Aclarity

Electrochemical Advanced Oxidation Process Technology and Product

Julie Bliss Mullen, CEO
julie.mullen@aclaritywater.com
617-213-0760

Clean. Safe. Water.
aclaritywater.com

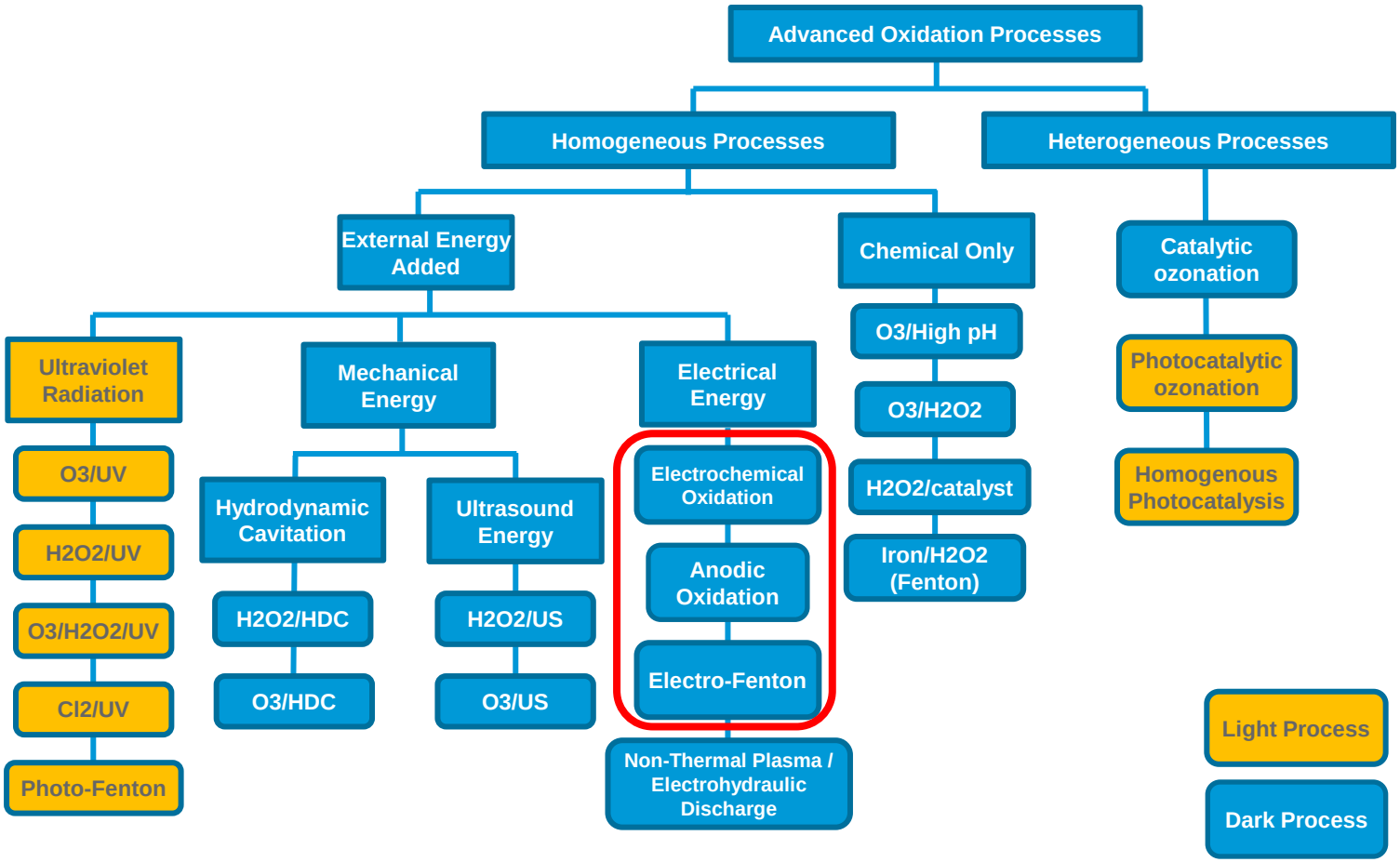
Aclarity - Background

- **Founded**
  - 2017– University of Massachusetts, Amherst
  - Julie Bliss Mullen & Barrett Mully
  - First commercial installations, sourced contract manufacturer
- **Financing**
  - Raised $700K from three Venture Capital firms
  - Awarded NSF SBIR Phase II for $1,000,000 + potential matching
- **Staffing**
  - 10 people
  - Hired Orren Schneider, Director of R&D, former American Water R&D
  - Hired Bud Dunbar, Judith Herschell Cole for business development and sales
  - Advisory Board

