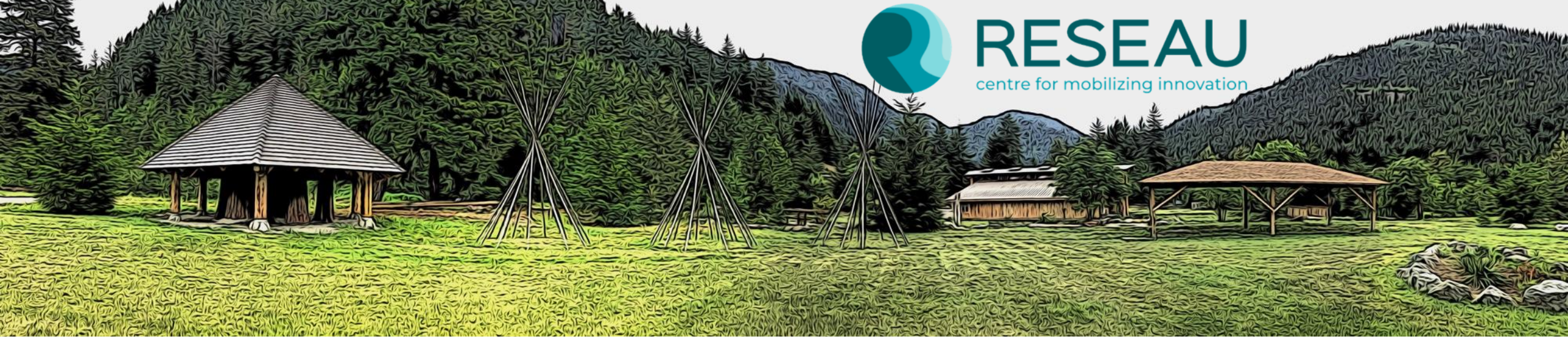


A Journey to Clean Water

The Power of Biological Filters

Madjid Mohseni, Ph.D., P.Eng.
University of British Columbia

2023 Water and Wastewater Workshop
Gander

Rural Communities: Separated by Geography and Culture

1. Delivery of consumables and spare parts
2. Internet and power connectivity

   → delayed technical support
3. Residents' communication and engagement
4. Relying on a single water operator

Solutions:

→ Robust, reliable, simple to operate, minimal consumable

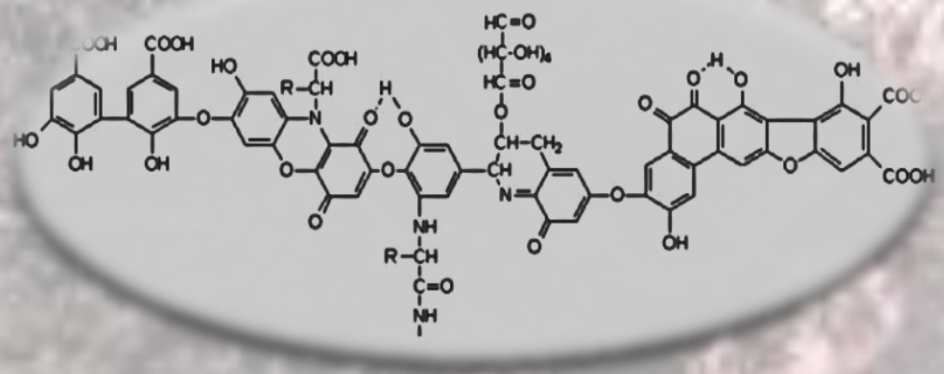
6 CLEAN WATER AND SANITATION

- ~Two billion people around the World (1/4) lack access to safely managed water.
- Canada has 1,000 drinking water advisories including 31 in First Nations (Nov, 2022).
- 77% of DWAs in Canada target communities < 5,000 people.

Organics in Drinking Water

- Natural Organic Matter (NOM) consists 1,000's of individual molecules

- NOM comes from:
  - Soil runoff
  - Decaying algae + organic matter



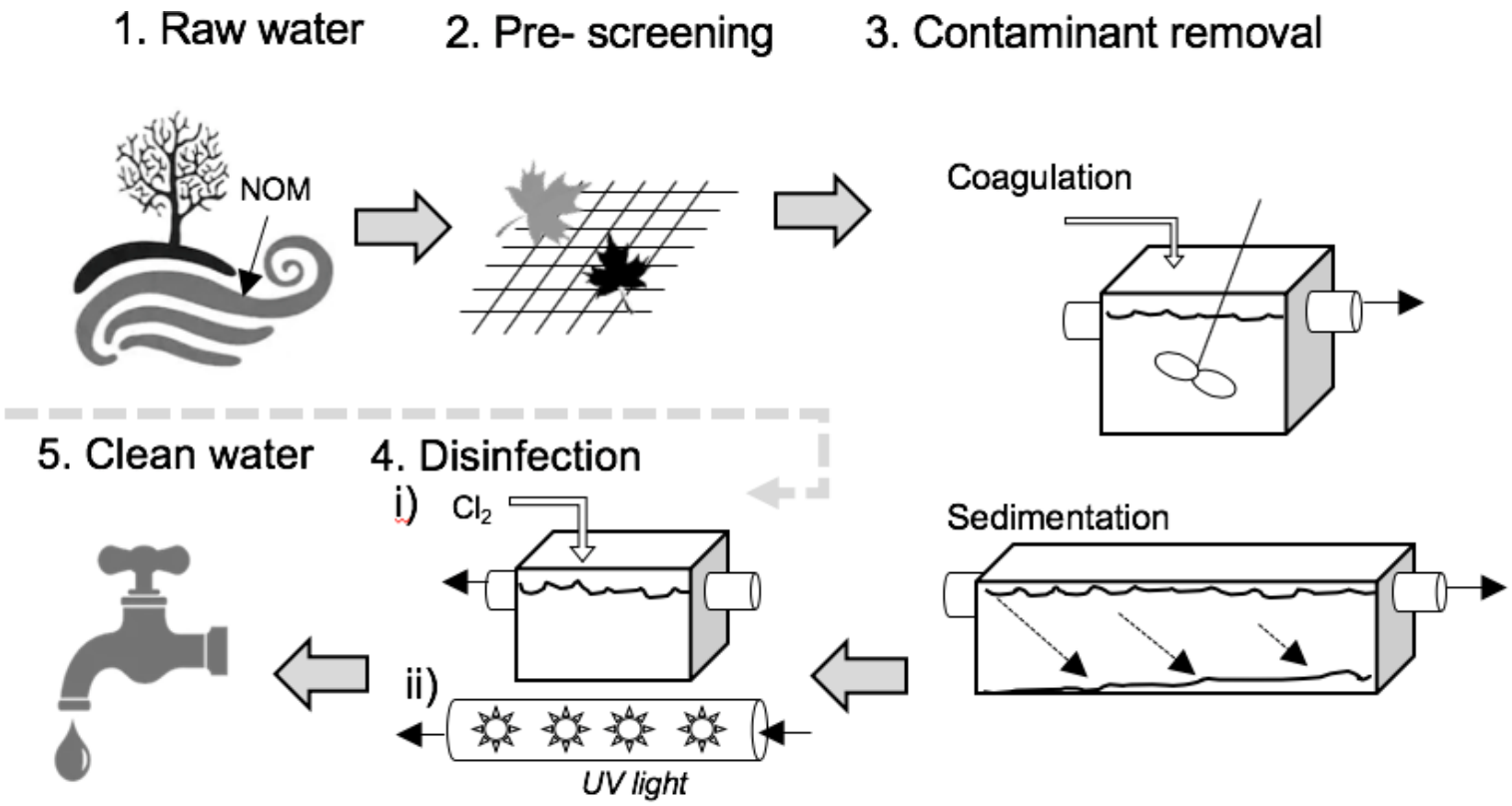
ORGANICS CREATE WATER TREATMENT CHALLENGES

1. Fouls filters
2. Provides food for microbial growth in pipes
3. Inhibits UV disinfection
4. Reacts with Cl_2 to form disinfection by-products (DBPs)

