On-site Wastewater Management Notes

GRAVELLESS TRENCHES and FABRIC/TEXTILE WRAPPED DISTRIBUTION PIPES

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1.0 Background
These notes are prompted by the recent introduction into New Zealand of a proprietary system for dispersing septic tank effluent into the subsoil known as “Advanced Enviro-Septic” which originates in the USA. Basically the system comprises a patented geotextile plus plastic fibre wrapped large diameter (300mm) perforated and ridged plastic pipe laid within a “system sand” bed which disperses treated septic tank effluent into the subsoil.

This note discusses the use of gravelless fabric/textile wrapped pipeline distribution systems and then reviews the Advanced Enviro-Septic proprietary system along with an alternative treatment and dispersal system, Eljen, also developed in the US.

2.0 Gravelless Trench Effluent Dispersal Systems

2.1 Origins: Plastic open bottom arched leaching chambers appeared in the US in the late 1980s as an alternative to gravel/aggregate and distribution pipe soakage trench systems for septic tank effluent dispersal into the subsoil [Ref 6]. As of 2002 over 700,000 plastic arch chambers had been installed country wide, with around one in four installations of trench systems being plastic chambered, the rest being mainly conventional gravel filled trench systems. Some states permitted a sizing area concession for such chamber systems because of efficiencies in effluent dispersion and subsoil treatment resulting from the storage capacity in the system and the vented airspace within the arch. They are expensive to construct if a ready source of low cost gravel/aggregate is available; on the other hand they are economical where gravel/aggregate is expensive due to long distance transport [Ref 7].

As an alternative to gravelless leaching chambers large diameter corrugated plastic tubing covered with permeable nylon filter fabric began to be introduced. The area of fabric in contact with the soil enabled septic tank effluent to infiltrate directly for in-soil treatment. With a 300mm diameter fabric wrapped pipe in a 600mm wide trench, the pipe flexibility enabled economical installation on steep slopes unsuited to conventional systems [Ref 7]. However, caution in use of fabric wrapped pipes is required – if conventional gravel trench systems do not work well in the area, or soils are “fine sandy organic rich with shallow groundwater” then these systems may not be suitable [Ref 7].

2.2 NSFC Newsletters: The Summer 2001 issue of “Pipeline” [Ref 9] noted that geotextile filter fabric wrapped plastic pipe gravelless distribution trench systems should incorporate a cleanout access point to enable inspection and for flushing out of any accumulated sludge. The move toward gravelless distribution trenches had been prompted by research indicating that up to 50% to 75% of the infiltrative surface in gravel filled trench systems is blinded by the gravel media, thus inhibiting the area available for in-soil treatment and soakage. Some jurisdictions thus allow a concession on design area for gravelless systems. However the EPA in 2001 cautioned against this until additional research justified such concessions, as it may well be that organic loading factors drive design area allowance rather than hydraulic shielding.

A follow-up item in “Pipeline” four years later [Ref 10] confirms the details discussed in the 2001 newsletter (including the need for cleanout access), and points out the advantages of the gravelless system as:

- more economical where gravel/aggregate supplies are non-existent or very expensive;
- faster installation;
- increased volume of void space per unit length (thus providing surge storage);
• soil compaction is reduced since the heavy equipment to haul and place gravel/aggregate in trenches is not needed; and
• good for remote sites with difficult access.

2.3 US Manufacturers of Textile Wrapped Pipeline Gravelless Distribution Systems: Two companies offering specialist technologies are discussed in sections 3 and 4 below. Two other companies offering geotextile wrapped pipe systems are as follows:

(a) Hancor Inc, Findlay, Ohio: Hancor produces a gravelless pipe for on-site wastewater disposal [Ref 13]. Two products are available:
• Hancor Gravelless Pipe.
• Geoflow Pipe

The gravelless pipe system comprises a fabric covered 200mm or 250mm diameter corrugated perforated plastic pipe with a geotextile spun-bonded nylon wrap. It is installed within a 450mm to 600mm wide trench some 500mm depth and backfilled with original soil.

The University of Minnesota evaluated the LTAR (long term acceptance rate) of the fabric covered pipe system for distributing septic tank effluent into 8 different soil types, with good performance in all soils except porous gravels.

The Geoflow Pipe system comprises a corrugated pipe surrounded by a symmetrical polypropylene grid then wrapped in a special geotextile fabric. This expanded media system enhances aerobic biological activity within the depth of the grid and textile material, thereby assisting the overall secondary treatment performance within the system before dispersal into the subsoil. The lightweight nature of the Geoflow Pipe system enables its use in locations where gravel trench systems would be difficult to install. In addition, some US State Health agencies allow a lower design footprint for the Geoflow Pipe because of its internal treatment effectiveness.