Aclarity

julie.mullen@aclaritywater.com

Electrochemistry is a Subset of AOPs



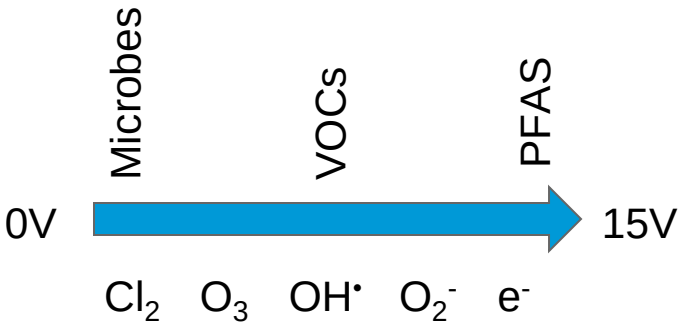
Source: Adapted from Sharma et al. 2011

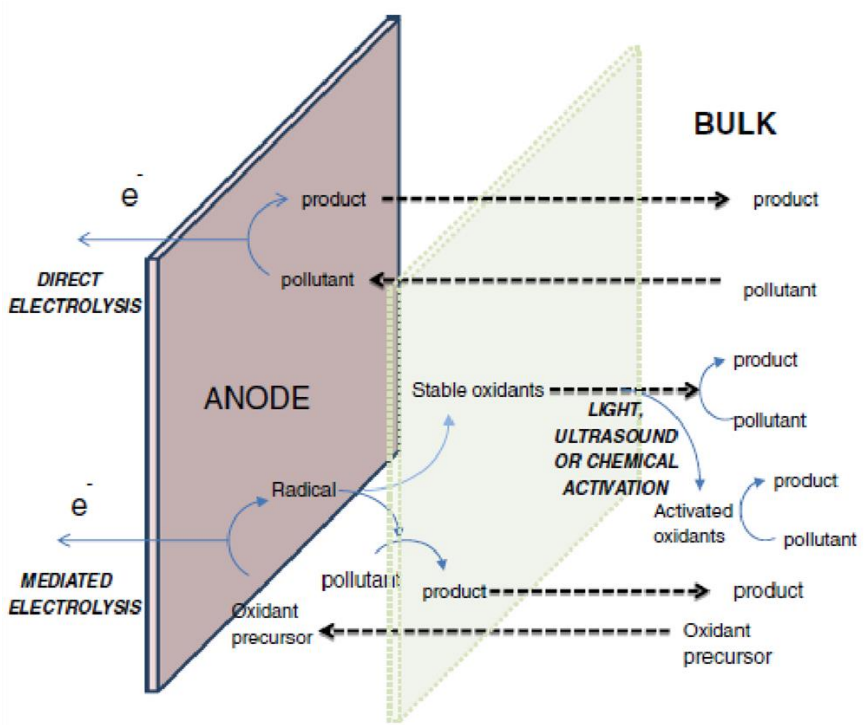
julie.mullen@aclaritywater.com

Electrochemical Advanced Oxidation (eAOPs)

- **Electrodes placed in water**
  - Heavy Metal Oxide Electrodes (SnO_2, Pt, TiO_2, IrO_2, etc.)
  - Boron Doped Diamond (BDD)
  - Graphite

- **Mixed oxidant production with increasing voltage**



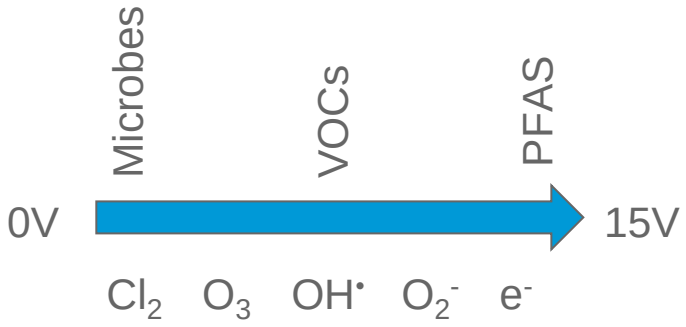


julie.mullen@aclaritywater.com

Aclarity AES has best performance and is cheapest on the market

- High oxidation potential
- Low energy
- Long-lasting electrodes (years)
- Less expensive electrodes
- No moving parts
- Low maintenance
- No chemical storage
- Modular, stackable
- Suitable for low and high flows

