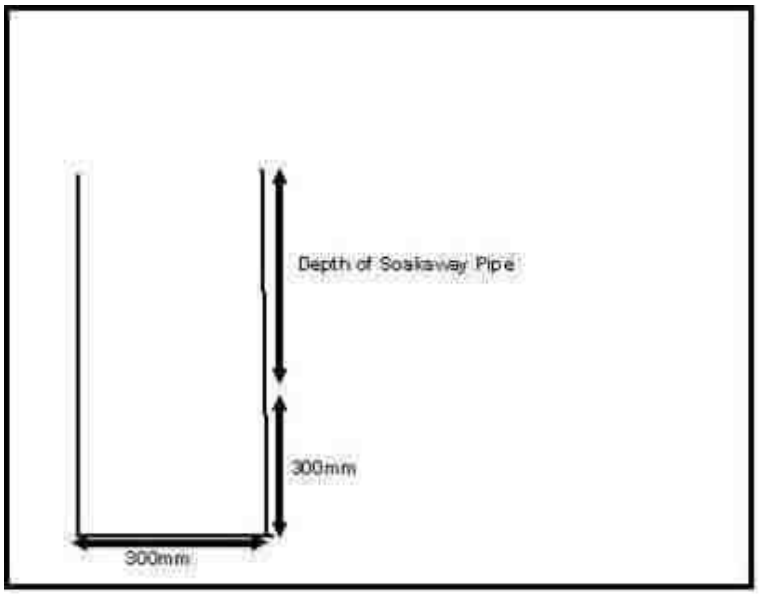
We anticipate that an MTP would be able to reduce the effluent loadings to 20 mg/l BOD and 20 mg/l ammonia. At 10,000 litres per day, the total loading becomes 400 grams total nutrient per day. The size of wetland required would then be reduced to 400g / 20 g/m^2 = 20 m^2. However, due to the reduction in loading, the size of wetland would need to be increased to be able to manage and treat the daily volume.

These figures are guidelines only and a full design study should be carried out for the site.

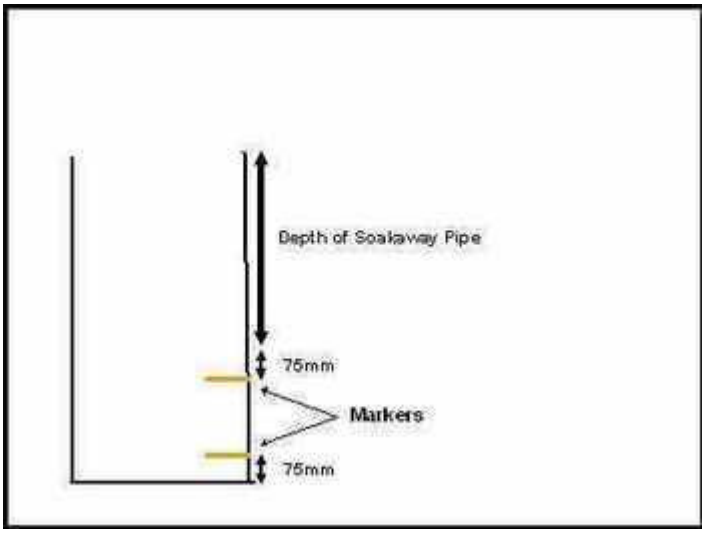
5.5 Percolation Tests

The Percolation test method explained

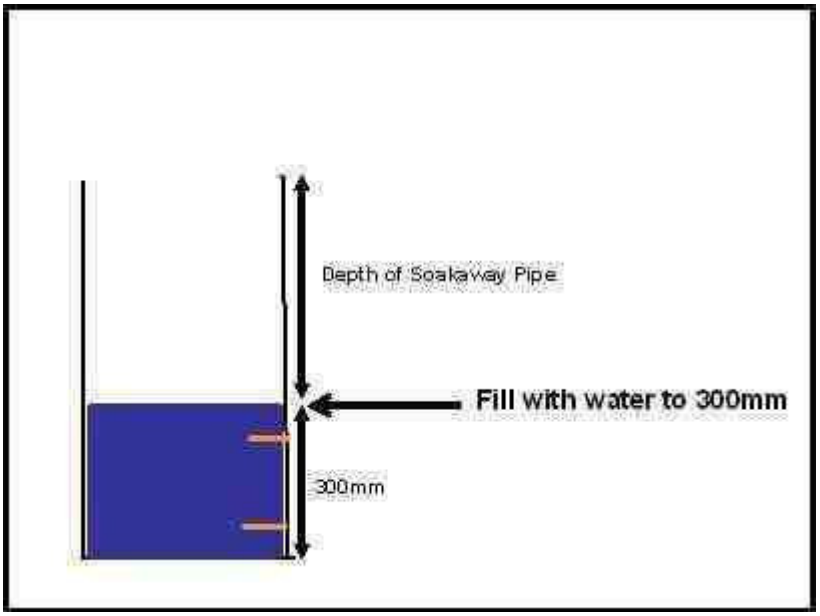
- A **percolation test** hole 300mm x 300mm x 300mm deep should be excavated below the proposed invert level of the effluent distribution pipe. For most septic tanks and sewage treatment units this depth is 1 metre, (i.e. the percolation test hole above is dug below ground for another metre to a depth of 2 metres). This usually requires a large hole to be dug to stand in whilst digging the small percolation test hole.



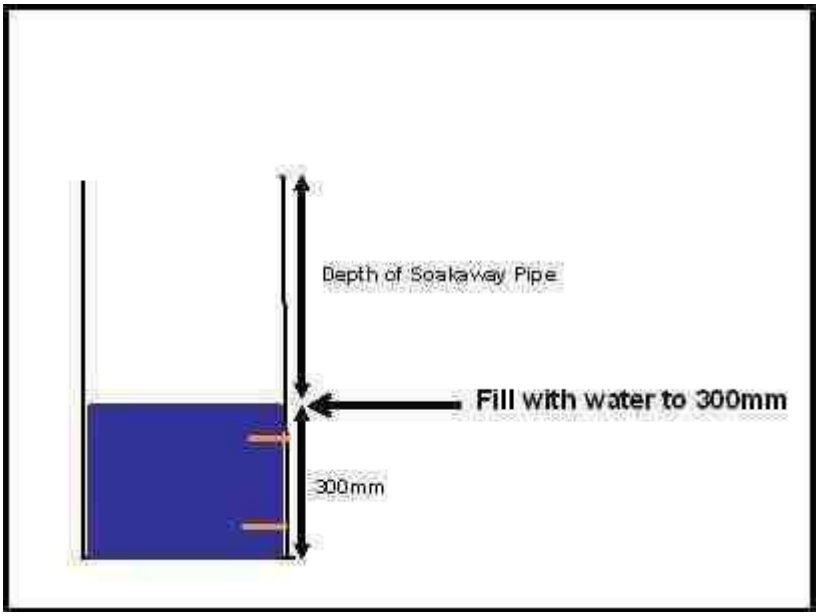
- 6 inch nails pushed into the sides of the hole, mark the hole 75mm from the bottom and 75mm from the top of the percolation test hole.

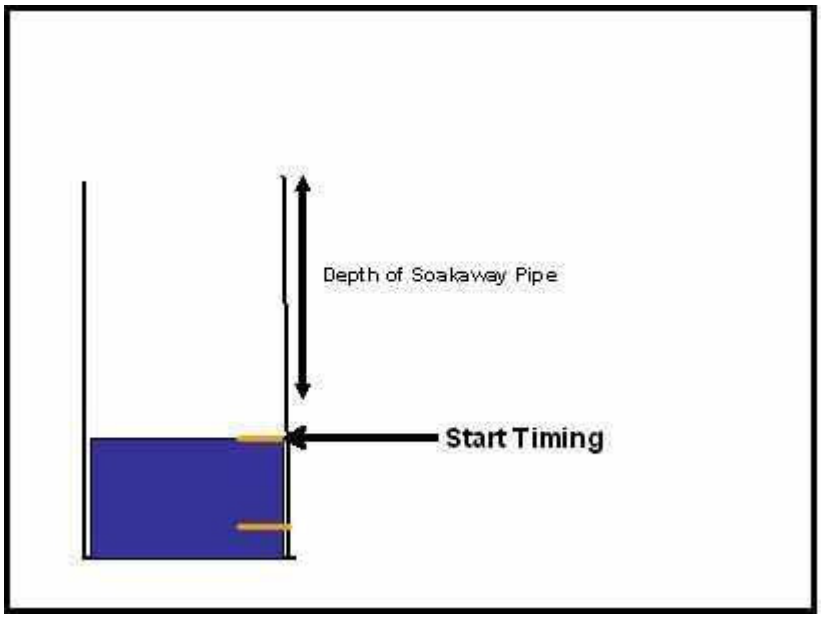


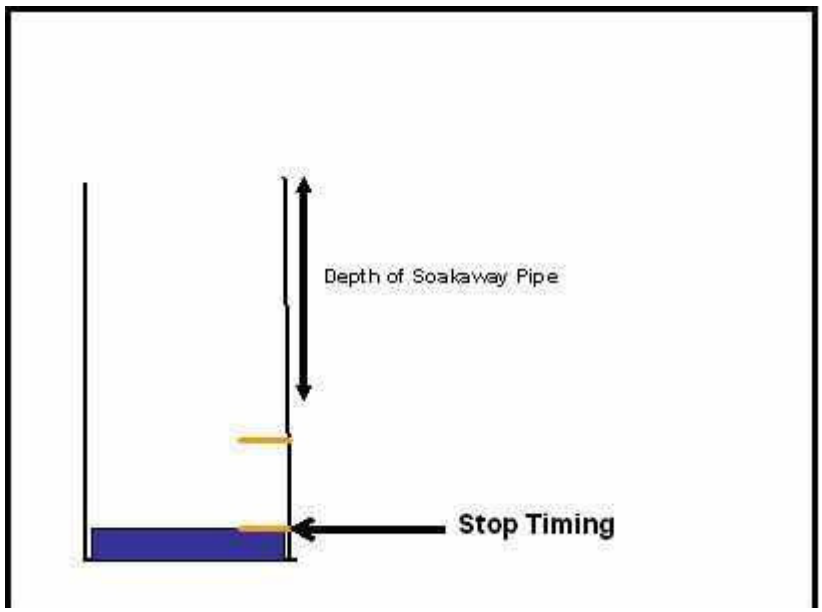
- Fill the percolation test hole to a depth of at least 300mm with water and allow it to seep away overnight.



- Next day, refill the test hole with water to a depth of at least 300mm and observe the time, in seconds, for the water to seep away from 75% full to 25% full level (i.e. a depth of 150mm).







Divide this time by 150mm. The answer gives the average time in seconds (Vp) required for the water to drop 1mm.

- The percolation test should be carried out at least three times with at least three trial holes. The average figure from the tests should be taken. The test should not be carried out during abnormal weather conditions such as heavy rain, severe frost or drought.

- Drainage field soakaway disposal should only be used when percolation tests indicate average values of Vp of between 15 and 100 and the preliminary site assessment report and trial hole tests have been favourable. This minimum value ensures that untreated effluent cannot percolate too rapidly into ground water. Where Vp is outside these limits effective disposal is unlikely to take place in a soakaway drainage field.

The percolation test calculations for a soakaway are as follows (see form below):

Area (A) = Vp X 0.20 for sewage treatment units and

Area (A) = Vp X 0.25 for septic tanks

V = the time is seconds for the water in the test hole to drop by 1mm.

p = the maximum number of persons that the unit is designed to serve

The calculation gives the AREA in SQUARE METRES required for the soakaway trenches. Further calculations are required to give the length of pipes required depending on the width of the trench, e.g. for a 600mm wide trench, the AREA would be divided by 0.6.

Other Factors

- Drainage fields are not to be constructed under driveways, parking areas, buildings, near trees, dwellings, boundaries, watercourses, boreholes, etc. Leave a minimum distance of 10 metres.

- Soakaway drains **MUST NOT** be installed unless the Site Assessment and Soil Profile deep test hole show that there is a minimum of 1.2 metres between the bottom of the drain and the water table or bedrock. If it is less than this, then the water does not have sufficient soil depth to drain away and pollution of the ground water can occur.

Set out below is a standard form that can be used to set out the percolation tests from the trial holes. The trial holes should be carried out in the vicinity of where the septic tank or mechanical treatment plant (MTP) is located. Building Control and SEPA or EA will require these tests to determine whether or not you will be allowed to discharge sewage from a septic tank or MTP to land.

Percolation Tests – Results and Drainage Field Calculation Form

I, *(name)*……on behalf of *(applicant)*……..…… have carried out percolation tests in accordance with the guidance provided with this form on (date)……in respect of premises at:

The overall depth of the trial holes dug was: *(state in metres / millimetres) for*
Trial Hole 1 Trial Hole 2

I confirm that the water table did not rise to within 1 metre of the invert of the proposed land irrigation scheme.

The weather conditions on the day were……

The results of the percolation tests were:

Trial Hole 1				***Trial Hole 2***			
	Time in seconds		***Vp***		***Time in seconds***		***Vp***
Test 1		÷ 150		***Test 1***		÷ 150	
Test 2		÷ 150		***Test 2***		÷ 150	
Test 3		÷ 150		***Test 3***		÷ 150	
Trial Hole 1 Average Vp				***Trial Hole 1 Average Vp***			

Take the Average Vp of Trial Holes 1 & 2 and incorporate this information in the following formula:

At = P x Vp x 0.25

where P is the no of people served by the tank, Vp is the time in seconds for the water to soak away and At is the floor area of the drainage field in square metres.

Assuming a 600 mm (0.6 m) wide drainage trench then At m^2 ÷ 0.6 m is the length of trench (in linear metres) required to soak away the volume of sewage from this population. Please note that drainage engineers can be engaged to carry out percolation tests.

I am aware that I require a Consent to Discharge from SEPA or the Environment Agency and this is attached / or has been requested *(delete as appropriate).*

Signed:…….. Address:……..
…….. Date: ……
……..
…….. Telephone No……..
…….....

6. Design considerations for public toilet facilities

The role of the public toilet: pathogen transmitter or health facilitator?

A 2006 research paper (C. Greed) discusses the role of public toilets as transmitters of disease, and their importance in contributing to the health and well-being of society.

"Research has shown that public toilets are vital components in creating sustainable, accessible, inclusive cities. But there is no mandatory legislation requiring local authorities to provide them. Over 40% have been closed in the UK in the last 10 years. The promotion of the 24 hour city, characterized by a male youth drinking culture, along with toilet closure, has resulted in increased street urination, creating the conditions for the spread of previously-eradicated, water borne diseases in city streets."