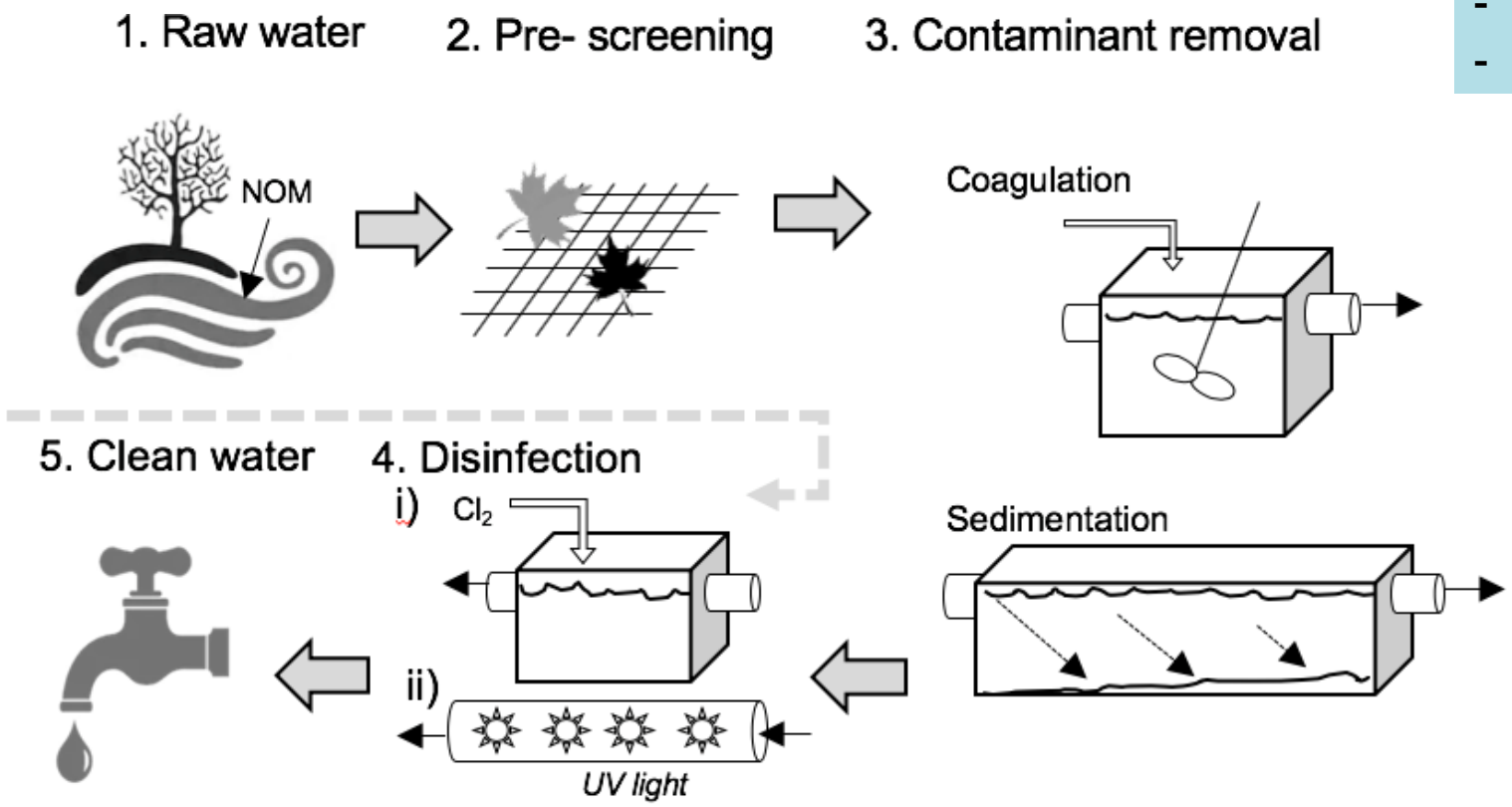
ORGANICS CREATE WATER TREATMENT CHALLENGES

So, we need to remove organics from water <u>before</u> disinfection!

A Tale of Organic Removal



A Tale of Organic Removal



- Coagulation + sedimentation
- Effective for large MW NOM
- $$$ infrastructure, consumables

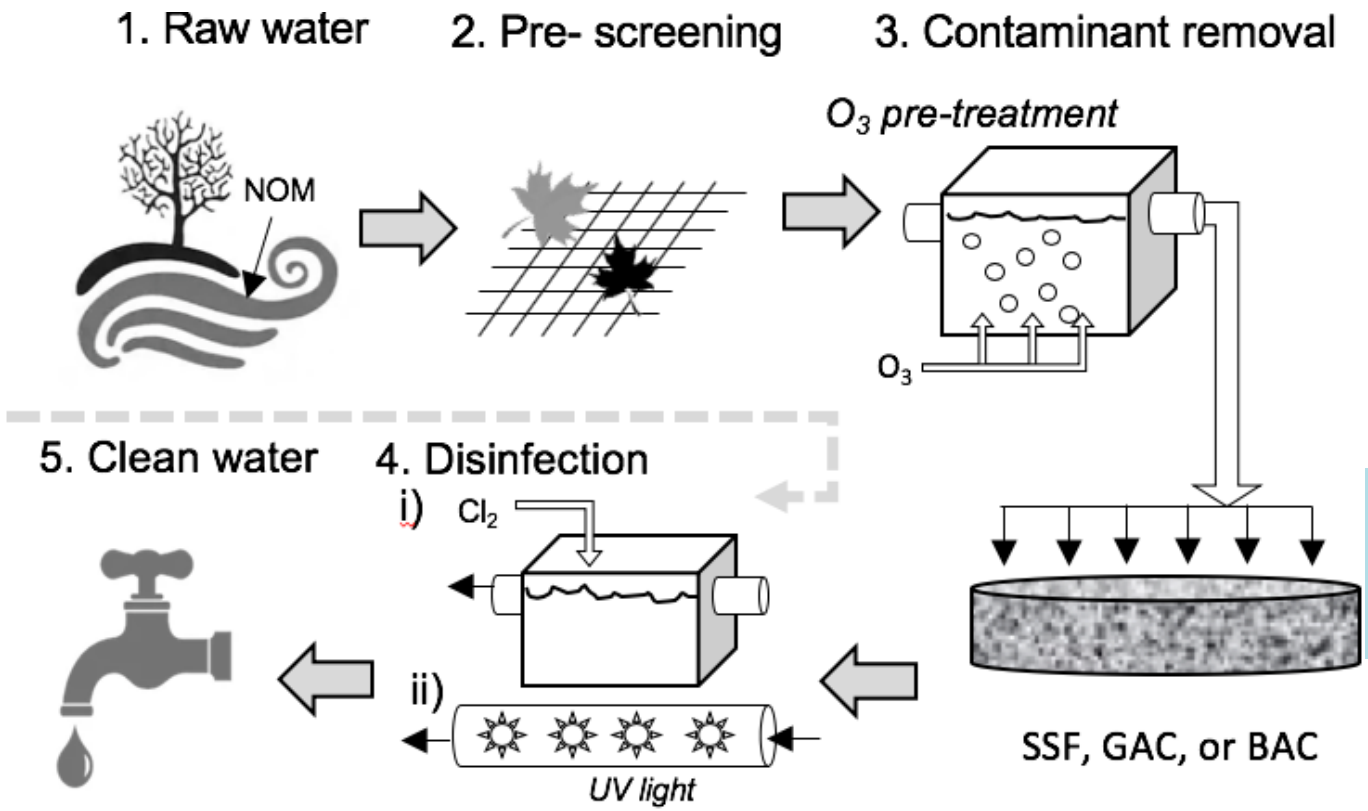
Large Cities: Conv

Small Cities: oxid+filter

Small Cities: IEX

Small Cities: BIEX

A Tale of Organic Removal



- Coagulation + sedimentation
- Effective for large NOM
- $$$ infrastructure, consumables

Large Cities: Conv

O_3 + Slow Sand Filtration
- max 58% DOC removal[1]
- Ozone = very difficult operation

Small Cities: oxid+filter

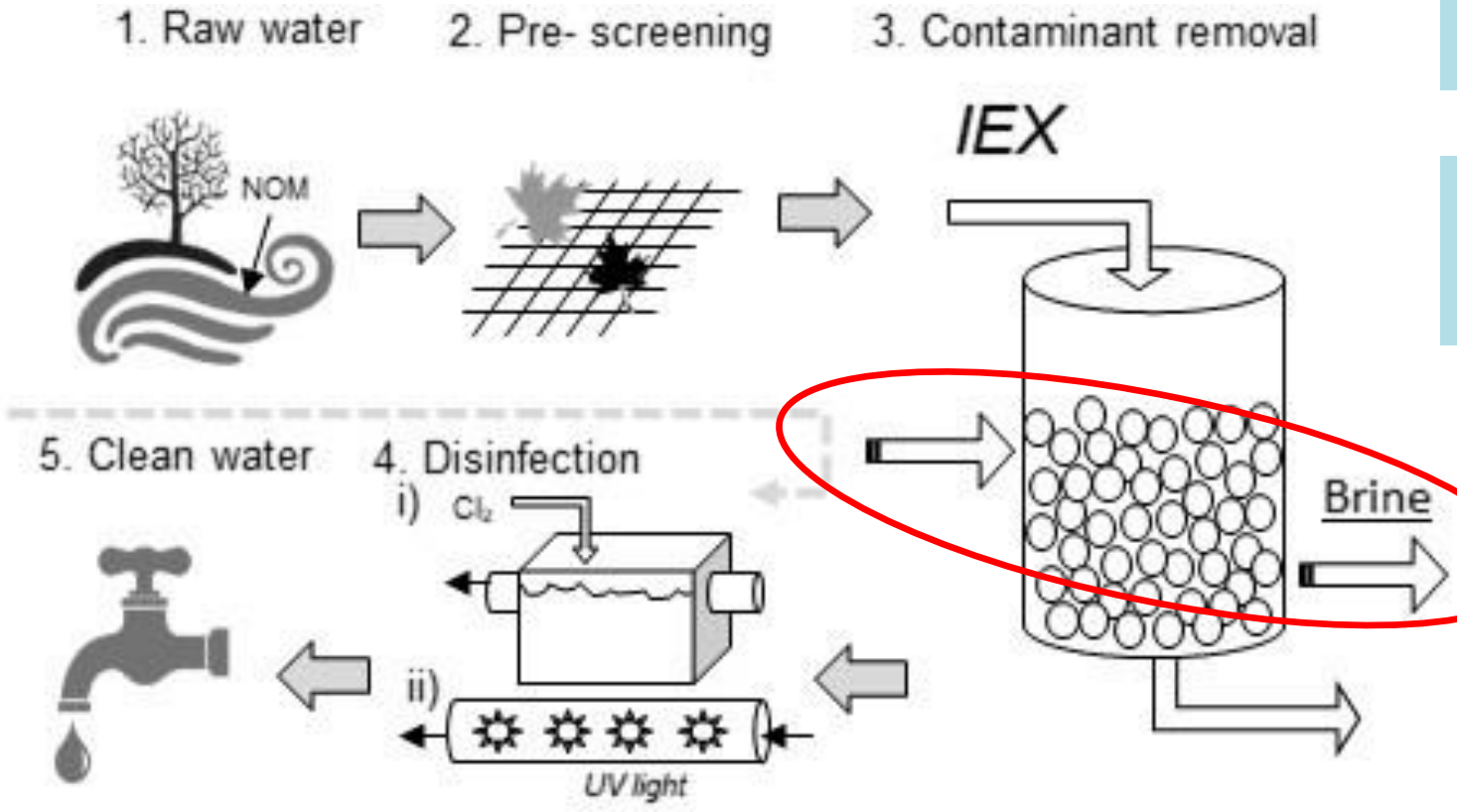
O_3 + Biological activated carbon
- BAC = low maintenance
- Only 5-20% DOC removal

Small Cities: IEX

Small Cities: BIEX

1. Agabab, Tubic, Dalmacija, Watson, Molnar, Roncevic. Investigation of the impact of ozone pretreatment and powdered activated carbon addition on the removal of natural organic matter by coagulation. Desalination and Water Treatment (2015), vol 56, issue 4.

