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Performance of the Randle Reef Treatment Plant: A Case Study

Marc Laliberté

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WATER TECHNOLOGIES

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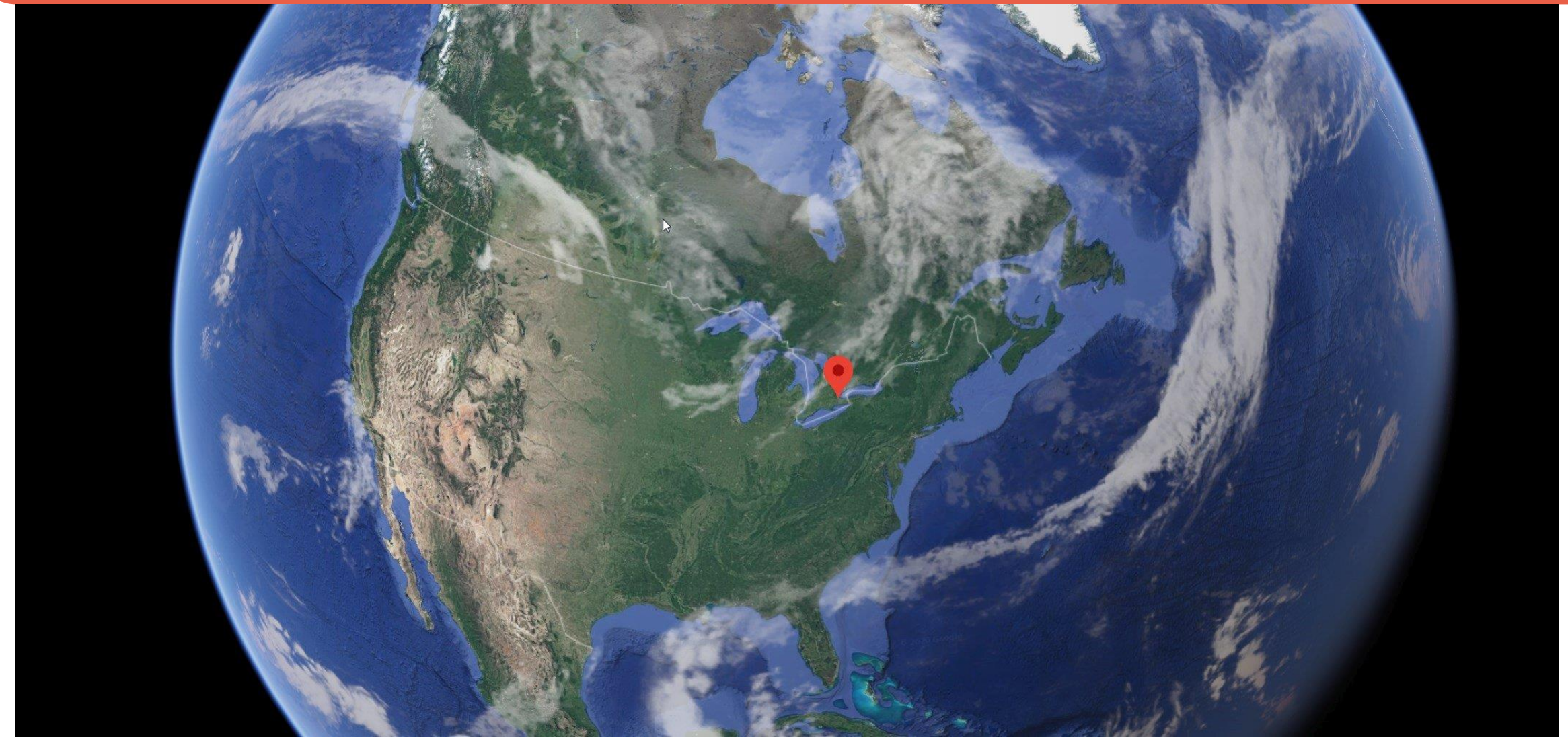
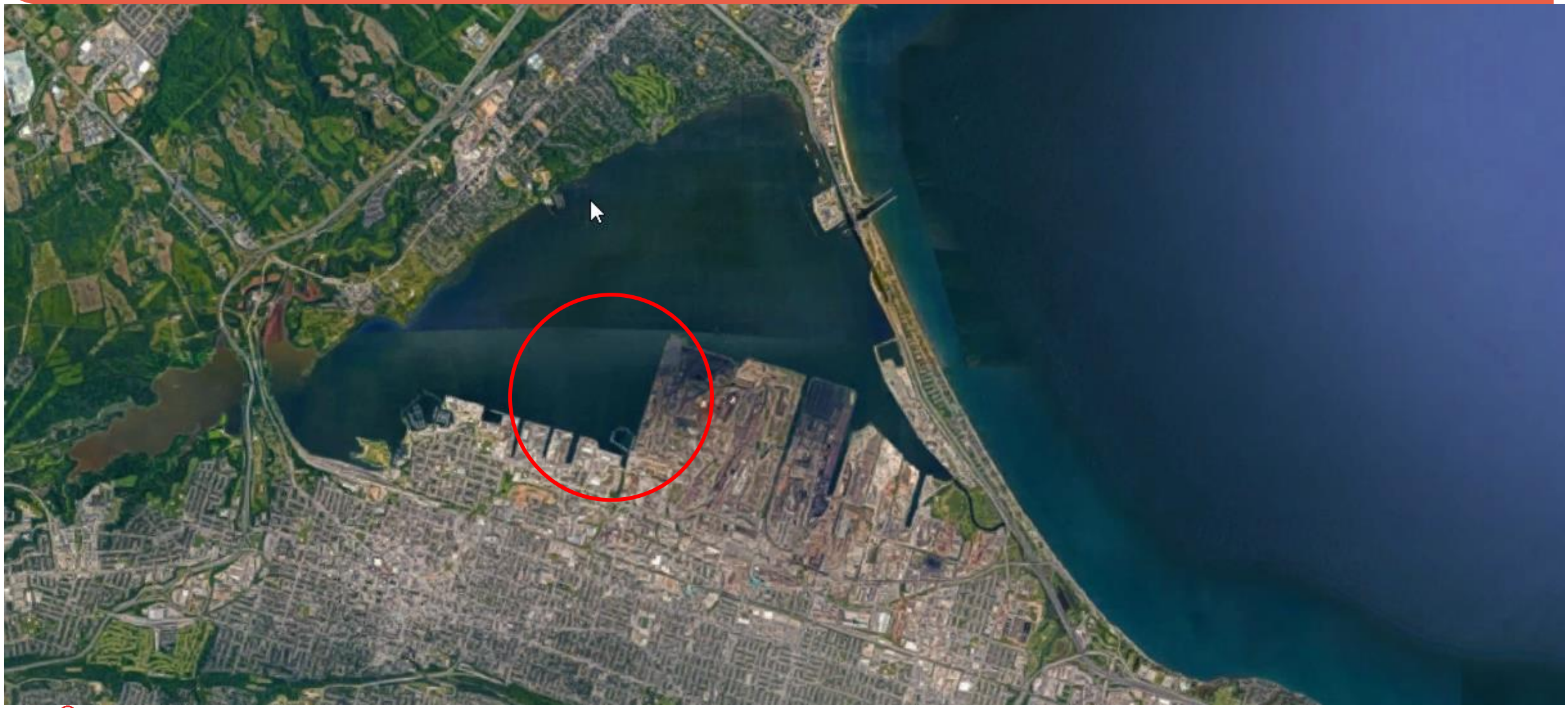
Hamilton Harbour is home to the largest and most contaminated site within the Canadian side of the Great Lakes – Randle Reef.