"Less visible, but as virulent, has been the effect of toilet closure for women. Women, in response to lack of toilet provision, are likely to 'hold on' resulting in urine (and pathogen) retention, and bladder distension increasing the propensity for continence problems. The elderly and people with disabilities may simply not go out for fear of there being no toilet when they need one. Those toilets that are available may be unusable. "

"The lack of regulation or compulsory standards results in poor toilet design, inadequate maintenance, and management and unhygienic conditions which leads to the spread of MRSA and other drug-resistant diseases. Unless compulsory legislation and increased funding is instigating its corresponding improved management, maintenance and cleaning regimes, public toilet provision will continue to be a source of disease."

6.1 Design of public toilet facilities

A starting point for any proposed toilet has to be good design of the public spaces. The public spaces must be easy to clean, the facilities need to be robust and easy to use, and good lighting and powered ventilation must be provided. The signage has to be clear, and carefully worded to avoid disgust and patronising language. Users should be encouraged to take a sense of ownership of the facility.

In Scotland, local authorities have no statutory requirement to provide or maintain public toilets, and yet the health and in many cases the livelihood from tourism of rural Scotland depends on proper sanitation and protection of the environment.

The British Toilet Association (BTA) argues that access to toilet facilities should be recognised a basic human need; that inclusive, clean, hygienic, publicly-accessible toilets for all types of users be provided where and when needed; and that independent audits be held to ensure compliance to standards.

The BTA has established the "Loo of the Year Awards" to highlight quality public toilet provision.

The following criteria sourced from the BTA website *www.britloos.co.uk* summarises their 'Best Practice' advice.

Typical reasons given by authorities for inactivity

- Capital cost of new toilets
- Cost of refurbishment of abused or neglected facilities
- Cost of cleaning and maintenance to attain satisfactory standards
- Vandalism considered to be insoluble

Consequences of authorities' inactivity

- Lack of facilities for residents and visitors
- Old and disabled prevented from leaving their homes
- Loss of attractiveness of area without toilet facilities
- Cost of street cleaning of urine and faeces due to lack of toilets
- Reliance on private facilities – bars, cafés, hotels
- Loss of visitors
- Loss of trade
- Loss of reputation

General

- Shelf for bags and hooks for outer clothing
- Sanitary and continence pad disposal
- A warm, clean, nice smelling environment

Age Friendly Facilities

- Adequate toilet facilities for the number of users at the location
- Accessible facilities – no steps or steep inclines
- Safe facilities – attendants on duty, well lit with exposed entrances
- Facilities available when needed – not just 09:00 to 17:00
- Larger cubicles available for the ambulant with wider cubicle doors
- Door handles and locks easy to use and in good working order
- Automatic or push taps

Family Friendly Facilities

- Dedicated unisex family toilet or facilities for both males and females
- Pushchair access
- Clean and safe baby change surface
- Nappy disposal
- Child friendly décor
- Low level WC and washbasin for children
- Toddler seat

Safe discreet facilities

- Female toilets with access separate from the male toilet access
- Sound privacy – provision of background sound
- Visual privacy – install bowl urinals with privacy screens
- Modesty screening between the urinal area and other areas e.g. wash basins, hand dryers, entrance door
- Cubicle walls and doors to ideally be floor to ceiling. If not, floor gaps should be the minimum needed to facilitate cleaning
- Secure cubicles – locks that work
- Lighting that is soft in tone

DDA Compliant Accessible Facilities

- DDA compliant access to the facility
- Adequate space for the user and at least one carer
- Planned to provide access to the WC, washbasin and all other facilities via a wheelchair
- DDA compliant grab rails to door, beside WC and wash basin
- Clean non-slip floor surface
- Toilet tissue, hand washing and drying facilities
- Shelf for bags and hooks for outer clothing
- Sanitary and continence pad disposal

Adult / Child Changing Facilities (for those with severe and multiple learning difficulties)

- A minimum of 3.5m x 2m to provide space for the user and 2 carers
- Separate from other able-bodied toilets
- Floor with non slip surface
- Fitted with height adjustable adult sized changing bed
- Fitted with a tracking hoist system
- Fitted with a screen or curtain to provide privacy
- A wide paper roll to cover the changing bed
- Hand washing and drying facilities for carer

6.2 Health & Safety (H & S) Considerations

Occupational health & safety is a cross-disciplinary area concerned with protecting the safety, health and welfare of people engaged in work or employment and creating a safe environment. The Health & Safety Executive produces numerous detailed documents for a wide variety of work environments and it is best to refer to their website for guidance on your particular requirements.

Much of the H & S documentation is written to protect those working in particular environments. For example, with regard to public toilet facilities, the health, safety and welfare of the personnel cleaning the toilet would need to be considered along with the public using the toilets

6.2.1 Workplace

Employers have basic duties concerning the provision and use of personal protective equipment (PPE) at work and the requirements of the Personal Protective Equipment at Work Regulations 1992 (as amended). PPE is defined in the Regulations as 'all equipment (including clothing providing protection against the weather) which is intended to be worn or held by a person at work and which protects them against one or more risks to his health or safety', (e.g. safety helmets, gloves, eye protection, high-visibility clothing, safety footwear and safety harnesses).

http://www.hse.gov.uk/contact/faqs/ppe.htm

6.2.2 Risk Assessment

A risk assessment is a careful examination of what, in your work, could cause harm to people, so that you can weigh up whether you have taken enough precautions or should do more to prevent harm. The law does not expect you to eliminate all risk, but you are required to protect people as far as 'reasonably practicable'. A risk assessment is process where you identify potential risks, assess the level of risk and write down measures that would prevent or neutralise the risk. The websites below provide guidance.

How to Carry out a Risk Assessment

http://www.hse.gov.uk/contact/faqs/riskassess.htm

This leaflet aims to help you assess health and safety risks in the workplace

http://www.hse.gov.uk/pubns/indg163.pdf

6.2.3 Construction, Design and Management Regulations

When does CDM 2007 (Construction, Design and Management Regulations 2007) apply to a project? http://www.hse.gov.uk/contact/faqs/cdm.htm

The CDM 2007 Regulations apply to most common building, civil engineering and engineering construction work. You must notify the Health & Safety Executive (HSE) of the site if the construction work is expected to either:

- last longer than 30 days; or
- involve more than 500 person days of construction work;
- involve more than 5 construction workers on site at any one time

HSE should be notified in writing before construction work starts; you can use form F10. Your notification should be sent to the HSE office nearest to the proposed site.

6.3 Insurance

With regard to public toilet facilities there are three main types of insurance that will be needed, and that insurance will be the responsibility of the owner of the buildings. These are guidelines and it will be necessary to speak with a professional insurance provider that can provide you with the most relevant insurances for your particular requirements.

They are:

Public Liability, which covers injury to the public, including both physical injury (e.g. slipping, falling tiles, part of the structure breaking) and disease caused by conditions in the toilet cubicle.

The claimant would have to prove that the owner was liable, i.e. that they had been negligent and / or had failed to take all reasonable precautions. This would include the display of suitable notices, (e.g. about slippery floors, hand-cleaning etc.) – whatever is needed in a normal toilet.

All Risks, with a Material Damage clause, which covers vandalism and collapse / failure of buildings. There may also be a separate building insurance.

Employer's Liability would be required to cover the operatives responsible for cleaning & maintenance if employed directly. If cleaning and maintenance services are contracted out, the company should have their own valid, relevant insurances.

If a Council is involved it is likely they will already have Public Liability and All Risks cover, and that it would be merely a case of extending these to cover the new facilities. Employer's Liability too will already be in place. If a Community is taking ownership of the public toilet facilities they would need to obtain their own insurance policies.

Examples of insurance (and other) costs as reported in 2009 at
http://www.monmouthshire.gov.uk/downloads/Internet_1_TOILETS.pdf

7. Infrastructure Support

7.1 Electrical supply

It is essential to provide good lighting and ventilation in a public toilet and in most cases this will require a supply of electrical power.

In situations where a mains electrical supply is not available, power can best be provided by deep-cycle lead-acid batteries and recharged by solar panels.

With modern technology, power requirements need not be large: 5 Watts is sufficient for a fan; a few Watts are sufficient for LED lighting.

As an example calculation, to provide power for two 5 Watt fans plus two 5 Watt LED lighting systems, assuming an average of 4 hours of sunlight per day would require one 105 Ah12V (volt) deep-cycle battery and a solar panel capable of generating 20 Watt. Calculations of the size of panel are not straightforward, however: the efficiency of the panel, the latitude, and the average cloud cover need to be taken into account.

It is not recommended to use car batteries as these are designed to deliver brief high-current power to start a car, and will be permanently damaged if discharged to low levels. In contrast, a solar system requires batteries capable of delivering low power on an on-going basis and designed to be deeply discharged without degradation.

Batteries must be protected against freezing and overcharging. They will risk permanent damage if repeatedly discharged by more than 80%. These factors stress the importance of matching the sizes of the panel and the battery.

Sources of information:

- www.solar-wind.co.uk
- www.freesunpower.com (includes solar calculator)
- www.alternativeenergystore.co.uk
- www.windandsun.co.uk
- en.wikipedia.org/wiki/Photovoltaic_array

Timers and self-stopping switches can be used to minimise power wastage.
Pneumatic timer switches (as used in French hotels) can be found here:

www.ecomonkey.co.uk/products/columbus-pneumatic-timer

Low power 12V LED bulbs can be found here:

www.brightgreensun.co.uk/index.php?main_page=product_info&products_id=21

www.virtualvillage.co.uk/2-x-12v-warm-white-light-12-led-g4-bi-pin-base-bulbs-002530-021.html

http://www.reuk.co.uk/buy-12V-LED-SPOTLIGHT-BULB.htm

7.2 Ventilation

It is essential to provide good ventilation in a public toilet. Small buildings are usually naturally ventilated but given the need to maintain freshness in a public facility, we consider that mechanical ventilation offers a better alternative.

Building Regulations in Scotland require that mechanical extraction be capable of at least three air changes per hour. For example, a 1.5m x 1.5m x 2.0m toilet cubicle has a volume of 4.5 m^3. Ventilation must achieve a change rate of 13.5m^3 / hour.

Vent-Axia consider, however, that in practice it takes 6-10 changes per hour to keep a toilet cubicle smelling fresh.

Building regulations information that applies to ventilation can be found here:
www.scotland.gov.uk/library5/development/ddsub/dbsr05nd-49.asp

Commercial compost toilets are usually supplied with passive ventilation via a spinning cowl and / or powered ventilation – typically via a 5 Watt fan. Information on chimney cowls can be found here:

http://www.fluefactory.com/

http://www.ascinfo.co.uk/building-company/ubbink-uk-ltd

Ventilation failure is a common problem with public toilets. It is important to install backup ventilation and ensure a replacement fan is readily available.

7.3 Low-flush toilets

Toilets account for about 30-40% of domestic water use and up to 90% for offices and public conveniences. As from January 2001, all new toilets installed in the UK have to have a maximum flush of 6 litres. This volume can be reduced further by efficient design.

Most of the low flush toilets currently available on the UK market use dual-flush valves (which use either a button-press or sensor system). These can save water until the valves become faulty, after which they leak water continually down through the pan. A study in the U.S.A. estimated that 20% of toilets leak. Valve mechanisms are also less robust than the traditional UK siphons and dual flush users may also need to be educated to avoid double flushing.

The Green Building Store proposes a toilet that answers both of these problems - a water-efficient WC with siphon flush which will never leak.
www.greenbuildingstore.co.uk/page--water-saving-toilets.html
A best-practice guide is available here:
http://www.greenbuildingstore.co.uk/media/page_content/Sanitaryware/Sanitaryware%20PDFs/WC%20report/WC-article.pdf

Toilets can also be flushed by vacuum, as is often installed in aircraft. Vacuum flush pedestals are not recommended by Phoenix for use in their composting toilet. One supplier is:
www.roevac.com

7.4 Urinals

A standard urinal that is not flushed often will soon stink and eventually block up. By contrast, a urinal that is flushed every 3 minutes (the typical time it takes to fill a cistern) is unlikely to smell or block. However, it is illegal to flush urinals on a continuous basis and most toilets employ either a simple tap or a more sophisticated flush controller to prevent such frequent flushing. Unfortunately, the reduction in the frequency and quantity of water passing through the waste pipes often leads to problems with odours and blockages.

A rule of thumb is that a standard urinal should be flushed within 20 minutes of use. This can be achieved using a flush controller that incorporates a usage sensor.

Most blockages in urinal waste pipes are caused by the combination of uric acid salts (contained in urine) with the limescale contained in water. Toilets with soft water are likely to experience less problems with blockages than those with hard water. When sitting static in the waste pipes, urine

and limescale combine to coat the pipework with a hard scale leading to blockage. The coating also provides an ideal medium for the development of odour causing bacteria.

With waterless urinals, there are broadly two approaches employed to prevent odours from the waste pipes reaching the toilet. Microbiological systems rely on bacteria to break down the urine before it becomes malodorous, while barrier and valve systems seek to trap the foul air in the waste pipework by passing urine through an oil-based barrier fluid.

Appropriate cleaning chemicals must be used and simple but regular maintenance is required. Details can be found here:

www.waterlessurinals.co.uk/about-waterless-urinals

Another waterless design combines an ergonomically designed urinal bowl with a small integral fan. The low wattage long life fan creates negative pressure, which maintains a gentle flow of air down the urinal bowls, removing all odour. Details can be found here:

www.greenbuildingstore.co.uk/page--airflush-waterless-urinal.html

Sources of information:

www.waterlessurinals.co.uk

www.falconwaterfree.com

www.greenbuildingstore.co.uk

Sites that have installed low-flush toilets and waterless urinals include:

High Peak Borough Council, www.highpeak.gov.uk

National Trust Visitor Centre, Sheringham Park, Norfolk, www.nationaltrust.org.uk/sheringham/

7.5 Building contractors

A number of building contractors specialise in the construction of public toilets.

Premier Hygienic has worked in collaboration with the Forestry Commission (Case Study [12.9]) to design a highly-insulating toilet superstructure suitable for Forestry Commission woodland sites in Scotland.

Premier Hygienic designs can include coin-operated doors, detection sensors, and a range of DDA features. Premier Hygienic also offers to upgrade existing facilities.

