Landfill Leachate Treatment

Engineered Wetlands

Parc d'entreprises St-Charles, Montreal

Curtis J. Sparks, P.E.

and

Marc L'Écuyer, Eng.

RemTech 2007

Jacques Whitford NAWE

Types of Wetlands

- Free Water Surface (FWS)
  - "surface flow"
- Horizontal Subsurface Flow (HSSF)
  - "vegetated submerged bed" (VSB)

- Vertical Flow (VF)

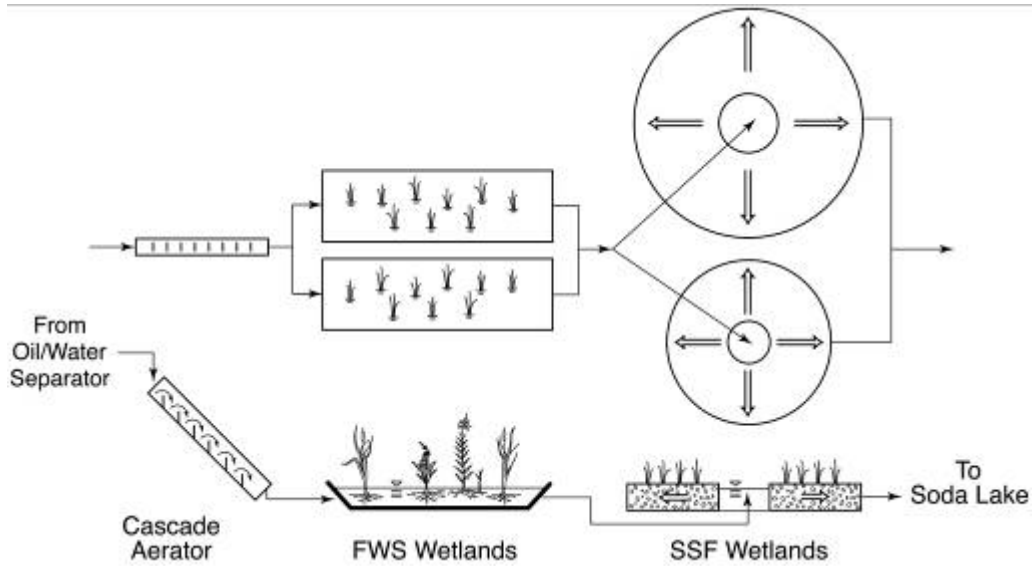
- Engineered Wetlands
  - aerated, fill-and-drain, reactive media, geometric configurations, etc

Jacques Whitford NAWE

Engineered Wetlands

"A little less passive"

- **Engineering Tools**
  - **Wetland Geometry**
  - **Aeration**
  - **Gravel type and size**
  - **Insulation**



Jacques Whitford
NAWE

Typical Applications For Engineered Wetlands

- Petroleum Hydrocarbons
- Chlorinated Solvents
- Landfill Leachate
- Industrial Wastewaters
- Glycols (aircraft deicing)
- Mining Waste (sulfides and metals)
- Municipal Wastewaters

Jacques Whitford NAWE

Engineered Wetlands for Landfill Leachate Treatment

Landfill Treatment Goals

- What are the goals?
  - Simple and robust
  - Minimize environmental impacts
  - Minimize costs
  - Long life
- What will it be like in 100 years?
  - What legacy do you leave
  - What impact does it have
  - Aesthetics (How does it fit the site?)

