Constructed Wetlands as a Viable Remedial Alternative Contributing to Improved Site Climate Resilience

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The business of sustainability

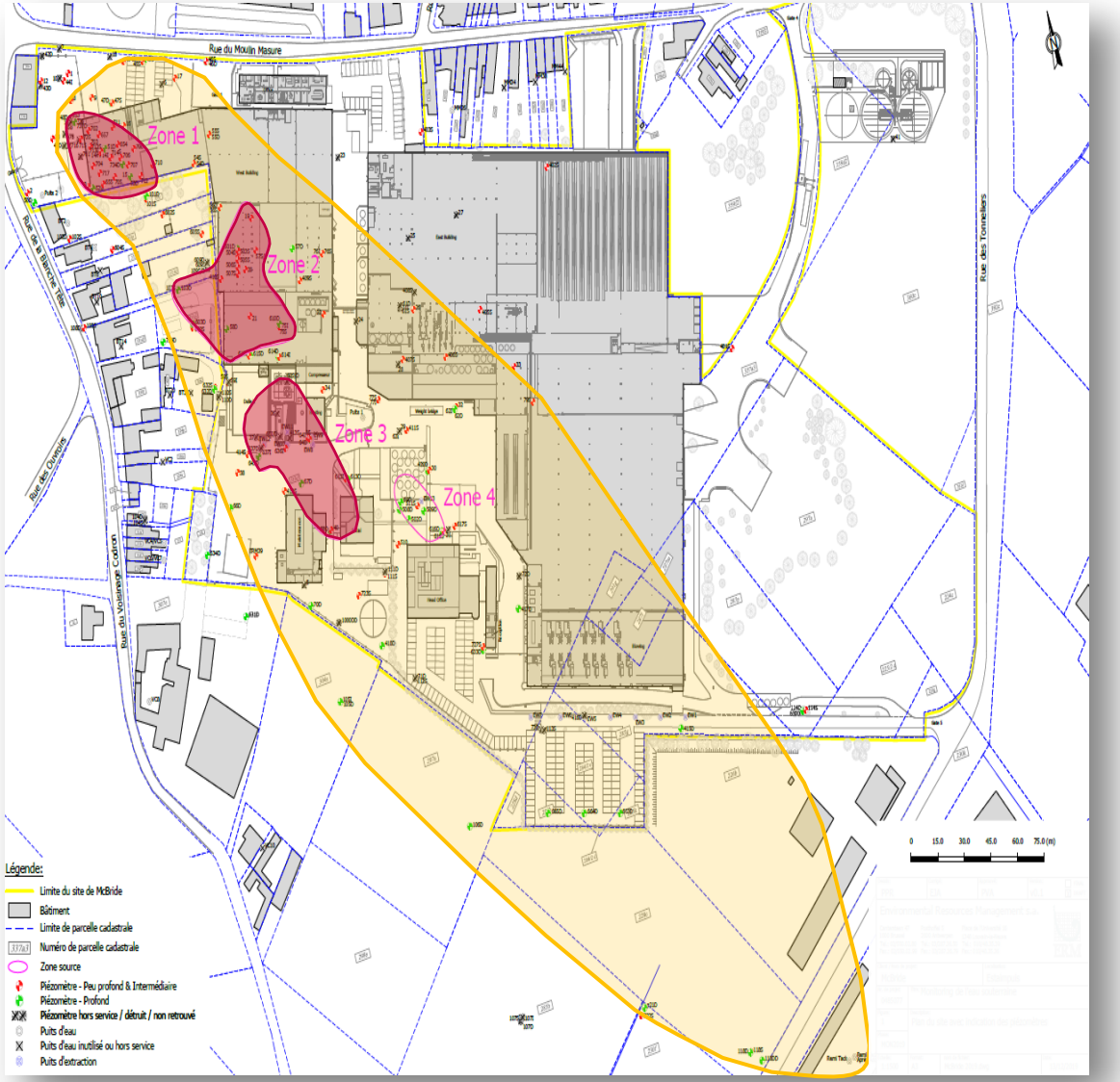
ERM

Overview

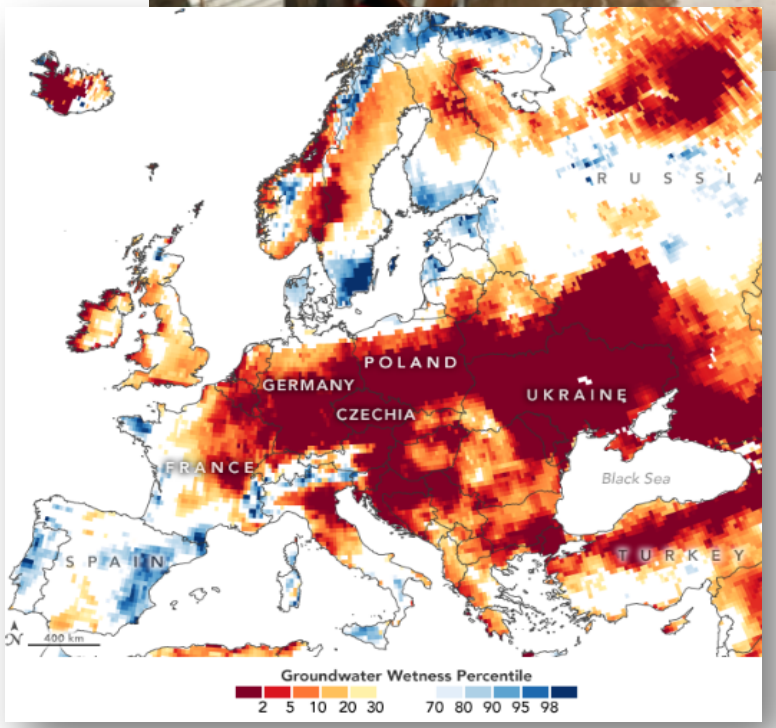
- Background
- Strategy
- Pilot Concept
- Results
- Lessons Learned
- Next Steps

Background

- Manufacturing facility since 1880
- Historical mixed impacts (CVOC, CB, 1,4-D) in soil and groundwater - Different source zones incl. DNAPL
- Initial Remedial Approach approved in **2012**:
  - Risk Removal
  - Mass Reduction (BATNEEC)
- Stepped Implementation:
  - Zone 1: Source excavation + MPE/SVE + ENA
  - Site Border: Hydraulic Containment Barrier + GWTI
  - Planned similar approach for Zone 2 & Zone 3 + P&T as Interim Remedial Measure