Suppliers:
- www.premierhygienic.co.uk
- www.thrislingtoneducation.com

Information:
www.hie.co.uk/sustainable-buildings-brochure.pdf

7.6 Hand cleaning

Providing a water supply for hand washing in a public toilet usually creates problems. The water will need to be treated before release into the environment, adding significantly to the size of the treatment plant. The water may be used for unintended purposes and may be left running, causing flooding. Where a dry toilet has been installed, water may be used to clean the toilets, resulting in flooding the composting chambers and compromising the composting process.

We understand that European legislation prohibits the use of rain or surface water for hand washing.

An alternative to water-based hand cleaning is anti-bacterial gels or alcoholic sprays. Anti bacterial products are environmentally unfriendly, as they introduce chemical products into the environment and toilet treatment system, as well as promoting the mutation of bacteria. Alcohol-based sprays appear to be the most effective available product for hand cleansing in public toilets.

Hand alcohol detail:

Hand alcohol is a type of antiseptic agent used in health care to avoid transmission of pathogens. Hand alcohol exists in liquid, foam, and easy-flowing gel formulations. The level of alcohol varies between 60% and 85%. The most commonly used level is 70%.

Despite common perceptions, hand alcohol is well suited to the skin. Several studies have demonstrated that it does not cause dehydration. In contrast, soap and water significantly decreases the epidermal water content compared to alcohol-based hand gels.

Hand alcohol should be thoroughly rubbed into the hands and on the lower forearm for at least 30 seconds, and then allowed to air dry. Optimal disinfection requires attention to all exposed surfaces such as around the fingernails, between the fingers, the back of the thumb, and around the wrist. To minimise carryover, jewellery should be removed from hands during use.

Alcohol rub sanitisers kill most bacteria, and some viruses. Alcohol rub sanitisers containing 70% alcohol kill 99.9% of the bacteria on hands 30 seconds after application.

Sources of information:

www.lewishygiene.co.uk
www.pearrocltd.co.uk
www.norinse.co.uk
www.calfarme.com
www.excalibur-hygiene.co.uk
www.gojo.com
www.tork.co.uk/Pages/ProductsServices/ProductDispatcher.aspx?id=9499&pid=420101&scid=1405

7.7 Bulking / soak material

'Soak' is a carbon-rich material added after defecation in a compost toilet. It serves to add bulk and aid the aeration of the accumulating faeces, and to balance the nitrogen to promote composting.

Wood waste such as sawdust or shavings is typically used as a soak, with shavings being preferred as they create more air spaces in the compost pile. Other soak materials include bark chips, leaves, straw, hemp and peat, although peat habitats are now protected and alternatives should be used. It is important to source products that have not been treated with chemicals.

NatSol proposes the use of hemp horse bedding:
www.hemcore.co.uk/bedding.php

A further valuable additive is mushroom compost. This serves as a compost activator. Cow pats or horse manure can also be used to provide additional nutrients and bacteria to aid the composting process.

8. Community Management Districts

In 2003, the U.S.A. Environmental Protection Agency (EPA) published a “Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems”

http://cfpub.epa.gov/owm/septic/index.cfm

This guide helps communities establish comprehensive management programs to ensure that all septic systems function properly.

Nearly one in four households in the United States depends on an individual septic system (referred to as an on-site system) or small community cluster systems to treat wastewater. In far too many cases, these systems are installed and largely forgotten - until problems arise.

EPA concluded in its 1997 Report to Congress that "adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas." The difference between failure and success is the implementation of an effective wastewater management program. Such a program, if properly executed, can protect public health, preserve valuable water resources, and maintain economic vitality in a community.

Some common scenarios considered in the report include:

- Waterfront seasonal recreational communities have transformed into year-round bedroom communities whose residents find their onsite systems overwhelmed and their water quality threatened.

- Growing numbers of retirees are creating a demand for development in relatively remote rural areas, which lack significant wastewater infrastructure or management capacity.

- Scattered rural populations, often with limited incomes, suffer nuisances and public health hazards due to poorly-built, inadequately maintained, aging septic systems.

- Increasing growth pressure is occurring in the fringe areas just outside established metropolitan areas, where it is not feasible to extend sewer lines from existing treatment plants.

The guide provides:

- A basic overview of the elements essential for the sound management of decentralized wastewater systems.

- A step-by-step process for developing a management program specifically suited to a community.

- Links to extensive resources (articles, publications, web sites, databases, software, government programs) for more thorough investigation of particular topics or management program elements.

The Scottish Context

The relevance of this work to Scotland is in sparking the idea of communities taking ownership of the sanitation provision in their local area. In Scotland, local authorities have no statutory requirement to provide or maintain public toilets, and yet the health and in many cases the livelihood from tourism of rural Scotland depends on proper sanitation and protection of the environment.

The U.S.A. experience suggests that the most effective way of ensuring high quality sanitation in rural areas is to establish 'management districts' where a community takes responsibility for all off-mains toilet systems, and ensures they meet suitable standards, not just at the outset, but on an ongoing basis through continuous monitoring.

The expectation is that setting up sanitation management districts will provide new employment through the need for monitoring, maintenance and cleaning staff, safeguard the environment, and encourage tourism through the provision of high quality facilities.

A rule of thumb for the non-industrialised world is that every pound invested in sanitation reaps a financial return of six pounds, through improved health, reduced absenteeism and enhanced tourism. Whether the figure for Scotland would be this great it unknown, but one can imagine the result of even a minor pollution scare on Loch Lomond. When a bird carrying avian flu was discovered in Fife in 2006, tourism and sales of local poultry and fish plummeted.

A cholera outbreak in Peru in 1991 - linked directly to poor sanitation - led to losses in agricultural revenue and tourism that were three times greater than the total amount of money spent on sanitation during the previous decade! [R: George, 2008].

The first point of contact between the public and the authorities charged with the maintenance of national parks is typically through the use of public toilets, and a poor experience here can tarnish the experience of visitors and promote anti-social behaviour.

Community management of sanitation

As we argue in this study, discharges from sewage treatment facilities should be minimised and tend towards zero. Many rural septic systems will have unknown and most likely high levels of discharge. As the management district guide suggests, this situation can be sensitively but surely brought under control and brought up to a suitable standard through a range of measures.

Much of the guide focuses on supporting a community to take ownership of a situation rather than relying on statutory authorities. The local environment needs to be surveyed and installations inventoried. Education is required for the community to come to realise the impact of poor sanitation and the benefits accruing from implementing change. Registration of all off-mains system can be required and then yearly verification of their function. Funds can be found to upgrade deficient systems.

Community badging schemes can encourage hotel and bars to provide access to their facilities to visitors, and signage to this effect can be established at rural parking areas and at the hotels and bars themselves. It is likely that the welcome extended by hotel and bars to visitors will result in increased trade and greater contact between locals and visitors.

Maintenance and cleaning contracts are likely to be more efficient and effective if a community takes on the responsibility for the management of all public toilets in their area. Lateral thinking may come up with other solutions – are school cleaners available during the summer months to augment the maintenance staff for public toilets?

An honesty box or charging for the use of toilets and / or parking spaces may be a means of generating an income to cover running costs. This can be combined with offering a café or other services, which would help to support local businesses.

8.1 Perth & Kinross Council & Community Partnership Schemes

http://www.pkc.gov.uk/Planning+and+the+environment/Street+care+and+cleaning/Street+care+and+cleaning+-+public+toilets/Comfort+Scheme+Locations.htm

Perth and Kinross Council currently operate 14 public toilets throughout the area. They are a mix of unattended facilities, located mainly in smaller settlements and parks which are free to use; and attended facilities which are situated in larger towns, where a 30 pence admission charge is made.

Perth and Kinross Council also offer a number of free to use public toilets through partnerships with service providers such as Hotels, Pubs and Public Buildings. This is known as The Perth and Kinross Comfort Scheme that offers their toilet facilities free of charge to members of the public, whether or not they are a customer.

There are currently 29 Comfort Scheme partners, whose facilities are now available for public use.

Mobile Toilets for Community Events

Perth and Kinross Council has recently entered into partnership with a local provider, to supply short-term hire of mobile toilets. Organisations who are holding community events throughout Perth and Kinross, and do not have access to public toilets can apply for the toilets free of charge. Examples of events include community organised fundraising for charities, gala days and fun days.

8.2 The Coastal Tourism project, Wales

“The Welsh Assembly Government continues its long term commitment to supporting tourism and public toilets. Tourism employs over 100,000 people in Wales and contributes in excess of £ 3 billion to the Welsh economy.”

“The Coastal Tourism project includes a Green Sea programme to maintain and improve our coastal heritage. It funds the maintenance of services such as public toilets and information facilities. These practical measures all help to enhance the experience and reputation of a visit to the Welsh coastline.” (Extract from Welsh Assembly Government Press Release - 18 February 2010).

9. Regulations

Legislation, Regulations and Approval Process

There are three main bodies in Scotland that must be consulted and from whom approval must be obtained prior to building a structure (e.g. public toilet facilities). Considerations include the need for drainage and any environmental issues arising from the development. The approval process is concerned with ensuring the best interests of a community and the wider environment. These bodies include the Planning Authority, Building Control and the Scottish Environment Protection Agency (SEPA). Scottish Natural Heritage (SNH) may also have to be consulted in for installations in sensitive environments.

Planning permission and a building warrant must be obtained before construction can commence. The main legislation governing these is summarised below and has been sourced primarily from the Scottish government website.

9.1 Planning

The Town and Country Planning (Scotland) Act 1997 is the principal legislation governing the use and development of land within Scotland.

The 1997 act is supported by various pieces of subordinate legislation, such as the Town and Country Planning (General Development Procedure) (Scotland) Order 1992, the Town and Country Planning (General Permitted Development) (Scotland) Order 1992, and the Town and Country Planning (Use Classes) (Scotland) Order 1997.

More recently, and following a white paper on *Modernising the Planning System*, the Scottish Parliament passed the Planning etc (Scotland) Act 2006, which sought to amend certain parts of the 1997 Act; including development plan preparation, development control, now known as development management in Scotland, and enforcement. These changes came into force on 3 August 2009 and amended the 1997 Act, which still remains the principal planning act in Scotland.

Planning Scotland Act 2009:

http://www.google.co.uk/#hl=en&source=hp&q=planning+scotland+act+2009&meta=&aq=1&oq=Planning+scotland&fp=c6c9946001627c7b

Scotland's Planning legislation:

http://www.scotland.gov.uk/Topics/Built-Environment/planning/modernising/progress/Legislation

9.2 Building Control

The Building Control System in Scotland

Local authorities administer building control in Scotland, enforcing regulations made by the Scottish Ministers subject to approval by the Scottish Parliament.

Building control applies to the construction, alteration, extension or demolition of a building or part of a building, or to any change of use which attracts additional or more onerous requirements under the regulations.

The essential purpose is to safeguard people in and around buildings. To this has been added the conservation of fuel and power used in buildings, and the provision of facilities for the disabled in

and around buildings. It is a pre-emptive system, ensuring as far as practically possible that the proposed buildings will not contravene the regulations and that on completion they do in fact comply.

Building Regulations: Technical Standards

http://www.scotland.gov.uk/library2/br/br-00.asp

http://www.scotland.gov.uk/library2/br/br-01.asp

The following regulations that must be met include the Building Standards (Scotland) Regulations 1990, as amended by the Building Standards (Scotland) Amendment Regulations 1993, the Building Standards (Scotland) Amendment Regulations 1994, the Building Standards (Scotland) Amendment Regulations 1996, the Building (Scotland) Amendment Regulations 1997, and the Building Standards and Procedure Amendment (Scotland) Regulations 1999.

The publication presenting the Technical Standards which are the relevant standards for compliance with the Building Standards (Scotland) Regulations 1990, as amended. The Technical Standards have full Statutory force by virtue of Regulation 9.

Although presented in separate parts to relate to particular regulations, the Technical Standards and the Regulations must be considered and applied as a whole. More than one standard or regulation may bear on a particular building element or design decision. Where this is relevant the most onerous standard applies [see for example Regulation 6 (4) or Regulation 7 (3)].

9.3 Scottish Environment Protection Agency (SEPA)

Scottish Environment Protection Agency (SEPA)

SEPA is a Statutory Consultee in the Planning process. SEPA will need to approve and issue a Controlled Activity Regulations (CAR) licence for the treatment system for foul drainage arising from a building or development prior to construction to ensure there will be no pollution to ground water, a water body or watercourse. SEPA will also need to approve the measures for the attenuation and treatment of surface water under legislation governing Sustainable Urban Drainage Systems (SUDS). SEPA also issues separate waste management licences for the management and treatment of contaminated waste arising on a given site. SEPA will also comment on flood risks.

The following summary has been sourced principally from SEPA's website.

Planning

http://www.sepa.org.uk/planning.aspx

SEPA is identified as a key agency under the Planning etc. (Scotland) Act 2006 and is proactively assisting delivery of the Scottish Government's commitment to provide a more effective and efficient planning system. SEPA provides formal environmental advice in relation to development plans and on a wide range of development proposals across Scotland.

Planning guidance notes and advice on different development types and topics can be found on the SEPA website. SEPA welcome early engagement on larger developments to help you identify opportunities, constraints and solutions. For small-scale local developments please refer to SEPA's Standing advice for small scale development.

The guidance note '*How and when to consult SEPA'* gives detailed information on the consultation process. To assist, they have developed a checklist for planning authorities to use when consulting with SEPA on planning applications.

SEPA's main role is to protect the wider environment from pollution and they have to ensure the European and UK legislation is adhered to and achieved to maintain and improve the water quality of receiving waters. Some of the most relevant legislation is listed below:

Water regulations

In 2003, an ambitious piece of European environmental legislation called the Water Framework Directive (WFD) resulted in the Water Environment and Water Services (Scotland) Act 2003 (WEWS Act) becoming law in Scotland.

The WEWS Act gave Scottish ministers powers to introduce regulatory controls over water activities, in order to protect, improve and promote sustainable use of Scotland's water environment. This includes wetlands, rivers, lochs, transitional waters (estuaries), coastal waters and groundwater.

These regulations are more commonly known as The Water Environment (Controlled Activities) (Scotland) Regulations 2005 (CAR). If you intend to carry out any activity which may affect Scotland's water environment, you must obtain authorisation to do so.

Discharges, disposal to land, abstractions, impoundments [G] and engineering works are all regulated by SEPA. The links below can be used to find out more about which regime your activity falls under, what kind of permission you need to continue operating and the charges that may apply.

