CONSTRUCTED WETLAND ASSOCIATION

GUIDELINES

Constructed Wetlands to Treat Domestic Septic Tank Effluent

Contents

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Dr Chris Weedon (Watercourse Systems Ltd);

Geoff Sweaney (Wetland Engineering);

Dr Rick Hudson (Cress Water Solutions Ltd);

Stewart Moir (Moir Environmental Ltd);

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Operational principles

There are several ways one might approach nitrification of domestic wastewater using wetland treatment systems. This standard has been developed for one particular approach, a pulse-loaded "vertical flow constructed wetland". Systems of this type are also commonly referred to as "compact vertical flow reedbeds" in scientific literature.

- These guidelines have been developed to be applicable to the legislative and regulatory framework of the UK.
- The design is intended to treat up to five cubic metres per day of domestic wastewater and to discharge to surface water.
- The wastewater should be settled in an effective septic tank suitable for the loads and type of effluent it receives.
- The effluent from the septic tank is to be fed in batches on to the top surface of a wetland treatment system with adequate rest periods between batches.
- Each batch should be distributed as evenly as possible over the top surface of the wetland.
- The treatment medium in the wetland needs to provide just the right amount of resistance to flow. It should be sufficiently free draining that it completely empties between batches, however must provide some resistance to prevent instantaneous drainage of water applied at the surface.
- The wetland should be free-draining at the bottom.
- If designed appropriately and sized correctly, the discharge from the wetland should not exceed 10:10:5 for BOD: suspended solids: ammonia.

In order to achieve these operational principles, the wetland should be designed and constructed as set out below. The guidance takes the format of a specification (green background), followed by an explanation of the reason for this requirement and/or how this relates to the operational principles (blue background) where appropriate, we have followed this explanation with an example of how this may be achieved in practice (grey background).

Specification
Purpose of specification
Reliable example

Design

The top surface of the treatment area should be at least 3m² per person equivalent (PE). The minimum total area is 15m² regardless of the population served, and the minimum width or length of the top surface is 2m*. The aspect ratio of the top surface is not important.

To ensure sufficiently low area loading rate for effective treatment, and to ensure "edge effects" are not significant.

NB the British Water Code of Practice for Flows and Loads #4 (current at the time of writing these guidelines) requires that domestic properties be designed for a minimum of 5 people (PE) i.e. 15m².

The total bed area should be undivided, or else divided into two equal beds to facilitate maintenance. If two beds are used, these should be loaded simultaneously (except when undergoing maintenance).

To ensure correct sewage loading rate to wetland surface.

*NB the sizing (and this standard generally) relate to wetlands treating small volumes of effluent from septic tanks. Smaller unit areas may be appropriate for other scenarios, e.g. tertiary treatment (receiving effluent that has already been treated in a package treatment plant).

**The measurement Vp is a value relating to the infiltration rate of the soil, defined in relation to a test described in the UK Building Regulations 2010 approved Document H2.

The wetland sides and base should be lined with a suitably protected waterproof membrane, or constructed in inert ground of Vp** > 100 s/mm.

To ensure treated effluent is directed to outlet. The Environment Agency allow septic tank effluent to infiltrate into soakaway between 15-100 s/mm, therefore infiltration at smaller rates where Vp >100 s/mm is acceptable.

If a waterproof liner is needed, a puncture-resistant synthetic membrane would be suitable, protected with geotextile membrane above and below according to the manufacturer's recommendation.

The wetland should be drained from the base using one or more "Base Drainage Pipes" connecting to a single pipe discharge of at least 70mm minimum bore.

To ensure the treatment layer is free draining.

A single, rigid base pipe 70mm in diameter is adequate for bed width <3m. For larger bed widths, parallel base pipes with 2m or less between centres would provide adequate drainage.