Hamilton



Hamilton Harbour



Randle Reef

Randle Reef - Context

- Approximately 60 hectares (or about 120 football fields)
- 695 000 m^3 of sediment contaminated with polycyclic aromatic hydrocarbons (PAHs) and other toxic chemicals.
  - *Largest PAH-contaminated sediment site on the Canadian Great Lakes.*
- PAH contamination at Randle Reef is a legacy of a variety of past industrial processes dating back to the 1800s.
- Multiple sources of contamination including coal gasification, petroleum refining, steel making, municipal waste, sewage and overland drainage.

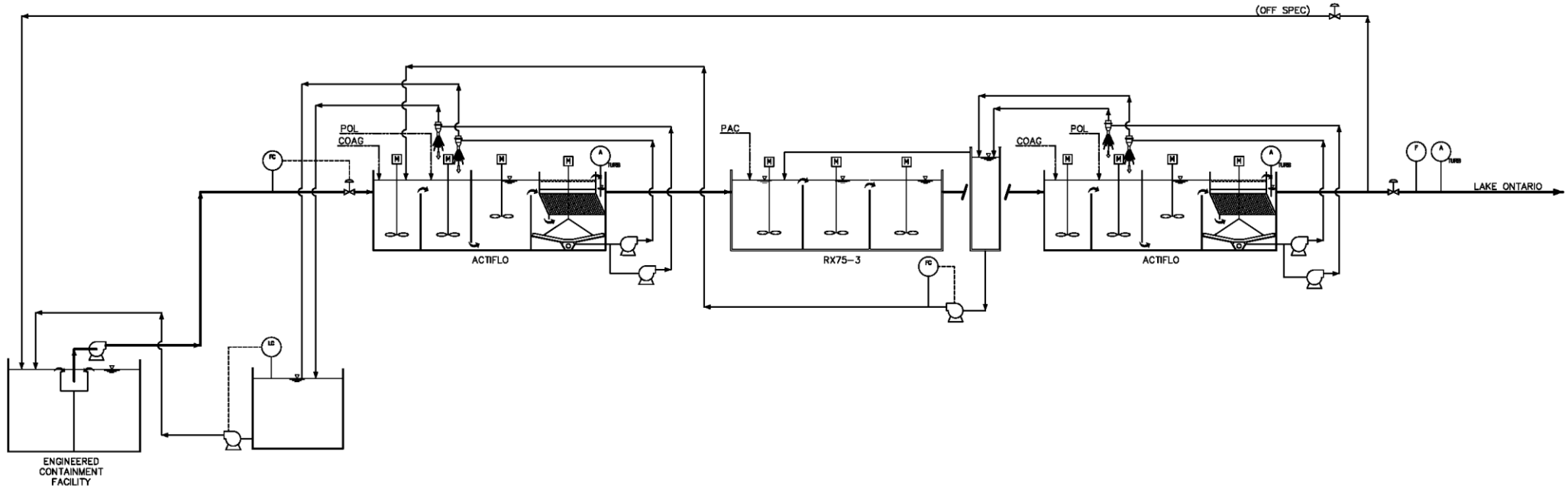
Randle Reef – the Project

- Site was identified as a principal target of Harbour restoration objectives in the late 1980s.
- Construction of a 6.2 hectare engineered containment facility (ECF) on top of a portion of the most contaminated sediment
- Dredging and placing the remaining contaminated sediment in the facility
  - *Excess water need to be treated before being discharged back in the harbour*
- Sediment will then be covered by a multi-layered environmental cap.

Our Solution

Process

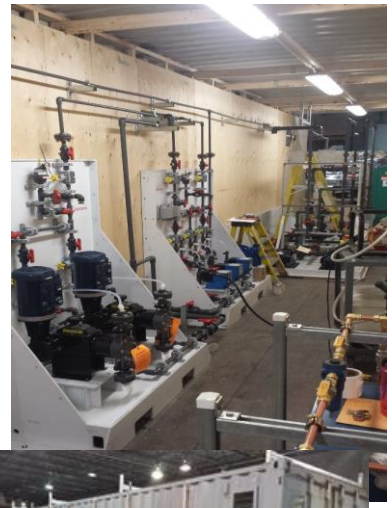
- Removal of TSS and metals using sand ballasted flocculation (ACTIFLO)
- Removal of PAHs and organics using powdered activated carbon (ACTICARB)
- Spent PAC, metals and TSS returned to the ECF



Construction

September 2017

DETAIL DESIGN & PREFAB



February 2018

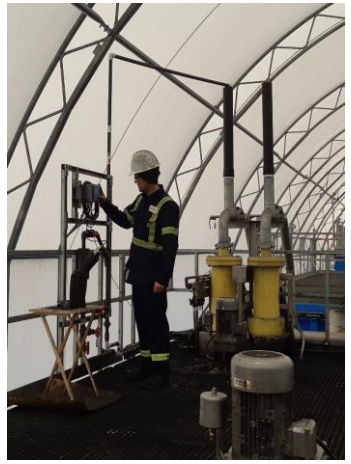
START OF CONSTRUCTION

May 2018

START OF COMMISSIONING

August 2018

START OF OPERATION



Construction

- Treatment plant designed to be dismantled easily once treatment is completed
- Plant is not operated in winter
  - *No dredging once ice is present*

Results

Available data

- Three years of operation, over a thousand samples taken and analyzed for
  - *Macro parameters (pH, TSS, Turbidity, Dissolved organic carbon)*
  - *Metals*
  - *Poly aromatic hydrocarbons (PAH)*
- Criteria generally in the chronic toxicity range
- Most samples taken on the effluent but enough samples taken on the raw water and between the first (ACTIFLO) and the second (ACTICARB) stages to evaluate the performance of the system

Statistical info

- Many results below detection limit
  - *Results below detection limits have been replaced by half the detection limit value*
  - *Impact the calculation of the averages*
- Results reported using the median and the 98th centile
  - *Minimizes the impact of the « detection limit » issue*
- Removal are calculated using median values

