# DEVELOPMENT OF KNOWLEDGE TRANSLATION TOOLS

TO FOSTER THE UPTAKE OF CONSTRUCTED WETLAND TECHNOLOGIES TO TREAT RURAL WASTEWATERS

CHRIS KINSLEY, ONTARIO RURAL WASTEWATER CENTRE, UNIVERSITY OF GUELPH

*Published April 2015*

Canadian Water Network

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## CONSTRUCTED WETLANDS FOR RURAL WASTEWATER TREATMENT

A series of research studies have been conducted in Ontario and Nova Scotia evaluating the use of constructed wetlands to treat common sources of rural wastewaters: domestic wastewater, dairy farm wastewater and septage (sludge from septic tanks).

Constructed wetlands can be classified as either surface flow wetlands (similar to natural wetlands) or subsurface flow wetlands, where the wastewater flows through a media. Subsurface flow constructed wetlands can either be horizontal flow systems (HW), where the media – typically gravel, is saturated with effluent flowing horizontally through the bed or vertical flow systems (VW) where the wastewater trickles through an unsaturated media – typically sand.

### HOW TO LEARN MORE ABOUT THE PROJECT

The project included the development of knowledge mobilization tools to disseminate findings on the use of constructed wetland systems to treat rural wastewaters, including:

- Videos
- Fact Sheets
- Design Manual

Visit www.orwc.uoguelph.ca to learn more.

# DOMESTIC WASTEWATER TREATMENT

## SURFACE FLOW SYSTEM

Two small-scale surface flow constructed wetlands were established in Truro, Nova Scotia, to evaluate seasonal effects on the treatment of domestic wastewater.

The two wetlands were constructed in parallel and each covered ≈ 100 $m^2$ (22.5 m x 4.5 m) (see Fig. 1). They were lined with a 45 mm ethylene propylene diene monomer pond liner. Both wetlands were designed to have two deep zones (0.85 m depth) at the inlet and outlet separated by a shallow zone (0.25 m depth) filled with local soil that was mostly sandy loam. The approximate volume of each wetland was 35 $m^3$. The design loading rate in each wetland was 1400 L of septic tank effluent $d^{-1}$.

Average daily outflows were consistently greater than the inflows; therefore, evaporation effects were not considered to be significant. Maximum outflows in the two wetlands were an order of magnitude higher than the average outflows in the two wetlands, indicating that wetland outflow was highly dependent on precipitation. Hydraulic retention times (HRTs) were calculated and used to calculate first order removal rate constants. The average HRT was 22.0 days.

Removal of most of the parameters was highly variable and showed no obvious seasonal trend. The systems were evaluated over a two-year period with biochemical oxygen demand ($BOD_5$) reduced by 69% and total suspended solids (TSS) reduced by 78%. Lower levels of nutrient removal were observed, with total Kjeldahl nitrogen (TKN) reduced by 46% and total phosphorus (TP) reduced by 39%. E.coli removal of 1.7 logs was observed.