A Tale of Organic Removal



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Large Cities: Conv

O_3 + Slow Sand Filtration
- max 58% DOC removal[1]
- Ozone = very difficult operation

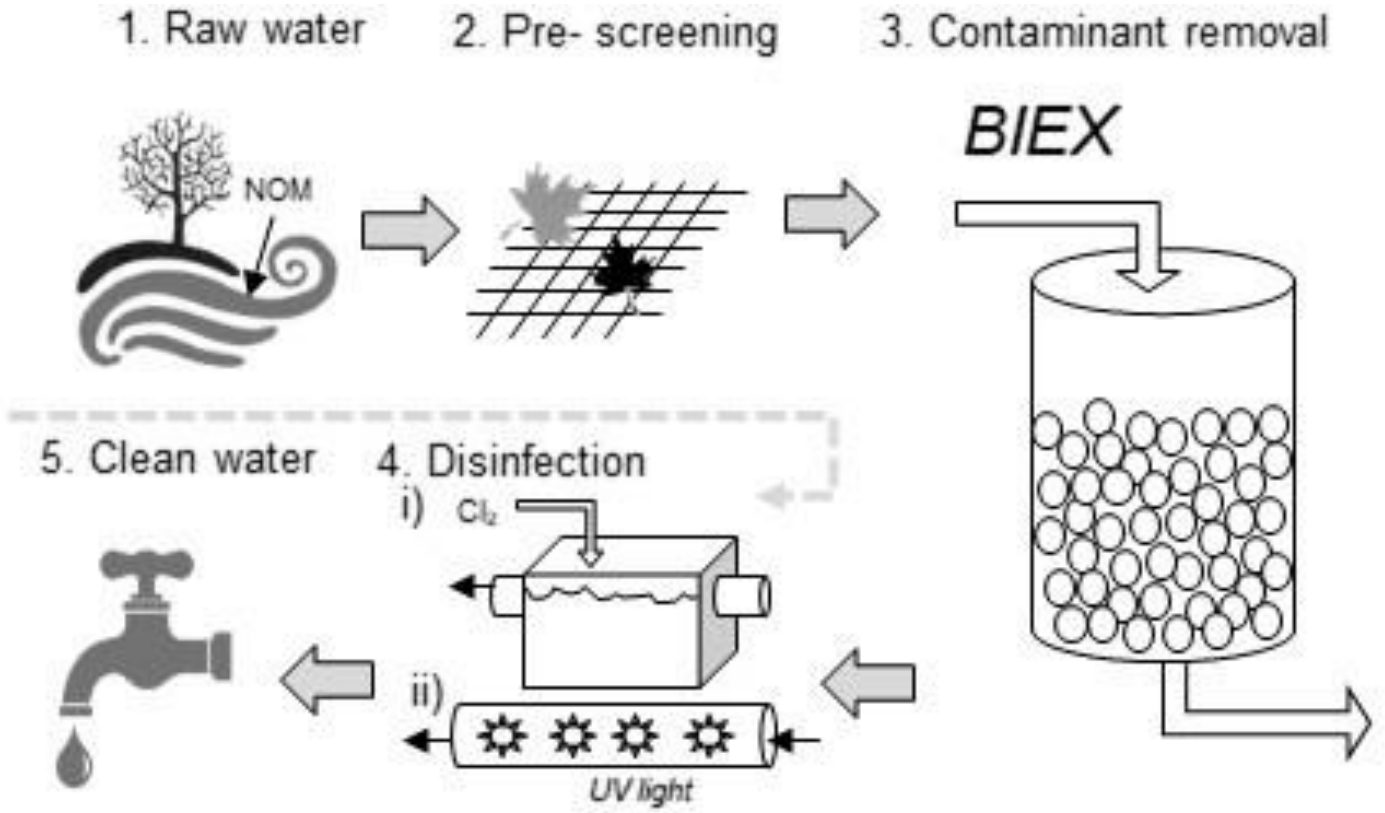
Small Cities: oxid+filter

- Up to 90% organics removal
- Scales to large or small cities
- Regeneration produces brine = waste!

Small Cities: Ion Exchange

Small Cities: BIEX

A Tale of Organic Removal



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Small Cities: oxid+filter

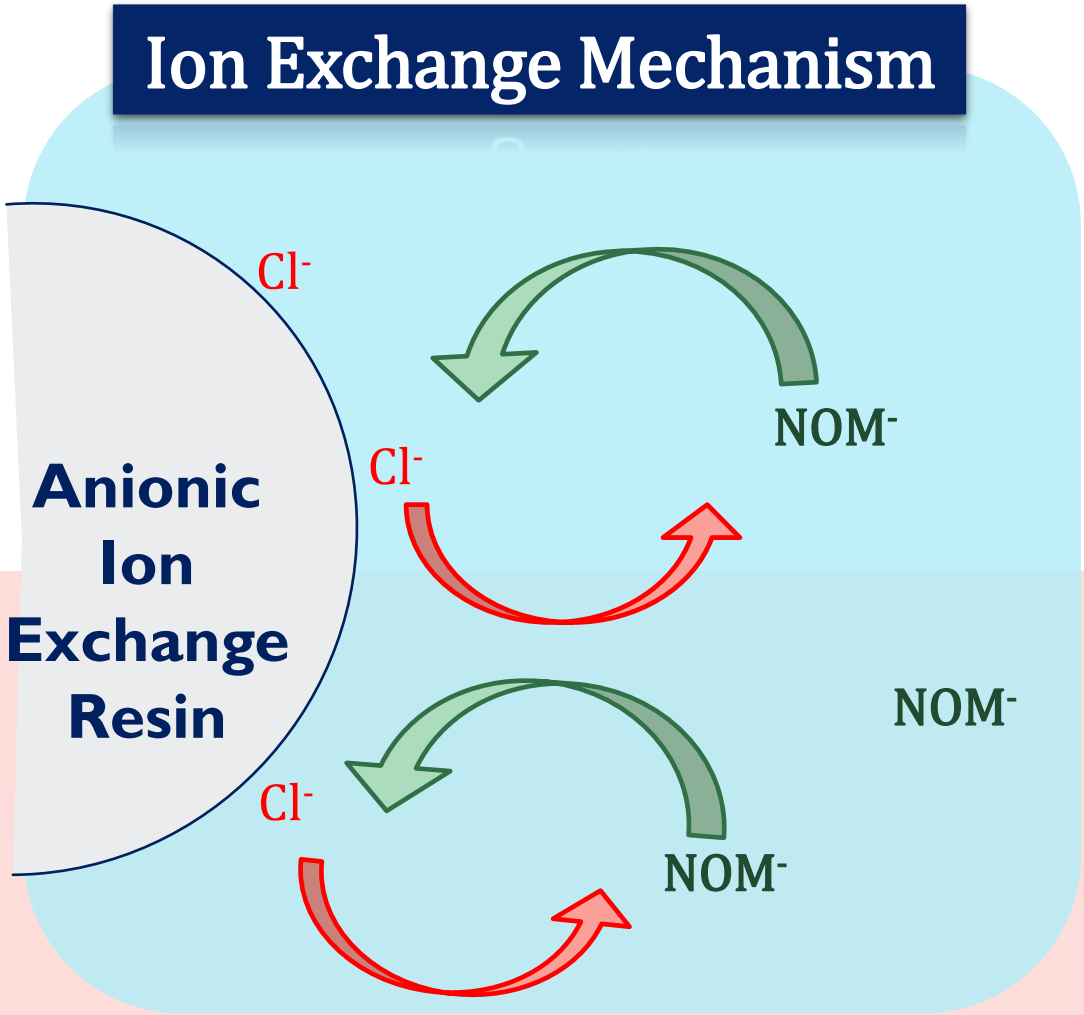
- Up to 90% organics removal
- Scales to large or small cities
- Regeneration produces brine = waste!

Small Cities: IEX

Biological Ion Exchange:
- ~50% organics removal for 2 yrs without regeneration!

