From Brown Water to Blue Water – Natural systems to recycle farm effluents

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Workshop Overview

- Overview of natural treatment systems
- Case Study 1: Alfred System - Constructed wetland treating domestic wastewater with possible grey water reuse
- Case Study 2: Dignard Farm System – Pond and constructed wetland treating milking centre washwaters and barnyard runoff
- Case Study 3: Three on-farm Systems – Constructed wetland treating milking centre washwaters
- Prescott and Russell Stream Study
- Closing Remarks

Treatment Ponds

Facultative Lagoon	Stabilization Ponds
- Primary treatment - Typical depths of 2 to 3 m - Handles high solids loading - Anaerobic at the bottom and aerobic at the top - Sedimentation for particulate removal and anaerobic & facultative bacteria stabilize organic matter - Long retention times	- Secondary treatment - Typical depths of 90 to 150 cm - Aerobic throughout depth - Organic matter is broken down by aerobic bacteria - Effective at removing ammonium and fecal coliform - Long retention times

Treatment Ponds

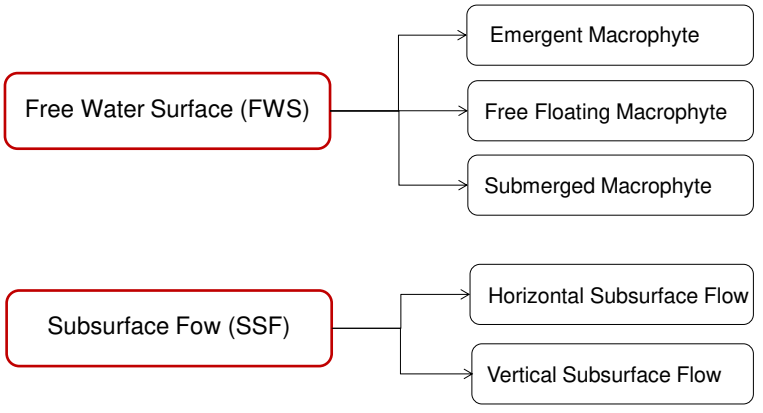
Facultative Lagoon

Stabilization Basin

Constructed Wetlands

- Use vegetation in combination with sedimentation, adsorption and biological degradation
- Used to treat: agricultural waste, landfill leachate, mine drainage, septic tank effluent, municipal wastewater, stormwater runoff, and many more sources
- Research commenced in Europe in the 1950's to look at the use of plants in removing contaminants from water
- Direct reuse and treatment of human excreta in aquaculture ponds and rice cultivation has been practiced for millennia in China

Classification of Wetlands



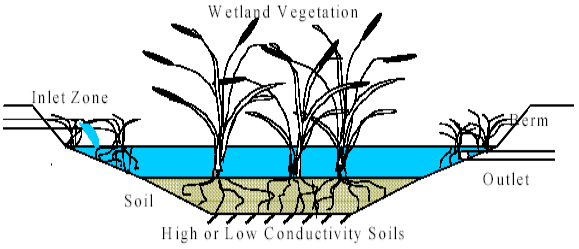
FWS Systems

- Emergent macrophyte most common type
- Cattails (*Typha*) and bulrushes (*Scirpus*) are most common
- Slow rate is applied
- Solids settle out - lowers BOD and removes particulate forms of phosphorus and ammonia
- Macrophytes supply oxygen to root zone through roots
- Macrophytes supply support for biofilm

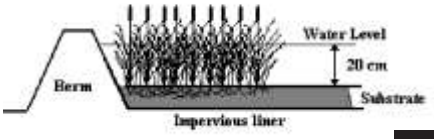
FWS Systems

- Floating macrophytes (duckweed and water hyacinths) remove nutrients and control algae growth
- Floating barrier grid used to support plants (plant mat blocks out sunlight)
- Submerged macrophytes still in experimental stage and not common in Canada