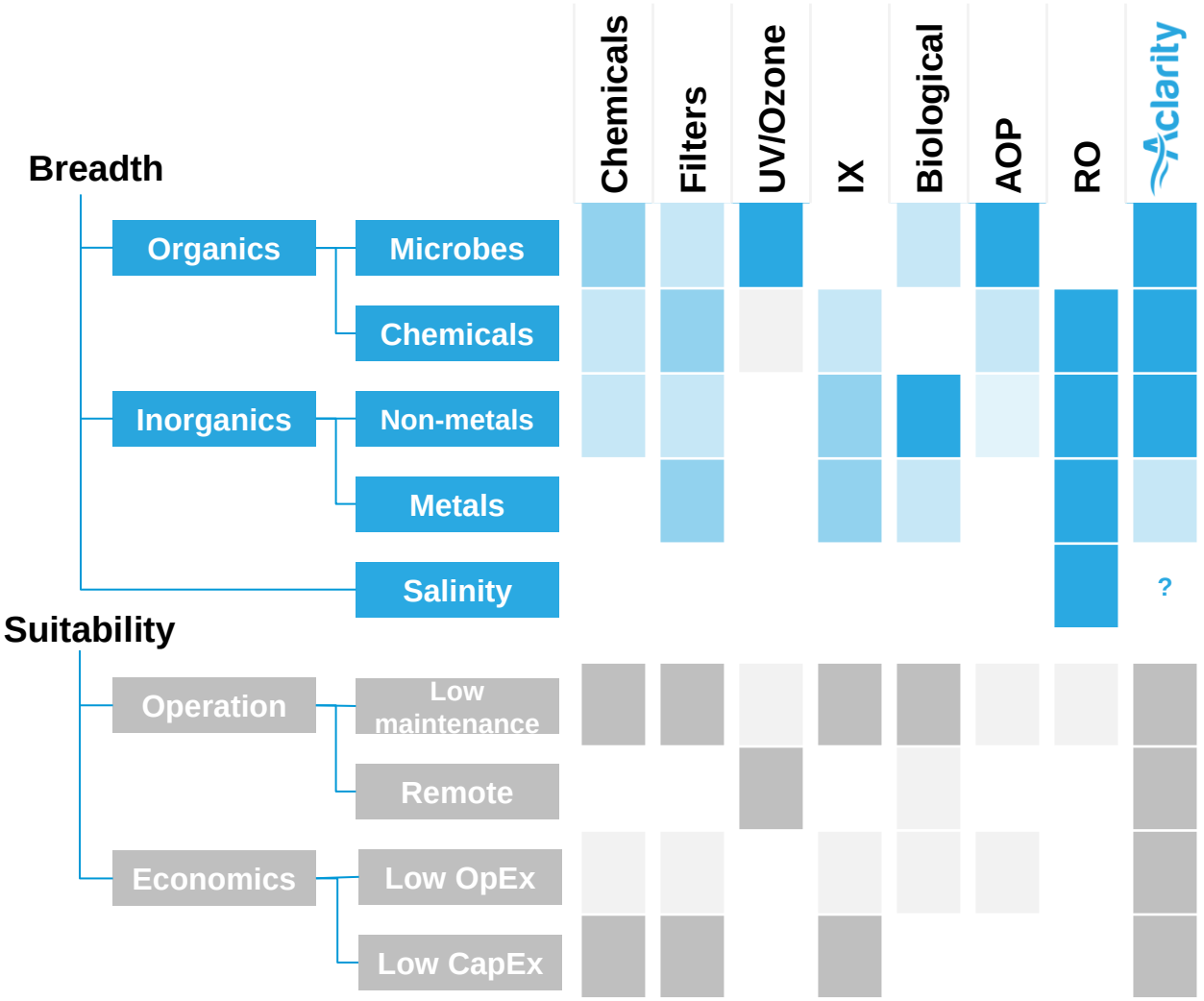
Electrode Material	Overpotential (V)
Aclarity	2.5+
BDD	2.2-2.6+
$Ti/SnO_2-Sb_2O_5$	1.9-2.2
Ti/Pt	1.7-1.9
IrO_2/Ta_2O_5	1.5-1.8
RuO_2/TiO_2	1.4-1.7



Aclarity

julie.mullen@aclaritywater.com

Breadth, ease of operation, robustness, and low cost outperform incumbents



Aclarity

julie.mullen@aclaritywater.com

Successful pilots in a variety of use cases

Organics

Inorganics

	Examples	Status	Case Studies
Microbes	Bacteria, virus, algae, cysts	✓ Live in field	NSF/ANSI P231 >6.4 log removal for bacteria and viruses Active municipal water system in Bamako, Mali
Chemicals	PFAS, VOCs, 1,4-dioxane, pesticides, pharmaceuticals, alcohols	✓ Field tested	Sizing 2 full-scale systems for automotive wastewater reuse Groundwater VOC pilot for municipal wells 15 pilots for PFAS contaminated water Partnership to sell skids for treatment of landfill leachate
Non-metals	Ammonia, nitrates, cyanide	✓ Field tested	Sizing full-scale system for ammonia treatment in dairy wastewater
Metals	Arsenic, hardness, iron	✓ Lab tested	TBD
Salinity	Sea water	-- Future device	TBD

