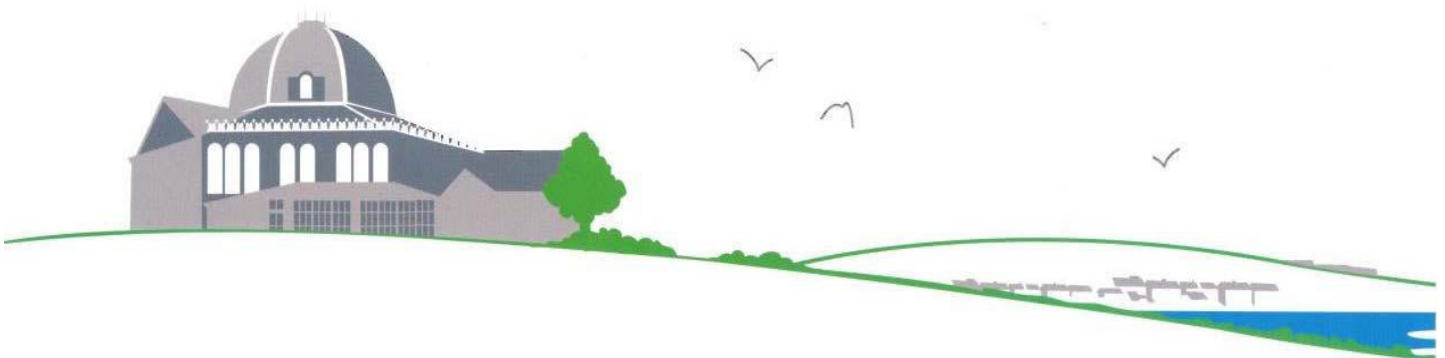




AVIAGEN TURKEYS

LLAY, WREXHAM, WALES

A WETLAND TREATMENT SYSTEM FOR THE
MANAGEMENT OF WASH-WATER AND TREATED
DOMESTIC WASTEWATER



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This project has been undertaken in accordance with PAA policies and procedures on quality assurance.



Signed: _____

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2	Preliminary Specification Stage II Ammonia and Phosphorus Surface Flow Willow Bed with Stepped Aeration

1. INTRODUCTION

- 1.1 Penny Anderson Associates Ltd (PAA) was commissioned by Aviagen Turkeys in March 2016 to provide a specification for the treatment and disposal of 'dirty' water generated at a proposed new turkey unit at Llay in Wrexham, Wales.
- 1.2 PAA has been involved in the design, construction, commissioning and management of habitat-based environmental buffers, wetland treatment systems and SuDS for over 25 years, and the design proposals outlined below take account of current literature and operational performance of such systems as presented in various publications including *Rural Sustainable Drainage Systems (RSuDS)*¹; and *The SuDS Manual*², as well as standard texts such as *Treatment Wetlands*³.
- 1.3 The driving principles behind these proposals are to provide a sustainable means of managing 'dirty' water generated by the site; to ensure adjacent catchments are protected from any potential impacts from the runoff from the site, and to provide some small-scale ecological benefits through the reedbed and willow copse habitats being used as part of the wetland treatment scheme.
- 1.4 This report provides an outline specification for a wetland treatment system which would be used to manage 'dirty' water runoff generated at the site. Section 2 of the report provides a brief scheme description of the wetland proposals, and Section 3 gives brief background details for the sizing and performance of the wetland system. Once the wetland treatment system design is agreed, a full operational and management plan would be produced. The system is, however, designed to be robust and reliable, and with only the simplest of management requirements would ensure a very high standard of environmental protection.

¹ Avery, L.M., 2012. *Rural Sustainable Drainage Systems (RSuDS)*. Environment Agency.

² Woods-Ballard, B., Wilson, Udale-clarke, H., Illman, S., Scott, T., Kellagher, R., 2015. *The SuDS Manual*, CIRIA C753.