Jacques Whitford NAWE

Landfill Leachate

- What does an engineer need to know?
  - Flow
  - Influent composition
  - Effluent limits
- For leachate, we know:
  - Flow is variable
  - Composition is complex and ever-changing
  - Effluent limits are based on means of disposal

Jacques Whitford
NAWE

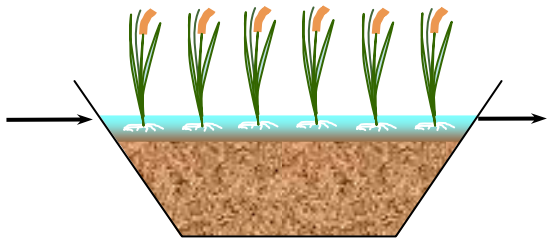
Engineered Wetlands

- **Engineered wetlands are flexible**
  - **Physical**
    - **Solids removal by filtration and sedimentation**
  - **Chemical**
    - **Precipitation of metals**
  - **Biological**
    - **Aerobic/anaerobic bacterial degradation**
    - **Plants: enhance microbial growth and evapotranspiration**

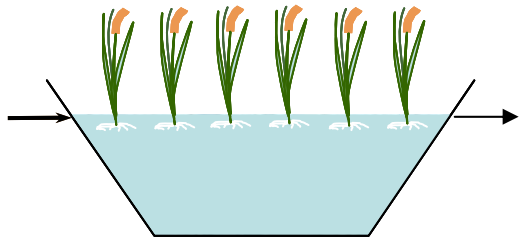
Jacques Whitford NAWE

Engineered Wetland Cell Options

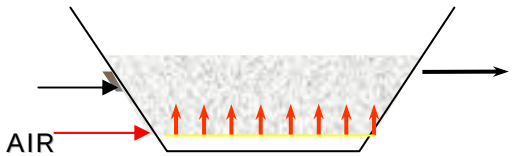
SEDIMENTATION POND



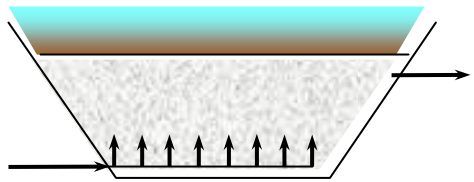
SSF WETLAND CELL



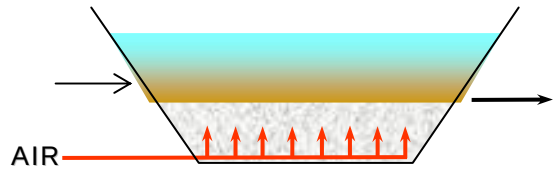
FWS WETLAND CELL



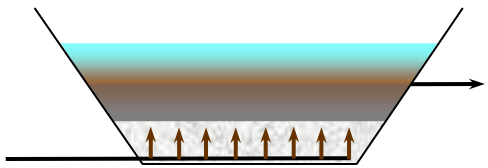
NITRIFICATION CELL



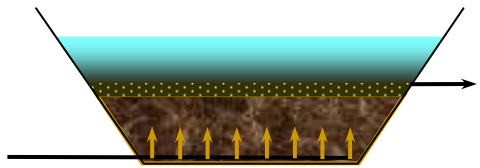
(AN)OXIC LIMESTONE DRAIN OR SAPS CELL



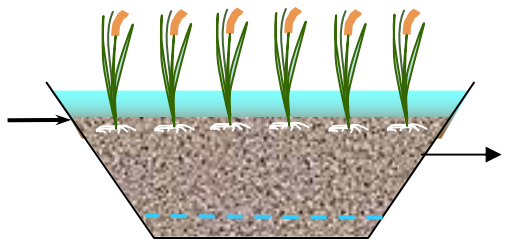
AEROBIC BIOREACTOR CELL



VFR CELL



ANAEROBIC BIOREACTOR CELL



PEAT OR COMPOST CELL

Jacques Whitford NAWE

Aerated Wetland Systems

Aerated Vertical SSF Engineered Wetland Cell

Benefits of Wetland Aeration

- **Low Energy Input (About 10% Of Activated Sludge Processes)**
- **10-Fold Increase in Nitrification**
- **Much Smaller Wetland Footprint**
- **North Glengarry, ON,**