Further information

- Water Framework Directive (or WFD)
- Water Environment and Water Services (Scotland) Act 2003
- Water Environment (Controlled Activities) (Scotland) Regulations 2005 (as amended)

Directives by subject

Directives are agreed by the Council of the European Communities. Each Member State is then obliged to give effect to them on a statutory basis. In Scotland this may be done either through regulations made under the European Communities Act, or under any other empowering primary legislation, such as the Environment Act 1995. A further option is for the Scottish Government to issue an official direction to SEPA, or any other body, specifying action to be taken to meet the directive's terms.

There have been numerous environmental directives issued over the years, some of them highly technical, and they can only be summarised briefly. The titles used here are often abbreviated. Many of the directives have a requirement for periodical reporting to the European Commission.

Water

- **Bathing Waters Directive** sets limits on indicator bacteria concentrations in seawater at 80 identified bathing waters in Scotland.
- **Shellfish Waters Directive** is intended to protect coastal waters in order to support shellfish.
- **Dangerous Substances Directive (and 'daughter' Directives)** sets concentration limits in fresh and marine waters for trace metal and trace organic substances. The more hazardous and persistent are known as List I (e.g. hexachlorobutadiene, chloroform, cadmium) and the less serious are known as List II (e.g. zinc, lead, copper).
- **Nitrates Directive** intends to control the pollution of controlled waters by preventing excess use of fertilisers on agricultural land.
- **Freshwater Fisheries Directive** requires compliance with certain standards to protect waters designated to support healthy fish populations.
- **Urban Waste Water Treatment Directive** sets out timetables for the implementation of appropriate treatment for sewage discharges which, for example, would require secondary treatment for all sizeable communities unless the discharge is to highly dispersive receiving waters. It also specifies quite demanding regulation in terms of sampling and analysis.
- **Directive on the Exchange of Information on the Quality of Surface Freshwaters** sets up a monitoring programme, with annual reporting on a suite of parameters. In Scotland there are sites on the Rivers Spey, Almond and Leven.
- **Protection of Groundwater Directive** intends to prevent pollution of groundwater by List I and List II substances.

Following the second and third North Sea Conferences, the UK undertook to monitor for Red List substances (e.g. pentachlorophenol, mercury) and to reduce their release to the aqueous environment by prescribed amounts (generally 50%) over a 10-year period relative to a 1985 baseline. The Paris Convention (PARCOM) agreement requires annual loadings to be quantified from all sources, including rivers and discharges, for a range of parameters, including nitrogen and phosphorus.

Security of the general water environment

Governed by Water Environment and Water Services (Scotland) Act 2003, http://www.opsi.gov.uk/legislation/scotland/acts2003/asp_20030003_en_1

Groundwater

Protection is governed by the **EC Groundwater Directive (80/68/EEC)**. This has been implemented in the UK by:

1. **Groundwater Regulations 1998**

http://www.environment-agency.gov.uk/business/topics/water/32018.aspx.

2. **Regulation 15** of the Waste Management Licensing Regulations 1994 and subsequently amended many times
(see *http://www.netregs.gov.uk/netregs/63492.aspx)*

Elsewhere, new 2006 regulations for England and Wales apply, and will be referred to and incorporated in Scotland.

The Groundwater Directive specifies groups of substances that are considered to be particularly undesirable in groundwater. Relevant to sewage are the substances in List 2:

- Metalloids and metals and their compounds (e.g. salt)
- Ammonia and nitrates
- Biocides and their derivatives (including certain disinfectants and cleaning agents)
- Hydrocarbons, oils and fuel

The Directive requires that any discharge is limited so as to prevent any danger, current or future, of deterioration of groundwater quality.

It directs that waste is recovered or disposed of without endangering human health or harming the environment, and in particular without risk to water, air, soils, plants or animals, without causing a nuisance through noise or odours and without adversely affecting the countryside or places of special interest.

Diffuse Pollution

Relevant Scottish regulations are the **Controlled Activities Regulations 2005 (CAR)**.
http://www.opsi.gov.uk/legislation/scotland/ssi2005/20050348.htm

Diffuse pollution from land use activities has a significant impact on water quality. To achieve the objectives of the Water Framework Directive (WFD), the quality of Scotland's water environment must be maintained and, where necessary, improved.

In rural areas diffuse pollution arises from land use activities such as livestock grazing, cultivation of land and forestry operations. Such activities release pollutants that can impact on water quality at the scale of a river catchment.

The pressures and impacts from diffuse pollution are described in the *Significant Water Management Issues Consultation Document* and include impacts on human health through pollution of drinking or bathing water. The pollutants of concern include the nutrients nitrogen and phosphorus, sediment, pesticides, biodegradable substances, ammonia and micro-organisms.

The issue of protection of catchments and river basins is explored more deeply in *Introduction to Significant Water Management Issues in the Scotland River Basin District*,
http://www.sepa.org.uk/water/water_publications/idoc.ashx?docid=0ea25dc7-7291-49de-b2a1-1922efbda38f&version=-1

SEPA maintains a Register of Protected Areas:
http://www.sepa.org.uk/water/register_of_protected_areas.aspx.

Composting

http://www.sepa.org.uk/waste/waste_regulation/composting.aspx

'Composting' means the autothermic (self-heating) and thermophilic (between 40 and 80 ºC) biological decomposition and stabilisation of biodegradable waste under controlled conditions resulting in a stable, sanitised material that can be applied to land for the benefit of agriculture, horticulture or ecological improvement. Composting can range from the very simple as in open windrows (large heaps), to sophisticated computer controlled in-vessel systems.

Composting is one of the main waste treatment processes used today to reduce the amount of waste going to landfill. Depending on the size of operation, the technology used and the types of waste processed, composting is regulated by:

- Waste management Licensing (Paragraph 12 - Exempt Activities)
- The Pollution Prevention and Control (Scotland) Regulations 2000
- Animal By-Products (Scotland) Regulations 2003
- Other technologies associated with composting are:
- Anaerobic Digestion (AD) and
- Mechanical Biological Treatment (MBT)

Waste

http://www.sepa.org.uk/waste/waste_regulation/application_forms/waste_management_licence.aspx

The Waste Framework Directive (WFD) (75/442 EEC as amended by 91/156 EEC) has been adopted in the UK. The definition of waste provided in the WFD is "any substance or object in the categories set out in Annex 1 which the holder discards or intends or is required to discharge". Annex 1 aims to include most sources and types of waste, but is incomplete.

This document states that "The definition should be read in the context of the holder (defined as the producer of the waste or the natural or legal person who is possession of it) of the waste since it is their intent or decision to discard which determines whether something is waste.

Regulatory controls apply to waste until it is fully recovered and has ceased to be waste. The fact that a holder may have a use for a waste or that the waste may have a value does not necessarily mean that it is not being discarded or that it has been fully recovered. Although a waste my be sold or traded, or is capable of being recovered, this does not mean that it has ceased to be a waste. Only once a final recovery operation has been completed – for example by being incorporated into a final product or being used in place of a non-waste material – does waste cease to be a waste".

Controlled Activities Regulations

http://www.sepa.org.uk/water/water_regulation/car_application_forms.aspx

Regulations Summary

The Regulations are intended to protect Scotland's water environment and have to be complied with by law. The relevant regulations are the Water Environment (Controlled Activities) Regulations 2005.

Licence Summary

A Car Licence is an environmental licence granted for specific activities including:

- Discharging in water and ground water
- Impounding water courses
- Abstracting water from water bodes
- Undertaking engineering activities in or near water bodies

The licence is issued by the Scottish Environment Projection Agency and the conditions in the licence must be complied with by law.

Eligibility Criteria

Owners and/or operators of activities not covered by a general binding rule (GBR) under the Water Environment (Controlled Activities) (Scotland) Regulations 2005 (CAR) need to apply to SEPA for authorisation. This will be in the form of either a registration or a licence. Whether or not the applicant is granted a licence will depend on a number of factors such as whether the activity complies with the environmental controls needed to protect the environment in Scotland. To discuss an application, contact the local SEPA office nearest to the proposed activity.

The Controlled Activities Regulations - A Practical Guide (540k) helps determine the correct level of authorisation and the application forms needed.

Application Evaluation Process

- For some applications, SEPA may ask you to advertise your application to allow local interested parties to engage in the licensing process.
- SEPA may seek to issue a draft licence for consultation under the EU Public Participation Directive.
- Evaluation of the application will consider a range of environmental factors and whether operator is a fit and proper person to hold the licence.

Tacit Consent

Tacit consent does not apply under CAR. There are clearly defined requirements for the applicant to enough information to enable SEPA to make a decision. Should that information not be available, the decision timescale will be extended to ensure that SEPA has adequate time to process all the required information.

SEPA CAR Licence with Guidance Notes and Glossary of Terms

http://www.sepa.org.uk/water/water_regulation/idoc.ashx?docid=b1eca6b8-0f05-4110-89c2-4631501aa3a6&version=-1

9.4 Scottish National Heritage (SNH)

The Natural Heritage and Designated Sites

The natural heritage is one of Scotland's biggest assets and its protection should be a prime consideration in any proposed toilet development. The role of Scottish Natural Heritage (SNH) is to look after the natural heritage, help people to enjoy and value it, and encourage people to use it sustainably. SNH is a Government body responsible to Scottish Government Ministers and through them to the Scottish Parliament.

SNH works nationally and locally through a number of units, with much of its day-to-day work being done through 11 Area teams based in offices throughout Scotland. To find the location and contact details of your nearest office, visit the SNH website at http://www.snh.org.uk/

Protected Areas

One of SNH's major responsibilities is to ensure the conservation and enhancement of habitats, species and landscapes. One mechanism to enable this is the system of 'protected' areas which operates on a UK and an international basis. Each of these designations carries its own level of protection and you may have to obtain consent for any development you want to carry out. To help

people find out more about designated sites and the natural heritage SNH has developed a set of interactive web tools that can be found at www.snh.org.uk/snhi/

In particular, the SNH Sitelink tool will help you find out about local sites designated for their natural heritage value. The best option is to use the Sitelink tool to check if your project is in or near a protected area and also to contact your local SNH Office for advice.

In Scotland protected areas form some 20 per cent of the land area. The main protected area designations are as follows:

- Wetlands of International Importance (Ramsar). These sites are internationally important wetland sites protecting wildfowl habitat

- Special Protection Areas (SPA). These areas are of European importance for wild birds.

- Special Areas of Conservation (SAC). These areas are of European importance for Wild Fauna and Flora. They range from sand dunes and forest to bogs and heath land.

- National Parks. The Parks have been established to deliver better management of some of Scotland's most special areas of outstanding natural and cultural heritage. They include Coastal & Marine National Parks Regional Parks. These Parks provide better management of large areas which are popular for informal recreation, close to the main urban centres.

- Sites of Special Scientific Interest (SSSI). These are exemplary sites in Scotland for nature conservation. They are special for their plants or animals or habitat, their rocks or landforms or a combination of these. Designation is a legal process.

- National Nature Reserves (NNRs). All of these sites are important nationally for nature, they are also designated SSSIs.

- National Scenic Areas (NSAs). These sites are nationally important areas of outstanding natural beauty. They represent some of the best examples of Scotland's grandest landscapes, particularly lochs and mountains.

- Country Parks. These Parks provide attractive venues for informal recreation and environmental education, close to the main urban centres.

- Local Nature Reserves (LNRs). These are sites with special local natural interest, set up to protect nature, and for people to enjoy and appreciate.

- Local Landscape Designations. A well-established and valued approach to protecting and guiding change in areas of particular landscape importance in Scotland.

10. ‘Exotic’ systems not considered

Non-standard solutions to the processing of human waste abound. Rather than survey all possibilities, we note here a range of technologies that we have not considered on the grounds that they are not sustainable, require too much management, energy or inputs, are not appropriate at the scale of toilet provision considered, or would not work in the climatic or rural settings being considered in this study.

- Cess pools – illegal in Scotland; flooding and overflow problems
- Biogas production – complex technology, currently only viable on a large scale
- Incineration – polluting; high energy consumption; non-ecological
- Pit toilets, bark rings and the like – temporary; problems of installation and manipulation; probably illegal (e.g. cess pools)

11. Lessons learned and next steps

As with many things human, the problem of toilet provision in rural areas rests on the psycho-social reality of a clash of cultures: most people nowadays live in an urban environment constrained by other people, buildings and regulations, and are somehow expected to behave responsibly in a 'natural' environment that few have any experience of.

Each attempted resolution of a problem typically makes the problem worse: civilisation gains a toe-hold in a national park, giving urban dwellers the 'freedom' of the hills. The presence of a track brings the demand for a road, which brings the demand for a car park, which brings the demand for a toilet, which brings the demand for maintenance, rubbish collection and policing. Most 'civilised' humans have lost the knack of living in balance with their planet, and the problem becomes one of re-training urban visitors to behave responsibly in a rural environment.

Inevitably this will turn into policing and control, as has been implemented in U.S.A. National Parks, where only a limited number of visitors are permitted to visit a National Park at any one time. Such control flies in the face of recent ground-breaking Scottish legislation guaranteeing responsible freedom of access. The trouble is that very few people have even an inkling of what behaving responsibly means. It is only occasionally a matter of wilful irresponsibility – usually, they just don't know.

Toilet provision

The varied toilet provision in Scotland's rural areas bears witness to an evolution of demand, regulations, knowledge of the environment, and design of toilet facilities. Taking this evolution to its logical conclusion, it is clear to us that any further changes to toilet provision in a sensitive environment should insist on zero discharge if possible, with a minimum discharge quality meeting tertiary standards.

We consider that the management of toilets in a sensitive environment cannot be left to the vagaries of individual owners, but should become the responsibility of a local community body, as outlined in [Section 8]. Toilet waste should be processed as autonomously as possible at each site and any remainder should be removed and batch-processed to completion at a purpose-built facility. All toilet provision should be properly documented and experience gained as to how best to manage such facilities.

Each site will have its unique characteristics, and the degree of management of each site will rely on the experience of local people. At Linn of Dee [Case study 12.2], it was found counter-productive to provide rubbish bins. At Rowardennan [Case study 12.11], provision of rubbish bins may well be a necessity, and a higher degree of maintenance and policing will always be required.

One of the most effective tools to promote toilet provision in the non-industrialised world is to focus on disgust: disgust is an underestimated emotion and lies behind human inability to take the problems of sanitation seriously. The fact that visitors to a public toilet will always find the detritus of others disgusting, and that maintenance staff will consider the work they do disgusting and demeaning emphasises the uphill struggle required to keep public toilets clean and in good working order.

A starting point for any proposed toilet has to be good design of the public spaces. They must be easy to clean, the facilities need to be robust and easy to use, good lighting and powered ventilation must be provided. The signage has to be clear, and carefully worded to avoid disgust – ideally with a light, humorous tone. Users should be encouraged to take a sense of ownership of the facility.