³ Kadlec, R.H. and Wallace, S.D., 2009. *Treatment Wetlands*, CRC Press

2. SCHEME DESCRIPTION

- 2.1 The proposals for a new turkey breeding unit at Llay involves the generation of two sources of 'dirty' water. The first is from the seven-month cycle of cleaning and washing-down the turkey units. This wash-down process occurs after the removal of fouled litter and involves washing down with detergents. The surfaces once dried are then disinfected. The second source of wastewater is generated from the staff facilities, including toilets, washrooms and showers; both these sources of potentially contaminated wastewater would be collected in an underground containment tank.
- 2.2 The combined volumes of the two sources of 'dirty' water amount to some 130m³ for a seven-month cycle. The content of this wastewater has been characterised using data from similar sized and operated turkey units elsewhere. In particular, Biochemical Oxygen Demand (BOD), Phosphorus and Ammonia are the parameters which have been used to scale and design a treatment wetland.
- 2.3 The treatment wetland would be in two stages. The first stage would be a sub-surface flow, gravel filled reedbed treatment system (77.5m²), primarily designed to reduce BOD levels by at least 95% (see Figure 1). Water would be pumped from the underground wastewater storage tank at a rate of only 1.08m³/day over a four month period. The water would enter the distribution chamber via a passive aeration cascade, and then into a narrow channel to distribute the flow across the 5m width of the gravel reedbed. Water would flow through the first cell of the reedbed at or just above surface level. A second open water distribution channel would then balance the flows to then continue through a second gravel reedbed cell. The flow would then be gathered in a final open channel before entering the outlet chamber. This chamber would contain a decanting arm that would enable precise water levels in the reedbed cells to be managed for performance and maintenance reasons.
- 2.4 The partially treated wastewater would then run into a control chamber for the second stage wetland treatment, a soil-based willow treatment bed with stepped aeration (see Figure 2). In this system (62.5m²) there would be three interconnected willow (Osier) cells where the water would be forced to take a sinuous flow around clay bunds in order to maximised the contact with the willow beds and reduce the risk of wastewater short-circuiting the system.
- 2.5 After the first willow cell there would be a sub-surface flow cell containing a substrate high in clay products. This might be crushed brick or lightweight clay aggregate. This cell would function as a sink for phosphorus, with phosphates being adsorbed onto the surface of the materials. Eventually this material would become saturated with phosphorus and would be replaced, and the used material would be disposed of as a fertiliser or hardcore. Between each of the interconnected willow and clay substrate cells there would be a steeped cascade to entrain oxygen in the flow, thereby encouraging the treatment of ammonia and the adsorption processes for phosphorus.
- 2.6 Flow from this second stage of the wetland would gather in an open channel and into a final stone filter before being collected in an outlet chamber. From this chamber the treated water would be spray irrigated onto the surrounding land. Given the evapotranspiration rates associated within the reedbed and willow cells, the treatment wetland would generate outlet flows of between 17 litres/hour and 89 litres/hour. Such low rates would easily be managed through spray or tankered irrigation locally.
- 2.7 This proposed wetland treatment system would be a robust and reliable means of managing the types and scales of wastewater that would be generated at the Llay turkey unit. Management of the system would be relatively straightforward and a detailed operation and management plan

would be developed as part of the full design specification. Similar wetland systems are used widely internationally and in particular by UK water companies and agricultural enterprises.

3. OUTLINE SPECIFICATION OF THE WETLAND TREATMENT SYSTEM

3.1 The following assumptions have been made:

- Volume of combine wash-water and treated discharge from Klargester = 130m³ (130,000 litres) on a 7 month cycle;
- Wash-water BOD = 160mg/l (nrm report dated 07/03/03);
- Klargester BOD = 20mg/l;
- Combined storage tank BOD 106mg/l;
- P concentration in wash-water 75.2mg/l (nrm report dated 25/04/16);
- P concentration from Klargester 2mg/l;
- Combined P concentration 47mg/l; and
- Ammonia concentration taken as 161mg/l (nrm report dated 25/04/16).
- Scaling of wetlands based on BOD, phosphorus and ammonia. The high levels of ammonia will require some form of aeration to be applied. The phosphorus will be addressed through the use of adsorption materials to retain the phosphorus within the Stage II wetland.
- Scaling of wetlands based on delivering the stored tank water to the wetlands over a four month period. This gives rise to a volumetric loading rate of 1.08m³/day.
- No account is yet made of topography and arrangement on the ground of the wetland treatment systems.