Aclarity

julie.mullen@aclaritywater.com

Disinfection: NSF/ANSI P231 Challenge Test >6.3 log removal

Client ID	Flow Rate, in gpm	Voltage, in Volts	Current, in Amps	Oxidizer Concentration (DPD), in ppm		Bacteria (Raoutella terrigena)*			Virus (MS-2)		
				Influent Water	Effluent Water	Influent (cfu/mL)	Effluent (cfu/mL)	Percent Removal	Influent (pfu/mL)	Effluent (pfu/mL)	Percent Removal
Unit A Tested 01/15/2020	10.0	13.0	8.05	0.0	0.55	8.38E+05	<0.3	>99.99996% >6.3-log	8.75E+05	<0.3	>99.99996% >6.3-log
Unit A retested 01/17/2020	10.0	12.9	8.01	0.0	0.51	8.26E+05	<0.3	>99.99996% >6.3-log	8.43E+05	<0.3	>99.99996% >6.3-log

julie.mullen@aclaritywater.com

Example: Disinfection at small municipal plant

- Community system for drinking water disinfection
- Disinfected >6.3 log removal of bacteria and viruses at 10 GPM
- 0.5 mg/L Cl_2 residual with 100 mg/L NaCl, 130 mg/L TDS
- Verified by NSF/ANSI P231 third-party testing

Current best-in-class

$3K OpEx/year

- Chlorine storage for addition is needed
- Expensive yearly

Aclarity solution

$3K CapEx

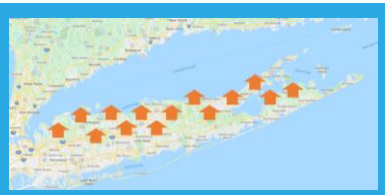
$200 OpEx/year

- In-situ disinfectants
- No waste produced or parts to change
- 10+ year lifetime
- >6.3 log removal of both bacteria and viruses at 10 GPM

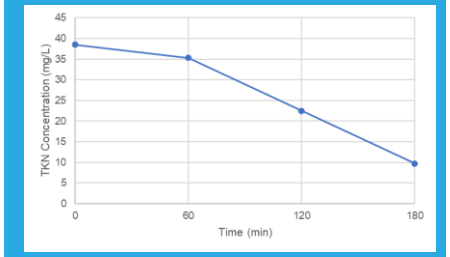
Aclarity

julie.mullen@aclaritywater.com

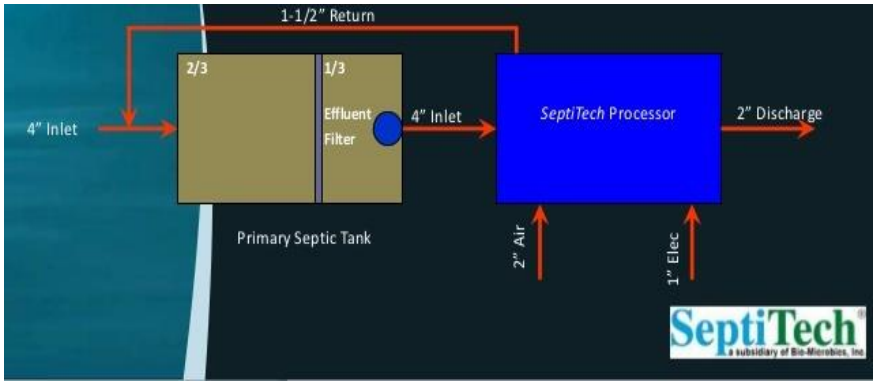
Example: Nitrogen pollution from septics on Long Island, Cape Cod



- Nitrogen seepage is killing surface water bodies
- Nitrates in drinking water, huge problem
- Massive subsidies to unsewered homes
- Current solution is not economic
- Each county needs technology approval