Toilet buildings need to be sited so as to take maximum advantage of their situation: high, so that wastes can travel by gravity; low so that DDA-compliance is easy; south facing, out of shade and

canopy cover, so as to benefit from heat, light and passive ventilation. The buildings should be constructed from highly insulating environmentally sound materials, be built to last and be built to avoid vandalism.

All possible abuse of facilities should be considered seriously and steps taken to limit it. Solar panels need to be mounted in such as way as to avoid theft and deliberate damage. Power and water supplies need to be vandal proof. Access to maintenance facilities should be secure. Parking needs to be arranged so that the discharge of chemical toilets into the facility is impossible.

When it comes to installing any below-ground facilities, from basements to septic tanks, the presence of ground water and the potential for flooding by surface water must be taken into account.

Toilet design

To achieve zero discharge (if possible) or to meet the most recent water quality standards, the standard rural water-based toilet provision of septic tank plus leachfield is inadequate. If power is available, the septic tank should be replaced by a mechanical treatment or equivalent plant, capable of treating to secondary standards and discharging to a tertiary stage such as a wetland.

A study of 24 composting toilets in parks in Tasmania in 1992 indicated that 16 showed no signs of composting and the remaining 8 were only partially composting. Lack of composting activity inevitably means liquid runoff from the toilets. Another study in 1999 found raised faecal coliform levels above recommended safe drinking levels in streams supplying drinking water in the vicinity of a remote campsite with composting toilets (Holman and Todd, 2001).

Liquid effluent from composting toilets, having leached through a compost pile, contains many harmful pathogens derived from faecal waste including viruses, bacteria, protozoa and helminths (Crennan 1992). On contact with humans or other animals these pathogens cause gastrointestinal disease (Brassington 1999).

We take the position that so called ‘composting toilets’ in the Scottish climate do not really compost at all – the temperatures are too low. This then suggests that endeavours to create ideal composting conditions are mostly a waste of time, that ‘composters’ should be considered primarily as storage vaults, and that the solid material should be removed periodically to be batch-composted to completion in a purpose built facility elsewhere.

Rather than focussing on creating ideal composting conditions, we consider that the focus should be on ease of construction and maintenance. To this end, we propose our design for the ‘ideal’ dry toilet.

- The space dedicated for the vaults should be as low as possible so that the resulting building remains low and easy enough to add short ramps for DDA access. The composting chambers should be easy to remove underneath the structure so that maintenance is facilitated. Access through the floor of the toilet should be avoided, and at least two cubicles provided so that there is always at least one cubicle available if the other fails.

- As with the Rota-loo [Section 4.4.2], we propose a collection of composting chambers on wheels which can either be rotated *in situ* or removed and spun around to give easy access for maintenance or rubbish removal. The chambers are lined with a geotextile bag then ‘Hemcore’ soak added, and leachate drained from the base of the chamber.

- When the time comes to empty the composter, the chamber is dragged out backwards in its entirety and the geotextile bag removed, perhaps with a hoist, to be batch-processed elsewhere. The chambers can also be closed with a lid and stored in the structure, awaiting removal.

- Ventilation is provided in the wall of the toilet chute (see the Corrour toilet [Case study 12.3]) so that a strong downdraft is created when the toilet lid is raised. The composting chambers are independently ventilated and sealed against ingress of rodents and insects.

- We consider that a more balanced leachate is achieved if the toilet design avoids urine separation and accepts all human excreta. However, if urine is to be processed separately, urinals together with the NatSol separation plate [Section 4.2] seem the best technology. In situations where there may be proportionally more urine to solids, the urine should be separated and treated in a batch composting process to avoid pollution of ground water.

- The leachate draining through the geotextile from the chamber should be treated in a purpose-built lined wetland and enhanced leachfield. The entry point to the leachfield will receive high-strength urine, and would best be filled with an inert material such as straw or wood shavings seeded with fungi, so that only those bacteria and fungi that can tolerate urine will develop. The leachfield can be planted with comfrey, a plant that thrives on urine.

- This initial treatment should then lead to a wetland capable of treating the leachate to tertiary standard.

Next steps

The Forestry Commission has developed an interesting design for the upper structure of a rural toilet, and this could serve as a standard for rural toilet provision. In situations where a water-based solution is not possible, the Forestry Commission is researching suitable dry toilet technology.

It would be valuable to pilot the urine / leachate treatment proposed above at Allean and / or Inchcailloch. The connection from the Allean composter to the septic storage tank could be diverted to a pilot leachfield / wetland as outlined above, and the pilot sampled and analysed over a period of time.

We consider that the leachate from the Inchcailloch Phoenix system should be monitored and analysed to determine its quality. If, as we suspect, there is in fact no leachfield provided, a similar pilot could be run at Inchcailloch. In any event, it would be a valuable exercise to fully analyse the efficacy of the Inchcailloch Phoenix system, and the quality of the resulting compost so these become known quantities, before installing further such systems elsewhere.

We also propose a pilot to trial the ‘ideal’ dry toilet described above.

12. Case studies

Due to the size of each of the case studies, we have taken them out of this report in order to enable most computers to receive the report by email. Please refer to the Forth Valley and Lomond LEADER website, www.fvl.org.uk, for the case studies as separate PDF documents. A complete report containing all the case studies will also be available on the website.

A Study into the Provision of Sustainable Toilets in Remote Rural Locations

Submitted to

Forth Valley and Lomond LEADER Local Action Group
February 2010

Section 13

APPENDIX

Questions posed to toilet suppliers with their responses

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

The Scottish Government

LEADER
FORTH VALLEY & LOMOND

The European Agricultural Fund for Rural Development:
Europe investing in rural areas

13.1 Questions about the NatSol composting toilet

To help us understand the approach taken by each supplier of composting toilet systems, we posited a simple scenario and asked each supplier to respond to a number of questions. The response from NatSol is given verbatim below.

Consider having operated a NatSol toilet for one year on a continuous basis at an average ambient temperature of 8 degrees C and having reached a point where the vaults are full and need to be emptied. Consider half of the year to be low use and low temperatures and half to be higher use and higher temperatures.

NATSOL answers in respect of the COMPUS TWIN FULL ACCESS model

OPERATION

[1] How much soak do you recommend adding per solid use?

One handful

[2] How do you recommend managing rubbish deposited into the toilet?

Prevent this from happening by locating a clearly marked bin in the cubicle. Separate from finished compost eventually.

No system is bullet proof with regard to misuse. If one wants people to behave responsibly then one must provide them with the opportunity to do so. Rubbish bin provision outside in a car parking area is surely essential.

[3] What is the best way to clean and maintain the urinals and dry toilets?

The urinals should be rinsed through with a little water on a regular basis (depending on levels of use) and scrubbed with a brush. Please see: www.natsol.co.uk/manage.html

[4] If people use the toilet for urine and it gets too wet what are the consequences and remedies for this scenario?

The toilet is urine separating so it won't get too wet unless men fail to use the urinal provided and urinate into the pedestal whilst standing. The system does not on rely on evaporation of urine, which we consider unreliable in the UK climate.

The cubicle is fitted with a urinal and clear notices indicating the importance of using this. A small amount of urine in the vault is unlikely to matter.

[5] How is the urinal storage and flow rate managed and monitored?

There is no urine storage although we are considering introducing a storage tank option for customers wishing to use urine as a fertiliser or cannot dispose of it to ground on the site in question.

[6] What is your recommended maintenance regime and number of hours needed per week?

It depends entirely on levels of use. Maintenance includes occasional checks on the composting pile and general cleaning of the cubicle and fittings. The pedestal requires less cleaning than a WC. Also, see link above.

With one hundred visitors a day any toilet system (including a WC) would need checking daily for cleanliness, toilet paper and hand cleaning resources (whatever those may be) if one wishes to maintain a good impression and avoid problems. In addition, on a weekly basis it would be necessary to spend another 20 minutes on management.

With 500 people a day I would advise more than one toilet and additional maintenance would be necessary.

SOLIDS

[1] What temperature needs to be achieved in the compost chamber to ensure degradation? How is this temperature achieved in the NatSol system?

NatSol systems rely on mesophilic not thermophilic i.e. decomposition is due to mouldering. This will take place above freezing. Because the vaults are in the ground the contents will be affected by ground temperature. In most parts of the UK for most of the year this will be above freezing.

The temperature of the vault contents reflect both air and ground temperatures. Ground temperatures do not vary considerably through the UK so the temperature of the vault contents will not vary as greatly as the air temperature.

Mouldering will cease if the pile freezes but the compost itself is a good insulator and we consider it unlikely that the bottom of the pile will freeze since this is in thermal contact with the ground at a depth of 800mm.

[2] How much material should be removed from the toilet? What volume would be expected for each model?

The vaults are emptied completely except for a small quantity left to seed the next batch with decomposer organisms. This emptying takes place not more frequently than once a year.

[3] Is the finished material determined on the basis of quality or quantity? How would an operator know when the material is ready to be removed?

The material can be removed when at least a year has passed since the vault was last used – though it will normally be left until the vault is next required. As for quality we would need more specific parameters to provide useful information about this. The compost is not unpleasant to remove.

One toilet should not receive more than approximately 30,000 day visits per annum or 3,500 uses from people using it as their only toilet. Compost should be at least one year old before removal, and the only health hazards could be the possibility of parasitic worms' eggs, which can survive for some years.

[4] How are the solids removed from the chamber? How is the chamber accessed?

Through floor hatches using a spade we provide. No entry into the vault is necessary.

[5] What quality of compost is produced? How is this quality measured?

See 3.

[6] How do you recommend disposing of this compost?

We recommend its use in tree planting or further composting in a dedicated compost bin for several years before other types of use. See link above.

LIQUID

[1] How much urine and leachate would be produced by the toilet over the year?

There is no leachate only urine. It depends on usage – approximately 30litres/100 uses.

[2] Please describe how the urine and leachate is collected and drained.

The urine is normally sent to a soakaway but see Operation [5] above.

[3] What happens to the leachate and /or urine if there is an overflow?

See above.

[4] Is a proportion of the urine or leachate recycled back to the compost pile to keep it moist? How is this measured or monitored?

No urine is recycled back. The pile moisture content can be adjusted with small quantities of water as required though this isn't often necessary.

Human faeces contain more than sufficient nitrogen to promote composting of the entire pile and some urine will inevitably enter the vault anyway. Examination of existing NatSol toilets has revealed that the moisture content is typically ideal for good composting with little intervention by managers. Drier systems tend to include woodlice amongst the degraders (they work on the wood-shavings) and damper systems are more active with micro-organisms. Staff are encouraged to check the pile every few weeks and to ensure that the surface is damp.

[5] What is the quality of the urine and leachate produced – BOD, COD, SS, N, P, ammonia, dissolved solids, coliform cfu count?

Not applicable unless you intend to collect urine and then the answer depends on how long it is stored.

[6] How do you recommend disposing of this urine and leachate?

See 2.

[7] What steps are taken to protect ground water or surface water from ammonia and other contaminants contained in the urine and leachate?

We comply with regulations governing the distance of a soakaway from a water course. Suitable planting in the vicinity of the urine soakaway can encourage uptake of nutrients.

If urine cannot be sent to ground on a sensitive site then we recommend that it is stored and removed as necessary. Whether the storage of urine constitutes a cess pit under Scottish regulations I cannot say. The only other approach is urine evaporation which we would consider unreliable in the UK climate - especially where a toilet is used by day visitors since most of this use is for urination only.

COST

One toilet could cope with 100 daytime uses per day or higher peak loadings. For use by those living on site one toilet would cope with 10 people, or more if seasonal. On sites where the ground is frozen for a significant part of the year these figures might need to be revised. Running costs are very low.

Capital cost for a toilet with building is currently £5800 + VAT + delivery and installation which normally take a day to a day and a half. Without a building the cost is £3600 + VAT etc.

INSTALLATIONS

Giving precise details as requested would take a considerable time. We have installed about 150 of the COMPUS TWIN FULL ACCESS MODEL and about 60% of these are on allotments. A scan through the examples page www.natsol.co.uk/examples.html will give a reasonable idea of the proportion of different site types.

The age of the oldest COMPUS TWIN FULL ACCESS is 4 years but conceptually this toilet is little different form toilets installed in 1995.

Any other comments

- Surveys of our customers have revealed that they are very happy with the product and do not experience smells or other problems.
- We are considering production of a urine storage tank to intercept urine going to soakaway for customers who wish to collect and use it as a fertiliser or cannot dispose of it to ground
- The system requires no electricity, water or sewage connection.
- We have a very good reputation for resolving any problems that arise and for after sales service. Our product guarantee is 2 years if the product has been correctly installed. The guarantee covers just the structural components of the toilet and its function if correctly installed. Our insurance includes product liability.
- The COMPUS TWIN has been proven to be a very reliable toilet system but has not been widely installed on genuinely public sites. As an example, allotment sites have a known and limited range of users. We are in the process of assessing the system for use on public sites to ascertain ways in which the public might, either deliberately or unintentionally, misuse an unfamiliar composting toilet system of any, or particular, design.

13.2 Questions about the Phoenix composting toilet

To help us understand the approach taken by each supplier of composting toilet systems, we posited a simple scenario and asked each supplier to respond to a number of questions. The response from Phoenix is given verbatim below.

Consider having operated a Phoenix toilet for one year on a continuous basis at an average ambient temperature of 8 degrees C. and having reached a point where the vaults are full and need to be emptied. Consider half of the year to be low use and low temperatures and half to be higher use and higher temperatures.

Answers to questions for a Phoenix which has been in use for one year.

Some of these questions are addressed in the Phoenix Public Facility Application Guide and Instruction for Operation and Maintenance. More detailed information is supplied below.

OPERATION

[1] How much soak do you recommend adding per solid use?

The Phoenix spray system has three purposes: to moisten the compost pile in areas away from where the toilet connects to the tank, to inoculate new waste on the top of the compost pile with decomposing organisms, and to keep the compost pile resistant from fires caused by vandalism. Spraying is controlled in three ways: automatically by the system controller, manually with a momentary switch located on the Phoenix tank, and automatically with an internal temperature sensor to detect fires. (Phoenixes have been in use for 25 years and there has never been a fire inside the tank.) The system controller uses temperature, battery voltage and use frequency to determine the amount of spraying. The operator can adjust the parameters used by the controller to determine spray interval and spray time. In a warm environment with heavy use, the spray system will add about 6 liters of liquid/day. With light use and cooler temperatures, spraying is reduced to about 2 liters/day.

