GLOUCESTER DAC
Waste Water from Churches

Elemental Solutions has been at the forefront of ecological water management since it was set up in 1996 by Nick Grant and Mark Moodie. Mark left the partnership in 2005 to pursue agricultural research but continues to work with Nick as a Director of Solution Elements Ltd.

The attached paper was commissioned by Gloucester DAC in 2001 from Mark Moodie.

The aim is to assist PCCs and their architects where consideration has been given to installing a wc or kitchen in a church, and where suitable mains drainage does not exist. The DAC has for many years been worried about the cost and archaeological impact of the conventional alternatives, which include septic tanks and sealed cesspools. The trench-arch solution is cheaper and less intrusive. It has already been used in a number of churches including the Gloucester Diocese.

The information provided in this paper shouldl enable a straightforward installation to be commissioned without further advice.

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Secretary, Gloucester DAC
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Wastewater from Churches

There is an increasing expectation that, where possible, a church should have toilet facilities. This paper assesses the implications for waste water (sewage) disposal and offers a broad view of the options and challenges. It focuses upon rural churches based on the assumption that toilets will use water - for an alternative see appendix 5.. A particular option, called a **trench arch**, is detailed for consideration. Minimal attention is given to the architectural and logistical issues of installing a WC facility in the church

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The challenges for sewage treatment at a church

Small rural churches have characteristics, each of which pose particular challenges to which the trench arch has as least partial and sometimes unique answers. Not all churches have all of these characteristics but many have most;

thick walls

pipes have to deliver water (usually 15mm) and remove the waste water (usually 110 mm) and each pass through the wall is dusty, laborious and can be costly and damaging.

distance from the main or public sewer

the main sewer is a simple option if it is close by and downhill from the Church. If available the main sewer is the default and recommended for simplicity and ease of maintenance.

archaeologically sensitive surrounds to the building

there may be archeological remains that are not to be disturbed around the building and even if these are not valued there may be institutional pressure to have an investigation made which will, at the very least, increase costs and delay any installation which requires excavation.

intermittent use and varying numbers when used

most sewage treatment systems work by hosting organisms which breakdown the waste organic matter. They work best with a steady load. Church facilities typically experience very variable use.

cellars

whilst these can accept water inwards from the surrounding soil - a potential hindrance to disposal in the surrounding soil - a cellar can also be a housing for the waste system – see appendices.

poor access for large vehicles

many sewage systems require sludge to be removed so a tanker needs to get access to the system. Typically a distance of 30m from tanker to septic tank or treatment plant is recomended but longer hoses can be used by arrangement with the contractor.

Waste water disposal law

The Environment Agency in England and Wales (EA), the Scottish Environmental Protection Agency (SEPA) or the local council in Ireland, have the responsibility for ensuring that water ways and groundwater are not polluted. They are statutory referees for new planning applications and will have a say when there is a new discharge of waste water. They will grant a 'consent to discharge' if waste water is to be put into a water course - stream or river. Then the amount of waste water to be discharged will be calculated and compared to the volume of water flowing through the water course and the ecological sensitivity of that water. Then they will calculate the amount of cleaning required for the waste water. If a consent is not granted it means that waste water cannot be discharged to a water course but you may still be granted permission for disposal to the soil if it is no closer than 10 m to a water course. This is the cheapest and easiest means of dealing with sewage with suitable soil. In the case of rural churches this is the likely outcome.

System options

‘Main’ or public sewer

Pros	Cons
Simple for user	May be very far away
Don't have to maintain it	Small fee levied
Fine for intermittent discharges	

Discharge to a water course - consented

Pros	Cons
Many off-the-shelf systems available	Maintenance required
	Power required for most systems
	Significant deep excavations required
	Sludge removal usually required
	Poor at intermittent and varying loads

Discharge to soil – septic tank

Pros	Cons
Well tried and tested	Soil may not be suitable
Power not required	Extensive excavations may be needed
Fine for intermittent discharges	Deep excavations may be needed
No fee levied	Sludge removal usually required
Site can be used as lawn	Anaerobic