(b) Crumpler Plastic Pipe Inc (CPP), Roseboro, North Carolina: Crumpler has produced the CPP No-Rock Septic-Leachate large diameter drainpipe system since 1985 [Ref 14]. It has advantages claimed for areas where gravel/aggregate for conventional trenches is limited or too expensive, in localities where soil conditions and topography create difficult access conditions for heavy machinery, and where flexible layout of shallow and narrow trenching can reduce the need to remove trees in the infiltration area. In such situations overall installation costs are cheaper.

The CPP No-Rock fabric wrapped pipes come in 6m lengths and 200mm or 250mm diameter. It should not be used in fine silt soils or some types of organic rich soil, nor installed in fill material.

2.4 State Information on Geotextile Wrapped Gravelless Distribution Systems in the US: A selection of Information from four States is set out below:

(a) Nevada: Gravelless drainfields have application in remote or difficult to reach sites or when gravel/aggregate for conventional trenches is too expensive or not available. However, fabric wrapped pipe systems are not recommended for septic tank effluent – sand filter pre-treatment is preferred [Ref 15].

(b) Maine: Gravelless trenches and beds utilising “fabric covered tubes” were approved for use in Maine from June 1989 [Ref 16]. The initial systems involved geotextile wrapping direct around the external circumference of corrugated pipes. This was followed by introduction of improved systems incorporating a plastic mesh between pipe and fabric – the mesh aided in mitigating the “establishment of a restrictive biomat between the pipe and fabric”. A third system approved for use in Maine was the “cuspated block” system (see section 4 below). The cuspated plastic blocks (somewhat like egg cartons) were interspersed with non-woven filter fabric. The system provides substantial surface area for development of biomat aerobic treatment of the septic tank effluent. The high surface area to footprint ratio provides a high degree of treatment. Both types of
gravelless systems are allowed a significant sizing concession in system design and installation compared to traditional gravel/aggregate trench and bed systems.

(c) University Extension Fact Sheets: Both the University of Texas [Ref 17] and Purdue University in Indiana [Ref 18] have described the use of fabric wrapped pipe gravelless distribution systems in extension service fact sheets. The advantages and cautions related to their use are discussed, and the importance of following manufacturer’s instructions are noted.

3.0 The Advanced Enviro-Septic (AES) Technology

3.1 Introduction: AES technology was developed by Presby Environmental Inc (PEI) of Whitefield, New Hampshire, USA [Ref 1]. Two products based on textile wrapped distribution pipes are available as follows:
- Enviro-Septic (ES)
- Advanced Enviro-Septic (AES)

The ES system comprises a plastic fibre mat wrapped 300mm ridged plastic pipe surrounded by a geotextile. The system is embedded in a specially graded “system sand” bed of overall 750mm depth. Septic tank effluent discharges by gravity into the ES pipe system in which passage though the fabric and textile layers achieves aerobic biological treatment. Final polishing occurs through a minimum 300mm sand depth below the ES pipe, with the treated effluent then infiltrating the subsoil below the sand bed. Where clearances to a restrictive horizon (impermeable layer; water table) are limited, the whole system can be constructed within a mound of around 850mm depth sitting some 550mm above ground level, with 300mm below ground level. The ES is thus a treatment and dispersal system [Ref 1].

The AES system includes a special patented geotextile fabric filter between the pipe exterior and the plastic fibre mat for some 1/4 of the circumference of the pipe below the invert. The fabric layer is patented as a “bio-accelerator” which promotes rapid development of an aerobic treatment biomat.

3.2 Design: Design loading rates based on the sand bed horizontal area are provided by PEI [Ref 3], and can be compared to AS/NZS 1547:2012 [Ref 4] as below.

<table>
<thead>
<tr>
<th>AS/NZS 1547 Soil Category</th>
<th>Soil texture</th>
<th>Soil Structure</th>
<th>AES DLR mm/day</th>
<th>AS/NZS 1547 DLR mm/day (primary treated effluent – maximum rate )</th>
<th>AS/NZS 1547 DLR mm/day (secondary treated effluent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coarse sand to sandy loams</td>
<td>Structureless</td>
<td>40 to 65</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Sandy loams</td>
<td>Weak</td>
<td>30 to 40</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Massive</td>
<td>20 to 30</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>Loams</td>
<td>Moderate</td>
<td>25 to 30</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weak</td>
<td>20 to 25</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>Clay loams</td>
<td>Moderate</td>
<td>24</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weak</td>
<td>12</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Massive</td>
<td>---</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Sandy clay, clay, silty clay</td>
<td>Strong</td>
<td>12</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate</td>
<td>12</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weak</td>
<td>--</td>
<td>---</td>
<td>8</td>
</tr>
</tbody>
</table>