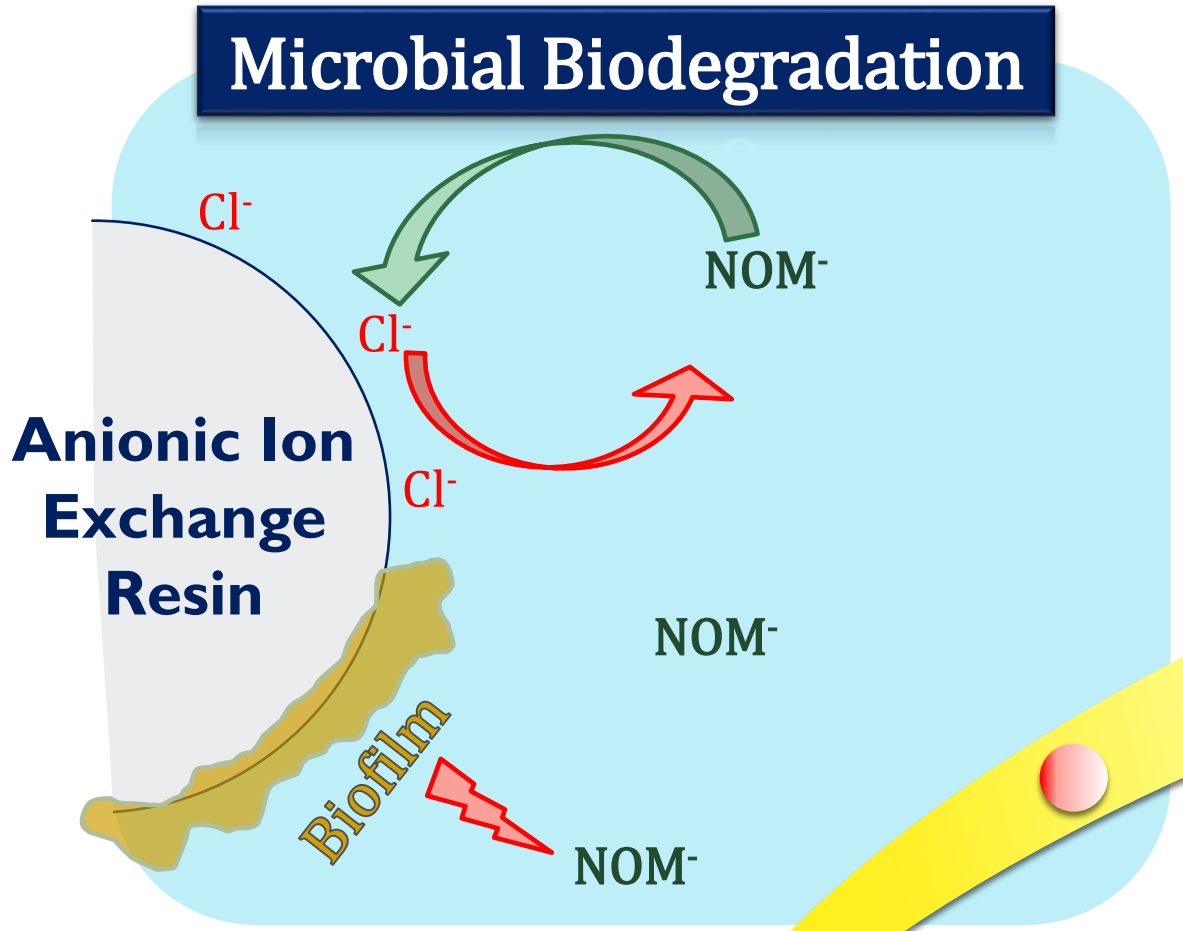
Small Cities: BIEX

How BIEX Work?



Brine Disposal

How BIEX Work?

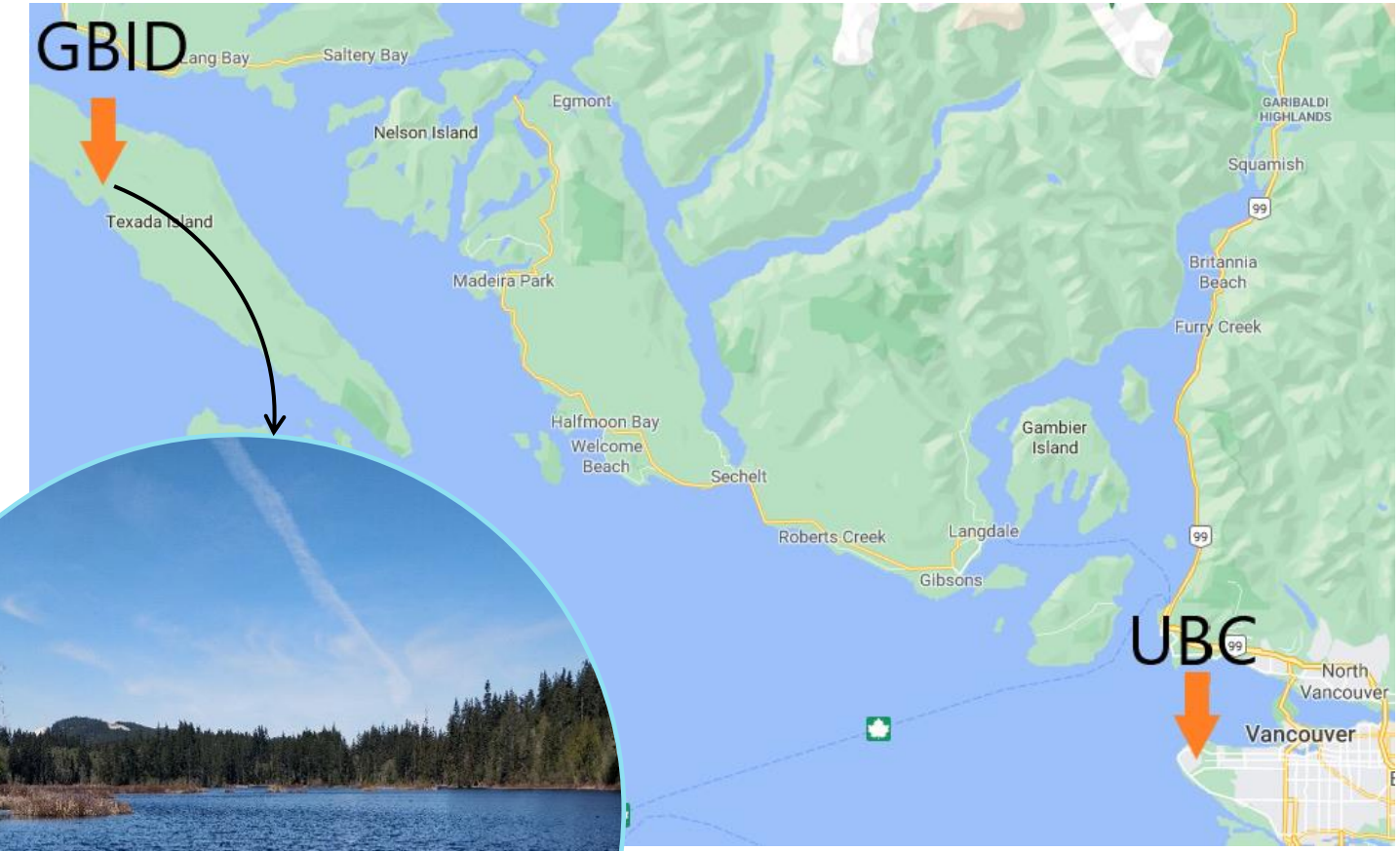


Biological Ion Exchange "BIEX"

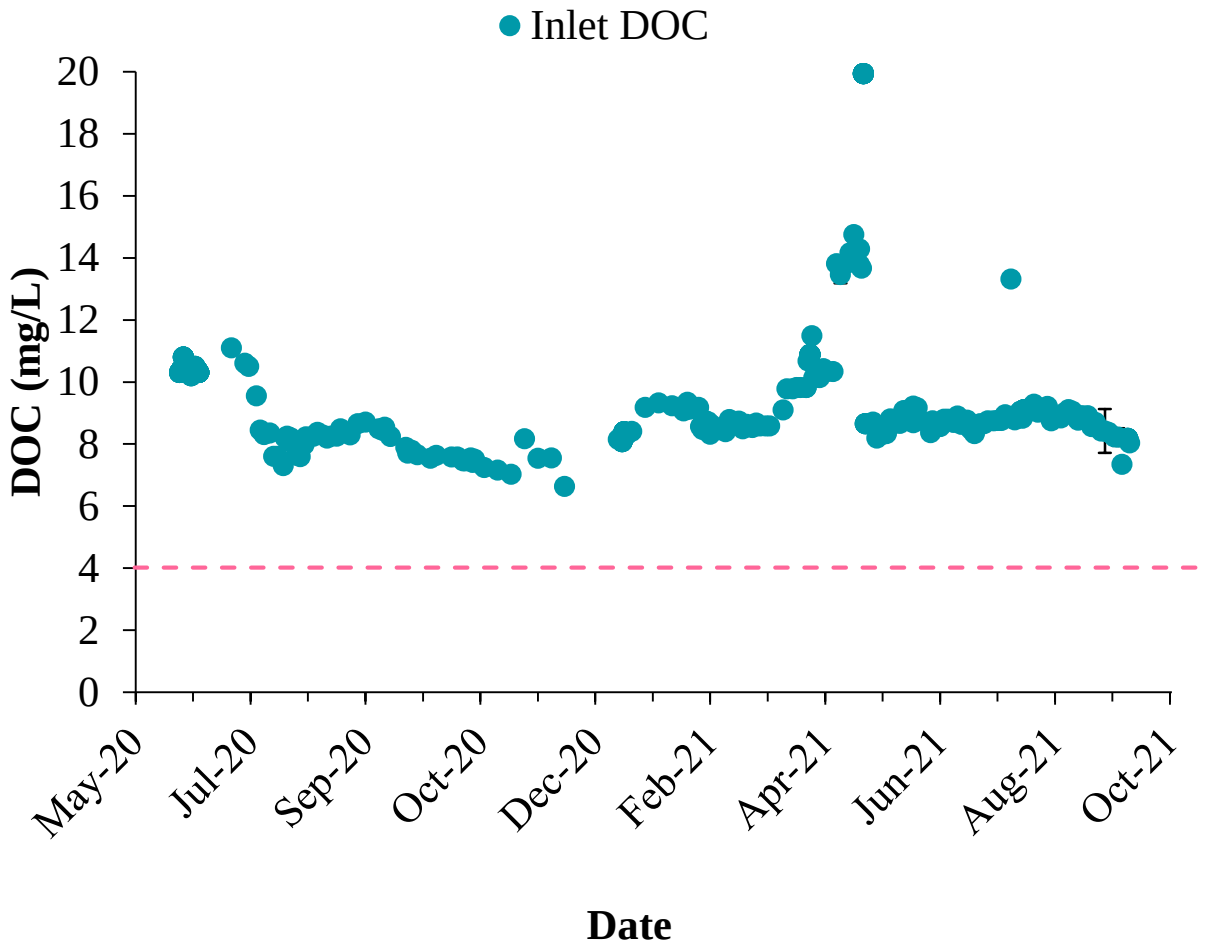
NO/Less Resin Regeneration

Ion Exchange "IEX"

