TREATMENT OF IMPACTED WATER FOLLOWING THE LAC-MÉGANTIC CATASTROPHE

Presented by

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ENVIRONMENTAL SERVICES INC.

REMTECH
ENVIRONMENTAL SERVICE ASSOCIATION OF ALBERTA

Banff, October 16, 2014

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LAC-MÉGANTIC, JULY 6TH 2013

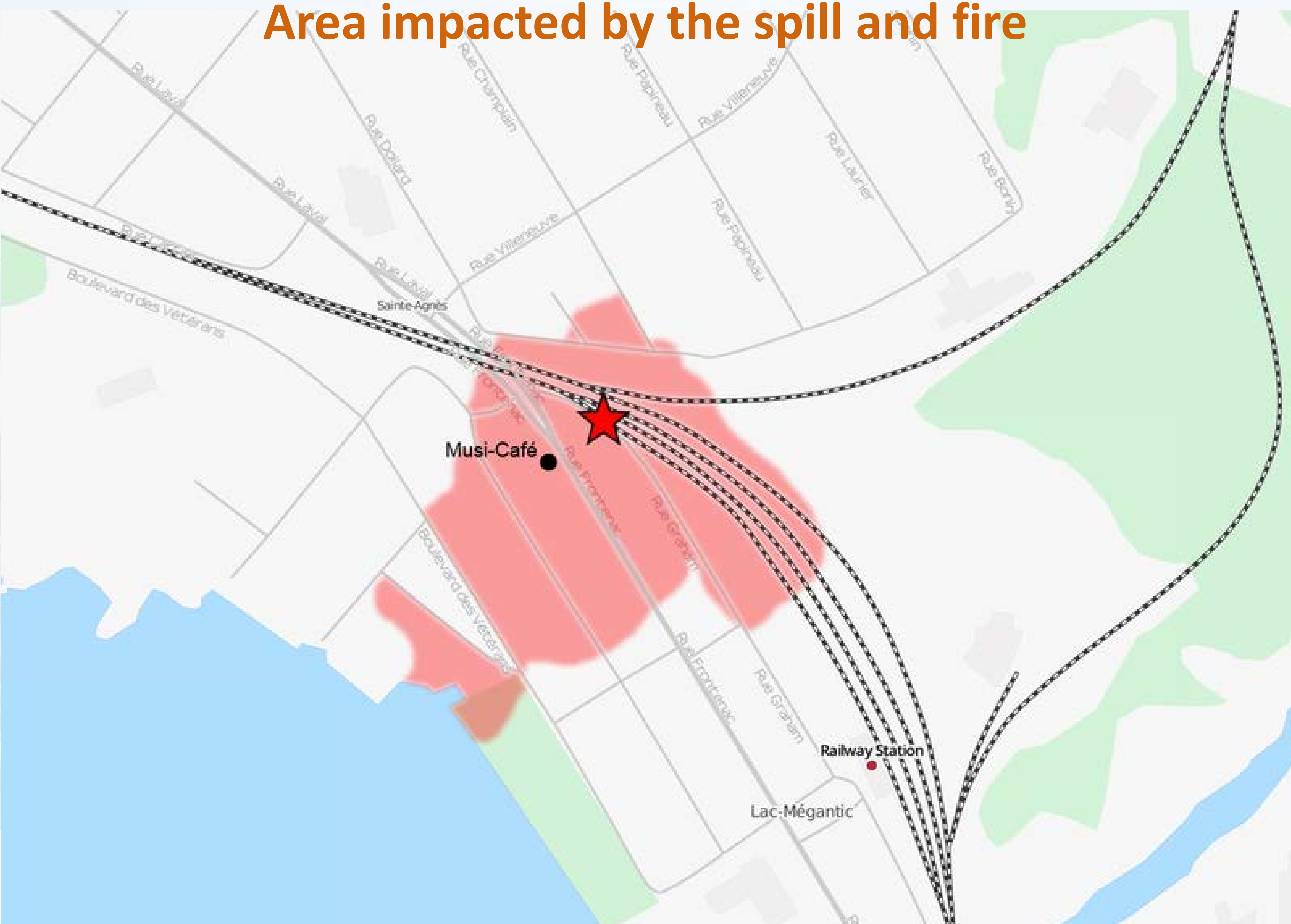
72 tank cars, carrying 8 million liters of light crude oil were involved in the train derailment