Background

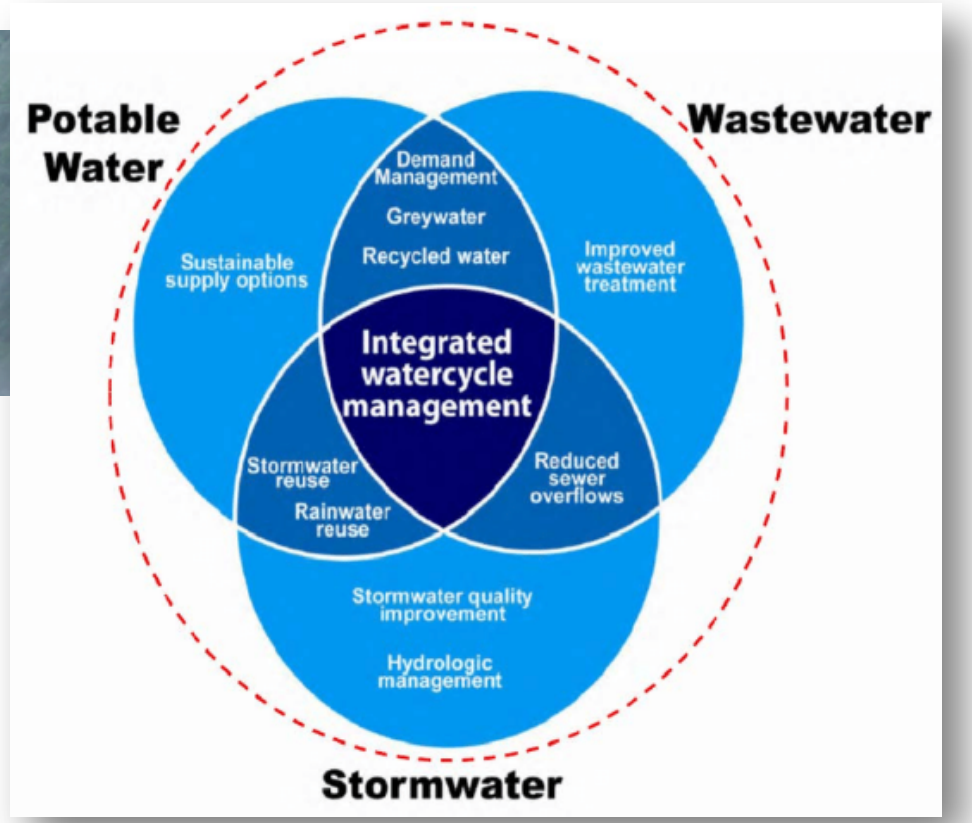


Source: NASA earth observatory

Background

- Summer 2021 Floods resulted in Regulatory pressure on **Comprehensive and Integrated Watercycle Management Systems**

- Strong focus on **Rainwater Infiltration**

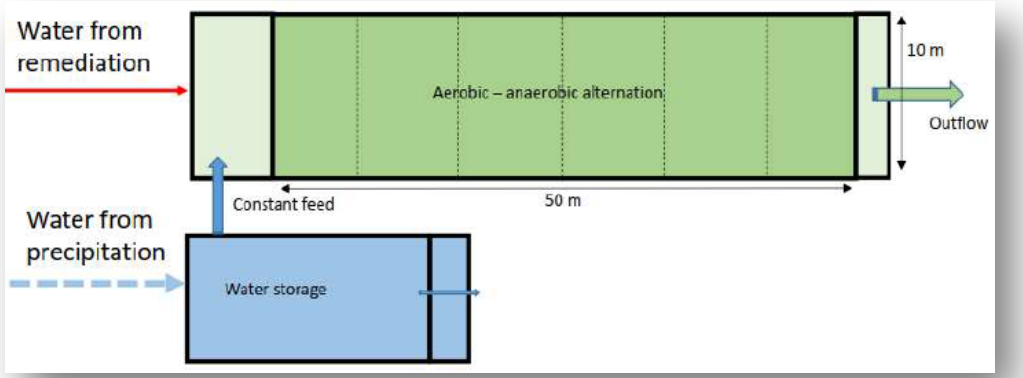


Source: Integrated water cycle management practices. (Weber and Ramilo, 2012)

Can we re-think the Remedial Strategy to better fit this new reality?

Strategy

- Evaluation of different nature-based Remedial Technologies as a Sustainable alternative for existing P&T/Barrier/GWTI