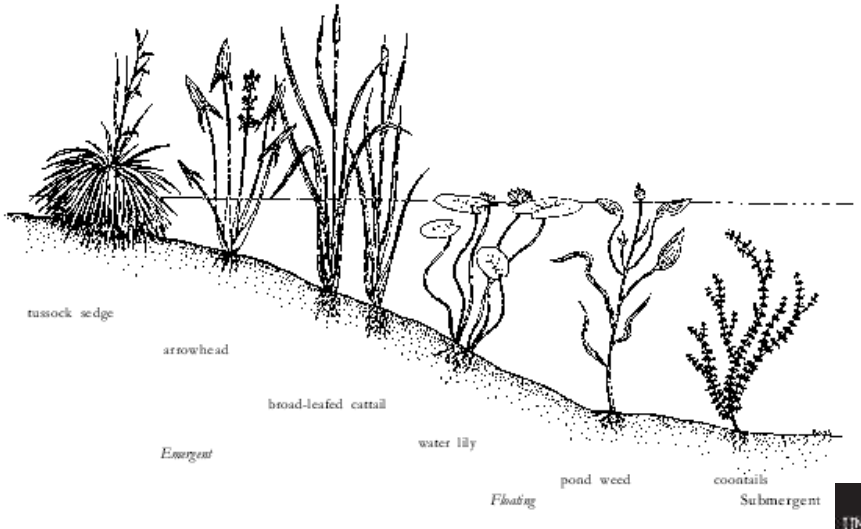
FWS Wetland
Emergent Plants



Source: Iowa Association of Municipal Utilities



Vegetation



Source: U.S. Environmental Protection Agency

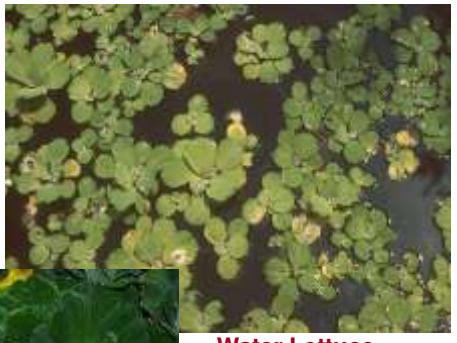
Emergent Plants

Soft-Stem Bulrush
Scirpus lacustris

Common Cattail
Typha latifolia

Common Reed
Phragmites australis

Floating Plants



Water Lettuce
Pistla stratlotes

Water Lily
Nymphaea odorata

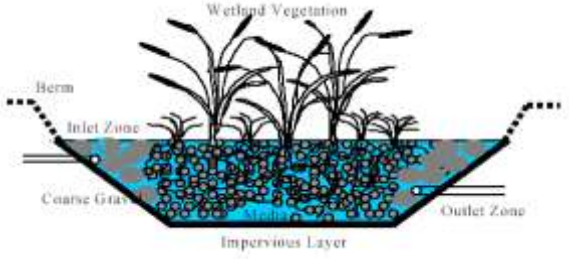
- Free-floating plants (e.g. water lettuce, duckweed)
- Floating-leaved plants which are rooted to sediments (e.g. water lily)

Submerged Plants

Ribbon Weed
Vallisneria americana

Water Starwort
Callitriche heterophylla

Subsurface Wetland
Horizontal Flow (HSSF)



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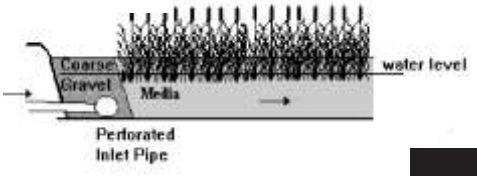


HSSF Wetland

Lawrenceholmes Farm Wetland

Alfred Pilot Wetland

Overview of Pollutant Removal

Organic Matter (BOD)	biological degradation, sedimentation, microbial uptake
Suspended Solids	sedimentation, filtration
Nitrogen	sedimentation, nitrification/denitrification, microbial uptake, plant uptake, volatilisation
Phosphorus	sedimentation, filtration, adsorption, plant & microbial uptake
Pathogens	natural die-off, sedimentation, filtration, UV degradation,

- Wetland systems very effective at treating for BOD, suspended solids and nitrogen

System Components

Main objectives in designing a constructed wetland for wastewater treatment include:

- Capability of providing a high level of treatment and discharging relatively clean water
- Inexpensive to build
- Inexpensive to operate
- Self-maintaining and simple to operate