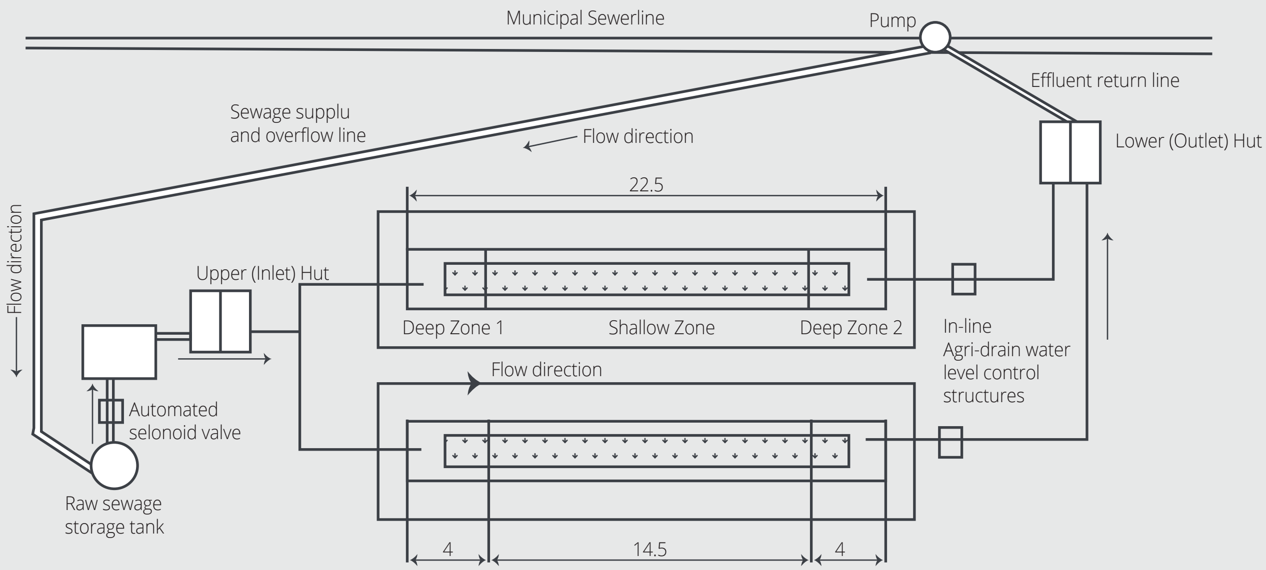
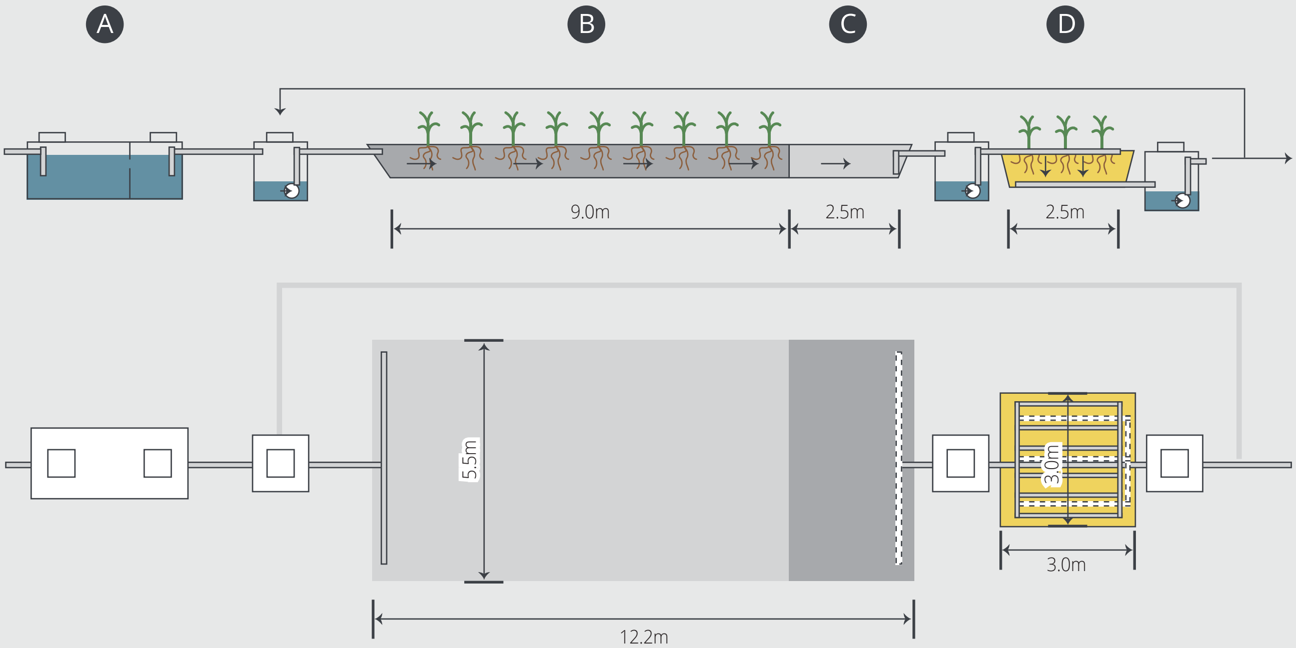



Fig. 1 Surface Flow Domestic Wetland Schematic

## HYBRID SUBSURFACE FLOW SYSTEM

This study evaluated the use of a hybrid wetland system consisting of a horizontal flow system (HW) incorporating a reactive phosphorus barrier followed by a vertical flow system (VW). The HW is efficient at removing both organic matter and solids with a low risk of clogging, while the VW is efficient at nitrification (the conversion of ammonia to nitrate). The nitrified effluent is recycled back to the inlet of the HW, to complete denitrification, the conversion of nitrate to nitrogen gas, which requires an anoxic environment and a source of carbon – from incoming wastewater (see Fig. 2).