- Considering all stakeholders and discussed with local regulators
- Identified **2 Technologies** as potential Sustainable alternatives
  - Phytoremediation (next conference?)
  - **Constructed Wetlands**



Strategy

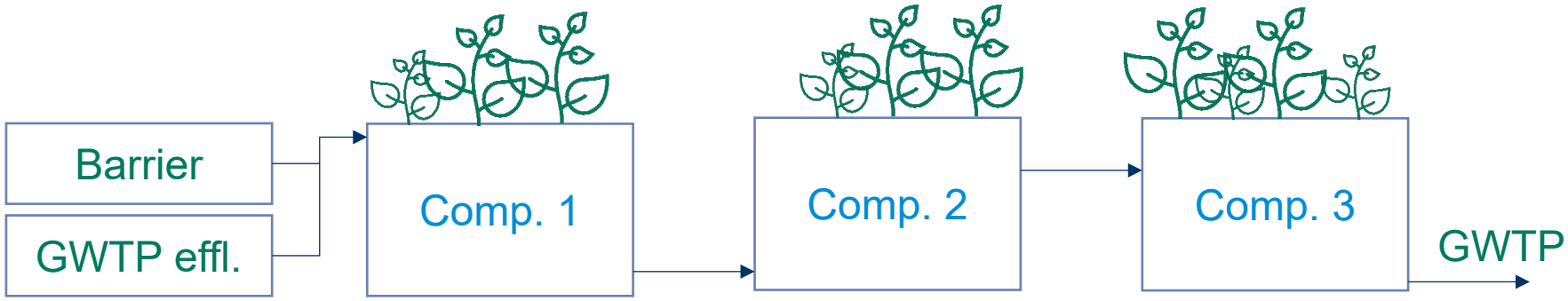
- **Constructed Wetlands (CW)**
  - Treating the impacted groundwater extracted via the Hydraulic Containment Barrier
  - Allowing Rainwater Infiltration/Aquifer Recharge
- Immediate local impact on floods and drought effects
- Increased biodiversity
- Limiting Consumables & Energy Use
- Limiting O&M Efforts

Cost Reduction!