Pictures from *La Presse*


NATX 310470
CAPY 30070 US GAL
CAPY 113800 L
1267
NATX 310470
PC

A large part of the downtown area was razed by the fire

Area impacted by the spill and fire



Booms deployed near the shore to contain the oil

EMERGENCY RESPONSE
WATER TREATMENT

- **MOBILIZATION AND SET UP**
- **TREATMENT OF 43 MILLION LITRES OF LIQUIDS RECOVERED FROM THE DERAILMENT SITE (WATER, CRUDE OIL AND SLUDGES) FROM JULY TO DECEMBER 2013**

Locations with respect to Mégantic Lake and the Chaudière river

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The operation of the municipal wastewater treatment plant was interrupted to prevent the release of oil to the Chaudière river

A thick foam caused by the fire fighting agents covered the 1 million liters of water

Treatment at first of the municipal wastewater laden with the spilled crude oil to allow recommissioning of the facility.

Mobilization of equipment to treat up to one million litres per day

Mixture of water, crude oil and sludge recovered at the derailment site


Incoming water
Partially treated water
10/07/2013 14:19

Baker tank (green) used to receive the water and mobile water treatment unit (white, 200 m^3/day) mobilized on July 8th

Water pumped to the mobile unit after settling

View inside the mobile unit

Larger Water Treatment System were set up in the days that followed

Activated sludge basin put back in service after one week of treatment

FILTRATION MEDIA DELIVERED IN 1 m^3 BAGS

Large filters erected for the removal of colloids and soluble organics, each with a throughput capacity of 400 m^3/day

A fleet of tanker trucks was used to transfer the liquids from the red zone to the water treatment area

90,000 LITERS BAKER TANKS WERE USED TO RECEIVE THE LIQUIDS AND FOR A FIRST SEPARATION

IN THE FRONT, BAKER TANKS FOR INTERIM STORAGE AND PRE-TREATMENT (COAGULATION/FLOCULATION) OF INCOMING WATER

6 m^3 sand/anthracite filter for the removal of suspended solids and oil

400 m^3/day Ultrasorption™ filters

Basin with level controlled pumps to transfer water from the Ultrasorption™ units to the adsorption units

400 m^3/day adsorption units

DISCHARGE OF TREATED WATER

CHARACTERISTICS OF THE WATER

- **Water was collected from sewers, basements, surface drainage, slicks confined by booms, cooling and washing operations, etc.**
- **The water received contained unburnt crude oil, pyrolyzed oil, soot and ashes, soil particles, fire fighting foams, burnt debris, etc.**
- **Initially, high concentrations of VOCs (half masks were worn initially because of benzene)**