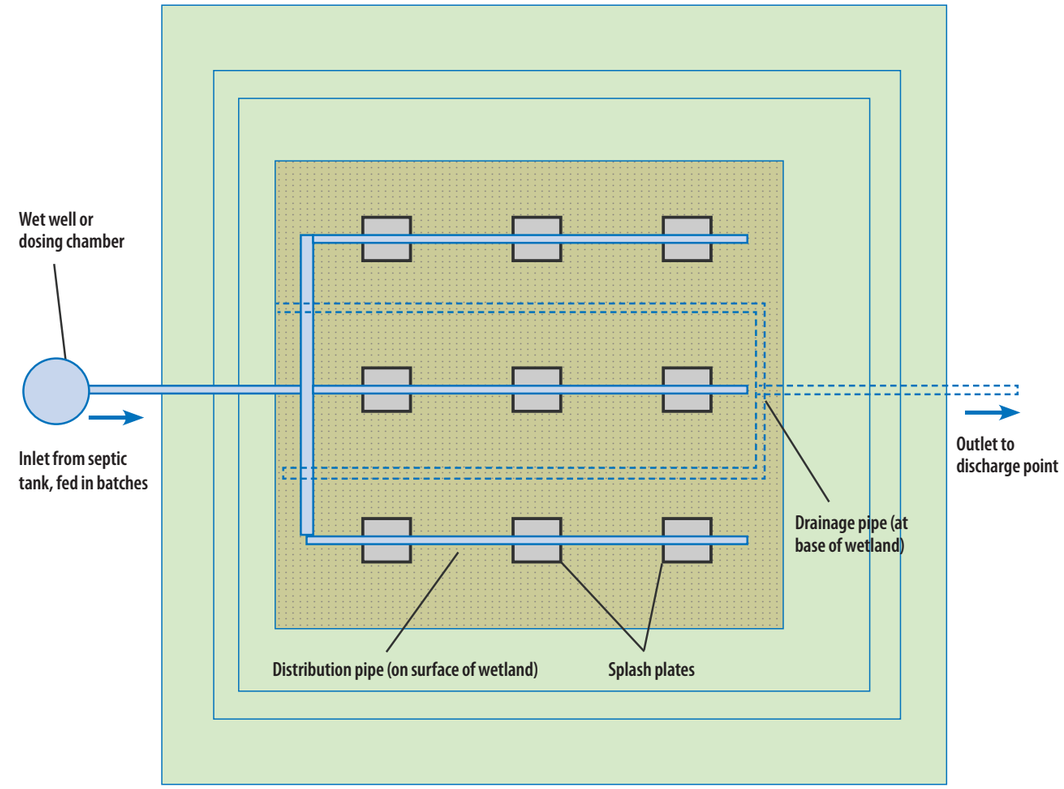

Figure 2. *Typical plan view of a vertical flow constructed wetland prior to planting*

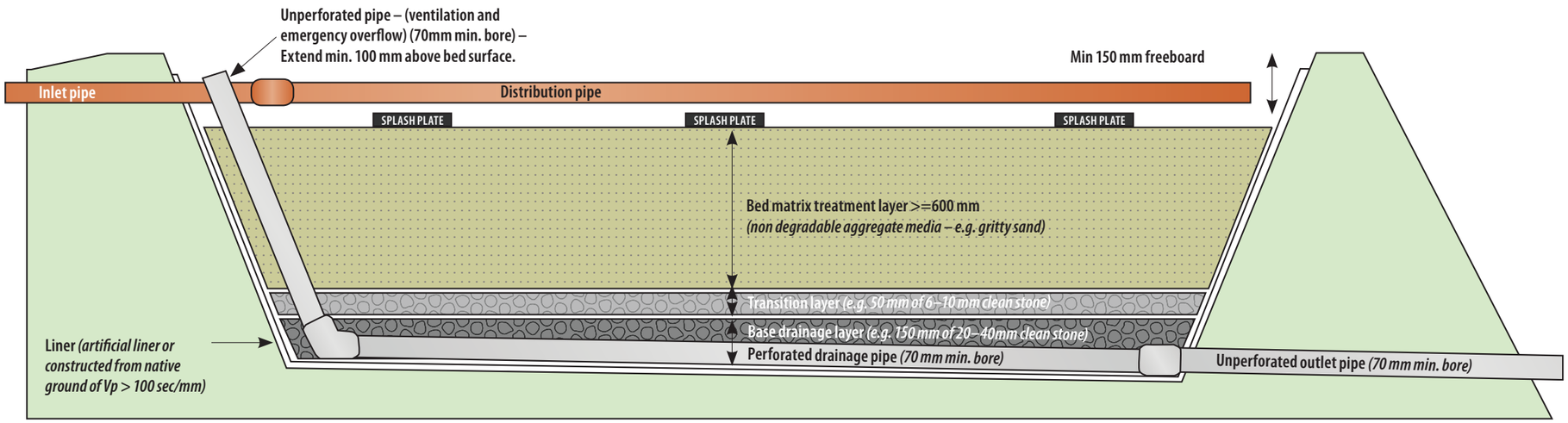

Figure 1. *Typical longitudinal section through a vertical flow constructed wetland prior to planting*

Photograph courtesy of Cress Water Solutions

The base of the wetland should be ventilated by means of "Ventilation Pipes". These should be made from perforated pipe set within the drainage layer, which is connected to non- perforated pipe that extends above the surface of the wetland. These may be dual purpose pipes (drainage and ventilation) or may be dedicated ventilation pipes.

To create an aerobic environment within the treatment layer.

One way to achieve this ventilation is to fit each base drainage pipe with at least one non-perforated riser, the end of which is positioned around 100mm above the wetland surface.

The Base Drainage Pipes should be completely covered with the "Drainage Layer" of the wetland. This must be a physically stable, chemically inert, free-draining gravel with a level surface.