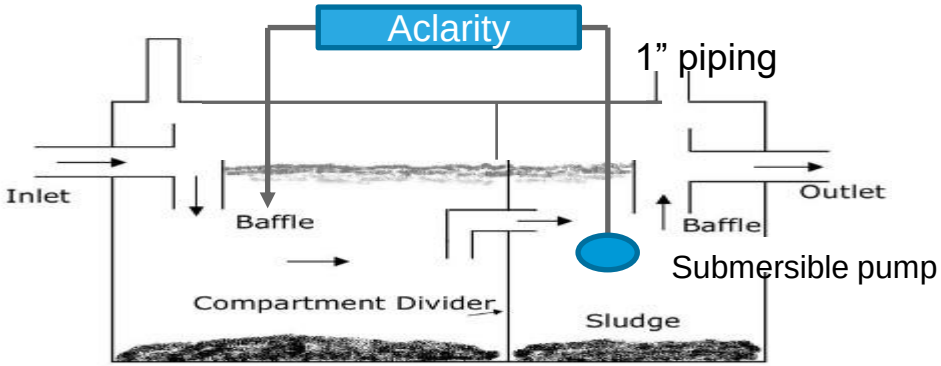
Current I/A OWTS's use nite/denite



$15-$20K CapEx,
$200/yr Electricity
$200/yr Maintenance

- Dig up yard to install
- Expensive
- Requires yearly maintenance

Aclarity solution



$5K CapEx
$200 OpEx/year

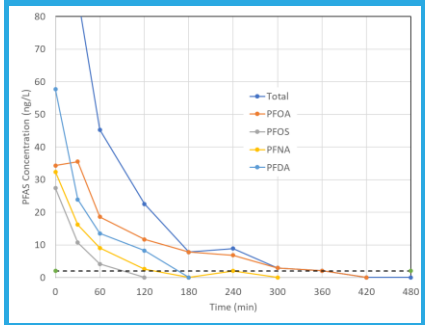
- External installation
- Affordable

Aclarity

julie.mullen@aclaritywater.com

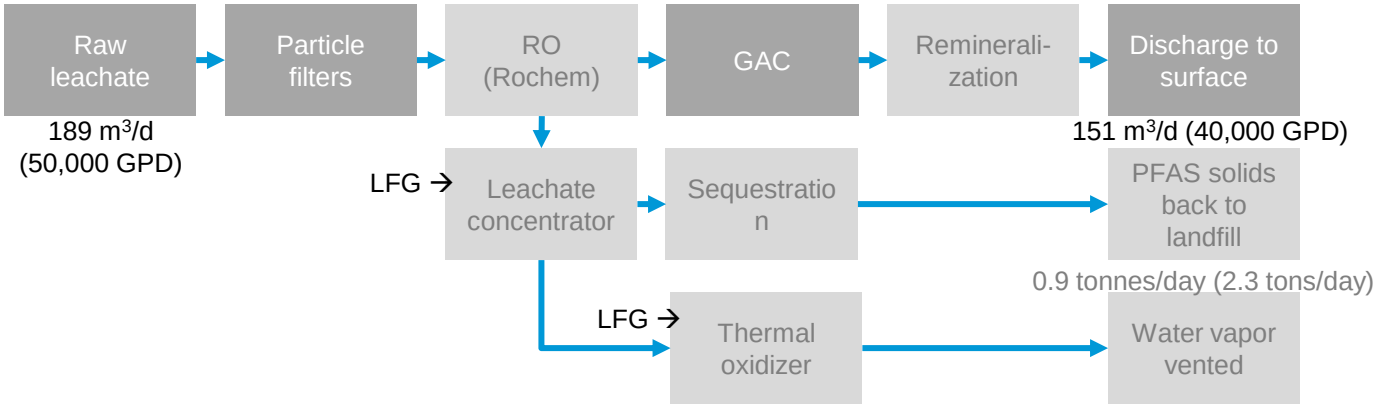
Example: PFAS destruction from landfill leachate

- Complex stream: PFAS, ammonia, etc.
- Existing treatment processes sequester contaminants
- Often far from treatment plants



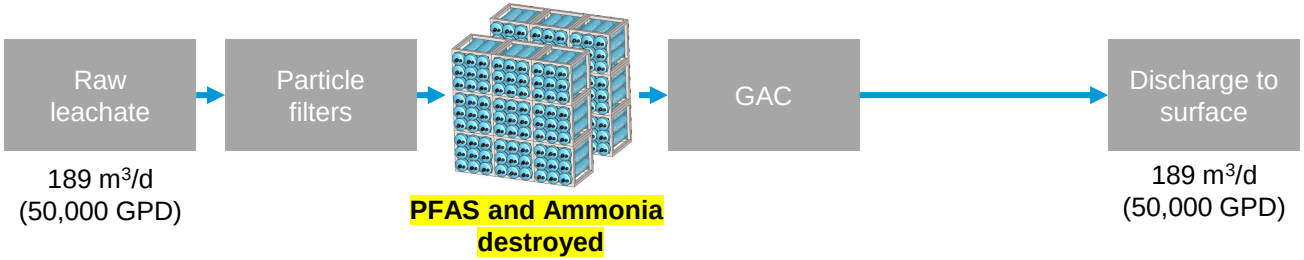
Current best-in-class

$17M USD CapEx
$900K USD OpEx/year



Aclarity solution

$5M USD CapEx
$450K USD OpEx/year



Source: Brown & Caldwell VT study, EPA LMOP database

julie.mullen@aclaritywater.com

PFAS in Drinking Water

PFOA pilot:

- Influent PFOA= 300 µg/L
- Treated via Aclarity Test System = 132 µg/L in closed loop for 80 minutes
- 66% removal
- 16V, 4 A= 62W
- 78 Wh/gal

Proposed method for PFAS destruction:

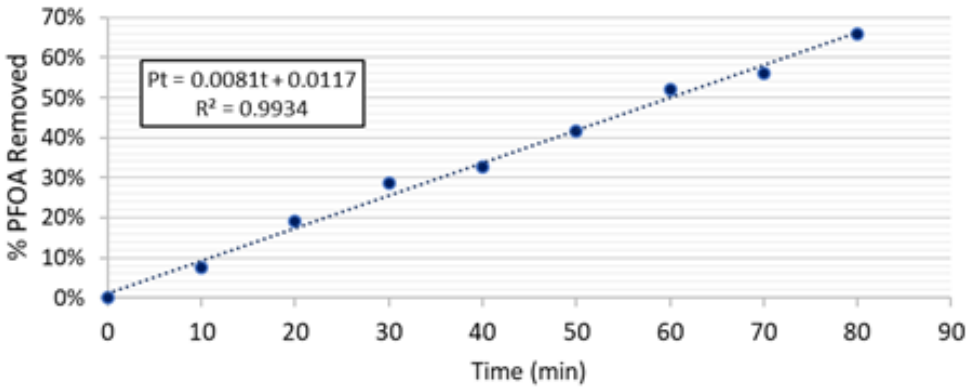
- C-F bonds broken by free electrons
- Fragments mineralized by $OH^{\bullet}$

Applications:

- IX brine treatment
- Military base remediation
- Municipal water streams

U.S. AIR FORCE

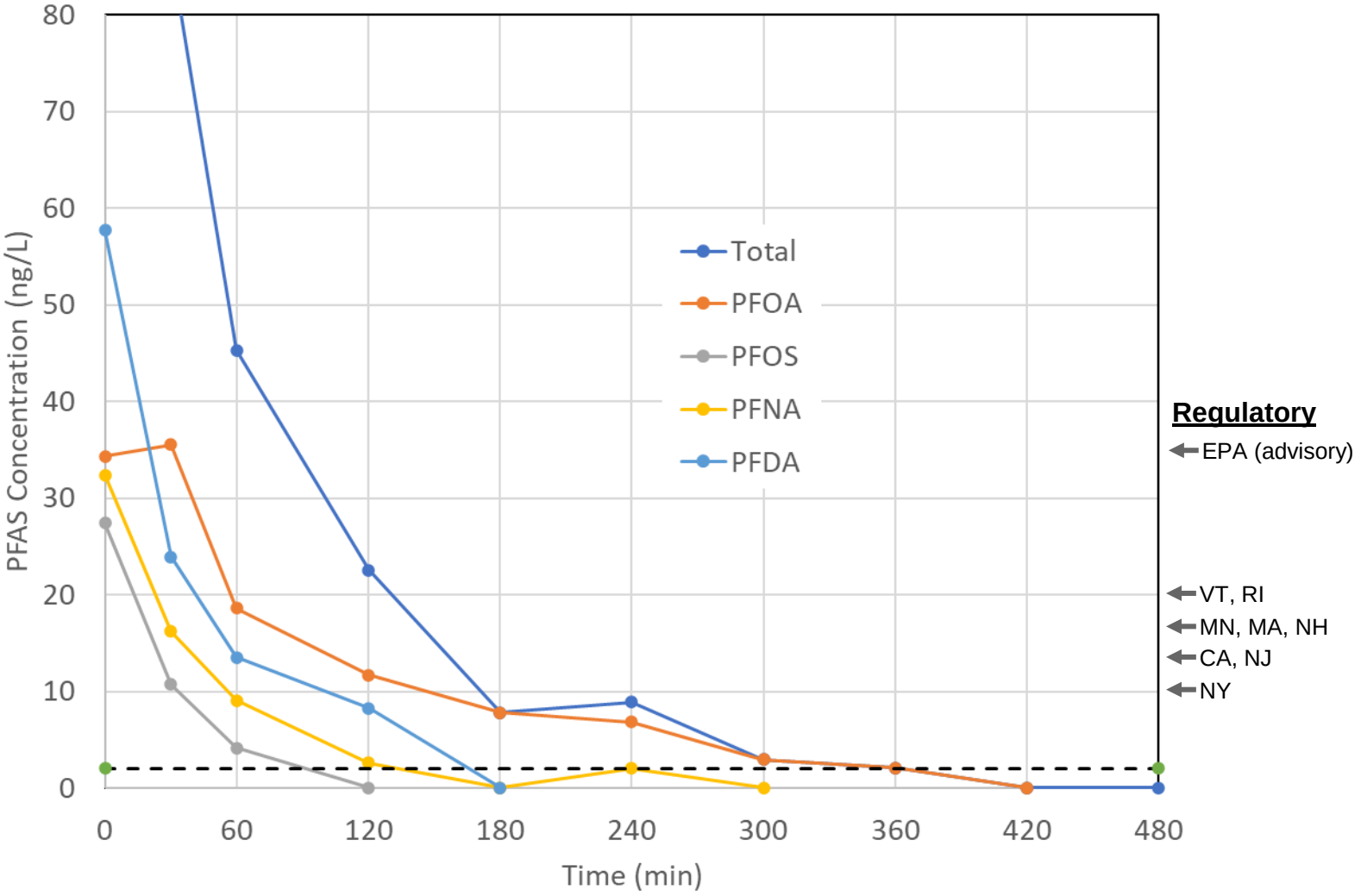
AMERICAN WATER



Aclarity

julie.mullen@aclaritywater.com

PFAS Destruction in ppt (ng/L) range



Source: Alpha Analytical (report 5/4/20 with Aclarity samples);
Bryan Cave Leighton Paisner, "State-by-State Regulation of Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water" (July 2019)
Note: EPA and MA levels are the sum of individual levels, shown here as the average allowed for each; median used if state has different limits for individual chemicals

julie.mullen@aclaritywater.com

Wastewater treatment applications

- **Aclarity eAOP directly converts Ammonia/TKN to Nitrogen gas**
  - Nitrification is the rate limiting reaction in aeration basins
  - Eliminating TKN could speed aeration to just BOD removal
  - Produces some nitrate, need to experiment with modulating voltage, reducing cathode catalysts, or flow into anoxic zone

- **Aclarity eAOP uses less electricity than UV to disinfect**
  - Produces 6 log disinfection vs 2.4 log for UV
  - No moving parts, titanium ceramic electrodes don’t burn out every year
  - Works in high turbidity, many plants struggle with this in UV
  - Replaces Advanced Oxidation Processes
  - Simultaneously destroys pharmaceuticals, contaminants of interest, and virtually everything else

- **Aclarity eAOP could destroy large molecules in cell membranes**
  - Break up large cell membrane molecules in biosolids, feed them back into AD, Increase biogas, decrease solids disposal

Aclarity

julie.mullen@aclaritywater.com

How we work with customers

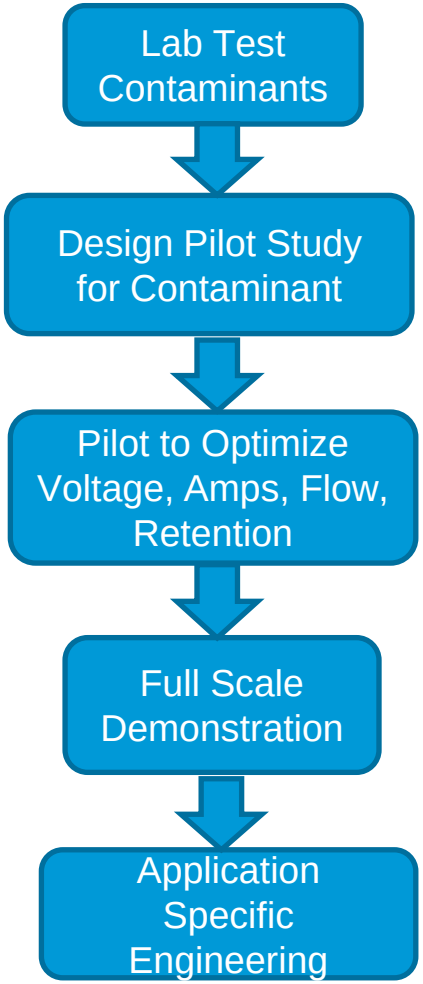
Find a site/champion to do the Pilot tests

- Break up cell membrane molecules in AD biosolids, recycle to AD, reduce solids disposal, increase biogas
- Convert TKN to N2 gas in screened primary effluent, eliminate/reduce aeration
- Replace UV for: disinfection, polishing

Use pilot test to find optimal volts, amps, flow, recycle rates, holding time (if any), confirm no biproducts