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Incoming water

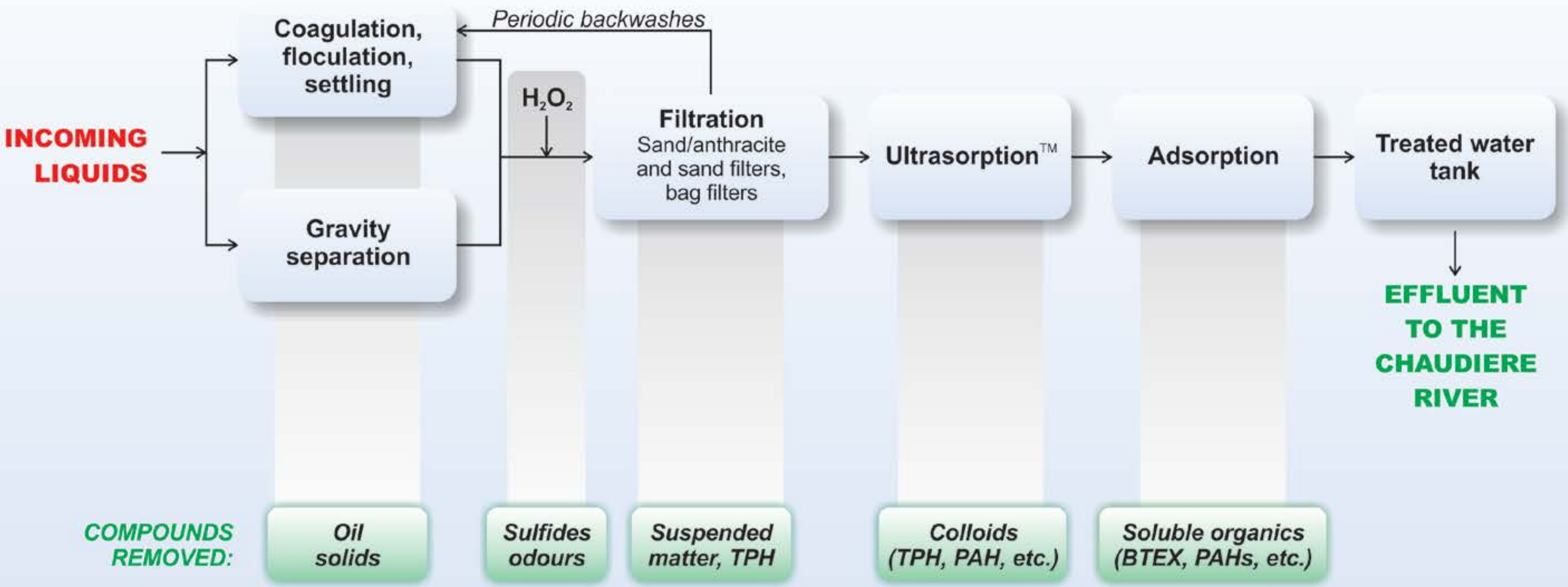

14/07/2013 10:16

Varying water characteristics and oil/solids content for every shipment

TREATMENT PROCESS AND PERFORMANCE

- **PROCESS SCHEMATIC**
- **TREATMENT OBJECTIVES**
- **INITIAL CONTAMINANT CONCENTRATIONS**

TREATMENT SCHEMATIC - Processes used



***Notes:** Three treatment trains operating in parallel*
Operation 24/7
Filter media replaced as necessary

RA13-310-1-04.cdr

MAIN CONTAMINANTS TARGETED

- **C_{10}-C_{50} PETROLEUM HYDROCARBONS (Objective of an average of < 1 mg/L)**
- **MONOAROMATIC HYDROCARBONS (MAHs)**
- **POLYAROMATIC HYDROCARBONS (PAHs)**
- **TOXICITY (Rainbow trout, Minnow, Daphnia Magna) (no acute toxicity)**

First day of treatment

Results of July 9th

Parameter	Units	Raw Water	Treated Water	Removal efficiency
PH (C_{10-50}) *	mg/L	980	< 0,1	> 99,99 %
Benzene	µg/L	620	< 0,1	> 99,98%
Toluene	µg/L	880	< 0,1	> 99,99 %
Ethylbenzene	µg/L	155	< 0,1	> 99,9 %
Xylenes	µg/L	1 600	< 0,1	> 99,99 %
Styrene	µg/L	3,8	< 0,1	> 99,7%
Other VOCs	µg/L	ND	ND	-
Naphtalene	µg/L	ND	ND	-
Σ PAH	µg/L	ND	ND	-