Gillies Bay Improvement District (GBID)



Cranby Lake Source Water



Technology Options

- Various technology available for drinking water treatment:
  - Ozone + slow sand filtration
  - Membrane processes
  - Conventional treatment

  → Not feasible

  - Ion exchange (IEX)
  - Biological ion exchange (BIEX)

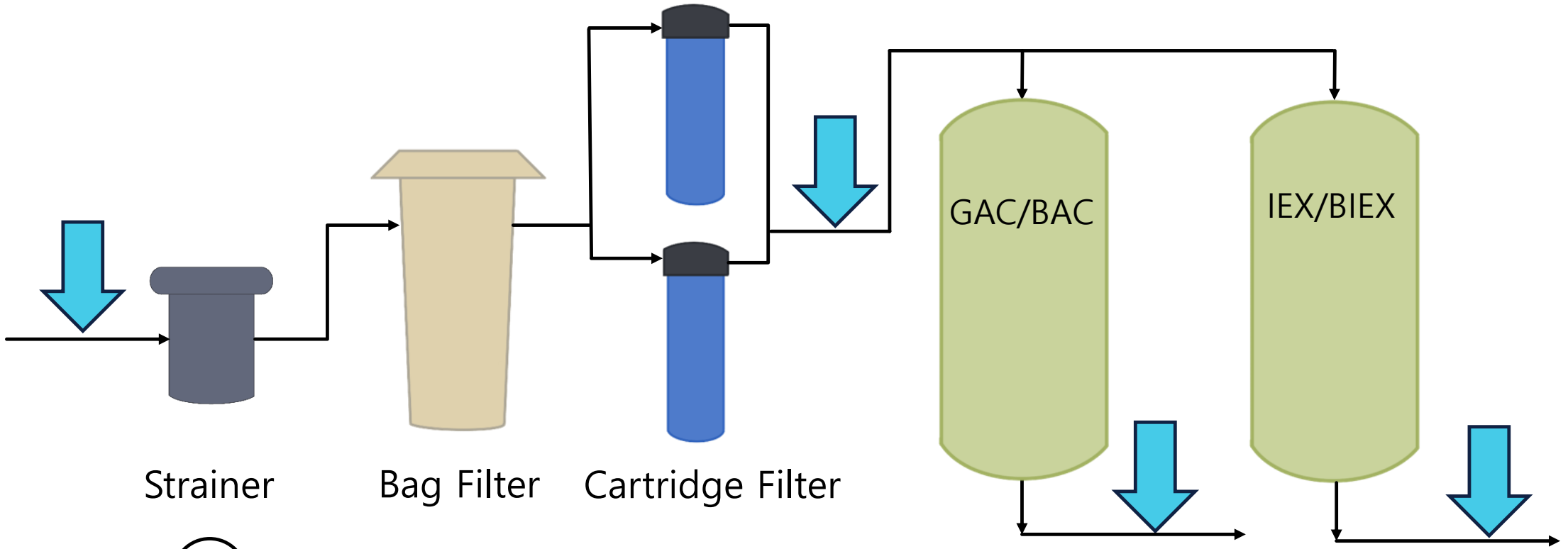
  → Selected for testing

  - Granular activated carbon (GAC)
  - Biological activated carbon (BAC)

  → Comparative analysis

Process Description

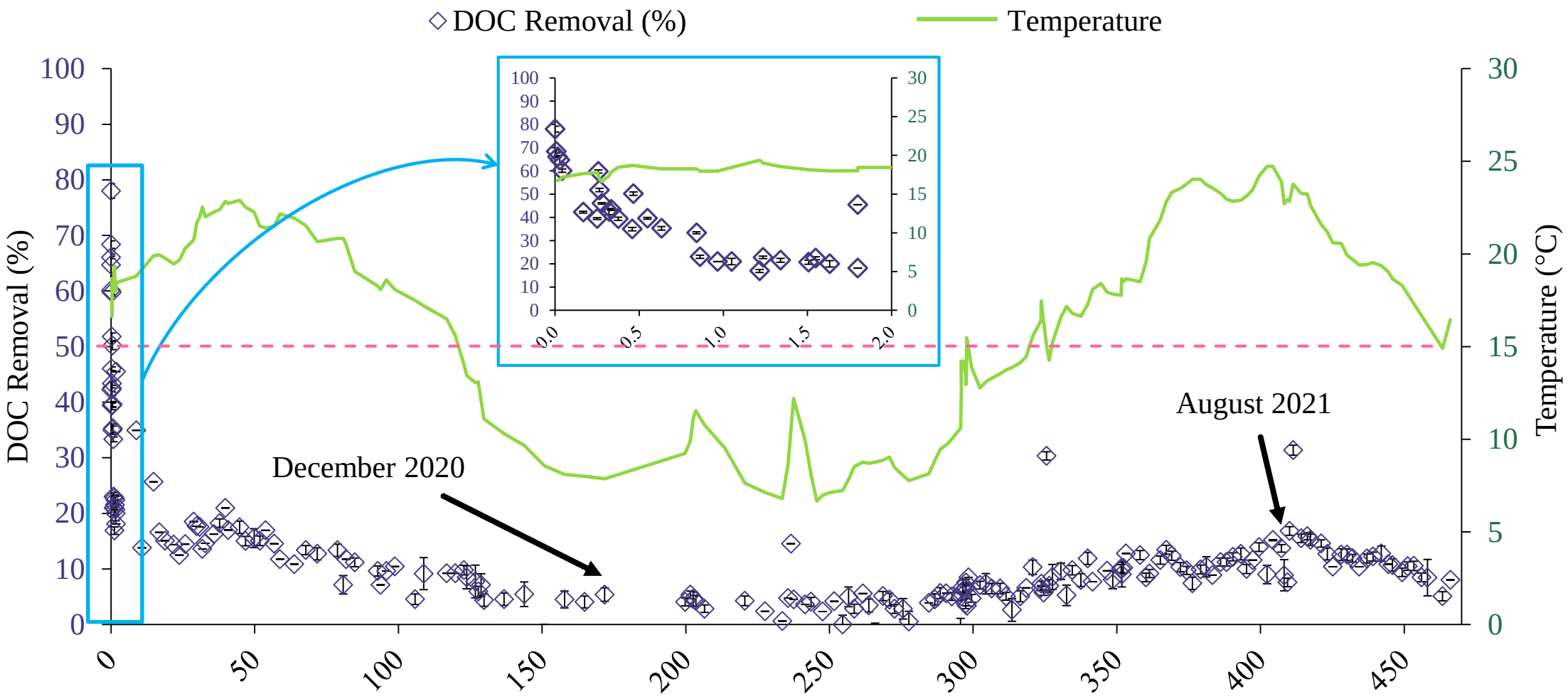
Process Diagram



Process Diagram

Results & Performance

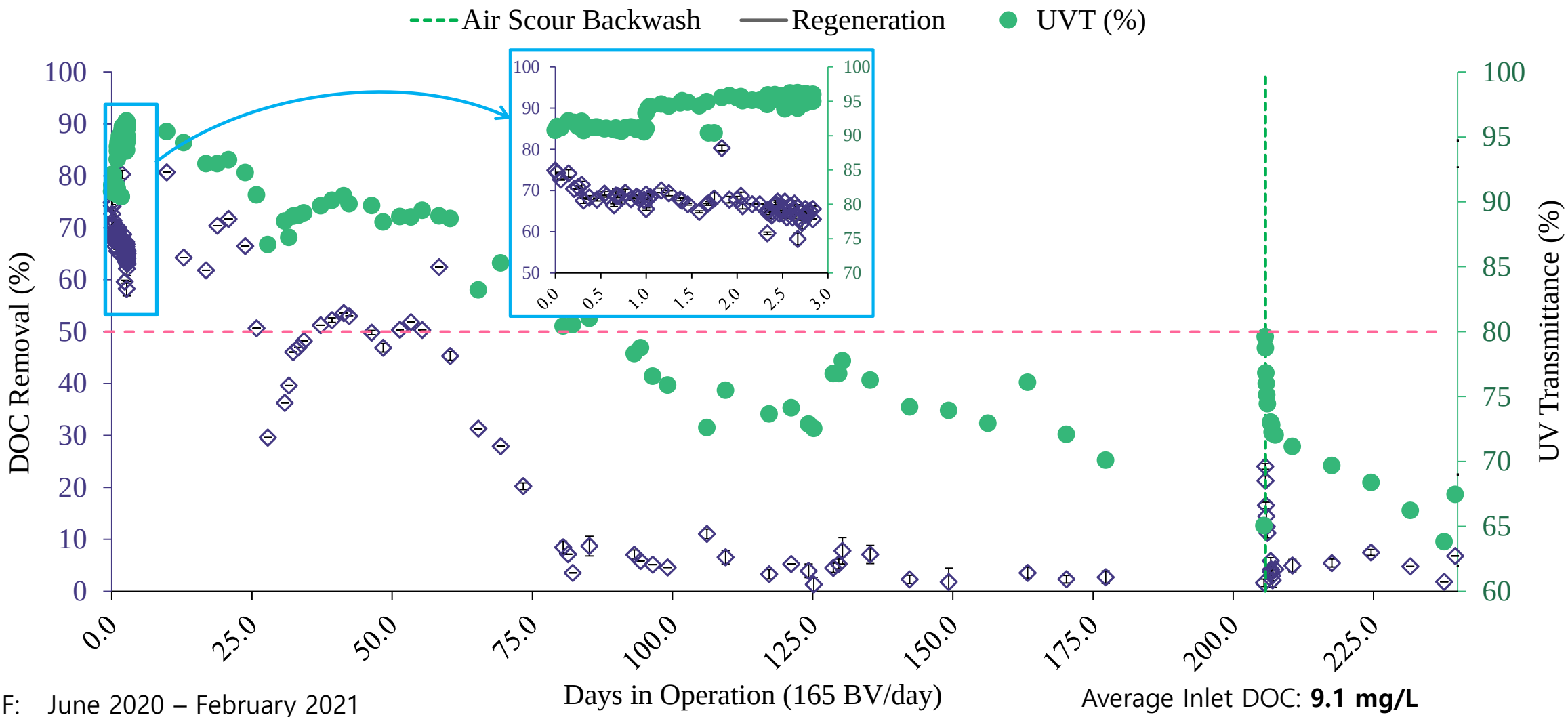
Granular & Biological Activated Carbon Column