If pilot tests are successful, fund 1 MGD scale demonstration project, we'll help you find grants

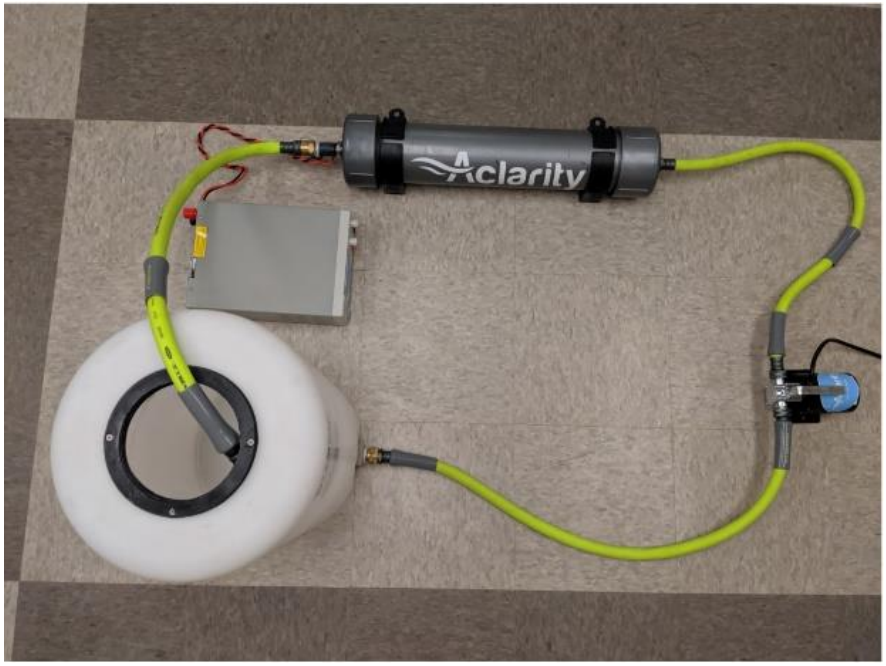
Specify product engineering for specific applications

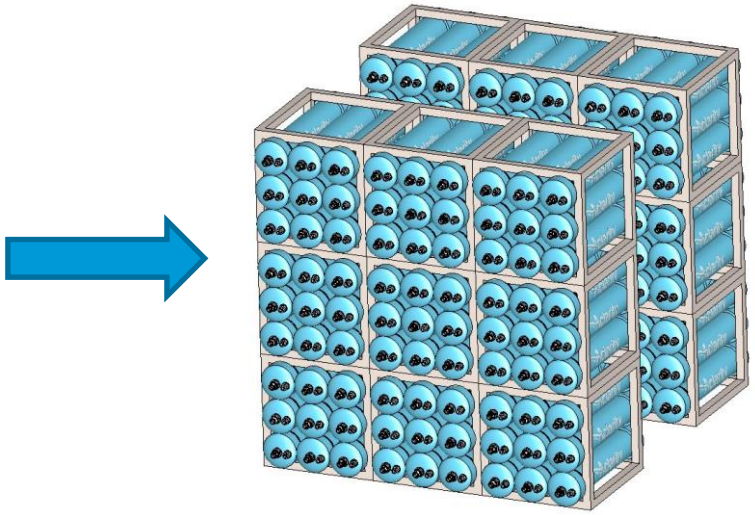


Aclarity

julie.mullen@aclaritywater.com

Aclarity Pilot Tests: Pilot to demonstrate Efficacy, optimize voltage, amperage, flow, retention time $6K, results (money back) guaranteed





Full Scale Implementation

Aclarity

julie.mullen@aclaritywater.com

Aclarity – Summary

1. Electrochemistry has the potential to become a disruptive technology
2. It generates the most powerful oxidants that break up molecules other technologies can't, e.g. PFAS, leachate brine, biosolids
3. This is a cost-competitive technology
4. It is highly flexible, changing voltage changes oxidant, changing amperage changes intensity
5. Three huge opportunities in municipal wastewater are: disinfection, ammonia/TKN, and biosolids
6. This is moving quickly. Aclarity has resources and partners to develop specific applications
7. Next phase of development - Economies of scale
8. Looking for pilot partners in these and other applications

Aclarity

julie.mullen@aclaritywater.com

Thank you!

Aclarity Contacts:

Julie Bliss Mullen, CEO
julie.mullen@aclaritywater.com
(O): 617-213-0760
(C): 774-551-6213

Bud Dunbar, AVP Sales
bud.dunbar@aclaritywater.com
(O): 617-213-0760
(C): 617-448-0440

https://aclaritywater.com