3.2 The first stage of the wetland design is based primarily on treating the BOD content of the tank water. The second stage addresses primarily ammonia and phosphorus (and other metals).

Stage I Wetland

3.3 The two sizing options for BOD treatment are:

- Kickuth Formula

$$A_h = Q_d(\ln C_0 - \ln C_t) / K_{BOD_5}$$

Where:

A_h (surface area of wetland bed m²)

Q_d (flow m³/day)

C_0 (concentration of incoming effluent mg/l)

C_t (outflow concentration mg/l)

K_{BOD_5} BOD₅ area-based rate constant (0.1–0.19)

- Loading rates to achieve 95% BOD reduction of 3gBOD/m²/day (Optimal loading rates have been determined through the analysis of the performance of 285 operating temperate wetland systems (Constructed Wetlands- can they cope? In: *Enact managing land for wildlife. Volume 4 No 3*. Autumn 1996, English Nature). The analysis concluded that to achieve a 95% reduction in BOD, and some impact on ammonia, nitrate and phosphorus removal, the loading rate should not be greater than 3gBOD/m²/day).
- The above sizing calculations for the Stage I wetland generated similar contact areas for effective treatment as 43m² and 38m² respectively. This figure has been increased to 50m² contact area to take account of the following:
 - Variability of discharge quality from the Klargestier;
 - Variability in the BOD content of the wash-water;
 - Impact of ammonia, nitrate and phosphorus on the BOD treatment processes; and
 - Risk of impact from other metals in wastewater stream.

Stage I Wetland – Brief Specification

- Gravel-filled sub-surface flow reedbed.
- Internal footprint 15.5m x 5m (plus batters).
- Inlet distribution chamber with aeration cascade.
- Outlet from chamber to reedbed must be c300mm above normal water level in reedbed to facilitate bulkage in the reedbed over time.
- Two gravel filled reedbed cells of 5m x 5m x 0.6m. 600mm depth of 10mm washed gravel planted with 250cc reed plugs at 6 per m².
- Reedbed cells separated by gabions with intervening narrow open-water channels.
- Floor of reedbed, inlet to outlet, should have c1 slope.
- Outlet chamber with decanting arm to regulate water levels within the reedbed.
- Outlet of Stage I bed could, if ground arrangements are suitable, discharge directly into the Stage II wetland.

Stage II Wetland

- 3.4 The Stage II wetland focuses on the treatment of ammonia and phosphorus (and other metals).
- 3.5 Ammonia levels in the treated water from the Stage I reedbed may rise due to BOD degradation processes. Therefore some form of additional aeration is required to treat the ammonia. Initially, this will be provided by simple stepped aeration at the inlet to the willow bed system. Upgrading of the aeration capacity could be achieved if required through:

- recirculation of the tank water;
 - aeration within the storage tank; and
 - creation of an aeration pond within the first cell of the Stage II wetland.
- 3.6 Ammonia reduction will also occur within the shallow flow of the willow beds.
- 3.7 Although only total phosphorus data is available, the sizing of the Stage II wetland is based on retention time principles. This will facilitate both sedimentation of particulate-bound phosphorus and adsorption of soluble phosphorus.
- 3.8 The intention is to use one cell in the willow bed as a dedicated phosphorus zone with materials such as broken brick or lightweight aggregates clay materials (such as Leca) to act as adsorption materials as the phosphorus passes through the media. Having a dedicated phosphorus removal zone will help facilitate ease of removal once the adsorption capacity has been reached.
- 3.9 Phosphorus retention will also occur within the willow beds and on the clay surfaces forming the system.
- 3.10 The sizing of the system is based on:
- $$\text{Retention Time (d)} = \frac{\text{Reactor Volume (m}^3\text{)}}{\text{Total Daily Flow (m}^3\text{/day)}}$$
- 3.11 Retention time in the Stage II Wetland would be **7 days**. This is more than adequate to facilitate aeration and adsorption processes in the wastewater.
- 3.12 Using the same retention time formula for the Stage I Reedbed, the retention period may be up to 17 days. This will ensure good degradation capacity for the BOD in the waste stream.