May 2020 – Oct 2021
Flow Rate: **3.4 L/min**
EBCT: **26 min**

Average Inlet DOC: **9.1 mg/L**

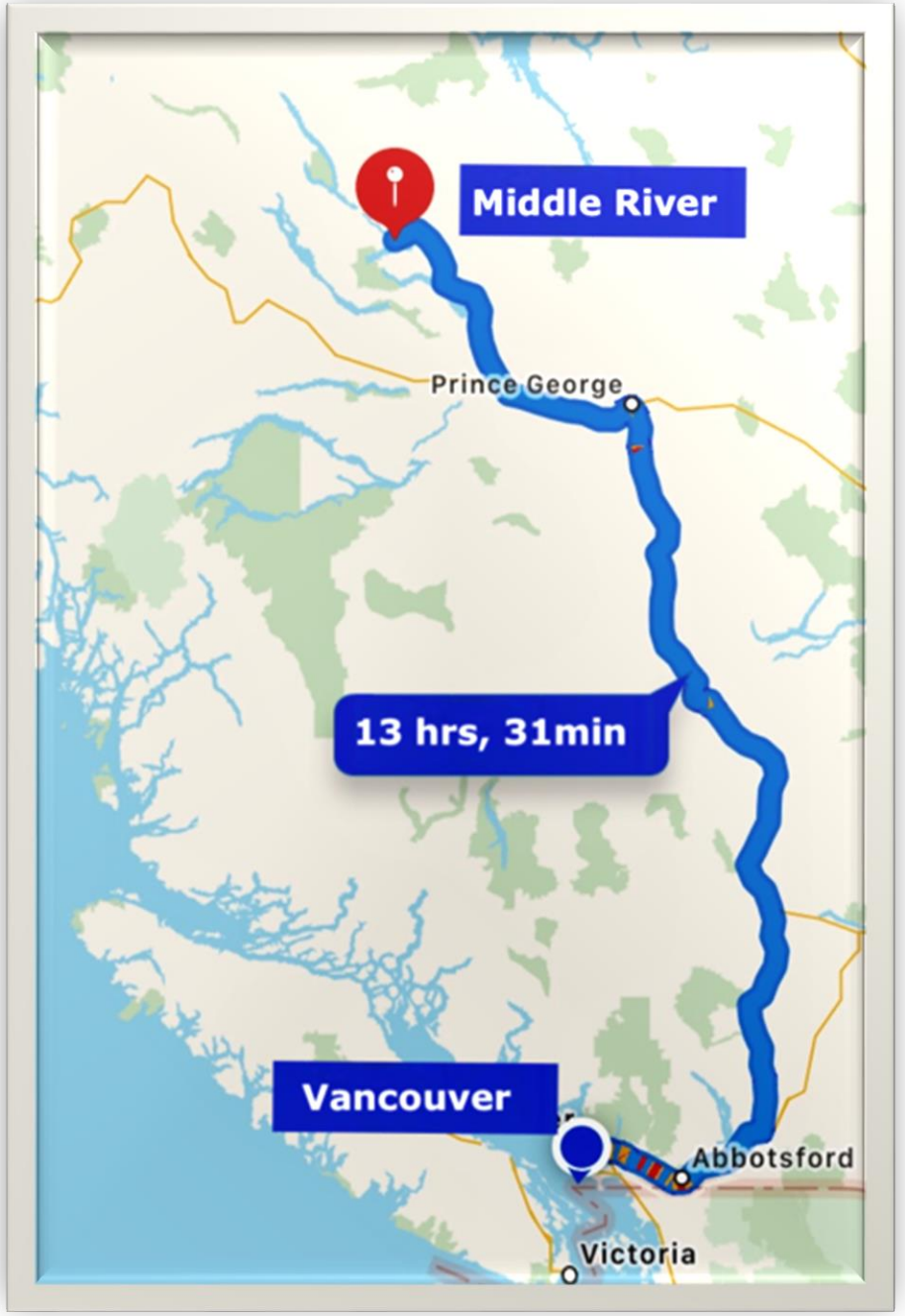
BIEX Performance



HF: June 2020 – February 2021
Flow Rate: **6.9 L/min**

Average Inlet DOC: **9.1 mg/L**
Average Inlet UVT: **66 %**

Middle River Village
Tl’azt’en First Nations



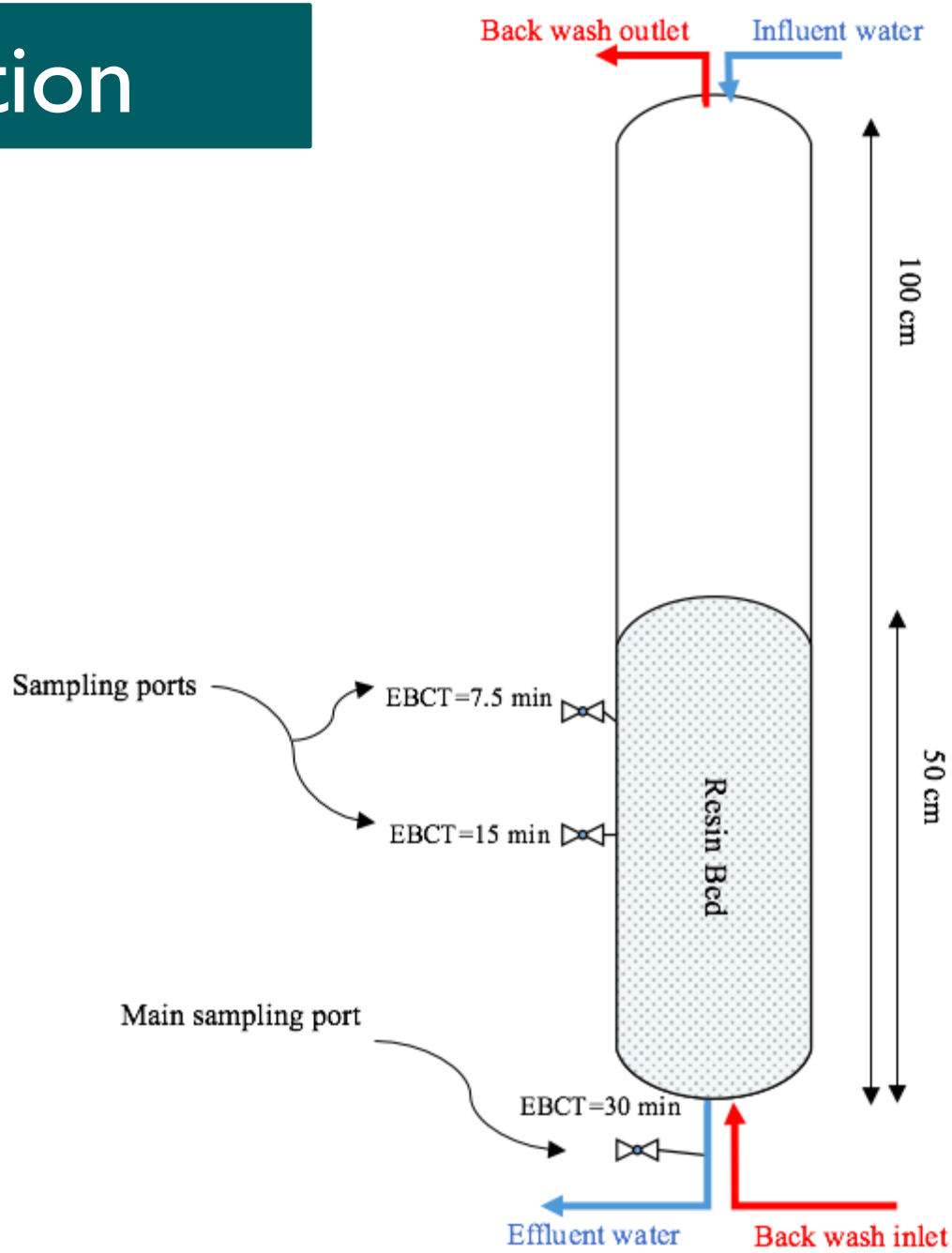
Site Conditions

River intake → Filtration → Chlorine disinfection

Source water characteristics	Value
Dissolve Organic Carbon "DOC"	~ 5 mg/L
pH	~ 7
Alkalinity	38.2 ± 7.7 mg/L
Turbidity	0.8 ± 0.1 NTU
UV_{Abs254}	0.16 ± 0.02 cm^{-1}
Chloride	0.7 ± 0.1 mg/L
Sulphate	4.1 ± 0.3 mg/L
Nitrate	0.5 ± 0.1 mg/L