- Pilot set-up to test feasibility

Pilot Concept
General Set-up

- CW feasibility test:
  - COC degradation rates of complex mixture
  - Specific design information for a full scale CW
  - Evaluating the feasibility of incorporating run-off water into a full scale CW
- Mobile open-roof 20 ft container *(HMVT, NL)*
- 3 Compartments with different physico-chemical conditions achieved by various layers of soil matrix



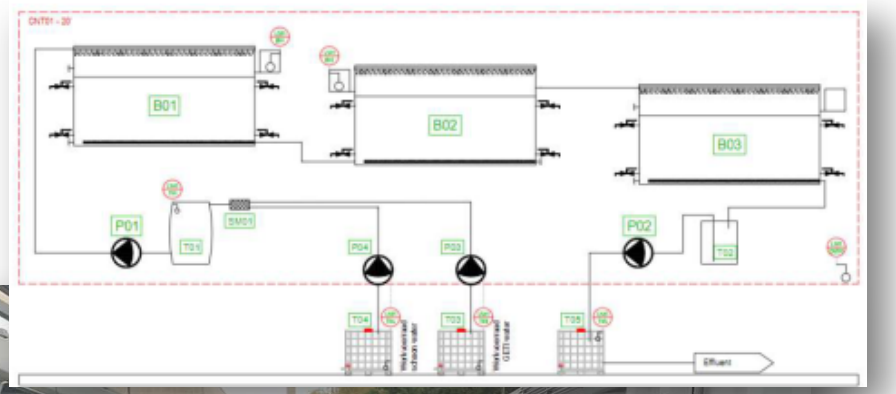
Part	Amount/dimensions
Compartments	3
Compartment length	2.23 m
Compartment width	0.72 m
Compartment height 0.80 m	0.80 m
Total volume of wetland matrix	Approx. 3600 L
Porosity	0.32
Flowrate	10 l/h
Retention time Approx.	115 hours