Stage II Wetland – Brief Specification

- This is a surface flow willow bed wetland 12.5m x 5m.
- The wetland is based on an impermeable clay substrate.
- The inlet chamber will direct the flow from the Stage II reedbed onto a 1m wide stepped cascade onto the floor of the first willow bed cell.
- The flow depth across the cell should be c50mm.
- At the outlet of the first cell a stepped cascade will direct the flow into the phosphorus adsorption cell. This will comprise 600mm depth of either broken brick (London Clay type not Northern Shale). Alternatively, lightweight aggregates would be used, for example Leca.
- Flow will be directed through the filter material to the cell outlet cascade.
- A further two willow cells with c50mm flow levels leads to an outlet stilling zone and gabion stone filter.

- 3.13 Mass balance flow calculations and associated discharge levels have been calculated for both Stages of the treatment wetland.

FIGURES

FIGURE 1 Preliminary Specification Stage 1 Sub-surface Flow Gravel Filled Reedbed

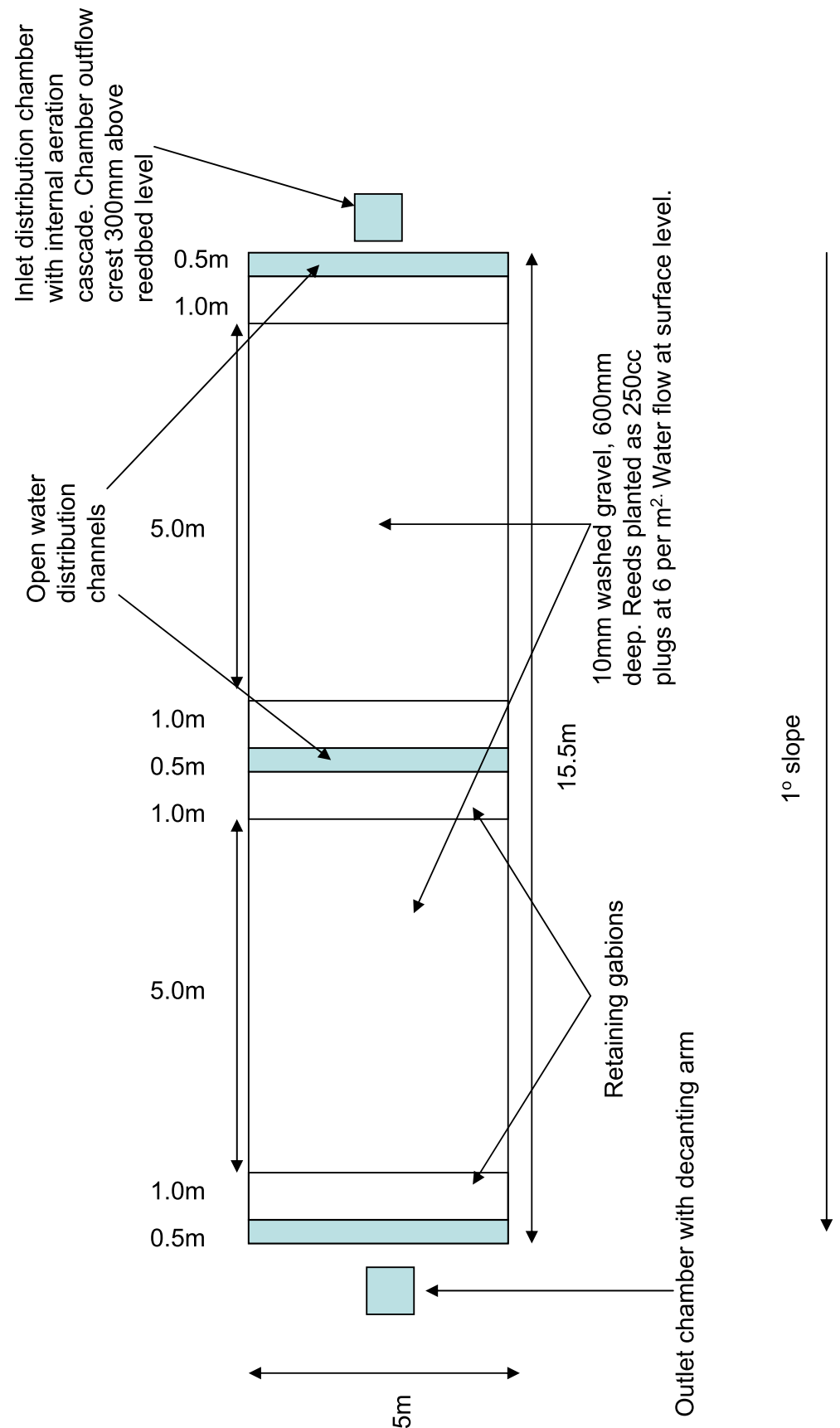
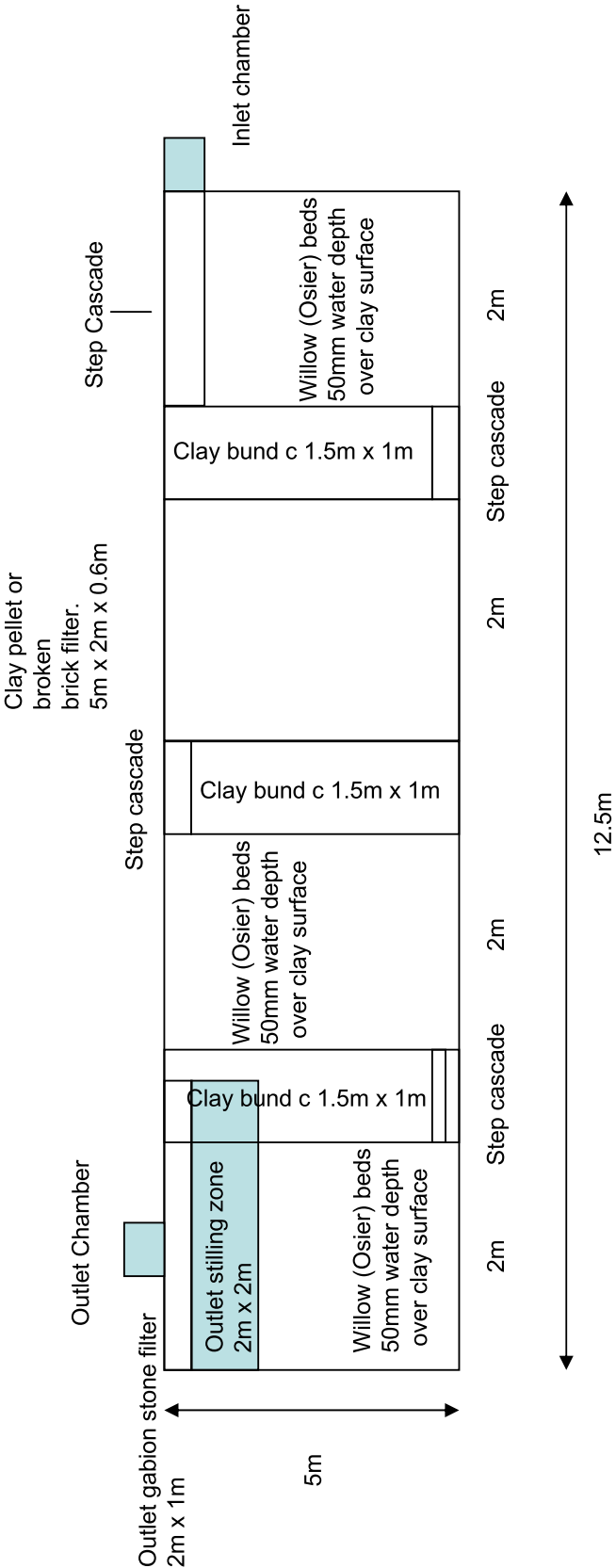


FIGURE 2 Preliminary Specification Stage II Ammonia and Phosphorus Surface Flow Willow Bed with Stepped Aeration



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