The AES structure descriptions include shape descriptions (massive/platy/prismatic-blocky-granular), hence some interpolation has been used in compiling the above comparisons.
3.3 Installation: The “System Sand” that surrounds the AES pipes is an essential part of the system. AES states that [Ref 3] “it is critical that the correct type and amount of System Sand is used when constructing the system. System Sand must be coarse to very coarse clean, granular sand free of organic matter”. Two concrete sand options are discussed along with qualifications re their preparation and use. Bed construction involves sand depth/width requirements as follows:

- 300mm depth below AES pipes;
- 150mm above AES pipes;
- 150mm of sand between adjacent pipes;
- 300mm of sand surrounding the perimeter of the pipe network.

Venting of the pipe system is most important, with a minimum differential of 3m between the high vent exhaust (the house vent on the drainage line to the septic tank) and the low vent inlet at the end of the AES bed system. This inlet to the low vent at the end of the bed must extend 1m above ground level. The venting requirement has been confirmed through smoke testing [Ref 8].

PEI provides training courses and follow-up design support for all its approved installers.

3.4 Operation and Maintenance: The AES system is designed to treat and disperse septic tank effluent into the subsoils via a vented AES pipe network which maintains aerobic biological secondary treatment in the biomat within the textile and fabric wrappings. Generally a significant air space is maintained above the liquid percolating through the geotextile thus supplying oxygen to the biomat as it drains free.

PEI recommends a minimum septic tank capacity of 3,800 litres and that no effluent outlet filter is installed [Ref 3]. The reason for this is that PEI believes that effluent outlet filters have a tendency to clog if not properly maintained and thereby restrict oxygen supply to the internal area of the AES pipes. However, an effluent outlet filter which allows free passage of air into the AES pipes is satisfactory.

PEI explains [Ref 5] that the treatment process within the AES system is based on aerobic biological action by bacteria within the multi layered plastic fibre/geotextile fabric wrappings. If aerobic action becomes inhibited in any way due to wastewater overload or lack of oxygen due to inadequate venting, bacterial conditions can become anaerobic. Anaerobic conditions will be indicated by odours, and the system sand around the AES pipes will become darker. Corrective action will include a “rejuvenation” procedure involving the following steps:

- investigate and address the causes of system malfunction;
- pump out the septic tank;
- excavate and expose one end of the pipework system;
- drain or pumpout any accumulated liquid and solids;
- allow natural ventilation to dry out the lines over a three day (72 hour) period; then
- restore system and restart flow.

If overload (or under-design) is the cause of the malfunction, the AES pipe and sand bed system can be readily extended provided sufficient reserve area has been set aside for this eventuality.

3.5 US State Approvals: Twenty four States/Provinces are cited on the PEI website in reference to state/province design and installation manuals [Ref 1]. Of these three permit a 75% reduction in bed area compared to traditional gravel system designs, one a 50% reduction and another 50% reduction for good soil conditions, and 25% reduction for other soils. One State allows a reduction in clearance to the water table at 300mm between the base of the system sand and groundwater level.

3.6 Performance Testing Results: The AES system was performance tested in Quebec, Canada under NSF-40 (US National Sanitation Foundation) and BEQ (Bureau de Normalization du Quebec) testing protocols. The testing programme was carried out over 12 months in 2008. Subsequently seven Canadian Provinces have approved the AES for installation.
Test results based on 30-day means were as follows [Ref 1]:

<table>
<thead>
<tr>
<th>Effluent Quality Parameter</th>
<th>NSF-40 Class I</th>
<th>BNQ Class II</th>
<th>US-EPA TS2</th>
<th>US-EPA TS3</th>
<th>Advanced Enviro-Septic Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>cBOD5 g/m³</td>
<td>≤25</td>
<td>≤25</td>
<td>≤30</td>
<td>≤30</td>
<td>&lt;2</td>
</tr>
<tr>
<td>TSS g/m³</td>
<td>≤30</td>
<td>≤30</td>
<td>≤10</td>
<td>≤10</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Faecal coliforms cfu/100ml</td>
<td>n/a</td>
<td>n/a</td>
<td>50,000</td>
<td>&lt;50,000</td>
<td>&lt;10,000</td>
</tr>
</tbody>
</table>

NSF Standard 40 Class I certification was issued in October 2009 [Ref 1]. The test results related to an installed system loaded at around 45mm/day (45 litres/m²/day) based on the area of the sand bed below the AES distribution pipes [Ref 2]. The depth of system sand below the AES pipes was 450mm with the sampling device laid within the lower 150mm of sand, that is underneath the normal 300mm sand depth to natural soil.