Results – macro parameters

	pH		Total Suspended Solids / mg/L		Turbidity / NTU		Total Organic Carbon / mg/L	
	Median	98th centile	Median	98th centile	Median	98th centile	Median	98th centile
Criteria	6 to 9		15		-		-	
Raw Water	7,96	8,20	18	199	26	151	4,9	5,7
After ACTIFLO	8,03	8,23	2,8	6,0	1,3	2,1	4,0	5,2
After ACTICARB	7,47	7,9	2,1	5,4	0,7	2,4	2,0	3,1
1st stage removal	Not calculated		85,0%		95,1%		17,4%	
2nd stage removal	Not calculated		23,6%		48,0%		50,2%	
Overall removal	Not calculated		88,5%		97,4%		58,9%	

Results – Selected Metals (1 of 2)

	Aluminium / µg/L		Iron / µg/L		Lead / µg/L		Zinc / µg/L	
	Median	98th centile	Median	98th centile	Median	98th centile	Median	98th centile
Criteria	75		300		25		30	
Raw Water	360	2580	950	11 200	10	157	57	848
After ACTIFLO	220	340	40	70	0,4	0,8	2	8
After ACTICARB	10	35	170	270	< 0,05	0,2	3	8
1st stage removal (TSS = 85,0%)	37,8%		96,2%		96,1%		95,9%	
2nd stage removal (TSS = 23,6%)	95,6%		-365%		84,9%		-39,1%	
Overall removal (TSS = 88,5%)	97,3%		82,2%		99,4%		94,3%	

Results – Selected Metals (2 of 2)

	Arsenic / µg/L		Cadmium / µg/L		Nickel / µg/L		Selenium / µg/L	
	Median	98th centile	Median	98th centile	Median	98th centile	Median	98th centile
Criteria	100		0,3		25		-	
Raw Water	1,39	5,81	0,123	1,909	2,69	10,51	0,27	0,53
After ACTIFLO	1,12	1,44	< 0,005	0,057	2,13	3,64	0,28	0,36
After ACTICARB	0,53	0,83	< 0,005	0,023	2,37	4,00	0,13	0,23
1st stage removal (TSS = 85,0%)	19,8%		98,0%		20,8%		-2,2%	
2nd stage removal (TSS = 23,6%)	52,5%		0%		-11,3%		54,3%	
Overall removal (TSS = 88,5%)	61,9%		98,0%		11,9%		53,2%	

Results – Polycyclic aromatic hydrocarbons (PAH)

	Anthracene / µg/L		Benzo (a) pyrene / µg/L		Fluoranthene / µg/L		Naphtalene / µg/L	
	Median	98th centile	Median	98th centile	Median	98th centile	Median	98th centile
Criteria	0,05		0,015		0,05		7	
Raw Water	0,138	2,615	0,036	1,483	0,62	6,87	2,78	228,3
After ACTIFLO	0,113	0,378	< 0,005	0,006	0,61	2,10	0,28	27,0
After ACTICARB	< 0,012	< 0,012	< 0,005	< 0,005	< 0,02	< 0,02	< 0,05	2,3
1st stage removal (TOC = 17,4%)	17,8%		> 93,0%		2,2%		89,8%	
2nd stage removal (TOC = 50,2%)	> 94,7%		Unknown		> 98,4%		> 91,2%	
Overall removal (TOC = 58,9%)	> 95,6%		> 93,0%		> 98,4%		> 99,1%	

Conclusions

Conclusion – Metals

- Aluminium and iron removal depends on whether they are used as a coagulant.
- Lead, zinc and (maybe) cadmium are removed as particulate
- Arsenic and selenium do not behave like particulate
  - *They are likely mostly dissolved*
  - *Removal depends on surface complexation on the iron floc, adsorption on activated carbon or both*
- Metals like nickel are not removed
  - *Nickel would require either a much higher pH or the addition of sulfide*
- In general, the performance of the system exceeds the discharge criteria

Conclusion – PAH

- PAH removal is difficult to establish because of limits of detection issues
- Some PAH behave like TSS and are probably bound to particulates
  - *Benzo (a) pyrene*
  - *Naphtalene*
- Some PAH are dissolved and are removed by activated carbon
  - *Anthracene*
  - *Fluoranthene*
- In all cases, criteria are easily met by the system

Other parameters

- Performance of the system was monitored for other parameters
- System works well for:
  - *Perfluorinated organic compounds*
  - *BTEX (Benzene Toluene Ethylbenzene Xylene)*
  - *Pesticides such as DDT and similar components*
  - *Many VOCs (Volatile Organic Compounds)*

Why did this work so well?

- Client did his homework and came up with a good project definition
  - *We knew what to target in designing the system*
- The technology is robust
- Good collaboration at the site from all parties involved
  - *Stuff happens, we're all there to get this working*

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Questions?
marc.laliberte@veolia.com

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