On-site Wastewater Management Training Course

Secondary Treatment; Constructed Wetlands

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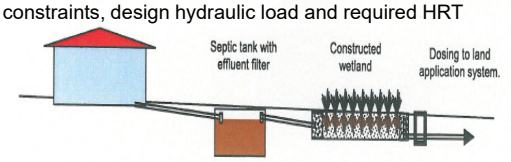
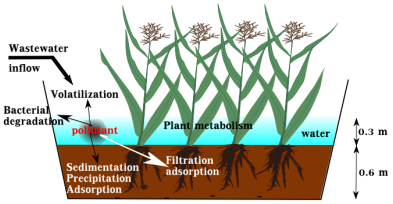
Constructed Wetlands (Reed Beds)

- Increasingly popular as a secondary treatment option to achieve secondary or advanced treatment (BOD, TSS and FC reduction)
- Low-maintenance and relatively inexpensive treatment
- Robust performance and seen as "natural" treatment - "ecotechnology"
- As with all on-site systems, refer to state agency websites for accredited or approved systems; local approvals for CWs often given based on specific or unique designs which consider site constraints, design hydraulic load and required HRT

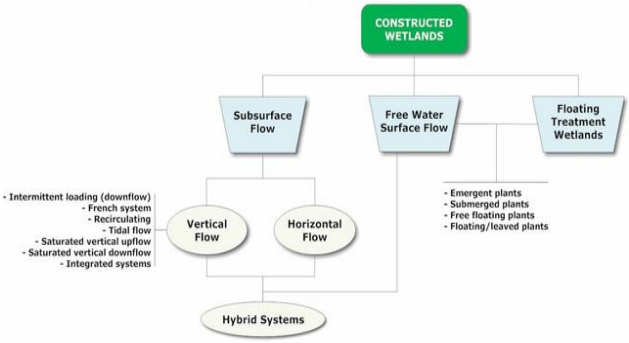


Treatment Processes in CW

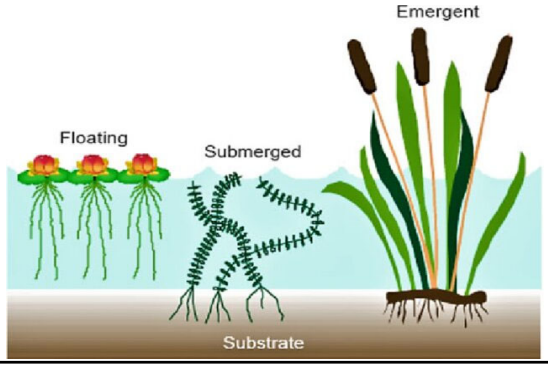
- Sedimentation, filtration and adsorption
- Gas loss/volatilization
- Uptake of metals and nutrients by plants
- Bacterial degradation by ultra-violet light, die-off and predation
- Decomposition of organic matter