3.7 AES in Australia and NZ: The Advanced Enviro-Septic distributor in Australia is based in Noosaville, Queensland (www.enviro-septic.com.au). NZ distributor is Environment Technology Ltd of Nelson (info@wastewaterdesign.co.nz).

It is understood that Queensland has given AES approval for installation in that State, and that Victoria has it under review. Most other States in Australia appear to adopt the position that the AES is a “disposal” system rather than a treatment system, and as their jurisdiction extends only to treatment systems, it does not fit within their approval responsibilities.

4.0 The Elgen GSF (Geotextile Sand Filter) Technology

4.1 Introduction: Like the PEI AES system, the Eljen GSF is also a treatment and dispersal system. It utilises geotextile surfaces in a patented “Biomat” module to provide aerobic biological treatment of septic tank effluent prior to further treatment in a sand layer between the base of the module and the subsoil. The technology was researched and developed at the University of Connecticut some 25 years ago, and there are some tens of thousands of systems currently in use [Ref 11].

4.2 The GSF Installation: The GSF system comprises a 100mm distribution pipe laid centrally onto a 600mm wide by 175mm deep “Biomat” module of length 1,220mm which sits on a 150mm depth of Specified Sand through which secondary treated effluent infiltrates into the subsoil. The inlet pipe and module are covered in geotextile fabric sheet over which topsoil is placed. The 150mm sand layer through which final treatment takes place has to be a medium to coarse sand of effective size 0.25 to 2.0mm. It should meet ASTM 33 specification and comply with a specified grading curve. Washed concrete sand is a reliable choice [Ref 12].

The 175mm deep module comprises three layers of plastic “cusp” core each separated by a Biomat fabric so as to facilitate bacterial growth, enable oxygen transfer from air circulation though the voids, and provide effluent storage while under treatment [Ref 11 and 12]. The final treatment stage takes place in the upper layers of the 150mm specified sand lying over the infiltrative surface of the subsoil.

4.3 NSF 40 Certification: The GSF system has undergone certification testing to the NSF-40 protocol, with an 18 module bed system for a 3-bedroom dwelling discharging 1,700 litres/day. Three testing units were set up, one pressure dosed on demand, one timer dosed, and one gravity fed. Each bed system comprised a three lateral layout with 300mm sand between laterals and a 230mm sand perimeter.
Test results were as follows [Ref 11]:

<table>
<thead>
<tr>
<th>Test Parameter</th>
<th>Gravity</th>
<th>Demand Dosing</th>
<th>Timer Dosing</th>
</tr>
</thead>
<tbody>
<tr>
<td>cBOD₅ g/m² (median)</td>
<td>7.6</td>
<td>1.0</td>
<td>2.2</td>
</tr>
<tr>
<td>cBOD₅ g/m³ (mean)</td>
<td>8.0</td>
<td>2.0</td>
<td>2.6</td>
</tr>
<tr>
<td>TSS g/m² (median)</td>
<td>5.0</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>TSS g/m³ (mean)</td>
<td>7.4</td>
<td>2.7</td>
<td>2.7</td>
</tr>
</tbody>
</table>

4.4 **Eljen GSF Distributors:** Currently the GSF system is accepted in 24 US States and two Canadian Provinces. No information is available on distribution outside of North America.

5.0 **Commentary**

The widespread use of gravelless geotextile wrapped pipe distribution trench and bed systems for dispersing septic tank effluent is well established in North America. The development of improved systems incorporating a special media within the wrapping materials has enabled manufacturers to claim their system provides substantial treatment benefits which warrant a concession on system sizing compared to conventional gravel/aggregate trenches and beds. These claims have been accepted by several approving agencies in the US.

The importance of following manufacturer’s design and installation instructions along with complying with operation and maintenance guidelines is emphasised in the literature.

**References:**

1. http://presbyeco.com
5. Presby Environmental (2010), AES Owner’s Manual, Operating & Maintenance Instructions
13. Hancor (2009), On-site Septic Systems, Brochure AD130209 1204/0209
17. Lesikar, Bruce & Persyn, Russell (2004), Gravel-less Pipe, Texas Agricultural Extension Service On-site Wastewater Treatment Systems, L-5343, 1-00, Reprint 10 April 2000, Reviewed 1 November 2010
18. Lee, Brad, Jones, Don & Bourke, Chris (2004), Gravel and Gravelless Trench Soil Absorption Fields, Purdue Extension Home & Environment, HENV-8-W, 12/04