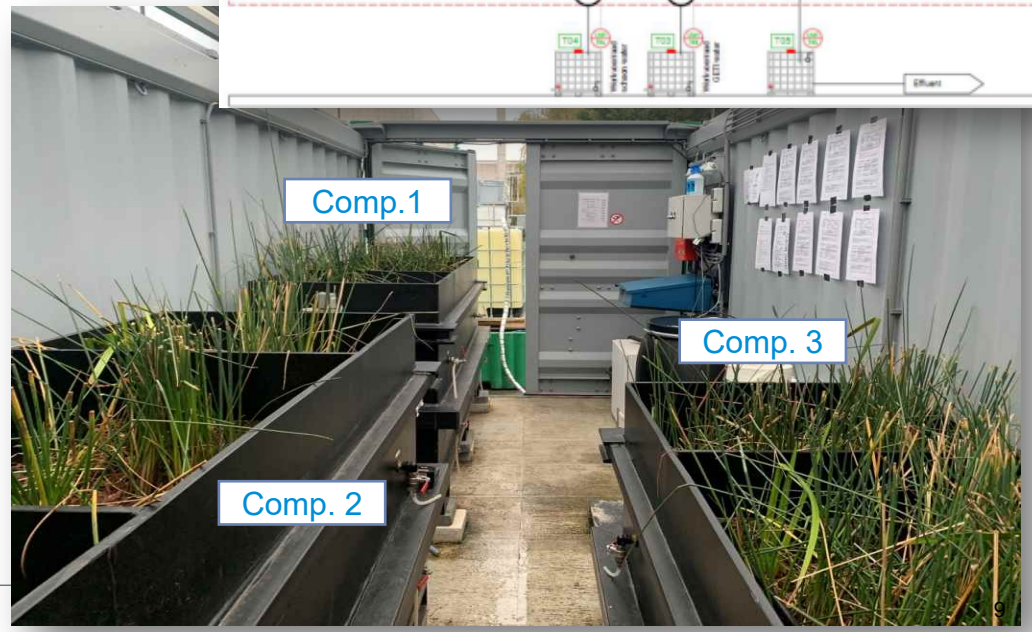
Pilot Concept
General Set-up

Schoenoplectus lacustris

Acorus calamus

- Mix of 2 different Wetland Plants
  - Schoenoplectus lacustris & Acorus calamus
- Compartment 1: **Aerobic → Anaerobic**
  - 1,4-D & CB
- Compartment 2: **Anaerobic**
  - PCE, TCE & 1,2 DCE
- Compartment 3: **Anaerobic → Aerobic**
  - VC
- Influent composed of water coming from the Barrier, diluted with treated GWTP effluent water
  - Dilution decreasing over time





Pilot Concept
Monitoring Plan

- Long-term (1 year) Pilot to mimic seasonal effects
  - Plant growth
  - Flow rates
  - Field measurements (pH, O_2, E_h & EC)
  - Temperature (ambient air + water)
  - Chemical Analysis on COC + Macro-chemicals (Calcium, Magnesium, Ammonium, Nitrate, Sulphate, Phosphate, …): water + substrate
  - Gas measurements
  - Microbial screening

Results

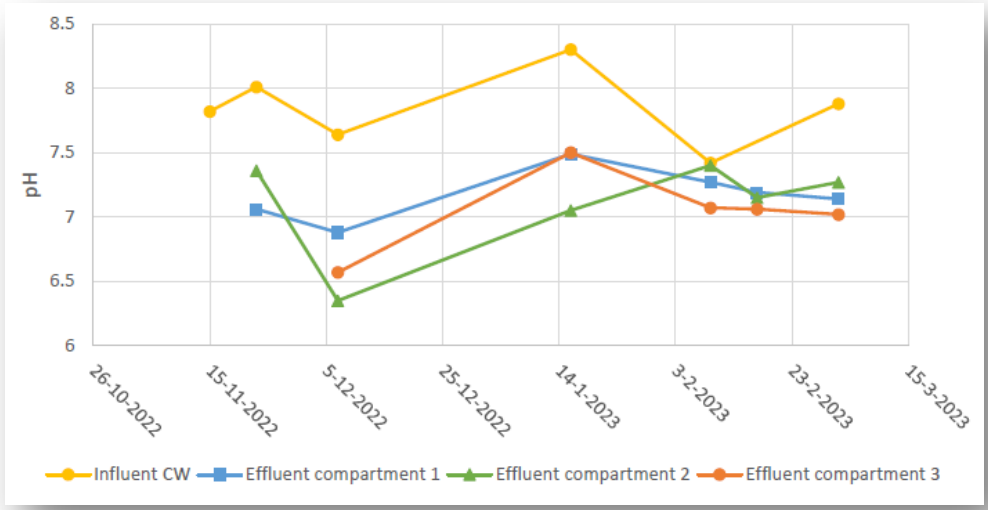
- Pilot started on **November 15, 2022**
  - Target flow rate = 10 L/hr
  - Started with a 4:1 Influent ratio, quickly adapted to 2:1
  - Winter conditions forced a System standstill in December 2022
- January 2023 Monitoring results indicating CVOC reduction
  - Volatilization?
  - Sorption Processes?
- No effect yet on 1,4-D
  - Linked with Redox Conditions – see next slide
- Increased BOD/COD linked to post start-up matrix flush-out (tree bark + mould) – normalized in latest sampling
- Influent ratio adapted to 1:2 on March 3, 2023