CW Classification

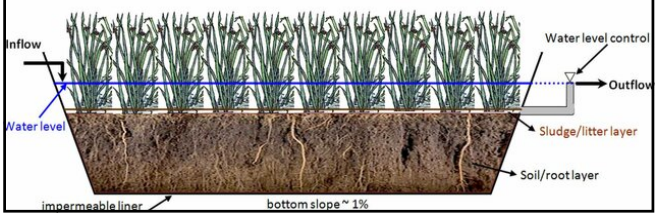


Macrophyte Plants Cultivated in CW

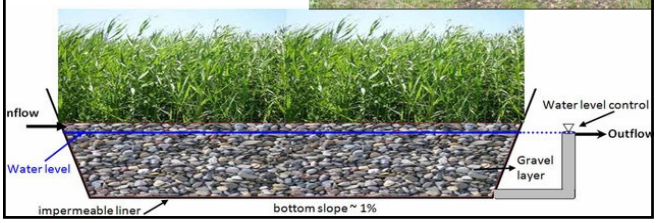


Free Water Surface Flow Systems

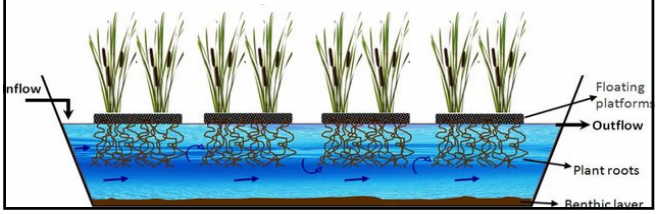
Free Water Surface Constructed Wetlands



Subsurface Flow Systems



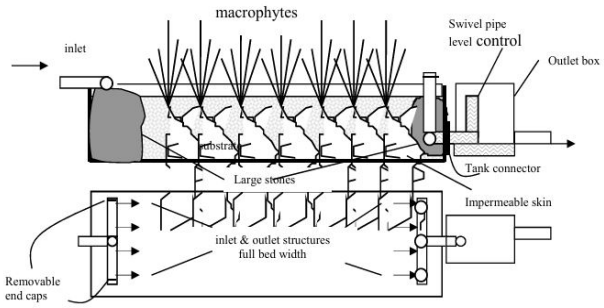
Floating Systems



SSF Systems

- Preferable for <u>domestic</u> on-site treatment
- Used for treating combined domestic load or greywater (also for excess from “dry” composting systems)
- Installed after primary treatment devices and considered a secondary treatment system
- Grease and fat removal in septic tank pre-wetland
- CW may be integrated with site landscape plan

Elevation and Plan Views of Typical Horizontal SSF CW



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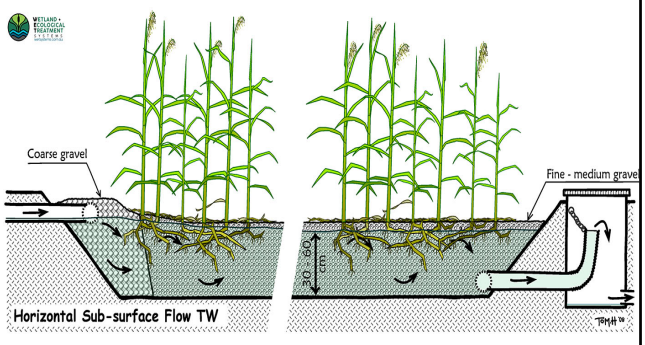
Horizontal SSF Systems



Source: https://wetsystems.com.au/

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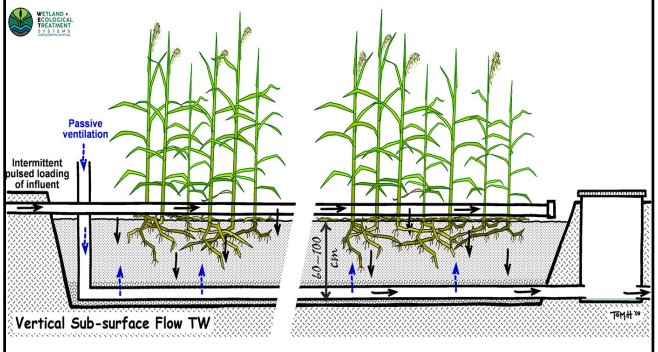
Vertical SSF Systems



Source: https://wetsystems.com.au/

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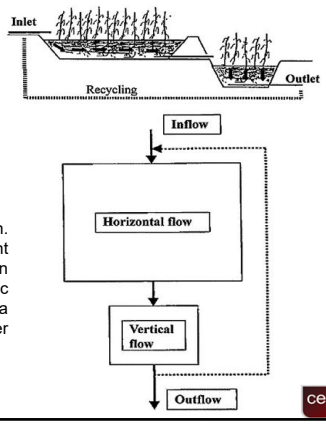
Hybrid CW System consisting of combined vertical and horizontal SSF systems



Designed to achieve N reduction. Nitrified effluent is returned to front end of system where denitrification can take place in less aerobic horizontal bed using inflow as a source of carbon needed for further treatment to occur.

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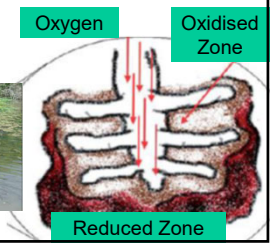
What Do Plants Do?