[2] How do you recommend managing rubbish deposited in the toilet?

We have used several strategies to deal with rubbish and the Phoenix. The most important strategy is to reduce the amount of rubbish deposited in the tank by supplying a rubbish bin in the toilet room or by the entrance. We also supply a sign by the toilet describing the composting toilet and encouraging users to cooperate in its use. Lastly, we supply a grabber so maintenance persons can remove rubbish from the tank through the upper access door.

[3] What is the best way to clean and maintain the toilet?

The large diameter of the chute (300 mm) reduces the amount of necessary cleaning. If water is supplied to clean the toilet room, the toilet can be cleaned by spraying the inside of the toilet with a hose. If pressurized water is unavailable, then a bucket of water and a commercial toilet brush can be used. All cleaning products should be biodegradable.

[4] What is the best way to clean the sprayers?

The three spray nozzles are located just inside the top access door. The nozzles themselves can be removed with a ¼ turn. The salts accumulating in the orifice can be removed with a small pointed object or the nozzle can be soaked in vinegar for several hours to dissolve more tenacious deposits.

[5] What is the recommended maintenance regime and number of hours / week?

The amount of maintenance required by the Phoenix depends on the amount of use the system receives, whether users add bulking agent and whether rubbish bins are provided. Tank maintenance requires about 5-10 minutes per visit, more time if nozzles or the fan have to be cleaned and bulking material added. If wood shavings and rubbish bins are provided, maintenance visits every 2-3 days are sufficient under high use conditions; every week or two is sufficient for low use periods.

Along with typical maintenance for any toilet room, e.g., emptying the rubbish bin, replacing toilet paper, mopping the floor and cleaning the toilet, there are several tasks specific to the composting toilet.

1. If a bin is provided for users to add wood shavings to the toilet, fill the bin.

2. Open the upper access door and remove trash if present.

3. Check compost moisture level and bulking agent (wood shavings) amount; add shavings if needed.

4. Check the spray system with the toggle switch on the tank. If the pump runs but no liquid is pumped, add some water (about 10 liters) to the tank either through the toilet or access door. Check the spray pattern and clean the nozzles if necessary.

5. Rotate the top tine shaft to mix the pile and use the rake provided to level and mix the waste. The quality of finished compost depends on the thorough mixing of human waste with bulking material.

6. Make sure the fan is running.

LIQUID

[1] How much leachate would be produced by the toilet over the year?

With no evaporation, about 20 liters of leachate is produced from 100 toilet uses.

[2] Describe how the leachate is collected at the bottom

As liquid from human waste and the metabolic activity of decomposing organisms filters down through the compost pile, much of the organic component is oxidized, e.g. urea from urine is converted to ammonia and then to nitrates. Near the bottom of the Phoenix, a porous floor separates liquid from solids, and the liquid passes into a peat moss medium in the bottom of the tank. An air layer above the peat moss encourages aerobic conditions to further reduce leachate BOD. Leachate then enters a high surface area tubular filter which is connected to both the re-spray pump and overflow drain.

[3] What happens to the leachate if there is an overflow?

The drain in the front of the Phoenix tank establishes the maximum liquid level in the tank. Any excess must exit through this drain

[4] What portion is recycled back to the compost pile to keep it moist? How is this measured or monitored?

As described above, a portion of the leachate is re-sprayed onto the top of the compost pile while the excess is drained. The amount of leachate re-sprayed is not a fixed proportion, but the amount needed to keep the compost pile moist and inoculated. The frequency and amount of re-sprayed leachate is established by the Phoenix controller and the maintenance person who visually inspects the compost pile and is somewhat independent of produced leachate.

[5] What is the quality of leachate produced?

The compost pile in the Phoenix has volume of 1200 to 1600 liters depending upon the level of the pile in the tank. Moisture content is about 60% so the pile contains a minimum of 700 liters of liquid in addition the 100 liters stored in the peat moss under the tank floor. At a moderate temperature and 50 uses / day about 10 liters of liquid are added to the Phoenix each day. Although the liquid is not uniformly passing through the compost pile, the retention time is certainly high so leachate stabilization is assured. Literature suggests that the composting process also reduces pharmaceuticals in the end products. We have measured various leachate characteristics from both residential and public facility installations as shown in the attached table and later in the BC MOTH performance assessment. The Phoenix is certified by the Canadian Standards Association to National Sanitation Foundation Standard #41 for composting toilets which requires <200 CFU / gram for the finished compost.

Leachate Characteristics

Site	Coliform	Odor	Moisture	SS	BOD	NH3	NO3	TKN
	Cfu/gr		%	mg/l	mg/l	mg/l	mg/l	mg/l
Residence #1	92	ok				300	5000	1123
Residence #2							1800	1252
Residence #3						336	2400	
PF shooting range	<1	ok	71.3					
PF USFS snake river	0						3300	2400
PF KHK National Park	0		44					

[6] How do you recommend disposing of this liquid?

Leachate from the Phoenix exits through a drain in the front of the tank near the bottom. There are several ways of dealing with this liquid, the choice of which depends on site conditions and environmental goals:

1. On site infiltration using a small leach field is the simplest and least expensive alternative and is applicable when the site is sufficiently far from ground and surface water.

2. Holding tanks have been used when onsite disposal is not permitted and when it is desired to use the leachate as a fertilizer and recover valuable nutrients.

3. At sites where infiltration is possible and where a holding tank is undesirable we have provided a secondary evaporation system. This system uses more energy for the fans, and needs warm, low humidity conditions to operate effectively.

SOLIDS

[1] What do you recommend in order to keep the fresh material separate from the older material?

The Phoenix composting toilet has been designed with tine shafts that control compost movement. The newest material enters the tank top through the toilet chute while the oldest material is removed from the bottom of the composting toilet through the maintenance door.

[2] How much material should be removed from the toilet? What volume would be expected for each model?

Advanced Composting Systems LLC manufactures 3 models; the 199, 200 and 201. The amount of material that needs to be removed from the composting toilet at one time is 300l, and is the same for all three models. This volume is the area beneath the bottom tine shaft and is also the oldest material in the tank. The tine shaft holds the newer material up until the older material has been removed and the maintenance door has been closed. The tine shafts are then turned and the pile will settle allowing for additional use. This is only the case if the composting toilet has been sized properly for the application in which it is being used.

[3] Is the material determined on the basis of quality or quantity? How would an operator know when the material is ready to be removed?

The finished material is determined on the basis of quantity. If the composting toilet is full then material has to be removed. If the sizing of the composting toilet is within the usage capacity and proper maintenance has been applied then the removed material will be completely composted. Completely composted material has been stabilized and its oxygen uptake is reduced.

[4] What quality of compost is produced? How is this quality measured?

We recommended that the use of specific oxygen uptake rates in addition to the 200 feacal coliform per gram standard as measures of product quality and stability. A specific oxygen uptake rate equal to or less then 0.5 mg of Oxygen per hour per gram of volatile solids, applies to a good quality compost which will meet the above bacteriological standard and be easy to handle. This is the standard that the Phoenix composting toilet is designed and has been tested to meet as long as usage and maintenance fall within ACS's specifications.

[5] How do you recommend disposing of the compost?

ACS recommends that all compost be disposed of away from public access unless it is pasteurized. Pasteurization occurs when the compost has been heated to 70 C for 30 minutes.

OTHER MODELS

- ***Does the vacuum flush model differ from the composting Phoenix toilet in its general operation? If so, please compare the two.***

- ***How does the additional water entering the toilet under pressure affect the composting process?***

Advanced Composting Systems LLC does not recommend the vacuum flush toilet for public facility applications.

COST

Please give an indication of the cost of materials and construction for a facility that would be required for a popular tourist destination or based on the sizes that you have installed. Please estimate expected running costs (per week).

The Phoenix costs for two No 201's (as installed at Inchcailloch) would be 2 @ £4,793 = £9,586 plus delivery per unit of £950 plus Customs duty of 6.5%. These costs are based on an exchange rate of $1.53 to the pound sterling. The installation cost of each Phoenix is £550 giving a total cost of approximately £13,209.

13.3 Questions about the Kazuba composting toilet

To help us understand the approach taken by each supplier of composting toilet systems, we posited a simple scenario and asked each supplier to respond to a number of questions. The response from Kazuba is given verbatim below.

Consider having operated a Kazuba toilet for one year on a continuous basis at an average ambient temperature of 8 degrees C and having reached a point where the vaults are full and need to be emptied. Consider half of the year to be low use and low temperatures and half to be higher use and higher temperatures.

OPERATION

[1] How do you recommend managing rubbish deposited into the toilet?

Spin the bin round to the one which rubbish has been dropped into and retrieve the object. Relocate the bin under the chute. Put object into a bag and put in your rubbish bin.

The Enviro Loo will continue to function as normal in spite of drinks cans, sanitary towels, plastic cutlery, nappies and so on being thrown into the system. They will be retrieved at the end of the cycle and disposed of in the normal way.

[2] What is the best way to clean and maintain the toilet?

[3] How is the toilet bowl cleaned?

This can be done with a brush and a little water, as per a water flush system. It is preferable to avoid using large amounts of water, as this will simply be added to the liquids already in the system waiting to be evaporated.

[4] What is your recommended maintenance regime and the number of hours needed per week?

If the unit is not overused, then this is a 5 minute procedure, which will not bring you into direct contact with human waste. If the unit has been overused and you arrive to find that the maintenance is overdue, then the waste pile at the front of the system will be larger than it should and will take you longer to move to the middle of the system. You will not come into direct contact with the waste, but some people might find the idea of this operation unpleasant. (Similar to changing the nappies of someone else's baby).

Service procedure

It is recommended that servicing is carried out 12 months after commissioning and every 12 months thereafter. Low usage applications might require only this service every 24 – 36 months. Tools required for servicing include a 8mm spanner, rake and gloves.

Fig 1.1, 1.2

Fig 1.3, 1.4

1.1. The drying plate can be considered to be divided into three areas (see fig 1.1): 1, the collection section; 2, the middle section; and 3, the top section. 1.2. Using the spanner, loosen the screws on each corner of the manhole and remove cover (see fig 1.2).

1.3. Remove the drying bag from it's support bracket. If the unit has been in service for a year or more, then the basket may contain dehydrated waste for disposal. (See 'Disposing of Waste', below). (If this is the first service, proceed to1.6).

1.4. Position the drying bag in the collection section with the open end facing the waste, as shown in fig 1.3.

1.5. Rake the waste, which is fairly dry, from the middle section of the plate into the bag. When completed, hang the drying bag back onto the support bracket.

1.6. Rake the waste found at the top section of the drying plate to the middle section. Secure the manhole cover when completed.

1.8. Ensure that the rake and any other utensils are thoroughly washed and avoid direct contact with any fresh waste.

[5] How does the ventilator handle heavy rain and high winds?

There are tens of thousands of Enviro Loos around the world in all conditions and rain and high winds do not present a problem.

[6] How sensitive are the exposed parts to vandalism?

The unit is made from UV protected 5mm thick low density polyethylene and is designed for the rigours of a South African town ship and game parks such as the Kruger National Park. The toilet is the choice of the South African Government for town ship renewal schemes that are off of a sewage network. There are tens of thousands installed in South Africa and we understand there has been no problem with vandalism.

The shell of the KL2 is made with durable FSC wood but we can make it even tougher by replacing this with an polymer wood substitute that is both environmentally sustainable and has increased resistance to fire and impact. The Frame is rigid galvanised steel.

Of the 150 loos Kazuba has installed in France and the UK we have had no problems with vandalism.

SOLIDS

[1] What do you recommend in order to keep the fresh material separate from the older material?

Please see the answer to Q 1.1 - The waste found at the top section of the drying plate is raked to the middle section. This separates it from fresh material and liquid and allows it to dry out and decompose.

[2] How much material should be removed from the toilet? What volume would be expected for each model?

All the material in the basket should be removed; the basket has a volume capacity of 24,000 cm^3

[3] Is the finished material determined on the basis of quality or quantity? How would an operator know when the material is ready to be removed?

The operator would know it is ready because at the end of the dehydration, decomposition cycle, the waste found in the drying bag will, under normal circumstances, be an entirely dehydrated, neutral, pathogen free, compost like material. If this is the case then it is then ready to be removed. So the finished material is determined by quality.

[4] What quality of compost is produced? How is this quality measured?

The compost is a very low quality in terms of its mineral/nutrition value. The majority of the minerals are in the urine that is evaporated. The minerals that are left as a residue in the bottom of the tank are irretrievable at this time. We are working on a mineral recovery system but this is still in development.

Refer to the Australia / New Zealand standard for composting Toilets 1546.2.2008

[5] How do you recommend disposing of this compost?

The material that comes out of the toilet can be safely disposed of by either mixing with earth or burying at the foot of a tree or bush, or by further composting using a traditional composting bin. Do not use this waste as compost on vegetables or other plants for consumption.

In answer to whether the waste can be removed by waste removal contractors “I don’t see why not as it’s not special/ hazardous waste so should be treated like other waste from your complex. Its not even ‘potentially offensive material’ as would be the case with large volumes of nappies, for example.

However, it should be checked out with the waste collectors who collect from your premises, or with the Council in case of dropping it to their depots. If getting it collected, the waste company will specify if they want it as waste going to landfill or waste going for further composting. That’s if you have grey bin/ brown bin separate collections. There are requirements to reduce the amount of biodegradable waste overall going to landfill so in theory this is biodegradable waste and shouldn't be going to landfill. The more sustainable option would be to further compost it on land / nutrient cycling in and around the forest.

LIQUID

[1] What happens if there is a liquid overflow?

If liquid should rise above the drying plate it will block the ventilation tubes and the contents will turn anaerobic. The liquid will need to be pumped out. To pump out excess liquid, open the manhole cover and insert a 50 – 75mm pipe through the hole in the collection section of the drying plate. Ensure that the end of the hose is well below the plate, as shown. The liquid should be pumped into a tank and disposed of according to local authority regulations as shown below

[2] If an overflow pipe is installed, how much leachate discharge would be produced by the toilet over the year?

We don't specify toilets with overflow pipes. We look to judge the usage of the site and specify the right amount of loos for that site. If excess liquid builds up as a result of an event that take the unit outside of its parameters temporarily then we recommend it is pumped out by a septic contractor in the manner described in [1].

[3] What is the quality of leachate produced – BOD, COD, SS, N, P, ammonia, dissolved solids, coliform cfu count?

See [2].

[4] How do you recommend disposing of this leachate?

See [2].