*: 15 mg/L oil and grease x 0,7 for conversion in PH (C_{10-50})

n. d.: Not detected

-: No value

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Concentrations 5 days later

Results of July 14th

Parameter	Units	Raw Water	Treated Water	Removal efficiency
PH ($C_{10\text{-}50}$) *	mg/L	42,7	< 0,1	> 99,8%
Benzene	µg/L	568	< 0,3	> 99,9%
Toluene	µg/L	741	< 1	> 99,9%
Ethylbenzene	µg/L	103	< 0,3	> 99,7%
Xylenes	µg/L	827	< 1	> 99,9%
Styrene	µg/L	< 20	-	-
Other VOCs	µg/L	-	-	-
Naphtalene	µg/L	32,9	1,2	96,4%
Σ PAH	µg/L	62	1,2	98%

* :	15 mg/L oil and grease x 0,7 for conversion in PH ($C_{10\text{-}50}$)
n. d. :	Not detected
- :	No value

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Average concentrations
First 10 days of operations

Parameter	Units	Average concentrations		Removal efficiency
		Pre-treated water	Treated water	
C10-C50 PHs	mg/L	28*	0,7	97 %
MAHs	µg/L	1472	1,5	99.9 %
PAHs	µg/L	44	0.5	99 %

* Excluding the water of the first day that contained 980 mg/L

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FLUOROSURFACTANTS

- **PFOA :** Perfluoro-octanoic carboxylic acid ($C_7F_{15}CO_2H$)
- **PFOS:** Perfluoro-octane sulfonic acid ($C_8F_{17}SO_3H$)
- and other fluorinated organic compounds (PFAS, Polyfluoroalkyl substances)

- Persistent compounds, with a potential for bioaccumulation and with effects on human health
- Oleophilic and hydrophilic compounds used in some fire fighting foams

REMOVAL OF AFFFs

AFFF: Aqueous Film Forming Foam (for fire fighting)

PFOA and PFOS now targeted as contaminants to be controlled in Canada

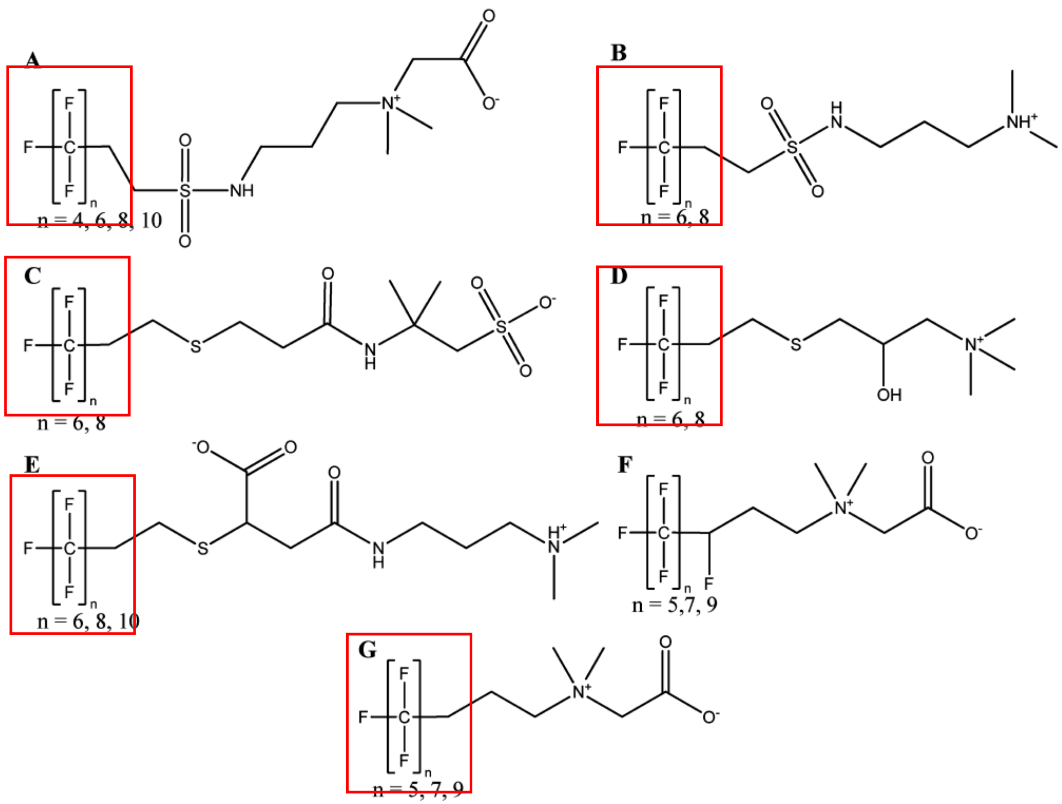
Removal rate in water of 80-99 % of AFFFs compounds possible with the technologies used