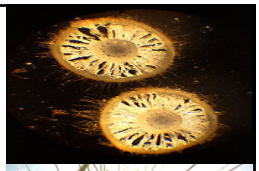
- Control algal growth
- Take-up nutrients
- Provide an oxygen source
- Develop strong algal and bacterial biofilms in root zone where treatment occurs

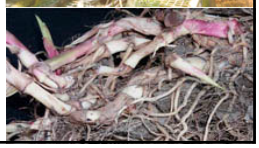
Source: Aqua Biofilter



What Do Plants Do?

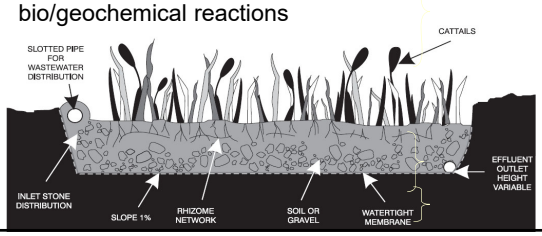
- Transport gases to and from the root zone via **aerenchyma** which are airways running from the aerial parts of the plant to the roots
- Aerenchyma assist with gas diffusion
- Rhizomes provide sites for oxidation while adjacent soils remain anaerobic (biofilms grow on submersed stems and leaves)
- Bacteria colonise and perform a wide variety of chemical conversions





Role of Substrate

- Provide rooting medium for wetland plants
- Support nutrients for plant growth
- Provide capacity to store water in pore spaces
- Adsorb to limited degree contaminants and reduce effluent concentrations
- Buffers pH which assists in maintaining uniform bio/geochemical reactions



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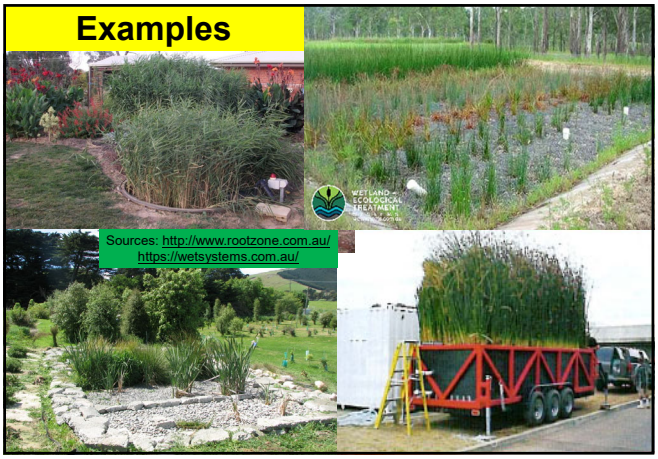
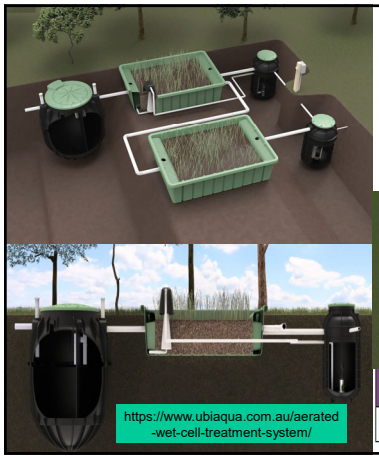
Examples





Ubi Aqua Aerated Wet Cell Treatment System

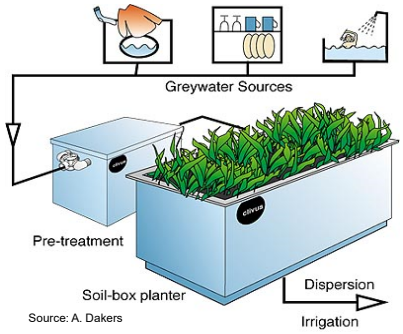
Approved for advanced secondary (AS1546.3)

Turbidity	TSS	BOD5	Ecoli	Dissolved Oxygen
< 5 NTU	< 5mg/Litre	< 4.4mg/Litre	< 10 cfu	> 3.75mg/Litre

Average water quality test results

https://www.ubiaqua.com.au/aerated-wet-cell-treatment-system/

Modified Plant System for Greywater



Source: A. Dakers

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SSF Design Considerations

- Site selection/location
- Sizing for design hydraulic load and HRT (Treatment in CW is a function of HRT)
- Liner - impermeable membrane or compacted clay or prefabricated unit
- Multiple beds – parallel or series?