To ensure rapid, efficient drainage.

One option for an effective base drainage layer compatible with 100mm base drainage pipe would be 20-40mm clean river terrace gravel, of nominally 150mm depth.

The Drainage Layer of the wetland should be covered with the "Transition Layer". This should be a physically stable, chemically inert gravel of smaller particle size than the Drainage Layer, and with a level surface. The particle size needs to be sufficiently small to prevent the sand of the Treatment Layer descending into the pore space of the drainage layer.

To prevent the small particles within the Treatment Layer medium being washed down into the Drainage Layer, while ensuring free passage of air through all the layers of the wetland.

Typically this may be 6-10mm clean river terrace gravel of 50mm depth.

The Treatment Layer of the wetland should be placed on top of the Transition Layer. This will comprise chemically inert, non-degradable aggregate material of appropriate percolation rate. The percolation rate should be such that the material will return a time of 30-60 seconds when subjected to the test defined in appendix A.

To ensure sufficient treatment time, avoiding surface ponding.

The Treatment Layer would typically be a gritty sand with a very low fines content.

The Treatment Layer should be at least 600mm in depth at the time it is placed, and of consistent density over entire bed.

To prevent short-circuiting and ensure effective treatment.

The surface of the Treatment Layer should be level to within +/- 10mm and regular.

To ensure maximum effluent spread during surface-flushing.

Typically, this may be achieved with a hand-raked surface.

The wetland basin should be shaped to provide sufficient freeboard (at least 150mm) above the surface of the Treatment Layer.

To ensure wastewater is retained in the treatment system.

Effluent should be introduced on to the surface of the Treatment Layer in intermittent batches, 5-12 litre/m^2 of bed surface, at sufficient flow rate to cover > 60% surface, in a manner that avoids sand-pitting (ponding). The interval between consecutive applications of effluent should be sufficient to allow the wetland surface to drain completely.

To ensure appropriate loading rate over treatment matrix, allowing effective effluent treatment and ensuring wetland plant development.

A sinking-pipe dosing device is suitable for achieving batch dosing at the appropriate rate where natural fall allows gravity feed. Pump-fed distribution is a suitable alternative. Splash plates would typically be used to avoid pitting of the wetland surface.

If pipework is used to achieve the effluent distribution on to the surface of the treatment layer, the pipe arrangement needs to be self-draining.

To maximise self cleansing and prevent ice accumulation in freezing temperatures.

This may be achieved by locating the distribution holes on the underside of the distribution pipes.

Photograph courtesy of WWT Consulting

Photograph courtesy of WWT Consulting

The wetland plant species should be selected to provide an even distribution of stems over the surface of the wetland. They should be planted as seedlings into the surface of the Treatment Layer, at a density of at least 4 plants per m^2.

To ensure rapid and robust plant growth.

Common Reed (*Phragmites australis*) is commonly used.

If earth bunds surround the wetland bed, these must be formed into a shape that is stable, clean and designed to prevent runoff from the surrounding land from reaching the Treatment Layer. Such bunds should be finished in materials resistant to erosion from rainfall.

To ensure longevity of the treatment system and protect the treatment layer from clogging.

Prepared turf is a suitable for a soft finish and paving slabs may be suitable for a hard finish.

Construction

Photograph courtesy of Moir Environmental

The perimeter of the wetland should be shaped to prevent rainwater runoff from the surrounding land from flowing on to the wetland surface. Where the wetland is formed by creating new banks, the material forming the banks should be compacted to a civil engineering standard appropriate to ensure that the banks have sufficient strength for the loads it will receive, and that the finished levels account for an appropriate amount of settlement of the newly formed banks. External slopes in soft landscaping should generally not exceed 1 in 3, and should be stabilised against erosion with turf or other erosion protection.

To ensure newly formed slopes are stable.

If a waterproof liner is needed, the base and sides of the excavation that will contain the wetland should be prepared to be free from any protruding stones or other materials that could damage the liner. The liner should be placed with adequate protection from puncturing from above or below, ensuring a watertight seal around any joins or pipe insertions in accordance with the manufacturer's recommendations.

To ensure the liner remains watertight.

If a waterproof liner is needed, this needs to be of a robust and durable material, recommended by a reputable supplier for its intended use. If in-situ testing of the liner integrity is required, this test should be completed with the Drainage Layer and Transition Layer (free draining gravel) in place, however the treatment layer (e.g. gritty sand) **must not** be in place, as prolonged submersion of the treatment layer may adversely affect its performance. Water tightness may be tested by filling the wetland basin with water, and monitoring the water level therein over a 24 hour period.

To confirm the liner remains watertight after placement of the gravel.

HDPE, LDPE, Butyl rubber and synthetic clay liners have all been used successfully as liners for wetlands.