Discharge to soil – Trench Arch

Pros	Cons
Power not required	Soil may not be suitable
Fully aerobic	Extensive shallow excavations
Fine for intermittent discharges	Authorities may not be familiar
No fee levied	Trenches not ideal for heavy traffic
No deep excavations required	
No sludge removal required	
Site can be used as lawn/paths	
Hard to block	

Recommendations

It is our opinion that anyone who is able to connect to the public sewer - assuming the budget allows and the pipe run is not too physically disruptive - would be well served by connecting to the main sewer. Furthermore, where a main drain is accessible, this will probably be the requirement from planning. Costing depends on distance, convolution and depth of the connecting pipe but can be approximated by asking for tenders from groundworkers.

If the mains is not appropriate but the site has suitable soil, then the best option, , is to dispose of the waste water to the land. Disposal to soil is particularly appropriate where the sewage load is intermittent and variable. The main concern is where sites have poor drainage or where the watertable is too high.

Therefore, the focus of the rest of this paper will be disposal of sewage to the soil, with the aim of maximising the pros and mitigating the cons.

Disposal of waste water to the soil

Traditionally disposal of waste water to soil has been achieved using a septic tank and soakaway. The waste water is collected in an underground tank whose outlet is just an inch or so below the inlet. As the sewage enters the tank gravity and buoyancy are allowed to work. Thus grits and some of the organic matter will sink to the bottom of the tank as 'sludge'. Fats and sweet corn and other organic materials will float and form a 'crust'. In between will be murky water with most of the gross solids removed. This is what comes out of the outlet. It is usually smelly and a cloudy light grey. It is known as settled sewage or septic tank effluent.

In very free-draining soils with low water tables - a hole at least a metre wide and deep might be excavated and filled with rocks the size of bricks. This is then capped over with some of the excavated soil. This is a soakaway pit. However, such systems provide little treatment and should not be used where there is a possibility of groundwater contamination.

In soils which are less able to accept water a larger area is required to ensure that the water disperses. This is done using a leachfield (aka 'tail drains', 'herring bone drains' etc). This is a network of perforated pipes which fall very gradually from the inlet and lets the water go into the clean stone which surrounds the pipes and then into the soil. Such systems are usually very good at treating the waste water and there are hardly any concerns for the water table in such cases.

Estimating water use

In a typical domestic situation (5 people full time) on a poor to reasonable soil (V_p = 60 s/mm) the septic tank will be about 3000 litres, and the leachfield will have about 75 metres of pipe in 600 mm wide trenches about a metre deep. ($A_t = V_p \times P \times 0.25$)[1]

A church is very unlikely to use as much water. Using informed guess work we might make an approximation to the most water that will be used in a day from a rural church. (**Note** that this is an imaginary example and should not be assumed to reflect this situation at your church. The real sum should be made by those with real knowledge of the church and take into account the likelihood of use over the next 20+ years!)

Changing flowers	6 litres
Cups of tea	12 litres
Washing paintbrushes for kids club	5 litres
Toilet use (6 litres x 20)	120 litres
Cleaning	10 litres
Miscellaneous	20 litres
Total	173 litres/day

Therefore, using conservative estimates (which in this case means overestimating water use) a church on a busy day may use 173 litres which is approximately what a statistically average person uses in a day at home. In the murky world of sewage this is known as 1 person equivalent or 1 pe.

In addition we should consider;-
- that very little wastewater is likely to be generated in the next 6 days of the week.
- that there may be occasional fund raisers and concerts where much more water is used - say 500 litres.
- and as an aside, people don't like to use the toilet in public, especially for a poo, so these estimates are very conservative.

Evaluating the soil in the area of waste water disposal

Usually the placement of the toilets will be determined by the layout of the church. In my experience this has meant in the vestry, or a partitioned part of the body of the church, or in a shed adjoining the church. It is ideal to use the land which is close by outside for the leachfield so pipe runs are as short as possible (graves, archaeologists, pathways, and trees permitting).

However, if this is not practical the waste can travel through the pipes for a long distance if the pipes are laid at a steady fall between 1:20 and 1:80. (Consult guidance to The Building Regulations.) Choice of actual site will depend on a host of local factors – making discharge of the water and pipe runs not too deep, not interfering with graves and trees etc.