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SSF Design Considerations

- Inlet structures to ensure uniform flow distribution
- Adjustable water level control
- Outlet/collection devices - dosing sump and pump well capacity
- Gravel sizes
- Macrophyte plant species to be used
- Maintenance of reedbed including vegetation and weed management
- And after the CW system?

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Sizing

- **Sizing can be based on simple rule-of-thumb approaches for "typical" situations.**
- **Guidelines often suggest different specific area requirements per Population Equivalent (PE) to achieve a Secondary quality (20/30 standard) or a specific HRT**
  - 2 m^2 up to 6 m^2 of wetland treatment area per PE/day for combined wastewater
  - HRT can be determined for a particular level of treatment but is typically recommended about 5-7 days
  - For greywater design 3 m^2 PE/d

Examples	Combined Wastewater	Greywater Only
Area of Reed Bed	24 m^2	17 m^2

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Example of SSF Area and Dimensions

BR/ PE	Hydraulic Load (L/d)	Surface area (m^2)	Suggested width (m)	Suggested length (m)	L:W ratio
3/5	900	30-33	4.5	7.2	1.6

Source: Table 1 in Tanner, C. Headley, T. & Dakers, A. (2011) Guideline for the Use of Horizontal SSF Constructed Wetlands in On-site Treatment of Household Wastewaters, NIWA, Hamilton, NZ

Rule of Thumb Sizing (HRT 7 days)

Water Depth (m)	Surface Area/p (m^2) All Wastewater	Surface Area/p (m^2) Greywater
0.3	6.5	5
0.4	5	4
0.5	4	3
0.75	3	2.5

Source: Table 1 in Lismore City Council (2005) The Use of Reed Beds for the Treatment of Sewage and Wastewater from Domestic Households

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Gravel Media and Plants

- Depth of gravel bed media typically 40 cm with water level maintained about 5 cm below gravel surface
- Plant selection - native wetland nursery species
- Low stature and high stature growth forms *(plants/m^2)*
- Issue of plant senescence and on-going maintenance (including whether to harvest) plus managing invasive weeds

Zone	Gravel	Size Range (mm)	Porosity (%)
Inlet & outlet zones	Coarse	40-60	45
Main wetland	Fine, angular	10-20	40

Recommended Species

Floating plants:

- *Lemna spp, Wolffia spp*

Submergents:

- *Myriophyllum*
- *Potamageton*

Emergents:

- *Typha*
- *Phragmites*
- *Eleocharis*
- *Schoenoplectus*
- *Baumea*

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CW Performance

- Properly designed, installed and serviced SSF CW can provide secondary or advanced treatment of primary treated effluent
- Able to produce 20/30 standard TSS/BOD; median levels of FC can be reduced by approx. 99% (2 log reduction)
- Rely on HRT to achieve level of treatment
- Reduction of N and P varies widely over time and is by biomass uptake and substrate adsorption
- Often variable for TP but initially high, later decreasing depending on substrate used; can be good for TN but dependent on oxidation and biochemical conversion of N
- Treated effluent should be discharged to an appropriate land application system

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Further Reading

- Lismore City Council (2005) The Use of Reed Beds for the Treatment of Sewage and Wastewater from Domestic Households, Lismore NSW
- Stephanakis, A. (2016) Constructed Wetlands: Description and Benefits of an Eco-Tech Water Treatment System, Chapter 12 in Impact of Water Pollution on Human Health and Environmental Sustainability, IGI Global
- https://www.igi-global.com/chapter/constructed -wetlands/140180
- Tanner, C. Headley, T. & Dakers, A. (2011) Guideline for the Use of Horizontal SSF Constructed Wetlands in On-site Treatment of Household Wastewaters, NIWA, Hamilton, NZ
- https://wetsystems.com.au/
- http://www.rootzone.com.au/
- https://www.ubiaqua.com.au/aerated-wet-cell-treatment-system/

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