COST

Please give an indication of the cost of materials and construction for a facility that would be required for a popular tourist destination or based on the sizes that you have installed. Please estimate expected running costs (per week).

An Enviro Loo can take up to 50 uses per day so depending on the traffic flow of the destination will obviously depend on how many loos are needed.

Kazuba RRP (*All our prices exclude VAT)*

KL1 (inc. Enviro Loo) £2,870

KL2 (inc. Enviro Loo) £5,420

KL2 prm (inc. Enviro Loo) £6,070 *

Installation Estimate

Installation costs vary with local contractor prices. As a guideline the:

KL1 would cost £1,500 to £2,000 to install

KL2/prm would cost £2,000 to £2,400 to install.

An accurate price can be given after a site visit.

Shipping Estimate

Usually between £300 - 400 in UK

An accurate price can be given with a post code.

There are no formal running costs apart from toilet accessories (i.e. loo paper and loo cleaner)

INSTALLATIONS

We would appreciate a note of how many installations of each type and environment (allotment, private, nature reserve etc.) have been installed, where, and how long these installations have been functioning.

13.4 Questions about the Rota-Loo composting toilet

To help us understand the approach taken by each supplier of composting toilet systems, we posited a simple scenario and asked each supplier to respond to a number of questions. The response from Rota-Loo is given verbatim below.

Consider having operated a Rota-Loo toilet for one year on a continuous basis at an average ambient temperature of 8 degrees C and having reached a point where the vaults are full and need to be emptied. Consider half of the year to be low use and low temperatures and half to be higher use and higher temperatures.

OPERATION

[1] How do you recommend managing rubbish deposited into the toilet?

Put up notices saying what can and can't go in the loo , like the saniflo notices.

[2] What is the best way to clean and maintain the toilet?

Water and Ecover NOT bleach

[3] What is your recommended maintenance regime and number of hours needed per week?

Depends on how often you want to the clean the loo, as often as a WC. Depending on the number of uses, the site manager can add "soak" materials at the close of business or every morning. For info on "soak" materials see Rota-Loo instructions on:
www.rotaloo.co.uk

For a family of five I empty a bin once every 6 weeks which takes 10 -15 minutes. Again see movie of what is involved:

www.rotaloo.com/rlhouseadsl.mov

www.rotaloo.com/movieADSL.html

[4] How does the ventilator handle heavy rain and high winds?

There is a vent cowl:

www.rotaloo.co.uk/brochures/950installation%20notes.pdf

[5] How sensitive are the exposed parts to vandalism?

If you have a glass fibre pan these are very resistant to vandalism and can easily be repaired to a very high standard.

SOLIDS

[1] What do you recommend in order to keep the fresh material separate from the older material?

We recommend buying a Rota-Loo and you never have this problem.

[2] How much material should be removed from the toilet? What volume would be expected for each model?

Again the Rota-Loo has a unique bin system which allows easy, quick and clean emptying. The bins of a 950 are 760mm tall and the Maxi is 900 tall. A full 950 bin which has completely composted weighs from 20kg if the user instructions have been followed. The larger bin has wheels to allow easy handling and is of course heavier.

[3] Is the finished material determined on the basis of quality or quantity?

When the bin is full the next bin is positioned under the shoot and filled so the answer to the above is not applicable.

[4] How would an operator know when the material is ready to be removed?

By looking down the loo to see if a bin is full and thus a bin needs emptying. If the contents still look like manure then a lid is put on the bin and the bin is left away from the public to compost further and an empty replacement bin is put into the Rota-Loo. So it can never run out of capacity.

[5] What quality of compost is produced?

Very good potting compost is produced.

[6] How is this quality measured?

We do not measure quality we use it in our polytunnel to grow our food.

[7] How do you recommend disposing of this compost?

There are many ways to use compost it would be a shame to “dispose of it”. You could use a shallow trench which is dug and the compost is tipped into it and covered over. Or use it on fruit trees, fruit bushes on the base of a hedge and around the garden

LIQUID

[1] What happens if there is a liquid overflow?

It depends on what equipment you have purchased. If you have a liquid absorption trench then the liquid flows into the trench. If you have a Soltran then the excess liquid is evaporated.

[12] If an overflow is installed, how much leachate would be produced by the toilet over the year?

This depends on the number of uses. If well managed with the soak material, then there should be very little overflow.

[13] What is the quality of leachate produced – BOD, COD, SS, N, P, ammonia, dissolved solids, coliform cfu count?

See ‘*Humanure: A Guide to Composting Human Manure’* by Jenkins
ISBN 978-0-9644258-3-5

[14] How do you recommend disposing of this leachate?

See answer to overflow. We also sell special purpose made biological filters which comply with the (Swedish) Stockholm water authority requirements:
http://www.wostman.se/wmfiltereng.html

COST

Please give an indication of the cost of materials and construction for a facility that would be required for a popular tourist destination or based on the sizes that you have installed.

The Maxi 2000 2m in diameter and 1.2 m tall. There are a large number of the Maxi 2000's installed in Australia at major tourist facilities. There is one at Ayres rock in central Australia which has had 56,000 visits without being emptied (visitors mainly pee).

The cost of a Maxi 2000 is £6,600 + VAT and delivery

We can supply a building but believe that in the interests of sustainability these should be sourced locally. The cost of such a building would follow the RICS standards for the cost to build / m^2.

Please estimate expected running costs (per week).

This again depends on the number of visitors, the same as running any public toilet facility. The cost of the “Soak” material (e.g. sawdust, wood shavings, and grass clippings) needed to make a good compost may be obtained free of charge. Use a plant material that is locally available and compostable.

Installations

We would appreciate a note of how many installations of each type and environment (allotment, private, nature reserve etc.) have been installed, where, and how long these installations have been functioning.

Many systems have been installed in Australia.

We have Rota-loos in Private houses in England Essex, Spain and France, at the Tain Rifle Club, Tain Scotland. South London allotments, Hastings Borough Council allotments.

Any other comments

Please add other comments that you would like us to publish. We may be required to edit comments.

Some of the key Rota-Loo features are:

- Inside a precision built Rota-Loo are six removable compost bins housed on a turntable.
- The turntable is manually rotated once a bin becomes full.
- The full bin remains inside the system to continue the composting process.
- Once a composted bin comes around for use again the contents will be reduced to two thirds of its original volume and transformed into a soil rejuvenating humus.
- There is no strenuous raking, bending or digging of any fresh waste.
- The Rota Loo has the lowest profile of any composting toilet.
- Virtually no maintenance.
- Unlimited capacity ... and the toilet room is always fresh.

One of the most significant benefits of the Rota-Loo system is its ability to use spare bins. If an installation receives a shock loading and all the bins become full before the first has fully composted, a spare bin can be put in its place and the other removed to finish composting in a safe place.

13.5 Questions about the Clivus composting toilet

We have contacted Kingsley Clivus and they no longer supply these units. Clivus have no European suppliers so this model has not been pursued.

At Linn of Dee [Case study 12.2], the solids do not decompose as advertised and access for maintenance via the toilet floor is difficult. The Yorkshire Dales National Park Authority is removing (2008) a Kingsley Clivus compost system and constructing a “new environmentally friendly on-site treatment plant” (case study 12.12). A Kingsley Clivus system installed at Loch Ossian Youth Hostel has overflowed with excess water and cleaning fluids. At Allean [Case study 12.9], the Forestry Commission modified the design to add an overflow. The toilet project at Inverlochlarig [Case study 12.8] has foundered, partly due to lack of support from the suppliers.

In a few cases, improvements made by the owners of failing systems have overcome the worst of the problems encountered.

The exception to difficulties with Kingsley Clivus systems is Loch Garten (Case study 12.10), where leaving the composter to rest over the winter period together with choosing a large enough composting vault has proved successful.

Further information about dry toilets can be found in the replies to questions asked of dry toilet suppliers (section 13).

14. References, contacts and suggested reading

References

The book “Inclusive Urban Design: Public Toilets” Greed (2003) provides a frank review of the design issues around public toilets.

The Centre for Accessible Environments (Lacey, 2004) provides information on the design of an accessible toilet cubicle within a building and this can be easily adapted for providing an accessible cubicle within a public toilet block.

The Accessible Toilet Design Resource (Hansen and Bichard 2007) covers the results of three years of research on the design of public toilets in city centres. The resource covers all aspects of the design (including tools and templates) and management of the accessible loo, including the requirements of families with young children, older people and people of faith communities.

L24, Workplace health, safety and welfare, approved code of practice and guidance, (ISBN 0717604136 - available from HSE Books).

Welfare at work - free leaflet [80KB]

Kenneth L. Temple, Anne K. Camper, Robert C. Lucas (1982)
http://www.jswconline.org/content/37/6/357.abstract

14.1 Books

The Big Necessity: Adventures in the World of Human Waste, George, R. Portobello, London (2008)

The Composting Toilet System Book: A Practical Guide to Choosing, Planning and Maintaining Composting Toilet Systems. Del Porto, D and Steinfeld, C. The Center for Ecological Pollution Prevention, Concord, MA, USA (1999)

Designing for Accessibility. Lacey, A. Centre for Accessible Environments and RIBA Enterprises, London (2004)
http://www.cae.org.uk/
http://www.ribabookshops.com/

The Good Loo Design Guide. Lacey, A . Centre for Accessible Environments and RIBA Enterprises, London (2004)
http://www.cae.org.uk/
http://www.ribabookshops.com/

The Humanure Handbook: A Guide to Composting Human Manure. Jenkins, J. Jenkins Publishing, Grove City, PA, USA (1999)

Inclusive Urban Design: Public Toilets. Greed, C. Oxford. Architectural Press (2003)

Lifting the Lid: An Ecological Approach to Toilet Systems (New Futures). Harper, P and Halestrap, L. The Centre for Alternative Technology, Machynlleth, Wales (1999)

The Role of the Public Toilet: Pathogen Transmitter or Health Facilitator? Greed, C. Faculty of the Built Environment, University of the West of England, Bristol (2006)

Septic tanks: An overview. Grant, N and Moodie, M. Private publication available from The Centre for Alternative Technology, Machynlleth, Wales (1997)

Sewage Solutions: Answering the Call of Nature. Grant, N, Moodie, M and Weedon, C. The Centre for Alternative Technology, Machynlleth, Wales (1996)

Solar Evaporation of Liquid Effluent from Composting Toilets. Holman, D and Todd, J. Paper presented at the ISES 2001 World Solar Congress. International Solar Energy Society (2001)

Toilets of the World. Gregory, M and James, S. Merrell, London (2006)

Waste in Troubled Waters: A Case for Alternative Sewage Treatment. Crennan, L. Board of Environmental Studies, University of Tasmania (1992)

Wilderness Management: Human Waste and Water Quality. Brassington, J. Thesis, School of Geography and Environmental Studies, University of Tasmania (1999)

14.2 Standards, reports and general reading

The British Toilet Association. http://www.britloos.co.uk/ *Design of buildings and their approaches to meet the needs of disabled people*. Code of Practice. BSI, BS8300:2001. British Standards Institute, London.
http://www.bsi.gov.uk and http://www.bsionline.techindex.co.uk

Green Mountain Club Backcountry Sanitation Manual. Backcountry Sanitation: A Review of Literature. Lachapelle, Paul. Green Mountain Club
http://www.appalachiantrail.org

An Introduction to the PAS100 Composting Standard
http://www.wrap.org.uk/downloads/Introduction_to_BSI_PAS_100-20052.0c63c8d0.2181.pdf

National Park Service Remote Area Toilet Facilities: Experiences and Observations 1983 and 1984. Jensen, M. E. NPS Report No. 85-01-NPS/ESSD. Washington, DC. (1984)

National Park Service RAMWAD Project (Remote Area Management, Waste Disposal). Jensen, M. E. (1984)
http://www.uvm.edu/~rlachape/rep-ramwad.htm

Outdoor Access Scotland
http://www.outdooraccess-scotland.com/

Sanitary Installations Parts 1 and 2. BSI (1996) BS6465. British Standards Institute, London.
http://www.bsi.gov.uk and http://www.bsionline.techindex.co.uk

The Toilet Paper. Volume 1, Issue 4, available at http://www.vivacity2020.eu/publications. Hansen, J and Bichard, J (2007). *Provides background to, and contact details for, the Accessible Toilet Design Resource.*

Useful contacts:
http://www.cityfarmer.org/comptoilet64.html

14.3 Contacts - Manufacturers and Suppliers

Clivus Multrum

(No longer any European supplier or stocker)
http://www.clivus.com/

NatSol

Natsol Ltd
20 Bethel Street
Llanidloes, Powys
Wales, SY18 6BS
http://www.natsol.co.uk/
01686 412653

Contact: Andrew Warren, Managing Director; Chris Frost, General Manager

Phoenix

Phoenix Composting Toilets UK Ltd
Regent House, 32 Princes Street
Southport, PR8 1EQ
http://www.phoenixcompostingtoilet.co.uk
01704 500878

Contact: David Beechey; Richard Beechey

Kazuba

Kazuba UK
Unit 343
Camberwell Business Centre
99-103 Lomond Grove
Camberwell
London SE5 7HN
http://www.kazuba.eu/
0203 239 7497

Contact: Joel Cormack

Rotaloo

Supplied by Dragon Contracts
Saffron Walden
Essex, CB10 2SS
http://www.rotaloo.co.uk/
01799 598086

Contact: Jonathan Cooke

14.4 Contacts - Case Studies

Inchcailloch

Bridget Jones
Loch Lomond & The Trossachs National Park Authority
Carrochan Road
Balloch
Alexandria, G83 8EG
01389 722600

Linn of Dee

Peter Holden
Mar Lodge Estate
Braemar
Aberdeenshire, AB35 5YJ
013397 41669 / 41983
http://www.marlodgeestate.org.uk/

Corrour Bothy

John Cant
Flat 2F1
3 Cornwall Street
Edinburgh, EH1 2EQ
http://www.compostloos.org.uk/

Cairngorm toilet

Nic Bullivant
Cairngorm Ranger Service
Cairngorm Mountain
by Aviemore, PH21 1NT
01479 861703

Eden Rivers

Becky Helm
Eden Rivers Trust
Units O&Q
Skirsgill Business Park
Penrith CA11 0FA
01768 866788

Barnluasgan Compost Toilet

Gordon Gray-Stephens
Old Poltalloch
Kilmartin
Argyll, PA31 8RQ

Sunart Oakwoods

Locate Architects
The Cobbler's Studio
19 Caledonian Place
Dunblane, FK15 9AF
01786 825111

Inverlochlarig

Alan Clarke
Tulloch Lodge
Balquhidder
Lochearnhead FK19 8PQ

Forestry Commission Toilets

Colin Pielou
Forestry Commission Scotland (FCS)
Buildings and Capital Works Manager
Lomond Court
Castle Business Park
Stirling, FK9 4TU
Tel 01786 225622

Loch Garten

Richard Thaxton
RSPB Scotland
Abernethy Nature Reserve
Nethybridge
Inverness-shire
PH25 3EF

Eastern shore of Loch Lomond

Bridget Jones
Loch Lomond & The Trossachs National Park Authority
Carrochan Road
Balloch
Alexandria, G83 8EG
01389 722600

Aysgarth Falls

Paul Drake
Yorkshire Dales National Park Authority
Colvend
Hebden Road
Grassington, BD23 5LB
01756 751600

14.5 Contacts - Organisations

Scottish National Heritage

Unit 7, Beta Centre,
Stirling University Innovation Park,
Stirling, FK9 4NF
01786 450362

SEPA

Bremner House,
Castle Business Park,
Stirling, FK9 4TF
01786 452595

14.6 Contacts: Councils and Other Contacts

Stirling Council
Viewforth
2 Pitt Terrace
Stirling, FK8 2ET
0845 277 7000

Clackmannanshire Council
Main Street East
Menstrie, FK11 7BL
01259 769439

West Dunbartonshire Council
Garshake Road
Dumbarton, G82 3PU
01389 737000

Falkirk Council
Municipal Buildings
West Bridge Street
Falkirk, FK1 5RS
01324 506070

Forth Valley and Lomond LEADER
Anne-Michelle Ketteridge (Programme Manager)
Room 227
Stirling Council,
Viewforth,
Stirling, FK8 2ET
01786 443123

15 Glossary

Abstraction (water abstraction, **water extraction**, **groundwater abstraction):** The process of taking water from any source, either temporarily or permanently. Most water is used for irrigation or treatment to produce drinking water. Depending on the environmental legislation in the relevant country, controls may be placed on abstraction to limit the amount of water that can be removed.