Pilot Design and Operation

Design	Length of the Column	100 cm
	Column diameter	2 inch
	Filter bed depth	50 cm
Operation	Service flow rate	2 BV/h
	Filtration velocity	1 m/h
	Volumetric flow rate	~ 32 ml/min
	Empty Bed Contact time (EBCT)	30 min
	Volume of treated water per day	~ 46 liter
	Backwash Frequency	After 4500 BV ~ Monthly
Sampling	3 sets of samples per week (Inlet and outlets with different EBCTs)	



Pilot Set-up

Pilot Set-up Over Time

July 2017
2 Days

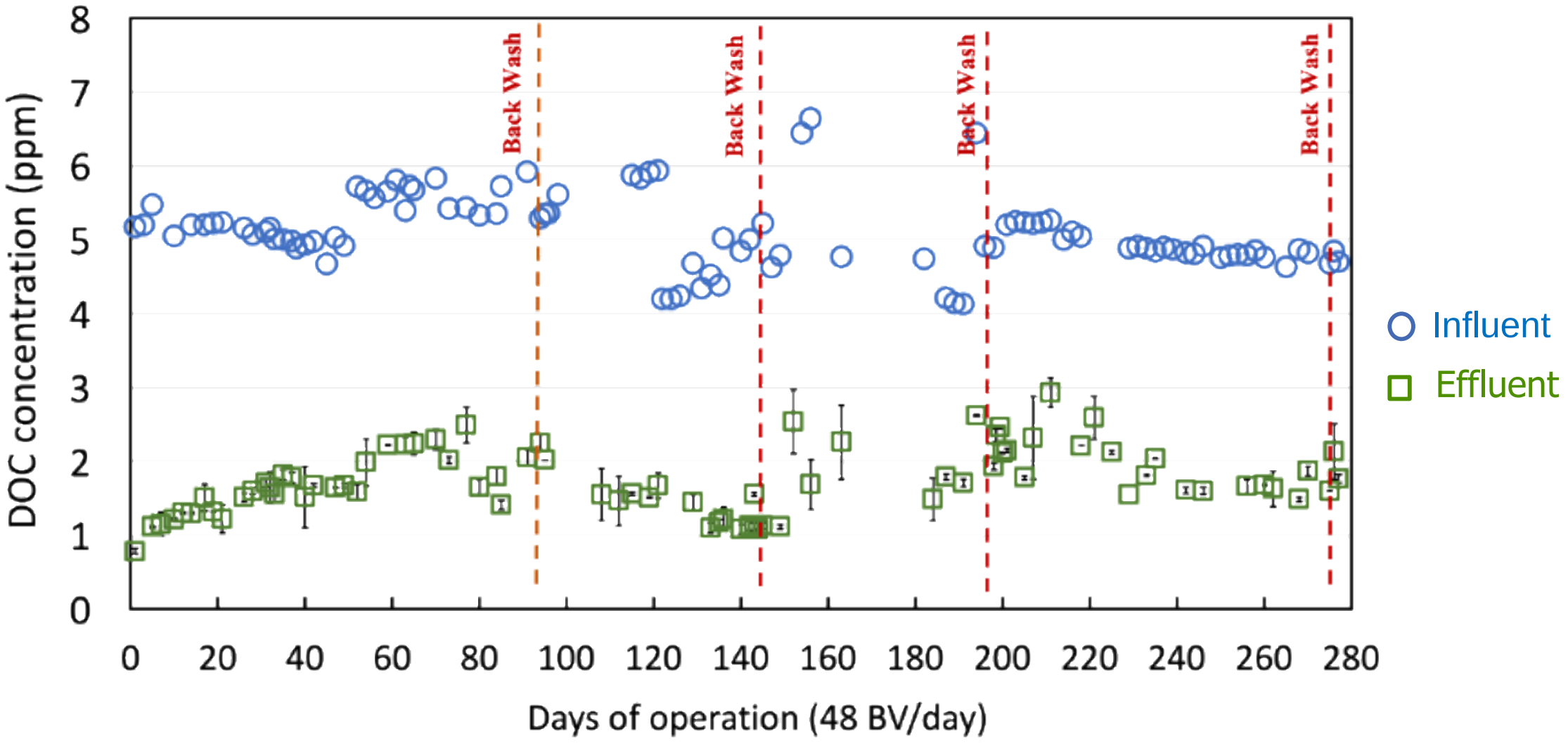
August 2017
31 Days

October 2017
94 Days

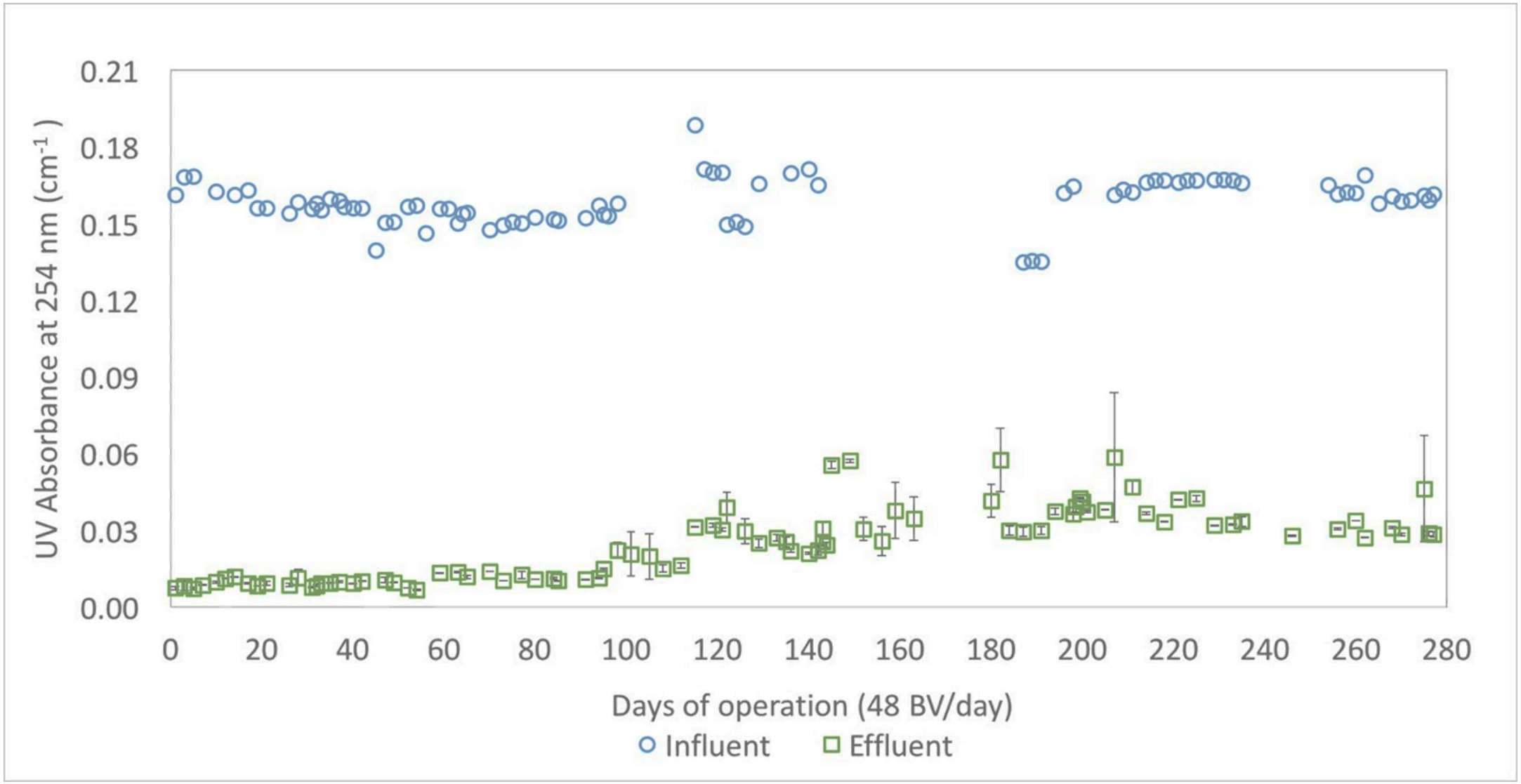
$$\textbf{Bed } \boldsymbol{V}\textbf{olumn}(\boldsymbol{BV}) = \frac{\textbf{Treated water}(\boldsymbol{ml})}{\textbf{Resin}(\boldsymbol{ml})}$$

February 2018
After 208 days of operation
(10,000 BV)

DOC Removal


DOC concentration (ppm)
0
1
2
3
4
5
6
7
8
Back Wash
Back Wash
Back Wash
Back Wash
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Days of operation (48 BV/day)
Influent
Effluent