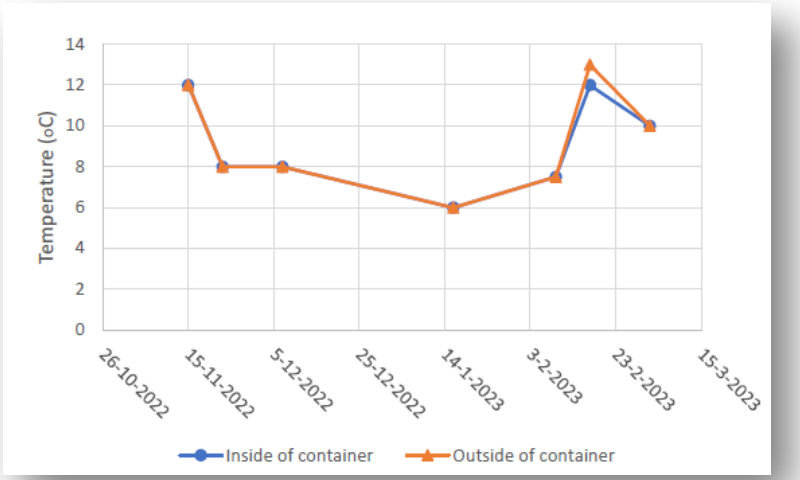
		Inf-C01	Eff-C01	Eff-C02	Eff-C03
PCE	ug/l	510	0,36	0,1	0,1
TCE	ug/l	73	6	2,2	0,1
1,2-DCE	ug/l	400	390	180	35
VC	ug/l	2,8	0,84	0,97	0,35
1,2-DCB	ug/l	120	0,2	0,2	0,2
1,4-D	ug/l	86	120	180	170
Chloride	mg/l	220	240	250	240
BOD5	mg/l	3	37	79	171
COD	mg/l	7,4	103	215	365
Nitrate	mg/l	0,75	0,75	0,75	0,75
Sulfate	mg/l	180	130	92	<5

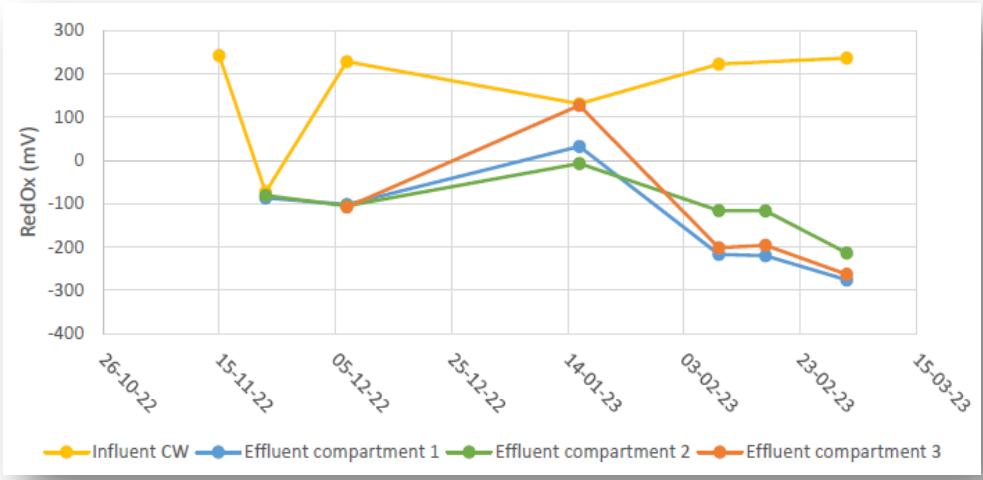
Sampling date: January 16, 2023

Results
Field Measurements

- Expected pH decrease confirmed
- No sludge formation observed yet
- Unsuccesfull in bringing Aerobic conditions back at Comp. 3
  - *Additional Aeration promoting 1,4-D degradation?*