Concentrations and removal rates verified by the team of Dr Jinxia Liu at McGill University; the slides that follow were prepared by them in the context of a joint R&D project

McGill

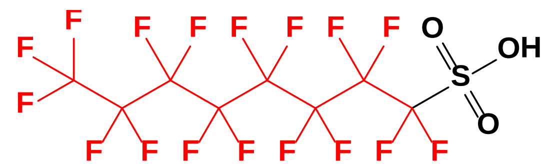
PFAS in Telomerization-Based AFFFs

<u>Fluorinated surfactants deemed “safe”</u>

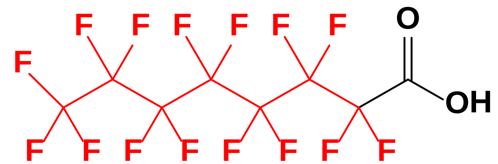


(*Place and Field 2012, ES&T)*

<u>Phased-out surfactants</u>



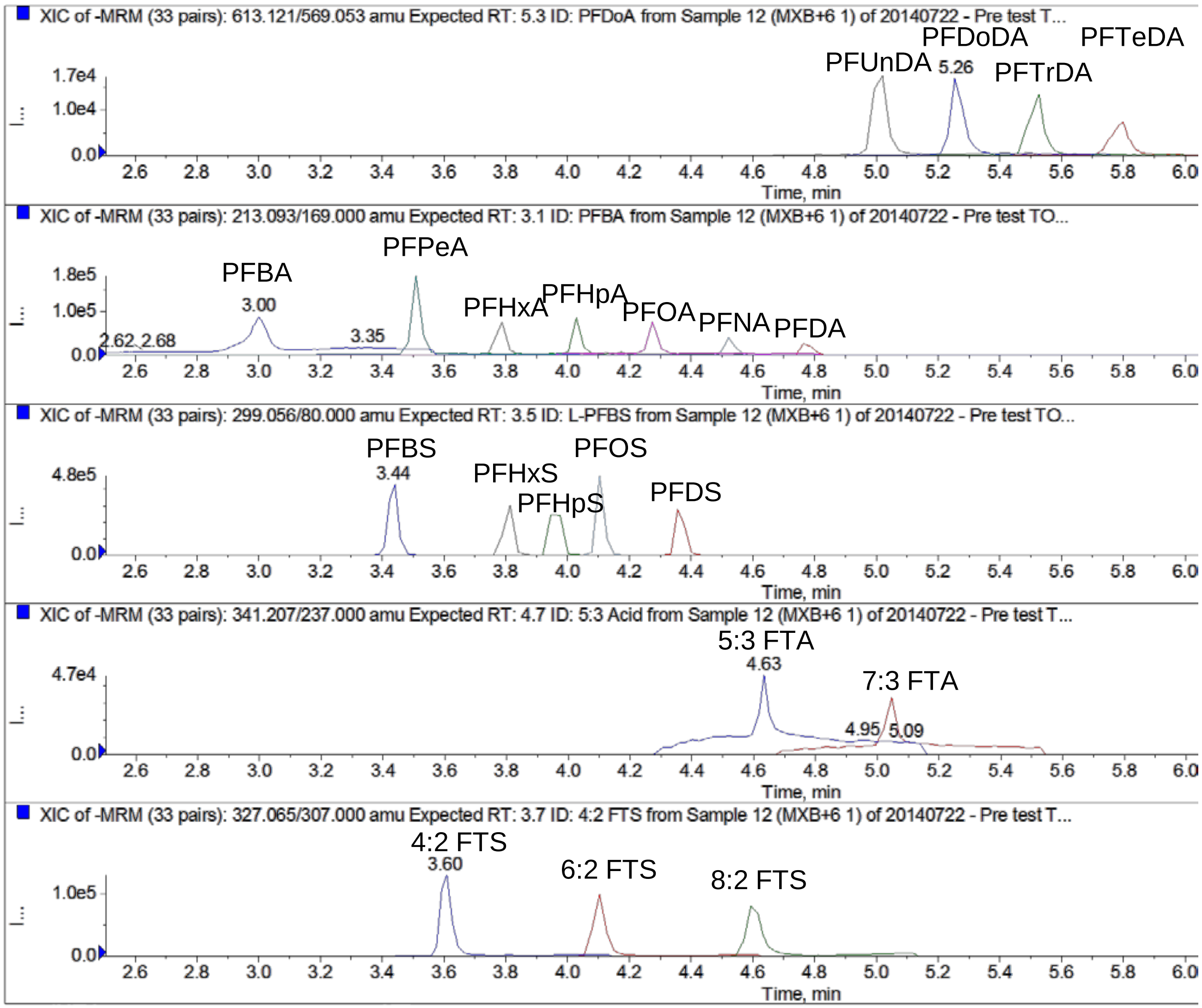
PFOS



PFOA

PFAS: Poly/perfluoroalkyl substances

LC-MS/MS Method
Individual PFAS compounds



1 ng/ml standard solution was used to demonstrate the excellent resolution of the 21 target compounds. Note that this result was achieved within the same run.