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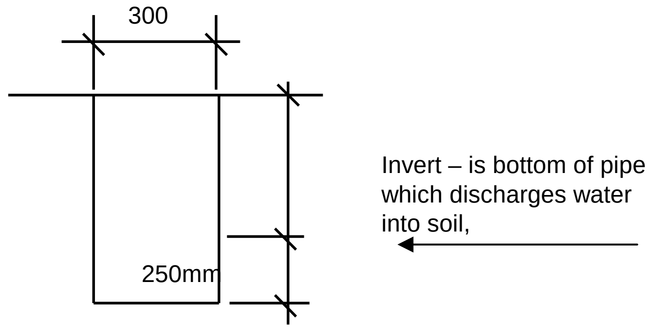
[1] - see 'Percolation Test' below

When the approximate area for the disposal is decided upon then it is strongly recommended that a porosity or percolation test ('perc test') is undertaken using the method below which is taken from the British standard BS 6297.

"Percolation" Test

Site: ....
....
Date: ....
Weather:..
Soil: ....

Percolation Test:



Test hole	Time for 250mm to drain	Vp
1		
2		
3		

Percolation Test.

A 300mm square hole is dug to a depth 250mm greater than the proposed *invert* of the drainage trench. This is filled with water which is left over night to soak away. The next day the hole should be refilled with water to a depth of 250mm and the time to drain away measured. Divide this time in seconds by 250 to get the percolation value Vp. The test should be carried out for at least three holes in the proposed leachfield area, repeated 3 times and the average value calculated. Care should be taken to avoid abnormal weather conditions such as heavy rain, severe frost or drought. Full details can be found in BS6297. A value of **100 seconds/mm is a recommended maximum** although values up to 140 are acceptable with good design and light loading provided the local authority can be convinced.

The area of the base of the trench (A_t - in square metres) under the perforated pipes is calculated using the following formula;-

$A_t = V_p \times P \times 0.25$

where V_p is the percolation value calculated in seconds/mm, and population is P. (each P is assumed to use around 150 litre per day so guesstimate the water to be used in the relevant case for a busy day and divide by 150 to give a value for P. Do **not** use the number who attend the church on a busy day!) Having done this you will have the figures you need to calculate a value for A_t - the area of the base of the leachfield.

The soil would be unsuitable if the percolation value is very high (≥ 140) or negative (ie if the test holes fill up!), or if there are objections from the archaeologists to such a deep dig, ~ 2m for the septic tank.

Worked example; -

Percolation value

Hole 1	5 hours
Hole 2	6 hours 20 minutes
Hole 3	5 hours 30 minutes

Therefore average **Vp** = (300 x 60) + (380 x 60) + (330 x 60)/(3 x 250)
= 18000 + 22800 + 19800/750
= 80.8 seconds/mm

Water use - as in above example - 173 litres
Divide by 150 litres/person = 1.15 pe

Therefore, equivalent domestic population (population equivalent or p.e.) is 1.15[2].

Area of trench, $\mathbf{A_t}$ = 80.8 x 1.15 x 0.25
= 23.2 m²

The standard installation

Usually the smallest possible septic tank would be purchased - 2.7 m^3 and a leachfield of 23.2m^2 /0.6m wide = 38.6 m long would be dug with a 600 mm bucket. Perforated 100 mm diameter pipes would be used at about 600 - 750 mm below the soil surface and these would be on top of and backfilled with clean stone. This would be covered by a strip of geotextile (a woven durable cloth) and then covered with the excavated soil again. This septic tank system would serve well and is a well understood and tried method. For further details see 'Septic Tanks - an Overview'.

The Septic tank system is recommended for its stability and for being so well known. In the table above listing pros and cons we have mentioned that sludge may have to be removed. This is because in a domestic situation septic tanks need to have sludge removed every 6 months to a year (more often in larger systems - if in doubt see your system designer. Rural myths to the effect that 'we have never had ours emptied' still persist but investigation shows that this tends to be ones which have lost their baffles and discharge to a very porous soil or which are so far from the house that the odurous back boggy patch is not associated with the sewage.)