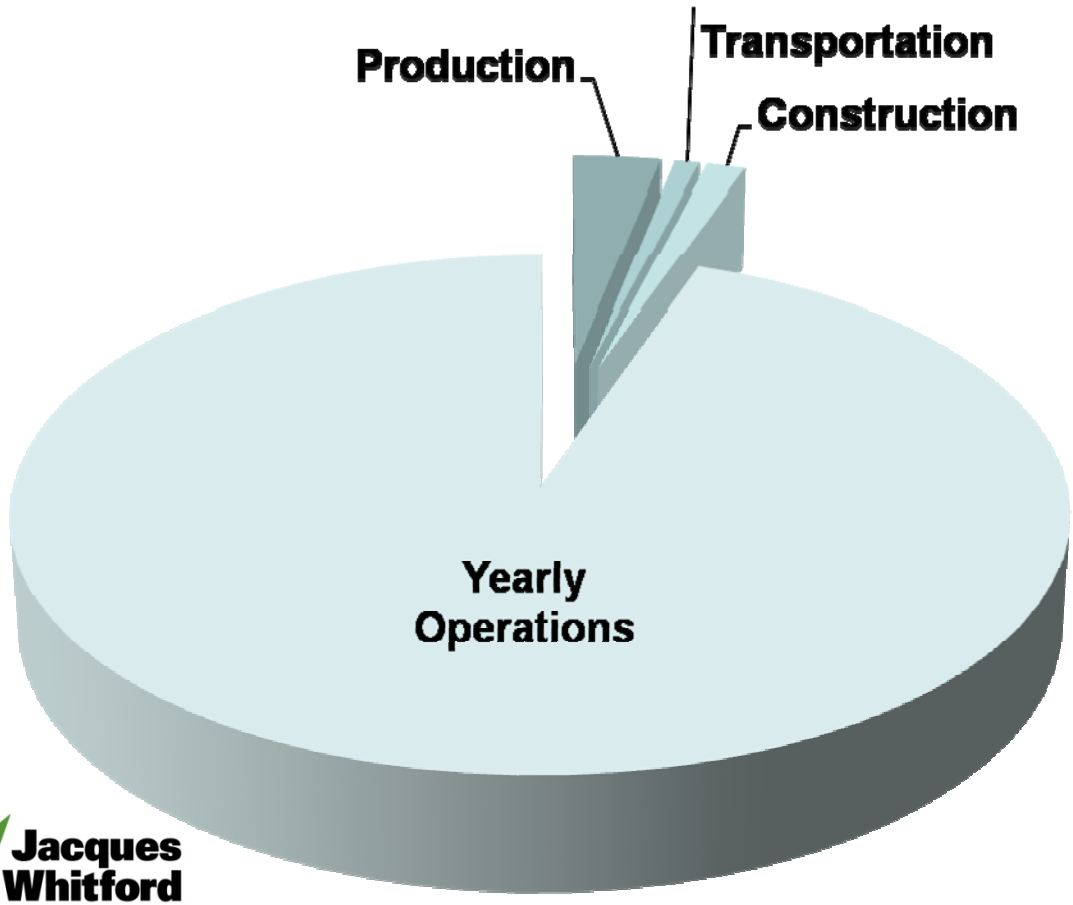
Example

30.4 ha non-aerated CW

1.4 ha aerated EW

Jacques Whitford NAWE

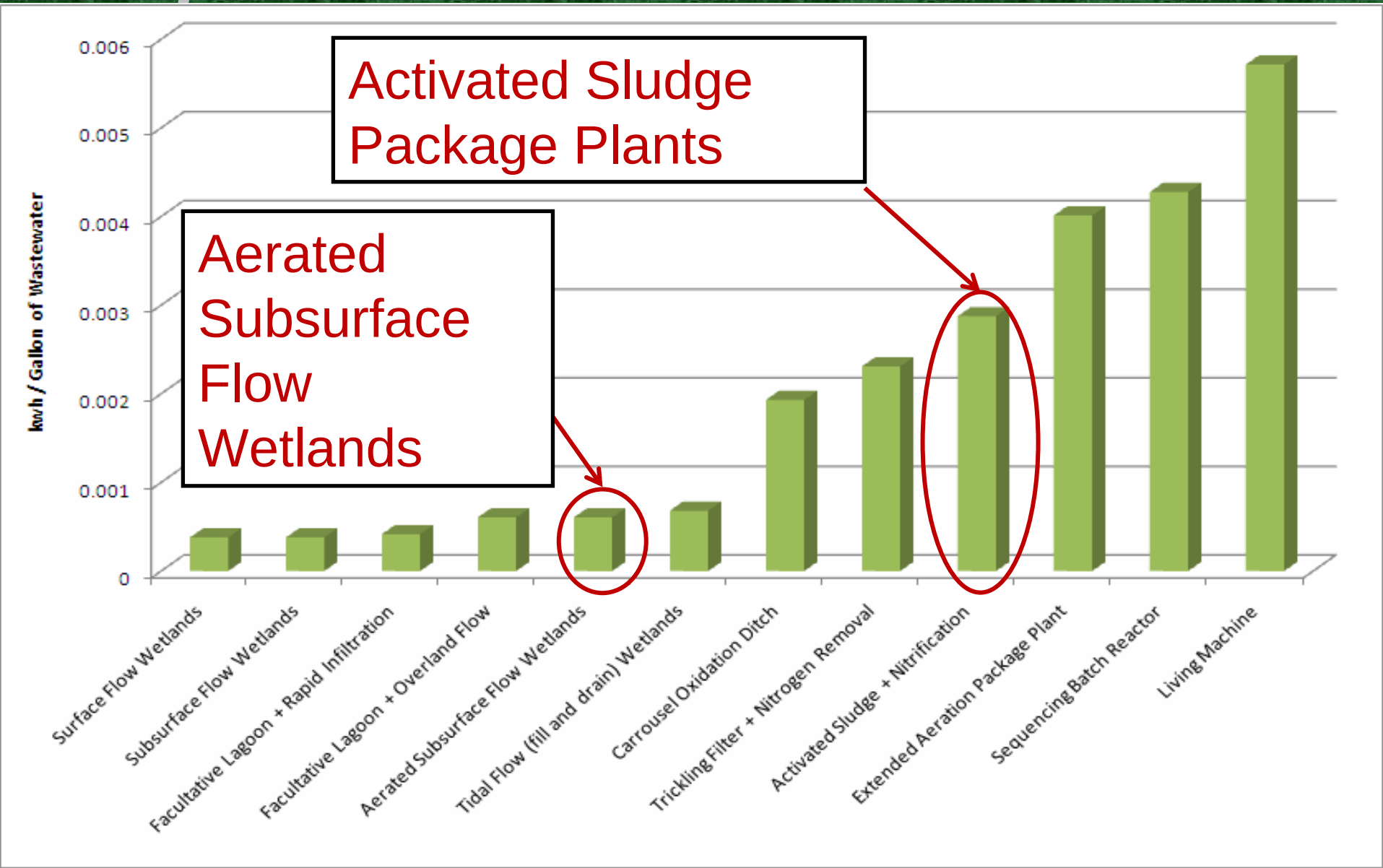
Carbon Analysis - Horizontal Flow Wetland and Infiltration Beds



CO2 Emissions (lbs)	
Production	2650
Transportation	750
Construction	1170
Yearly Operations	81000
Total Yearly	*85570*

Jacques Whitford
NAWE

Wastewater System Energy Requirements = Carbon Emissions



Landfill Design Process

- Desk Top Study
  - Define unit processes
- Treatability Test
  - Determine sizing kinetics
- Onsite Pilot
  - Verify performance under actual site conditions
- Detailed Design

Jacques Whitford NAWE

Results of a Typical Pilot-Scale Treatability Test:

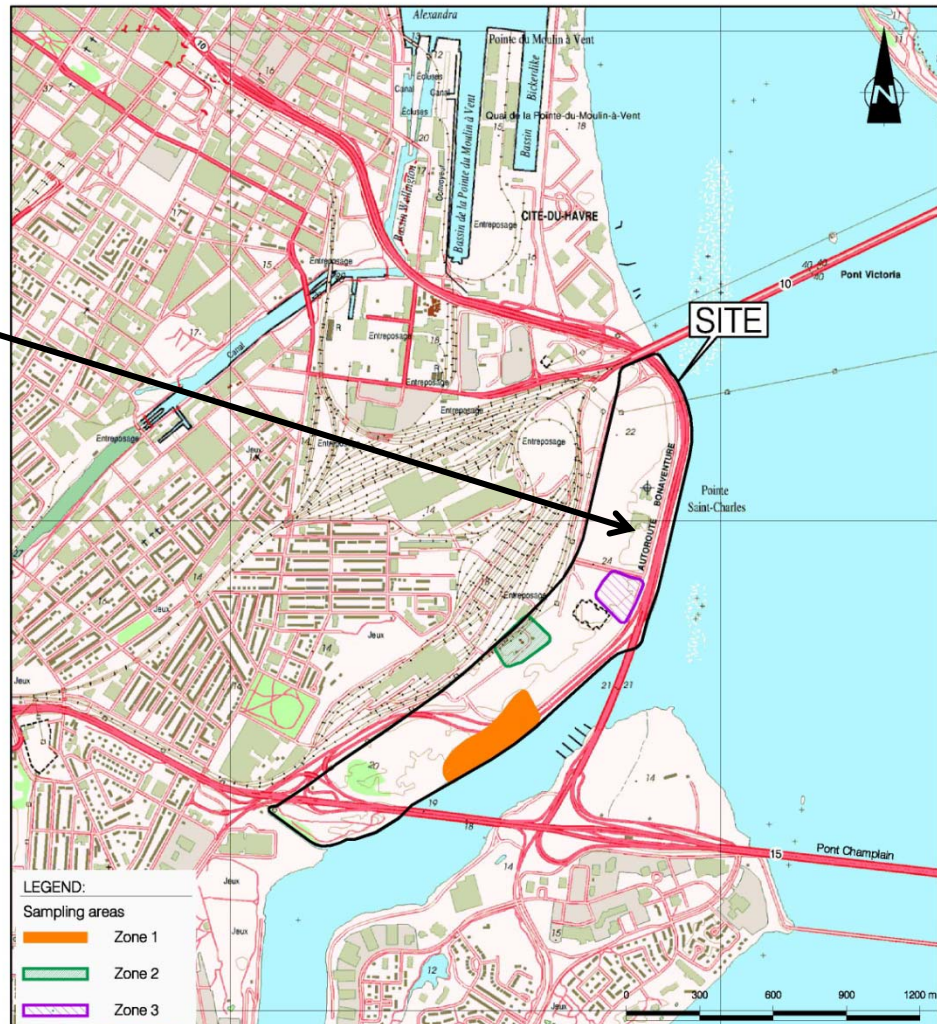
Parc d’entreprises St-Charles

Montréal, QC

Jacques Whitford NAWE

Landfill on St. Lawrence River

Area of Fill



Jacques Whitford NAWE

Pollutants of Concern

- Ammonia
- TSS
- Hydrocarbons
- Metals (Fe, Cu, Se, Sn, Zn)
- Barium
- Chronic and Acute Toxicity

Jacques Whitford
NAWE

JW's Proposal was...

- Conduct Pilot-Scale Treatability Testing - JW Campus D'Alfred Test Unit
- All 3 Technoparc Groundwaters
- High & Low Temperatures

Jacques Whitford NAWE

Pilot Test

LEGEND:

Pump

Valve

TRANSPORTATION TANKS USED FOR IMPORTED GROUNDWATER (TOTE)

VEGETATION IN EW CELL

GRAVEL (SUBSTRATE) COVERED BY PEAT

REEDS IN NATURAL ENVIRONMENT

HEAT EXCHANGER

- For cooling

IMPORTED GROUNDWATER TO BE TREATED

TRAIN 5 C°

TREATED EFFLUENT

SUBSTRATE (BIOSOLIDS)