Sample Collection

Sand Filter → Ultrasorption® Filter → Activated carbon Filter

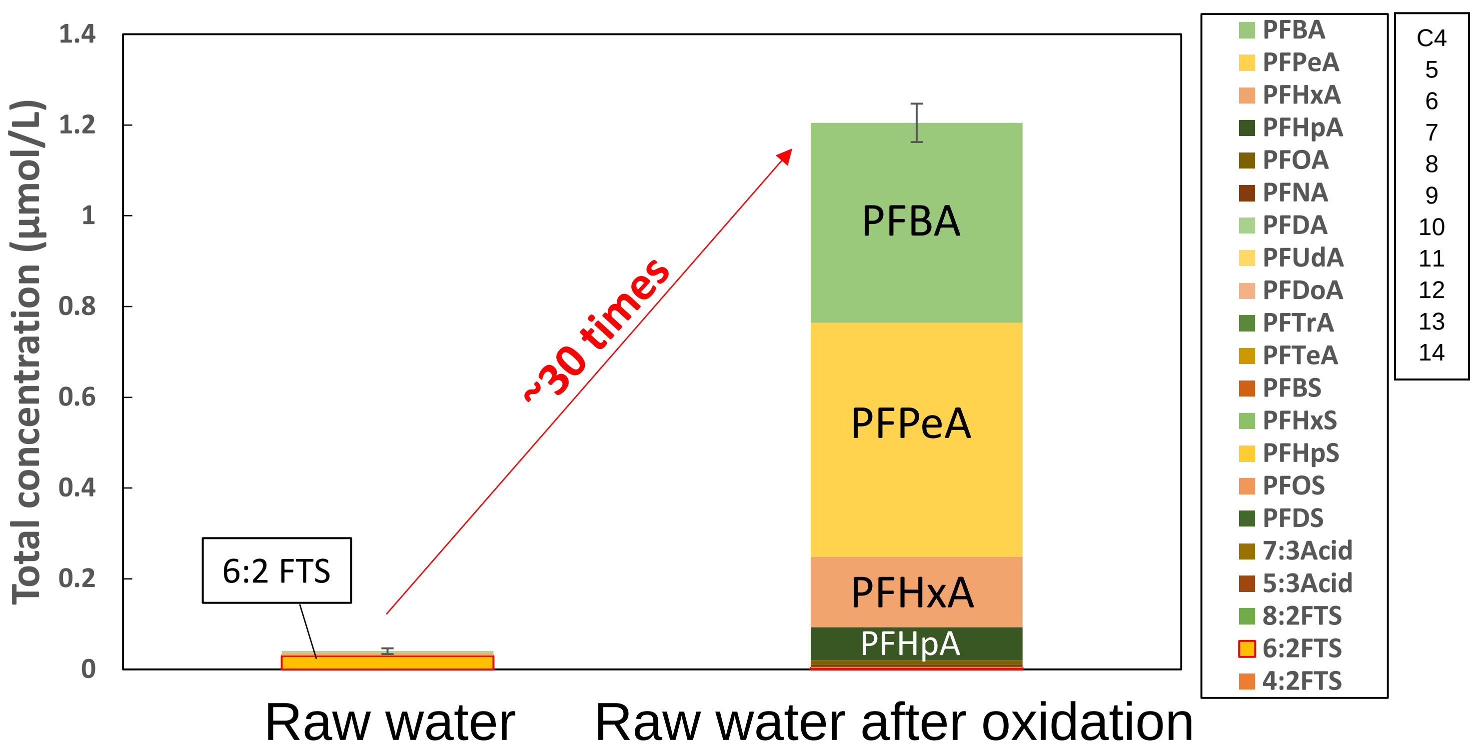
Small filtration system

Large filtration system

Sand/Anthracite Filter → Ultrasorption® Filter → Activated carbon Filter

Total PFAS in the Raw Water before/after Persulfate Oxidation

- Most of the PFAS in the AFFF-impacted water are not directly measurable
- Persulfate oxidation is required for AFFF sample quantitation



Raw water sample and the same sample treated by TOP. (n=3)

Removal Efficiency

Removal rate of each filtration stage:

$$\frac{\text{Lqiox hqw\#Fr qf hqwudwlr q}}{\text{Hiiox hqw\#Fr qf hqwudwlr q\#}}\%$$

Small system:

Overall Removal rate*

Stage	Removal rate
Sand Filter	0 %
Ultrasorption® Filter	36 – 52 %
Activated carbon Filter	86 – 97 %
Overall	90 – 98 %

Large system:

Overall Removal rate

Stage	Removal rate
Sand/Anthracite Filter	31 – 32 %
Ultrasorption® Filter	16 – 46 %
Activated carbon Filter	77 – 99.8 %
Overall	87 – 100 %

* Rates are respectively for the removal of directly quantified PFAS and of total PFAS

DRINKING WATER PROTECTION

PFOS ≤ 0.3 µg/L (Health Canada); ≤ 0.2 µg/L (US EPA)

PFOA ≤ 0.7 µg/L (Health Canada); ≤ 0.4 µg/L (US EPA)

The raw water contained only a low concentration of these two compounds (0.5 µg/L of PFOA, no PFOS) and about 17 µg/L of compounds in the PFAS family;

The treated water contained 0.1 µg/L of PFOA and 1.2 µg/L of PFAS compounds.

With a river to effluent flowrate ratio of 3200 to 1 and with the removal efficiency obtained, AFFFs were therefore not a concern in this project.