However, in the case of a church, using the assumptions given above, there is so little that will not be soluble that the septic tank will not fill very quickly with sludge and crust - if at all. Therefore, given the light and intermittent loading one could assume very infrequent calls (every 5 years perhaps) for the sludge tanker.

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[2] Strictly, this is not really so straightforward since there are other factors to consider; busiest day (peak storage capacity), uses /year – solids capacity, days without use (>4/week then may not need resting).

However, calculated in the way shown in the text should be safe. If it results in slightly more area than available then get in touch with Elemental Solutions and we can use some of these factors to 'finesse' the calculation.

The issue of anaerobic vs aerobic is that aerobic sewage smells. However with a good vent or stink pipe - which should be part of the design of the new toilet facilities - and the fact that the dispersal pipes in buried the soil it is unlikely that this should impinge upon the church.

The trench arch

This waste water disposal system emerged from our research DoE sponsored. It encorporates the standard Australian disposal and other work from Australia by DOWMUS Resource Recovery. The backbone of the work was to find a way in which worms could digest the waste water contaminants on site. It has several advantages which may be useful in the case of the rural church in the UK.

1 Sludge is not generated

The waste water from the Church is discharged directly into the long wide chamber - solids and all. The water disperses over a wide area and is dispersed down and sideways in the top soil. This leaves a dark moist and protected habitat for the worms to come and digest the solids. These are transformed into worm casts on the floor of the chamber and assist in the generation of a friable and permeable base.

2 It is fully aerobic

The organic matter is surrounded by air. Thus the organic mater breaks down quickly, becomes soil, and does not smell.

3 It is hard to block

The chamber is wide - we recommend at least 400 mm wide through the void between the blocks, and it slopes gently away from the inlet. Any solids are physically degraded by the incoming water and are spread on the further and flatter parts of the chamber base.

4 It accepts occasional high peaks on usage

When there are large flows into the chamber the volume of the stores the water temporarily for discharge over a prolonged period. This temporary inundation does not stress the digesting creatures beyond their limits.

5 It does not require deep excavation

It is ideal if the trenches are planned so they can be in the biologically active top-soil soil where there is greater porosity and greater soil life.

Such shallow systems must be constructed where there is no vehicular traffic or livestock grazing which could cause damage. But it is generally stable and can take foot traffic and hand lawn mowing. We have made the system using paving slabs as the top layer so the end result looks just like a path but these are normally covered by a layer of soil or gravel.

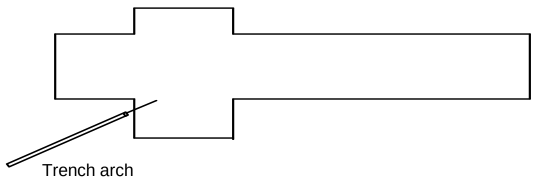
6 It can be done 'in-house' without great expertise

This report has been commissioned because it will enable a resonably fit and thoughtful person to make the system. All that is needed is some planning and very straightforward labour.

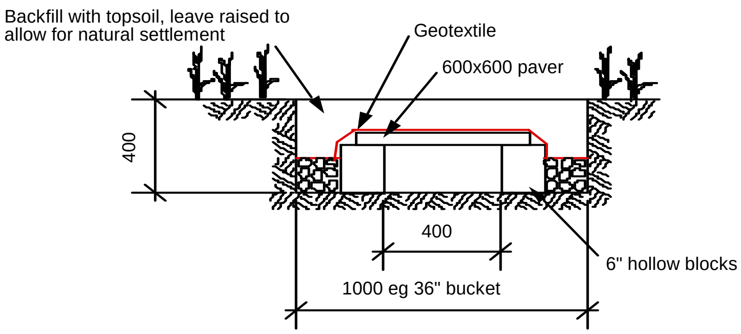
7 It can also work in marginal soils

By a marginal soil I mean one which has a poor percolation value (Vp) say between 80 and 140 s/mm. The trench arch assists here because it uses the upper soil which is more porous. In addition, in very poor soils, it is simple to use a diverter so that two trench arches can be used in rotation - say a month on and a month off. This enables each leg to rest so that original porosity values can be re-established. However, in the case of Churches the amount of time between uses - compared to a house - already encourages this alternation between use and drying to occur so we do not ususally recommend that there are two trenches as we would for a domestic situation.