The bed media should be placed carefully in position without mechanical compaction. Plant and machinery should not track on the treatment layer. Care should be taken that media when placed is of even density taking care to prevent voids and loose areas which may settle unevenly. Reasonable pedestrian access for tasks such as planting, maintenance and preparation of the bed surface is acceptable.

To ensure the bed media, particularly the treatment medium retains a consistent and appropriate permeability to water.

The bed media can normally be placed using a mechanical excavator accessing the ground surrounding the wetland only, without tracking on the treatment area. A long reach excavator can be used for larger wetland cells if necessary. Media can be levelled using pedestrian access to the treatment area, and raking by hand. Light compaction by systematic and even "treading" on the surface by pedestrians can be beneficial to avoid uneven settlement.

Sequence of activities in wetland construction. Photo courtesy of Moir Environmental

Operation and maintenance

Photograph courtesy of Watercourse Systems

Upstream system features (e.g. septic tank, flushing chamber/pump chamber) need to be maintained in good working order. The septic tank should be emptied at least once every 12 months, or according to the manufacturer's recommendation, whichever is the more frequent.

To prevent excessive solids carry-over to treatment layer surface.

Cut grass and other vegetation on bunds and bed edges to retain the defined shape of the wetland cell.

To ensure the wetland cell is continuously defined and free from unwanted invasive plants.

Scythe or strim the grass and remove cuttings.

Photograph courtesy of Cress Water Solutions

Remove all weeds from the surface of the Treatment Layer, retaining a regular sand surface.

To select for wetland species, so ensuring surface permeability and ease of maintenance.

Hand-pull weeds.

Keep the surface of the Treatment Layer free from excessive build-up of organic debris (e.g. decaying leaves and other plant matter).

To ensure a free draining surface and preserve the hydraulic performance of Treatment Layer.

If the wetland is planted with Phragmites, reed stems should be cut to a height of 25-100mm at least every two years (ideally annually). This should be done in December, January or February for a UK growing cycle, and any substantial build-up of leaves should be removed annually. To protect the biodiversity value of the wetland, this cut can be carried out by rotation, cutting half the wetland each year.

Photograph courtesy of WWT Consulting

Annex A

Constructed Wetland Association Test for permeability of sand treatment layer for Vertical Flow Wetlands

The test outlined below will ensure that the sand media for the treatment layer of the wetland has the correct permeability to be used for a vertical flow wetland of this design. It is based upon the similar "Grant Test" test described in Annex 4 of BRE publication 420. There are some important differences adopted in the CWA approved test owing to an improved understanding of the performance of wetland systems that has been gained since the publication of BRE 420 in 2001.

TEST PROCEDURE

1. Stand a 350mm length of 110mm OD uPVC pipe on a bed of free-draining gravel (e.g. 50mm depth of 10mm gravel);
2. Place test material into the pipe, levelling the material's surface to a depth of 200mm after firmly tapping the outside of the pipe;
3. Add 500ml clean water to the surface of the sand;
4. Record the time taken for the water to descend, until just disappearing below the sand surface;
5. At the moment the water disappears, add 500ml clean water to the sand surface;
6. Record the time taken for the water to descend, until just disappearing below the sand surface;
7. Repeat 3–6 until the time remains relatively constant (about 8–10 iterations);
8. This constant time should be in the range 30–60 seconds for the sand to be suitable for a vertical flow wetland Treatment Layer.

REFERENCES

N Grant, M Moodie, C M Weedon, 1996. *Sewage Solutions – Answering the Call of Nature*, ISBN 1-90217-526-3. Became *Choosing Ecological Sewage Treatment* in 2012.

N Grant and J Griggs 2001. *BRE publication 420: Reed beds for the Treatment of Domestic Wastewater. CRC Ltd, London* ISBN 1 86081 486 7

C M Weedon, 2003. *Compact vertical flow constructed wetland systems – first two years' performance*. Water Science & Technology, Vol 48, No 5, pp15-23.

C M Weedon, 2010. *A decade of compact vertical flow constructed wetlands*. Water Science & Technology, Vol 62, No 12, pp2790-2800.

C M Weedon, C Murphy, G Sweaney, 2017. *Establishing a design for passive vertical flow wetlands treating small sewage discharges to meet British Standard EN 12566*. Environmental Technology, Vol 38, Issue 2, pp220-229

C M Weedon, 2017. *Tertiary Sewage Treatment by a Full Scale Compact Vertical Flow Constructed Wetland*. Environmental Technology, Vol 38, Issue 2, pp140-153

CONSTRUCTED WETLAND ASSOCIATION

CONTACT US

Constructed Wetland Association, Slimbridge Wetlands Centre, Gloucestershire GL2 7BT, United Kingdom.
Web: www.constructedwetland.co.uk