Aerobic: Containing free oxygen (i.e. oxygen gas). Usually refers to conditions required for certain types of bacteria to thrive. Typically, aerobic processes require at least 1 to 2 mg/l of dissolved oxygen.

Algal bloom: A rapid increase in the population of algae, resulting in the water becoming opaque and discoloured. Algal blooms are often the result of eutrophication, and may occur in freshwater as well as marine environments.

Algae (singular *alga*): A collection of simple freshwater and marine aquatic plants varying in size from single cells to filamentous forms that can be metres in length.

Ammonia (NH_3): A sharp-smelling gas that readily dissolves in water, forming ammonium ions (NH_4^+), which are highly toxic to aquatic organisms.

Ammoniacal Nitrogen (NH_4-N): Nitrogen combined with hydrogen in the form of ammonia gas (NH_3) or the ammonium ion (NH_4^+); present in sewage. It is toxic to fish and typically restricted in discharges to less than 5 mg/l.

Anaerobes (anaerobic): Organisms capable of living in the absence of free oxygen. Strict anaerobes cannot survive in the presence of oxygen.

Bacteria (singular *bacterium*): A colony of microscopic unicellular organisms. Bacteria are ubiquitous in every environment on Earth, including soil and water.

Biochemical Oxygen Demand (BOD): The amount of oxygen required by micro-organisms to break down organic matter. BOD is measured in milligrams of oxygen removed per litre of water measured over a given time period, usually 5 days in the UK.

Biodegradation: The decomposition of organic matter through the action of bacteria, fungi, micro-organisms and invertebrates.

Blackwater: Wastewater from toilet flushing, as distinct from greywater.

CAR licence: Controlled Activities Regulations – an authorisation by SEPA or the EA to release controlled substances such as contaminated water into the environment at rates and concentrations not exceeding specified values.

Cesspool (cesspit): A large tank or underground pit (usually at least 18 m^3) for the storage of sewage. It differs from a septic tank in that it has an inlet, but no outlet, so that liquid cannot escape. Cesspools do not treat sewage, but simply store it for later removal. Cesspools are illegal in Scotland.

CFU (cfu) count: In microbiology, the Colony-Forming Unit count is a measure of the viable bacterial or fungal content of a substance. The test establishes whether a single bacterium can grow and become a colony.

Coliforms: A broad class of bacteria found in our environment, including in the faeces of humans and other warm-blooded animals. The presence of coliform bacteria may indicate the presence of disease-causing organisms, known as pathogens.

Constructed Wetland: See Wetland Treatment System

Chemical Oxygen Demand (COD): The amount of oxygen required to break down all degradable matter present. COD is measured in milligrams of oxygen removed per litre of water measured over a given time period, usually 5 days in the UK. COD is always equal to or greater than BOD because it includes all the material oxidised biochemically.

Composting: The autothermic (self-heating) and thermophilic (between 40º C and 80 ºC) biological decomposition and stabilisation of biodegradable waste under controlled conditions, resulting in a stable, sanitised material that can be applied to land for the benefit of agriculture, horticulture or ecological improvement. Composting can range from the very simple as in open windrows (large heaps), to sophisticated computer controlled in-vessel systems.

DDA Compliance: The DDA aims to end the discrimination which many disable people face. This Act gives disabled people rights in the areas of: employment, access to goods, facilities and services and buying or renting land or property.

Dissolved Solids: Soluble substances that are present in water and which remain in solution, (e.g. organic matter, urea (from urine), fatty acids, ammonium ions, chloride, nitrate, phosphate, metals and a range of other substances).

Dry Toilets: Toilet systems not using water as a flushing medium.

Ecosystem: A functional unit of living communities which interact to form a stable and self-sustaining system. An ecosystem can be of any size, from a pinhead to the whole biosphere.

Effluent: A liquid flowing out or from a source. For example, septic tank effluent is the liquid material contaminated with human waste. Effluent can be treated through natural and engineered biological / ecological systems to make it fit for re-use by animals and humans, though not on food crops.

Environment: The surroundings of any organism or group of organisms, including the physical world and other organisms.

Eutrophic: Conditions present in a lake or river having a high concentration of dissolved nutrients, characterised by discolouration of the water and in extreme circumstances, by algal blooms.

Eutrophication: In a water system this process is characterised by an increase in organic matter, enrichment by nutrients (e.g. nitrates and phosphates) and a decrease in the concentration of dissolved oxygen. There is a high decay rate in the upper layers and therefore little oxygen in the lower layers. Eutrophic waters are generally shallow. They lack species diversity and tend to be dominated by a few species of algae.

Excrement (excreta): Digested solid or semi-solid waste material discharged from the bowels of an animal or human.

Faeces: See Excrement

Forest Stewardship Council (FSC): An independent, non-profit, non-governmental organisation whose mission is to promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests. The FSC runs a global forest certification system with two key components, Forest Management and Chain of Custody: www.fsc-uk.org

FSC Certified Forests: Woodlands managed to standards which take into account legal, social and environmental issues and are covered by a comprehensive, long-term forest management plan. There are nearly 100 million hectares of FSC-certified forests in 75 countries.

Forced-air Composting: A composting technology that uses air blowers to force hot air though a compost pile, significantly speeding the decomposition of waste. This is used extensively to for Public Authority large-scale composting operations and composting animal remains in the meat industry.

Fungi (singular *fungus*): These are simple plants that include the yeast, molds, rusts, smuts, and mushrooms. Fungi are very different from green plants, as they contain no chlorophyll or chloroplasts. Fungi must take in food materials synthesized by other organisms. Most fungi are decomposers and cause decay. Mushrooms are the fruit of certain kinds of fungi – the rest of the fungus is made up of a web of fine threads in the soil, tree or dead leaves.

Greywater: Wastewater from kitchens, showers, baths, sinks, roofs, etc, but not from toilet flushing. If flush water is present, the liquid is known as blackwater.

Heavy Metals: Metals of high atomic weight that are toxic to living organisms even at low concentration. Examples are mercury, lead, cadmium, chromium and nickel. Not all high atomic weight metals are toxic, but many are.

Helminths: Parasitic worms that live in the human digestive tract. They can cause malnutrition and lower resistance to infection.

Humus: The dark organic material in soils essential to the fertility of the Earth, produced by the decomposition of vegetation and animal matter.

Impoundment: Water abstraction where there is a need to divert or alter a flow.

Leachate: Water that collects hazardous contaminants as it trickles through faeces, landfills, agrochemicals, farm slurry and other wastes. Composting and dry (non-flushing) toilets typically discharge a leachate that can contain pathogens, nutrients and ammoniacal nitrogen. Leachate need to be treated prior to discharge to land or to water in order to prevent pollution of soil, ground water or water bodies.

Leachfield (soakaway): A series of perforated pipes running in gravel in underground trenches. In a well-designed leachfield in suitable ground, the waste water is treated by the bacteria in the soil. A leachfield is often the last component of a treatment system and traditionally receives the discharge from a septic tank.

Marsh (wetland): Low land flooded in winter and usually wet at all times.

Mechanical or 'package' treatment plant (MTP): An 'off-the-shelf' mechanical system for treating raw or primary-treated sewage to 'secondary' standard. They are often compact and can be installed quickly. There are many models, but all will require power and proper maintenance and would be vulnerable during power cuts. A large quantity of secondary solids is produced and sludge removal is required twice annually. An MTP can be followed by a wetland system to improve effluent quality prior to discharge to a watercourse.

Mesophiles (mesophilic): Bacterial species involved in biodegradation – the digestion and decomposition of organic matter – that are more active in temperatures ranging from 15°to 35°C (59° to 95°F) are termed mesophilic bacteria. They take part in the web of micro-organic activity that forms the humus layer in forests and other fertile soils.

Psychrophylic bacteria start the biodegradation, being active in lower temperatures - from below zero up to 20°C (68° F) - and generate heat in the process. When the temperature inside the decomposing layer reaches 15°to 35°C (59° to 95°F), mesophilic bacteria become active and continue the biodegradation. The peak of mesophilic bacterial activity is reached between 30–37°C (86–99°F), and further increases the temperature in the soil environment. Between 40 to 85°C or even higher (104 to 185° F), thermophilic bacteria takes up the process that will eventually result in organic soil, or humus. Several species of fungi also take part in each decomposing step.

Microorganisms (micro-organisms, microbes): A class of organism too small to be seen by the naked human eye, including bacteria, green algae and plankton.

Mycorrhizal Fungi: Fungi attached to the roots of trees and leguminous plants. They form a symbiotic relationship with the plant, providing each other with food and vital nutrients.

Nitrate (NO_3^-): One of the three major plant nutrients, non-toxic to aquatic life (in limited amounts) but producing eutrophication in high concentration. Nitrate is best not discharged to water, but at suitable concentrations can be used as a nutrient by land plants, fungi and soil organisms.

Pathogen: disease-causing organisms. Pathogens can be viruses, protozoa or bacteria. Waterborne pathogens cause diseases such as hepatitis, giardiasis, and dysentery.

pH: A measure of the acidity/alkalinity of a liquid on a scale from 0 (very acid) through 7 (neutral) to 14 (highly alkaline). It is the negative logarithm (base 10) of the molar concentration of dissolved hydrogen ions.

Phosphate: An essential plant nutrient more easily assimilated by land plants than by aquatic plants. Phosphate can trigger algal blooms even at very low concentration, e.g. 0.05 mg/l in still water and 0.1 mg/l in running water. A typical concentration in sewage effluent is in the range 5 – 15 mg/l.

Primary Treatment: A predominantly physical process in which the heavier solids in a chamber (e.g. septic tank) are settled by gravity and any floating objects are removed.

Protozoa (protozoon): A class of single-celled microorganisms present in soil, water and faeces. They play an important role in maintaining the balance of the Earth's ecosystem. Some are parasitic in humans and can cause disease.

Reedbed: A type of wetland.

Secondary Treatment: Removal from effluent of the bulk of the BOD (mainly soluble organic material) and suspended solids, via the breakdown of organic material by microorganisms.

SEPA: The Scottish Environmental Protection Agency

Septage: The anaerobic solids /sludge contained in the bottom of the septic tank. It is difficult to treat and contains a high level of pathogens. Septage must be removed by a tanker (once a year, on average) and taken to a sewage works for treatment.

Septic Tank: An underground vessel for storing sewage effluent, with both an inlet and an outlet. A septic tank is smaller than a cesspool because it is designed to receive only the maximum daily flow, plus capacity for the settlement of the solids (septage).

SNH: Scottish Natural Heritage. See Section 9.1.

Soakaway: See leachfield

SSSI: A Site of Special Scientific Interest is a conservation designation denoting a protected area in the United Kingdom. SSSIs are the basic building block of site-based nature conservation legislation and they are the basis of most other legal nature/geological conservation designations in Great Britain, including National Nature Reserves, Ramsar Sites, Special Protection Areas, and Special Areas of Conservation.

Suspended Solids (SS, TSS): Tiny particles, most of which remain suspended indefinitely in water and give it a cloudy appearance (e.g. bacteria, faecal particles, food particles, fats, oils and greases, detergents and soaps). SS can be removed by various processes including passage though treatment wetlands.

Tertiary Treatment: The biological removal of a high fraction of the BOD and SS remaining after secondary treatment. It can also mean removal of nutrients (e.g. nitrogen and phosphorus compounds) and pathogenic organisms.

Thermophiles (thermophilic): A thermophile is an organism that thrives at relatively high temperatures, between 40 and 85°C (104 and 185°F) or in some cases higher still. Thermophiles are found in various geothermally heated regions of the Earth as well as in decaying plant matter such as peat bogs and compost. As a prerequisite for their survival, thermophiles contain enzymes that can function at high temperatures.

Urea: A simple organic compound, and the main nitrogen-containing substance in the urine of mammals. It is highly soluble in water, where is converts to ammonia, and thence into the highly-toxic ammoniacal nitrogen.

Wetland: A complex web of certain plants (e.g. reeds) and their associated bacteria, microorganisms, invertebrates and fungi, that thrives in wet conditions such as marshes and the edges of ponds and rivers.

Wetland Treatment System: A constructed wetland used to treat water contaminated with substances that the plants and other organisms can take up as food. Wetland ecologies have evolved to make very efficient use of nutrients, including human and animal wastes. Nutrient-laden water introduced appropriately into a wetland will be cleaned to very high standards.

Windrows: Piles of materials requiring composting, laid in large, long rows, usually a minimum of 2 metres high. Purpose-built machines turn these piles over periodically to mix, aerate and re-blend the materials.