Plan of generic site



Section across trench arch



Section along trench

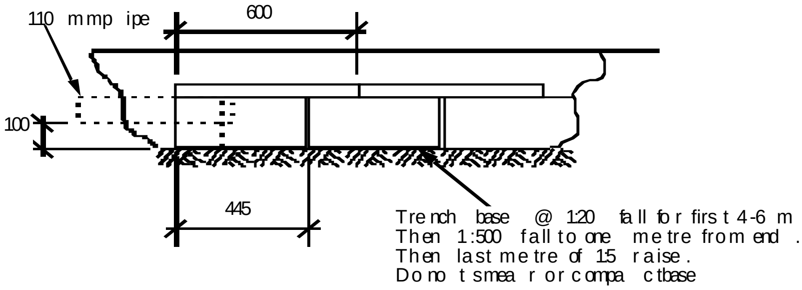


Figure 1 this system for a house has two parallel trenches. Both have been excavated and the bases have been laid so the first 6 metres fall at 1:20. The blocks have been laid with a gap of about 30 mm between them and the slabs lay on the top. Please note that the base of the trench ahead of the slabs has been raked to avoid smearing and compaction.

Figure 2. The trenches are now both covered by the slabs and the geotextile is laid on the top.

Figure 3 Clean stone – 20mm average – is laid in the gap outside the blocks to the level of the slab. Earth and turf is laid over the blocks to bring the level up to that of the surrounding soil. Note the roots showing that the system has been created in the topsoil. The size of the void greatly reduces any danger of blockage by roots.

This is the order in which jobs should be taken on;-

1. See if main drain available and affordable - if so connect; if not continue.

2. Have a preliminary discussion with the Environment Agency/SEPA/Council (in England and Wales/Scotland/Ireland respectively). Submit an outline of your situation to see the most likely way of disposing of the waste water. If the authorities say you must discharge to a water course waste water will have to be treated by a treatment system - see appendix 6. If disposal to ground is likely continue.

3. Choose site of WC in church and where the waste water will exit.

4. Find likeliest site for waste water disposal and survey for levels. Surveying can be done with a theodolite which can be hired from a tool hire service. Alternatively professionals can be hired – see yellow pages.

5. Undertake percolation tests in this area as above.

6. Guesstimate water use on busy day bearing in mind likely use over next 20 years

7. Calculate soakaway floor area required - $A_{t.}$

8. Design system – make a list of necessary materials and prelimenary budget

9. Apply formally to Environment Agency for consent - may be done already through planning - with plans for system.

10. If Agency says OK to use soil....

11. ... make system

i. Calculate level at which the waste pipe enters into the trench arch - try to keep it as shallow as practical in the soil.

ii. Excavate trench starting at 100 mm below base of incoming pipe and using the slopes as shown in the drawings and the area calculated.

iii. Lay 6" hollow blocks

iv. Lay cover slabs

v. Backfill with stone

vi. Cover with geotextile if slabs to be buried and back fill with soil and turf

Remember to keep plans of the installation for later years so that no-one attempts to dig a fresh grave anywhere near the sewage system.

Appendix 1 Water Saving

Whilst water saving is good thing per se it may also have a crucial impact on very marginal soils - ie ones in which the percolation test gives a high number. As most water use is likely to be through the WC this is where the greatest saving can be had. There are toilets which use only 4 litres and we recommend the Ifö Cera ES4 - because we sell it! But we sell it because we think it is the best available - see accompanying literature. Also see appendix 5 below. A further advantage with the ES4 is the low noise level.

Appendix 2 Frost

When water freezes it expands with great force. Remember in unheated churches that the water supply will need to be protected from frost along its full length. Additionally we would recomend installing a stopcock in an easily accesible place and turning off the water when not required.