Over a two-year study period, the technology performed very well, with high effluent quality of less than 10 mg/L $BOD_5$ and 15 mg/L TSS in all seasons at a hydraulic loading rate of 5.6 $m^3$/d (2.3 day HRT). Total nitrogen reduction of 65-75% can be achieved with 100% recycle rate in both summer and winter. The phosphorus filter performed well for 18 months, after which outlet phosphorus concentrations increased.




A - SEPTIC TANK - primary treatment

B - HORIZONTAL FLOW WETLAND - removal of organic matter and denitrification

C - PHOSPHORUS FILTER

D - VERTICAL FLOW WETLAND - pH neutralization and nitrification

Fig. 2 Hybrid Subsurface Flow Wetland Schematic

# DAIRY FARM WASTEWATER TREATMENT

## SURFACE FLOW SYSTEM

A free water surface constructed wetland was built to treat the farmstead runoff from a 150 dairy cow operation in Ontario. The marsh/pond/marsh system treats the solid manure pile runoff, milking parlour washwaters and exercise yard runoff from the farm. The system consists of a facultative pond, wetland, pond, wetland and a vegetated filter with a total system retention time of 273 days and operates from May to October (see Fig. 3).

The system was monitored for six years. The wetland achieved very high removal rates, with average $BOD_5$ reduction of 98% and TSS reduction of 97%. Nutrient removal was also very high, with TKN reduction of 97% and TP reduction of 89%.

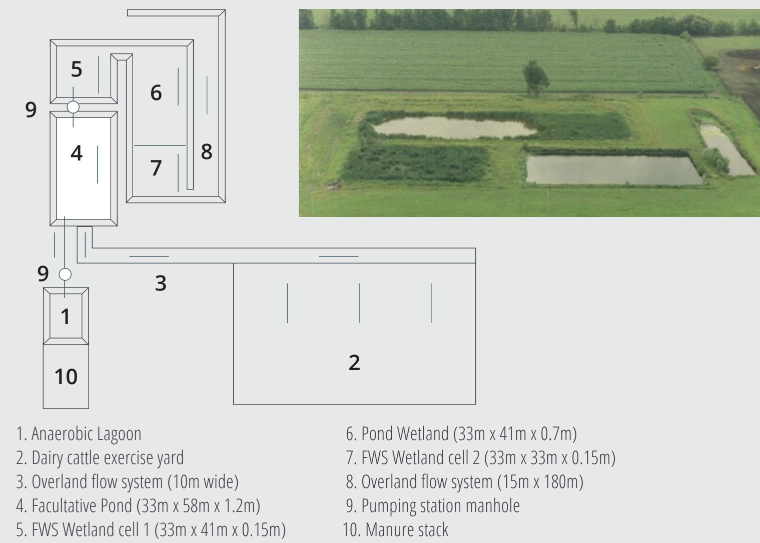



Fig. 3 Dairy Surface Flow System Schematic

## SUBSURFACE FLOW SYSTEM

Milking centre washwaters include the rinse waters from the milking lines, as well as any floor washwaters from milking parlours. Milking lines are rinsed four times during each milking session with water, acid, sanitizer and again with water. The washwater may also include manure and bedding residues from parlour floor rinsing. Milking centre washwaters can be 10-20 times more concentrated than domestic sewage.

A subsurface flow wetland system at a dairy farm in Eastern Ontario was designed to reduce solids and organic matter concentrations to below septic tank effluent levels and to reduce phosphorus concentrations prior to discharge into septic bed trenches. The system was designed for 1700 L/d. Two 3600 L septic tanks were installed prior to the wetland cell to remove settleable solids and grease, with the second tank retrofitted to act as a grease trap. The wetland cell consists of a lined bed filled with gravel with a blast furnace slag filter for phosphorus removal (see Fig. 4).

The combination of two pre-treatment tanks and a subsurface flow constructed wetland cell performed very well in reducing both $BOD_5$ and TSS concentrations to septic tank effluent quality (< 200 mg/L); which represents removal rates of 90 and 94%, respectively. The blast furnace slag filter (P removal) exhibited good removal during the first 4 months of operation, reducing TP concentrations by 74%. However, over the following 12 months an average removal rate of only 35% was observed. Significant nitrogen removal was observed in the pre-treatment tanks (57%), where manure solids were removed through settling; however, no nitrogen removal was observed in the wetland cell.