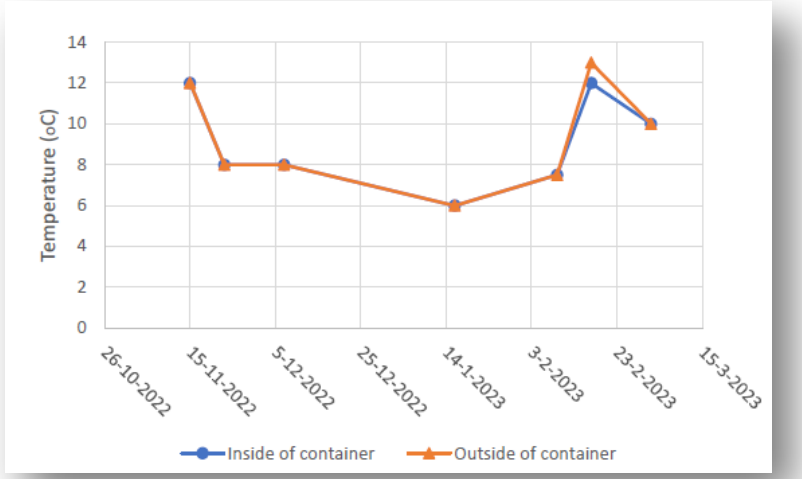




Lessons Learned

So far…

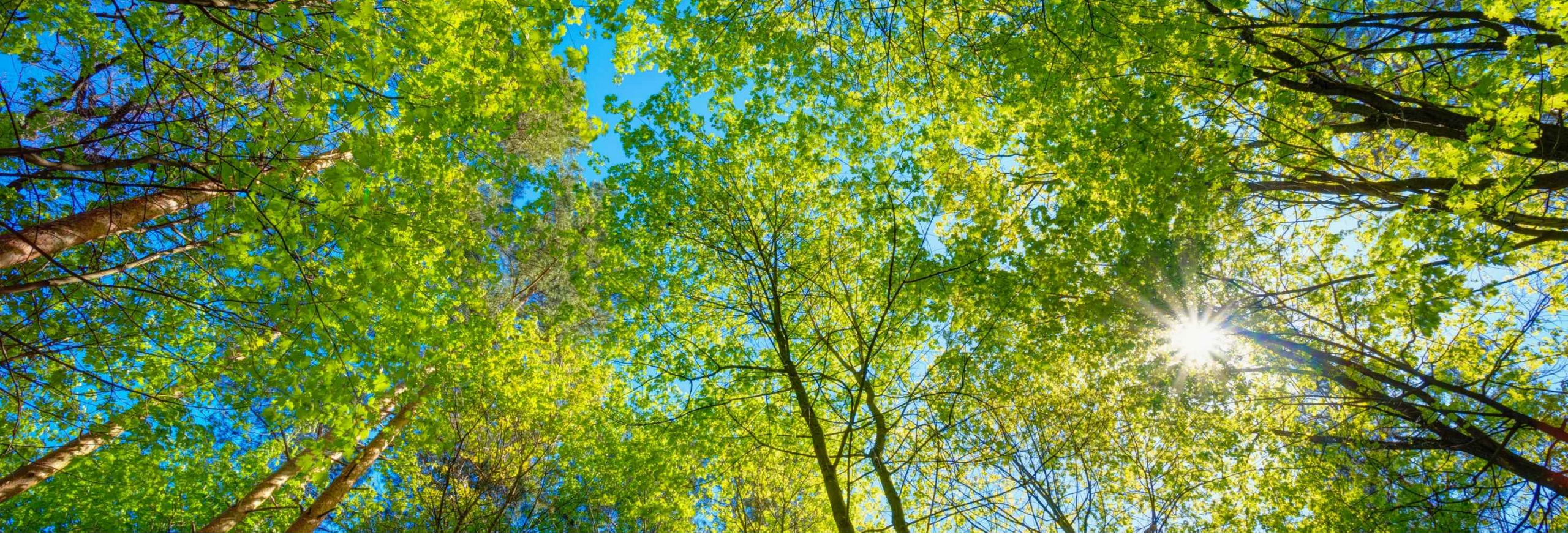
- Take sufficient time – Plants need to grow and do not like winter…
- Focus Monitoring plan on different processes to understand:
  - Sorption
  - Dilution
  - Vaporization
  - Degradation
- Active aeration? – Keep in mind your general goal!



Next Steps

- Continuing Pilot test till end October 2023 (1 year, different seasons)
- Stepped increase towards undiluted Influent water
- Continue + Extend Monitoring Plan:
  - Include Microbiological Rhizosphere Assessment
  - Increase understanding of Sorption Processes
  - Increase understanding of Vaporization Processes

- Use Pilot data for full scale design & cost estimate
- Balancing pro's and con's with other nature-based Barrier alternative (i.c. Phytoremediation)



Thanks!

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