There are a number of products on the market designed to detect burst pipes and leaks and shut off the water supply to minimise water loss and damage. Most of these products work by starting a timer when flow is detected. If the flow continues beyond a preset time then the supply is shut off. When flow stops the timer resets. An override is provided to allow, for example, irrigation. A few devices also detect high flow rates due to a burst pipe and most provide a simple switch to turn off the water when the building is unoccupied for any length of time. Since the devices are usually fitted in-doors they do not detect leaks in the pipe between the water meter and the building.

The main reason for installing such devices is for property protection rather than water conservation. Turning off the stopcock when the church is unused may provide similar protection. Electrically actuated stopcocks are available to simplify this operation.

Appendix 3 Thick walls

Waste water is usually lead away from the back of a WC in a 110 mm pipe. This has to make its way outside and this often means through very thick masonry walls. An alternative is to use a very small box which chews it up and pumps the waste water out in a very much smaller pipe - eg 22 mm. Such a pipe can be directed though a door frame or other non masonry route and it can go uphill. This may have particular uses for discharging to a trench arch which benefits so much from being high in the soil, or from WCs below the discharge system. Waste water from the sink can also go to the same pump so no separate system is needed. The most famous name of such a system is Saniflo.

Appendix 4 Aquatron

Is is possible to make use of cellar as part of the treatment system. Many Churches have vaults or boiler rooms or other space beneath the toilet which can be used. In one Church in Worcestershire we have installed a system called an Aquatron. This is an unpowered device which separates the solids from the liquids in a flush. The solids are deposited in a composting chamber and the liquid continues to the disposal system - in this case a soakaway via a small pump set. see appendix 3. The Aquatron has the advantage that no sludge is generated. See accompanying information.

Appendix 5 Compost toilets

As for appendix 4, the cellar can be used but for a composting toilet but it must be directly beneath the WC. A composting toilet is a long drop - ie the toilet has no water but is the top of a chute to a box which has some compost, a hole for drainage of the extra moisture, a door for maintenance and compost extraction, and a vent which may be assisted with a fan to stop smells coming up through the toilet.

This has many advantages - water economy, frost proof, no sludge, useful final product. Its disadvantages include lack of public familiarity, and not dealing with the rest of the waste water.

We recomend the book ‘Lifting the Lid’ published by the Centre for Alternative Technology.

See attached details

Appendix 6 Cess pools

If

- the mains is too far away,
- if there is no water course to go to
- and if the soil gives a very poor percolation value

then there is nothing for it; the waste water will need to be tankered away. This is done using a large holding tank which is emptied every time it is nearly full. This may be worth considering even if all other possibilities (except mains) are open. The smallest tank that is used in a domestic situation is 18 m^3. If 173 litres is used on a busy day - let us say an average week uses 200 litres then the tank will not be full for 2 years. Emptying the tank is the only maintenance expense and, currently, would cost about £300 every 2 years which is not such a crippling cost compared to the burden of having a cess pool for a house. Water economies will greatly assist in reducing times between emptying. The EA publish free Water Saving Fact Cards, tel: 01903 832073.

The drains feeding such a system must be completely watertight otherwise rainwater will enter the tank. This is a particular issue since cesspools are usually used where soil is heavy or the watertable is high.

Appendix 7 Package treatment plants

If the waste water must be discharged to a water course ('consent to discharge') then the authorities will also state how clean the water must be. It is tempting to think that you won't be tested on a Sunday when the use will be highest but deliver yourself from that one!

However, treatment is not simple because of the intermittent use as explained above. If this is the only way of dealing with the situation please look for local expertise to investigate the best way. Consider the cess pool as above along with water economies to prolong the period between emptying.

Bibliography

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Grant, Moodie and Weedon
CAT 1996 and 2000
ISBN 1-89804-916-5

A general primer to the subject if more depth is required

Septic Tanks – an Overview
Grant and Moodie
ISBN 0-9526957-1-5
Grant 1995 and 1997

Septic tanks and percolation tests in greater depth.

Lifting the Lid
Harper and Halstrap
CAT 1999
ISBN 1-89804-979-3

An introduction with designs for composting toilets