Vegetated Filter Strips

- A vegetated area that slows down the flow and treats the wastewater by:
  - Settling
  - Filtration
  - Dilution
  - Absorption of pollutants
  - Infiltration into soil
- Wastewater enters the filter strip in a broad, shallow, sheet flow and continues traveling along the strip (designed at a uniform gradient)
- Strip can filter nutrients, sediments, organics and pathogens from the wastewater
- Used for various wastewaters: municipal, agricultural and food processing
- Used as buffer strip to protect water courses

Components of a Vegetated Filter Strip

A vegetated filter strip system consists of:

- Storage reservoir (if only one filter strip is being installed)
- Settling basin
- Gravel spreader or Header
- Vegetated filter area
- A lagoon at the end of the filter

Vegetated Filter Strips

Alfred Wetland
(Alfred, ON)

Dignard Wetland
(Embrun, ON)

Vegetated Filter Strips

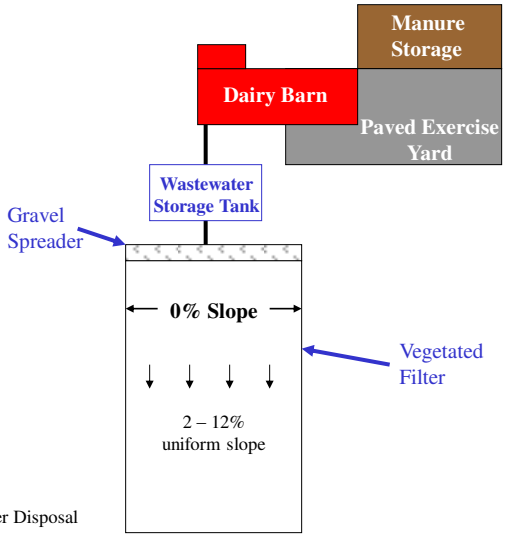
Influent Header

Screens

Orifice after Screen

Source: OMAFRA

Components of a Vegetated Filter Strip



Milking Centre Wastewater Disposal Manual, 2005

Vegetated Filter Strip Summary

- Inflow is generally continuous
- Application period can vary from a few days to a month – with rest periods to allow for filter maintenance
- 2 week operation period followed by a 2 week rest period is recommended
- Strip lengths should range from 45 to 90m
- Even distribution of wastewater across width of strip
- Design for 100% infiltration across length of strip (zero-discharge)

Case Study 2

Dignard Dairy Farm

Wetland System

Background - Dignard

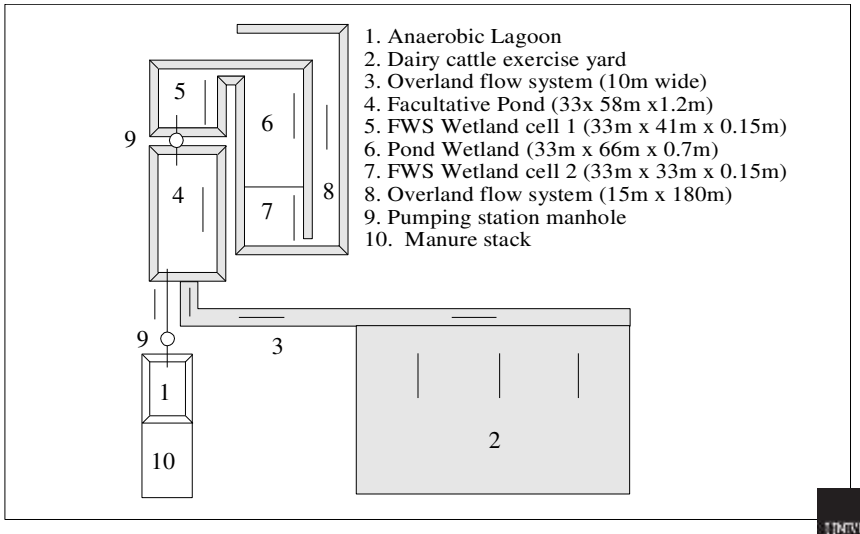
- Embrun, Ontario
- 150 dairy cow operation with waste from: manure pile runoff, exercise yard stormwater runoff, milkhouse wastewater
- Prior to the wetland, manure pile runoff collected in a lagoon and used for irrigation, exercise yard runoff and milkhouse wastewater not collected
- Needed a system to treat the liquid wastes without a need for liquid manure spreading

