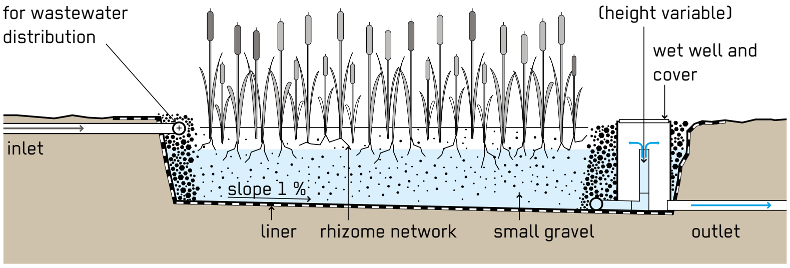
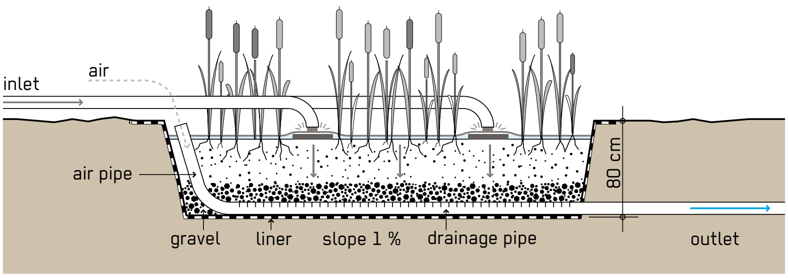
Constructed Wetland

Phase of Emergency	Application Level / Scale	Management Level	Objectives / Key Features
Acute Response * Stabilisation ** Recovery	* Household ** Neighbourhood ** City	* Household ** Shared ** Public	TSS and TDS reduction, Nitrification
Space Required	**Technical Complexity**	**Inputs**	**Outputs**
*** High	** Medium	Effluent, Blackwater, Greywater	Effluent, Biomass

horizontal subsurface flow constructed wetland



vertical flow constructed wetland



Constructed Wetlands are engineered wetlands designed to filter and treat different types of wastewater mimicking processes found in natural environments.

Constructed Wetlands can effectively treat raw, primary or secondary treated sewage, as well as greywater. The main types of Constructed Wetlands are horizontal flow (HF) wetlands and vertical flow (VF) wetlands, including the French VF wetland, which is a double-stage VF Constructed Wetland. In Constructed Wetlands a gravel media acts as a filter for removing solids, as a fixed surface to which bacteria can attach, and as a base for vegetation. The important difference between a vertical and horizontal wetland beyond the direction of the flow path, is the aeration regime. Compared to other wastewater treatment technologies, Constructed Wetlands are robust in that performance is less susceptible to input variations.

Design Considerations: For HF and VF wetlands efficient primary treatment is essential to prevent clogging. French VF wetlands can receive raw wastewater and require no pre-treatment. VF and French VF wetlands require intermittent loading (several times a day) to ensure aerobic conditions in the filter whereas HF wetlands and free-water surface (FWS) wetlands are loaded continuously. The specification (grain size, etc.) of sand and gravel used for the main layer defines the treatment efficiency in VF and French VF wetlands. In HF wetlands mainly anaerobic processes occur, whereas in VF and French VF wetlands with intermittent loading, aerobic processes are dominant. If topography allows intermittent loading it can be done with siphons thus avoiding external energy and pumps. Sizing of the surface mainly depends on the organic load (chemical oxygen demand per m² per day) and minimum yearly temperature. French VF wetlands consist of two stages, with at least two treatment lines to be used alternatively. The wetland plants must have deep roots and should be able to adapt to humid environments with slightly saline and nutrient-rich soil conditions. Phragmites australis or communis (reeds) are often chosen because they form a matrix of rhizomes efficient at maintaining the permeability necessary for large filtration and also decrease the risk of clogging.

Materials: In principle, Constructed Wetlands can be built using locally available material, however, availability of sand and gravel (with required grain size distribution and cleanliness) is often a problem. Additional materials include a liner or clay, wetland plants, and a syphon or pump for intermittent loading. They are typically not suitable for pre-fabrication.

Applicability: Constructed Wetlands require wastewater to function and therefore are applicable only for water-borne sanitation systems. They are a viable solution where land is available and a wastewater treatment solution is required for a longer period of time. Wetland plants take time to become established, therefore the start-up time for Constructed Wetlands is quite long. Thus this technology is not suitable for the acute response phase but for the stabilisation and recovery periods and as a longer-term solution.

Operation and Maintenance: In general, operation and maintenance (O & M) requirements are low. For VF and HF wetlands, the regular removal of primary sludge from mechanical pre-treatment is the most critical routine O & M activity. In French VF wetlands, the loading has to be alternated between the VF beds of the first stage on a weekly basis. Distribution pipes should be cleaned once a year to remove the sludge and biofilm that might cause blockage. During the first growing season, it is important to remove weeds that can compete with the planted wetland vegetation.

Health and Safety: Under normal operating conditions, users do not come in contact with the influent or effluent. Influent, scum and primary sludge must be handled with care as they contain high levels of pathogenic organisms. Removal of primary sludge can be a health hazard and appropriate safety precautions have to be taken. The facility should be designed and located such that odours (mainly from primary treatment) and mosquitos (mainly relevant for FWS wetlands) do not bother community members.

Costs: As Constructed Wetlands are self-sustaining their lifetime costs are significantly lower than those of conventional treatment systems. Sewer lines might be the highest costs when implementing a water-borne sanitation system using Constructed Wetlands. The main O & M costs are related to the removal of primary sludge from the primary treatment (for VF and HF wetlands) and cost of electricity if pumps are used for intermittent loading. The cost of changing the filter material (approximatively every 10 years) should be factored in. The systems require significant space, and are therefore not preferred where land costs are high.

Social Considerations: Usually, treatment wetlands are easily accepted by locals and only minimal technical capacity is required for O & M.

Strengths and Weaknesses:

(+) Low O & M requirements
(+) Robust treatment performance and resistant to sudden loads of organic material or flow increases
(+) Adaptable to local conditions
(+) Long service life and possible use of the harvest material

(−) Land requirement
(−) Risk of clogging, depending on pre- and primary treatment
(−) Electric pumps required for intermittent loading of VF and French VF wetlands (if landscape does not allow gravity-driven systems)

→ **References and further reading material for this technology can be found on page 194**