GRAVEL (SUBSTRATE) COVERED BY PEAT

WALK-IN REFRIGERATION UNIT

AIR

STORAGE TANK

MIXING TANK

- Flow control

ABR

VSSF EW CELL

STORAGE TANK

Specific Objectives

- To demonstrate the technology is effective.
- To determine components of the system and its potential implementation.
- Verify that applicable standards can be met i.e. toxicity

Jacques Whitford
NAWE

Results

- **Contaminated groundwater was successfully treated by engineered wetlands.**
- **Ammonia can be treated at low temperatures (<5 ºC) even lower than anticipated on-site.**

Jacques Whitford NAWE

Results

- **No detectable concentrations of PCBs, nor Petroleum Hydrocarbons (C_{10}-C_{50}) were found in the groundwater to be treated.**
- **Previous pilot tests revealed that those compounds could be easily treated through an Engineered Wetlands.**

Jacques Whitford NAWE

Results

- **PAH Compounds can be easily treated**
- **Metallic compounds will precipitate as mental salts through the use of anaerobic bio reactors.**

Jacques Whitford NAWE

Results

- No compounds identified in the groundwater from the site had any negative impacts on the bacteria metabolism.
- After acclamation, the effluent is non-toxic.
- No environmental impact is anticipated for residuals generated after treatment.

Jacques Whitford NAWE

Results - % of Removal

- Physico-chemical Parameters
  - Ammonia: 98%
  - PAHs: 99%
  - Metals: up to 98%
- Ecotoxicological Parameters
  - Non-toxic

Jacques Whitford
NAWE

Advantages of Engineered Wetlands

- **Low Maintenance**
- **Low Energy Requirements**
  - **Solar Powered!**
  - **Gravity Powered!**
- **Applicable In Remote Locations Without Utility Access.**
- **Decreased Emissions And Sludge Production Compared To Conventional WW Treatment Plants**




Jacques Whitford
NAWE

More Advantages...

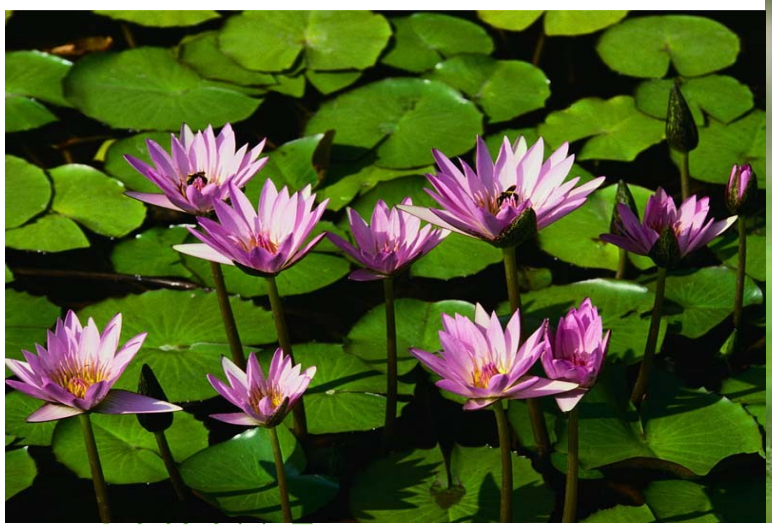
- Effective Reliable Treatment
- Inexpensive To Construct
- Economical To Operate Due To Low Labour Requirements
- Can Accept Varying Loads
- Tolerant Of Fluctuating Hydrological Conditions
- Able To Remediate Sites With Multiple Or Mixed Contaminants




Jacques Whitford
NAWE

...Added Benefits

- Habitat Creation
- Favorable Public Perception, Increased Aesthetics and Lower Noise Than Mechanical Systems
- Increasing Regulatory Acceptance And Standardization
- Lowest Greenhouse Gas Footprint



Why Engineered Wetlands?

- Plants And Bacteria Work For Free, People And Machines Don't
- Trade Land for Mechanical Complexity
- Sites with Very Long Time Horizons
- Remote, Difficult to Access Sites
- Life Cycle Cost Savings Due to Low O&M

Jacques Whitford
NAWE

Questions?

Jacques Whitford
NAWE