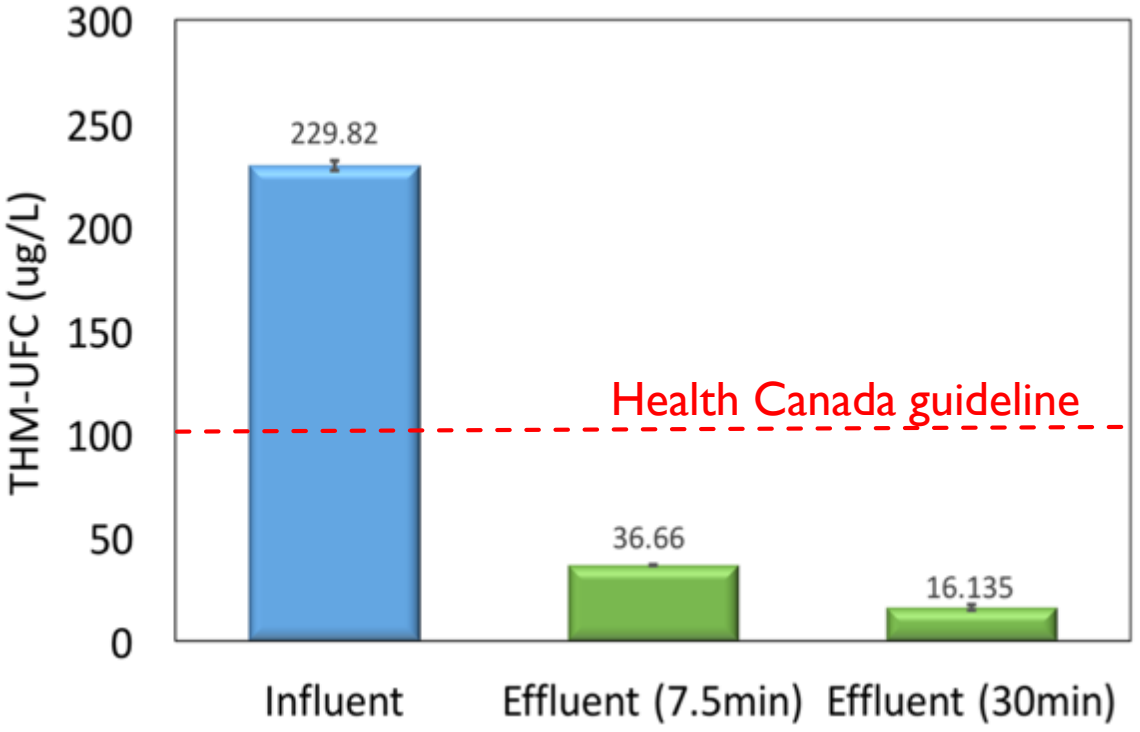
UV Absorbance at 254 nm



THM Formation

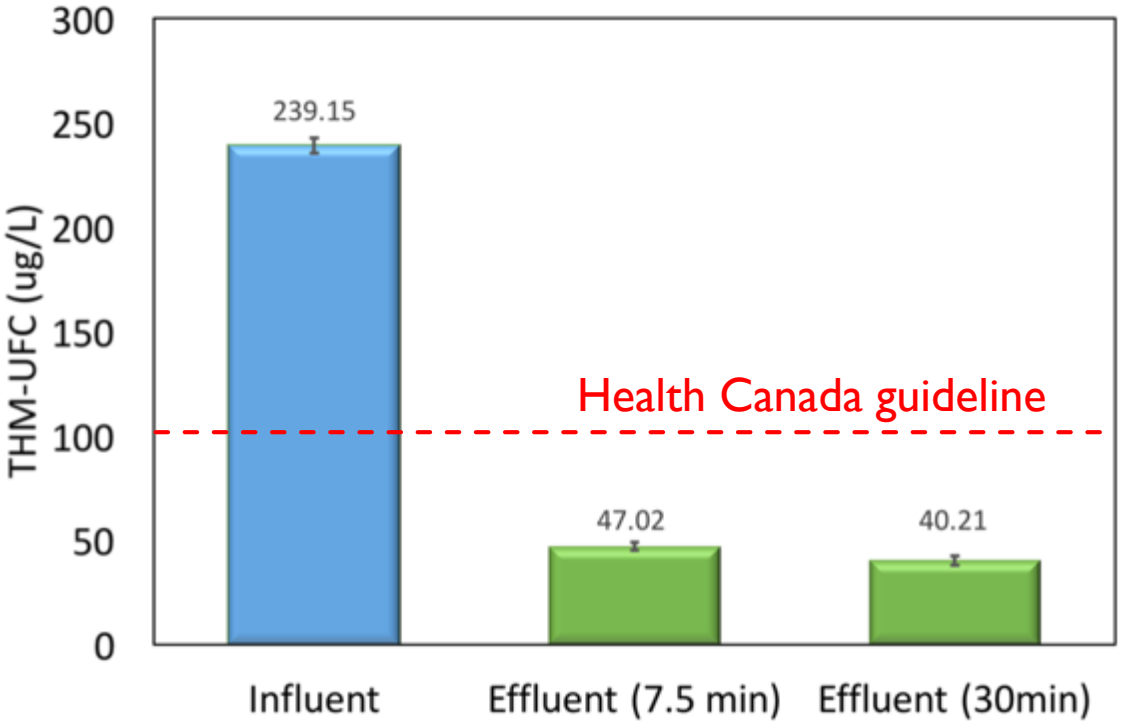
6,912 BV

DOC (30 min) = 1.1 mg/L



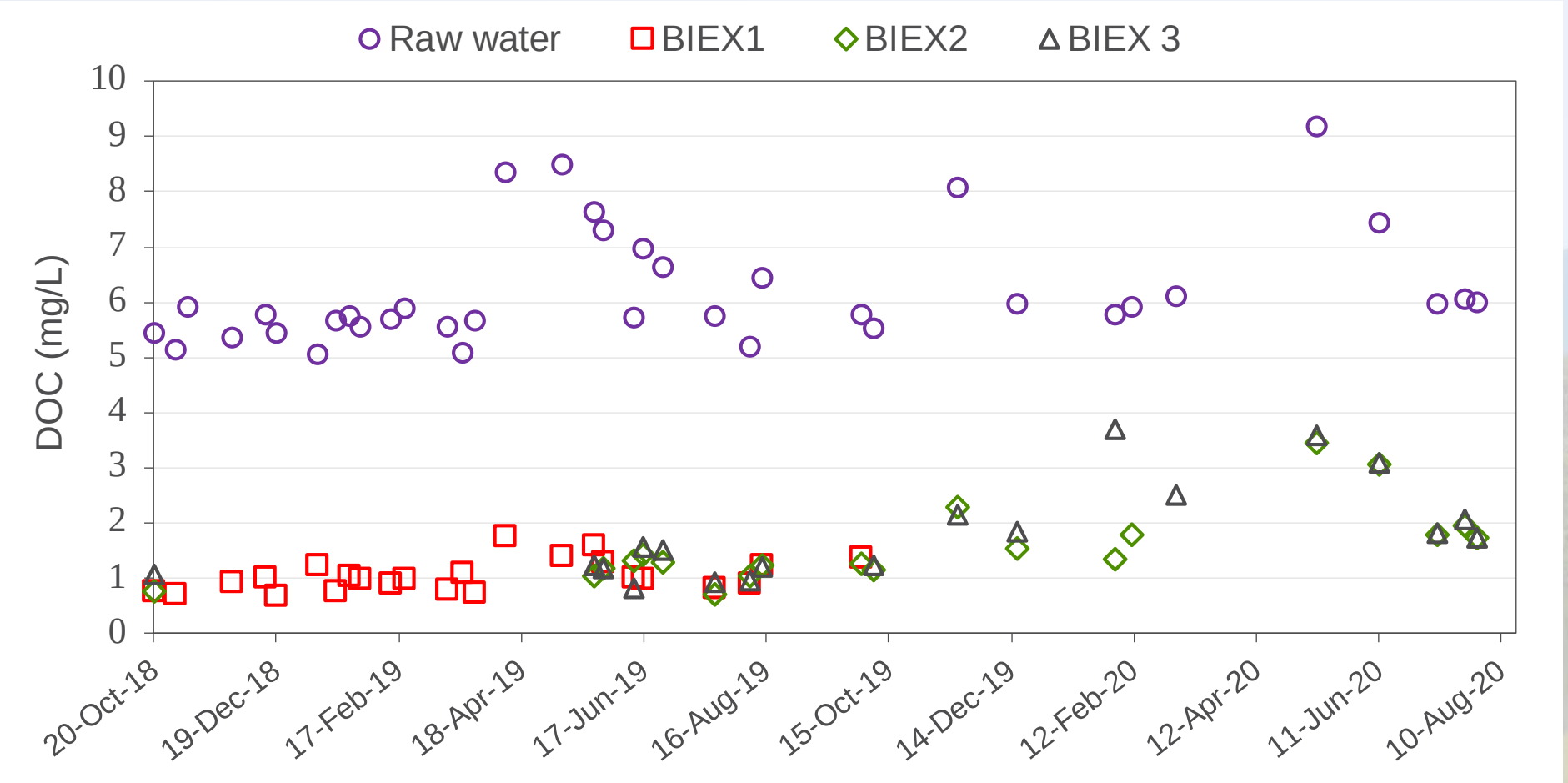
13,296 BV

DOC (30 min) = 1.7 mg/L




IX241

MIDDLE RIVER SYSTEM EXCEEDING EXPECTATIONS



- Full scale system installed fall 2018
- Three BIEX tanks = variable capacity
- DOC removal > 80%
- No regen “required”
  - (but done 1x / year, when operator available)

BIEX CONTRIBUTED TO BWA REMOVAL

Summary & Conclusions

Summary & Conclusion

- BIEX proved superior to GAC for organics removal
  - Greater than 50% DOC removal, even after the primary IEX process (e.g., resin exhaustion)
  - It can be operated without regeneration for few to several months, depending on water quality and operational conditions
- THM formation in the BIEX treated water was significantly lower than that in the influent
- Sulphate in raw water can contribute to extending the operational life of the BIEX

Stop regenerating your IEX systems!!*

- They will keep working! (*in most cases)

Acknowledgements

UBC

RESEAU
centre for mobilizing innovation

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SUSTAINABLE WATER AND INNOVATION RESEARCH LAB

POLYTECHNIQUE MONTRÉAL
WORLD-CLASS ENGINEERING

Indigenous Services Canada

GILLIES BAY
IMPROVEMENT DISTRICT

Tl'azt'en Nation

Thank you!
Questions?