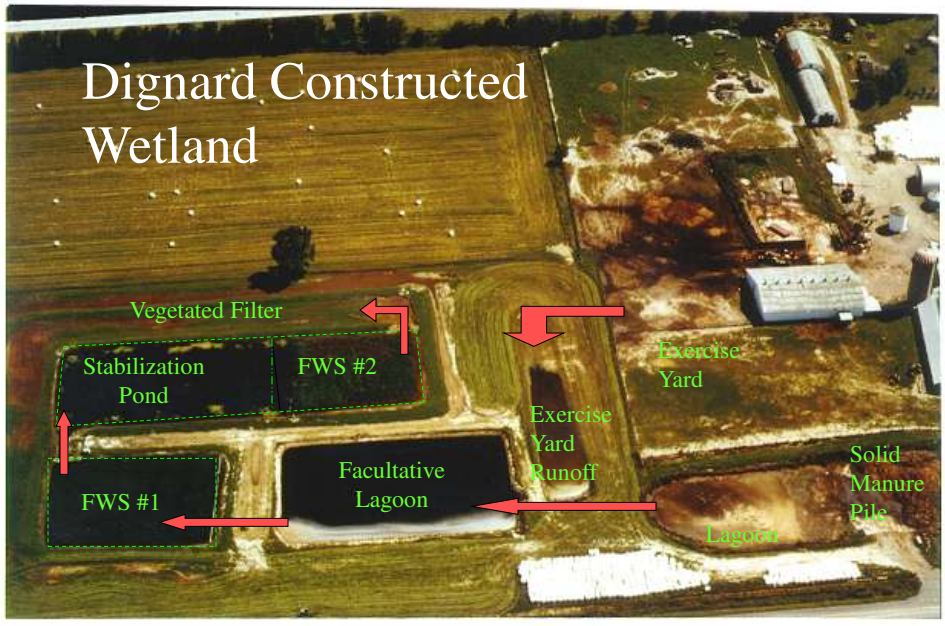
Solution

- Use existing lagoon for winter storage of milkhouse wastewaters
- Free water surface wetland for continuous treatment of manure pile runoff, exercise yard runoff and milkhouse wastewater from May to October
- Vegetated filter strip for phosphorus polishing

Solid Manure Pile and Runoff

Dignard Constructed Wetland Schematic





Wetland Operation

- All three wastewaters get collected in facultative pond
- Only 2 pumps in entire system
- Flow is gravity fed within wetland system and controlled using v-notch weirs
- 100-day retention time in wetland system
- Very little maintenance required
- Harvesting of vegetation on filter strip is ideal

Exercise Yard Runoff and Facultative Pond

Aerobic Pond, FWS# 2, Vegetated Filter and V-notch Weir

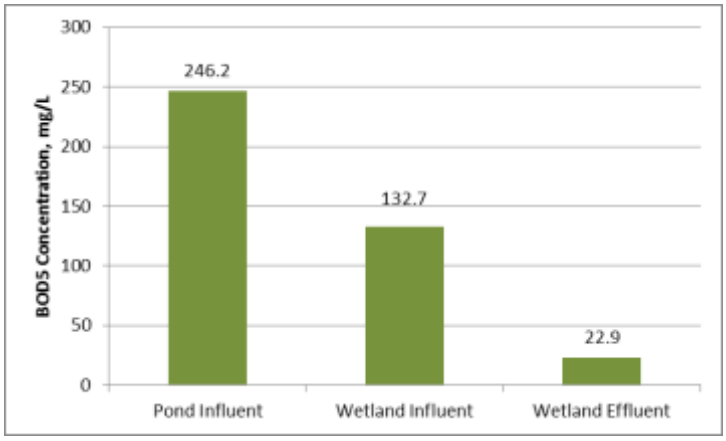
Treatment in Dignard Wetland

Design Criteria

System designed for the following target effluent concentrations:

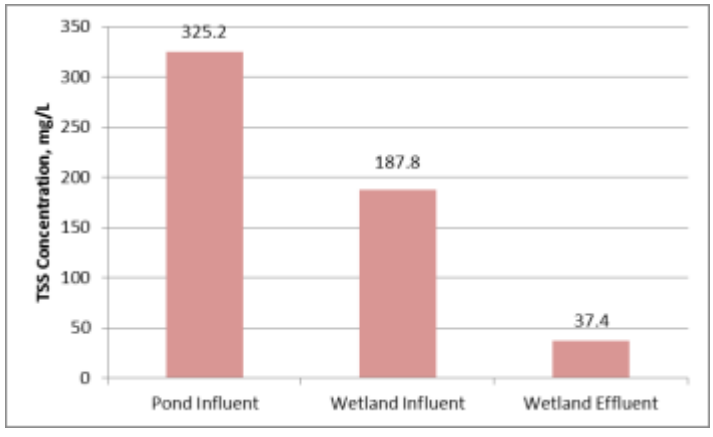
- BOD_5 = 20 mg/L BOD_5
- TSS = 20 mg/L TSS
- TKN = 10 mg/L

6-Year Average of BOD_5 Concentrations



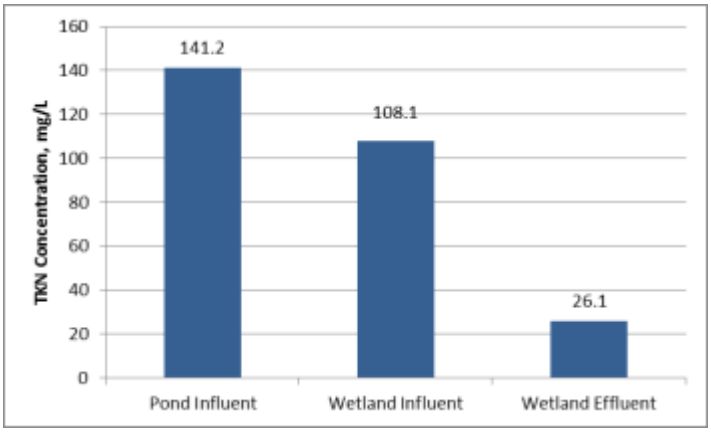
- 46% BOD_5 removal in facultative pond
- 83% BOD_5 removal in FWS wetland

6-Year Average of TSS Concentrations



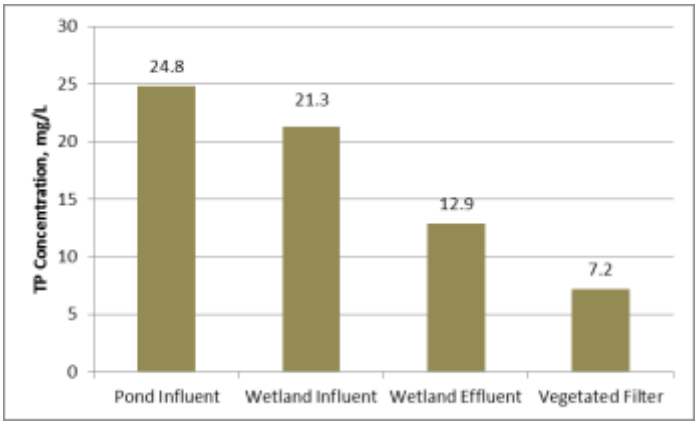
- 42% TSS removal in facultative pond
- 80% TSS removal in FWS wetland

6-Year Average of TKN Concentrations



- 23% TKN removal in facultative pond
- 76% TKN removal in FWS wetland

6-Year Average of TP Concentrations



- 14% TP removal in facultative pond
- 39% TP removal in FWS wetland
- 44% TP removal in vegetated filter

Summary

- Facultative pond is ideal for pre-treatment of BOD and TSS prior to wetland
- Wetland system highly efficient in removing pollutants
- Vegetated filter strip effective at polishing phosphorus to below design criteria
- System has low operating and maintenance costs
- Ideal treatment system for milkhouse washwaters and barnyard runoff

Acknowledgments

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