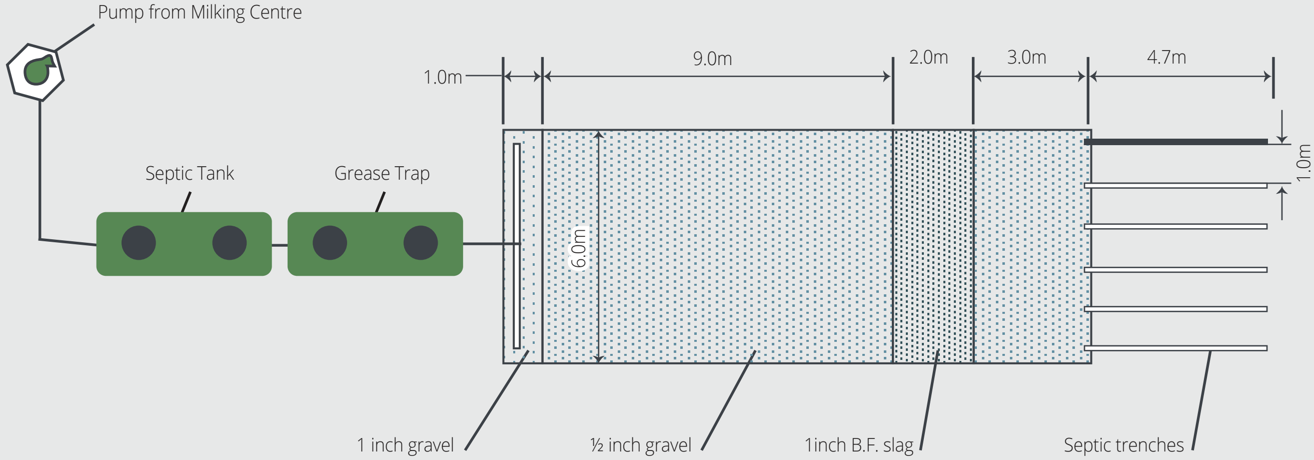



Fig. 4 Dairy Wastewater Subsurface Wetland Plan View Schematic

# SEPTAGE TREATMENT

Septage, the solids accumulated in septic tanks, has traditionally been applied to agricultural land without treatment. However, septage is increasingly being regulated as a biosolid requiring treatment. Wastewater treatment plants in small communities often do not have the capacity to accept septage, so alternatives are required.

Reed bed filters are simple technologies which have been used extensively in Europe for sludge dewatering. Reed bed filters are similar in design to conventional sand drying beds only planted with common reeds (*Phragmites*) and the dewatered solids are left to accumulate in the bed over a period of 7-10 years, greatly reducing operating costs (see Fig. 5).

Canadian winters also play an important role in sludge dewatering as the freeze-thaw cycle acts as an effective solid-liquid separation process during the winter months when the plants are dormant.

A pilot reed bed system was established at the René Goulet septage lagoon in Green Valley, Ontario and was monitored for five years.

The filters reduce organic matter and nutrient concentrations by 96-99% and produce an effluent comparable to a low strength domestic wastewater, which can be stored and land-applied as irrigation water, treated by an onsite wastewater technology or discharged at a WWTP.

Dewatered sludge averages 23% dry matter, has nutrient content similar to solid dairy manure, and meets biosolids land application standards in terms of *E.coli* and metals.

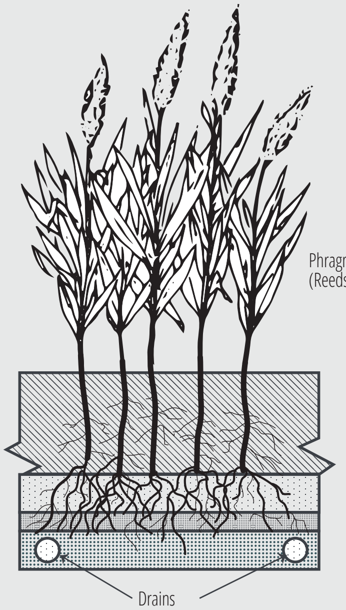



Fig. 5 Schematic of Reed Bed Filter

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