CHALLENGES

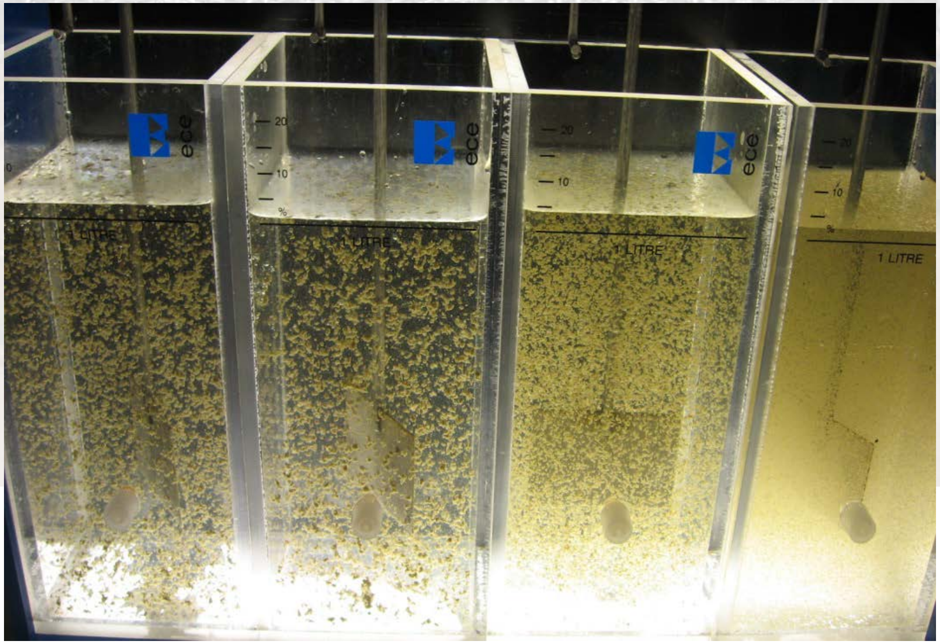
- The changing quality of the incoming water
- Getting rapid results for continuous discharge
- Surfactants playing with the chemistry of the contaminants
- Logistics of 24 hour/day, 7 days/week work three hours away from our base
- Not knowing what comes next

Coagulation/floculation tests conducted to identify how best to clarify the water in the pre-treatment step

The characteristics of the liquids received were highly variable.

Different selection of products and injection rates would ideally have been required from one day to the next.

The pre-treatment step could not be optimal and the subsequent filters had to perform better than usual to meet a good quality of effluent.




Occasional batches with
high concentrations of
surfactants

Work 24/7 during the first two 2 months

… in all sorts of weather

SOLUTIONS

- Use of an unconventional process (Ultrasorption™) to help deal with surfactants and colloids
- Overdesign; not trying to optimize things on a batch per batch basis; use a compromise as a coagulation recipe; operate with long residence times
- Use of a UV photo-ionizer to check the quality of the water
- Using turbidity and surface tension as indicators that treatment is either adequate or incomplete
- Use of local people to work with experienced Sanexen technicians
- Work very closely with suppliers

Field assessment of water quality

- Certified laboratories located 3 hours away from the site
- Turbidity used as a prime indicator of water quality
- PID used to quickly assess residual hydrocarbon concentration in water and to assess when filtration media had to be replaced
- Water odour used to adjust the injection rate of hydrogen peroxide
- A zeta meter would have been useful to adjust coagulant dosage

Test kits to verify water quality

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Surfactants make treatment more difficult, but turbidity is a good indicator of water quality

Prior experience helps …

TREATMENT OF 140 MILLION LITERS OF CRUDE OIL LADEN WATER UPON THE REVERSAL OF THE SARNIA-MONTREAL CRUDE OIL PIPELINE

Thanks to the other organizations involved

Government of Quebec
Municipality of Lac-Mégantic
MDUN, Solvarec and RSR Environnement
McGill University

Thanks to our suppliers and sub-contractors

Canada Colors & Chemicals
Quatrex, Chemco, Durpro and A.C. Carbone
AGAT, Exova and Maxxam
Rollex, Pompes Ultra, Équipement Terra
Transport Robert
and others

Thanks to our employees

(who worked long hours away from their families)

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Questions?   Discussion?

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