LOTIC TECHNOLOGIES INC

EC-AOP

Electro-Catalytic
Advanced Oxidation Process
Technology

Lotic Technologies

Innovative Environmental Solutions

«Water is our most Precious Resource»

Lotic Technologies was incorporated in 2015, and provides its patented, innovative environmental technologies to multiple industries and sectors. We manufacture our own equipment to the particular custom specifications of each projects' certain requirements.

Lotic is an environmental leader in water management and provides cutting-edge technology, while delivering expert solutions to problems – meeting clientele needs in a cost effective way and providing a positive impact on the environment.

Electro Catalytic AOP

What is it?

A Water Treatment System ideal for highly loaded, difficult to treat waste waters.

The Goal of this wastewater purification system is to maximize the reduction of organic contaminants, chemical contaminants, and overall toxicity of wastewater discharges to such an extent that the cleaned wastewater may be reintroduced into the environment.

Lotic's patented Electro Catalytic Advanced Oxidation Process ("AOP") produces four powerful oxidizing agents, which combine to breakdown, reduce, and remove residual organic compounds in waste streams at an accelerated rate.

Electro Catalytic AOP

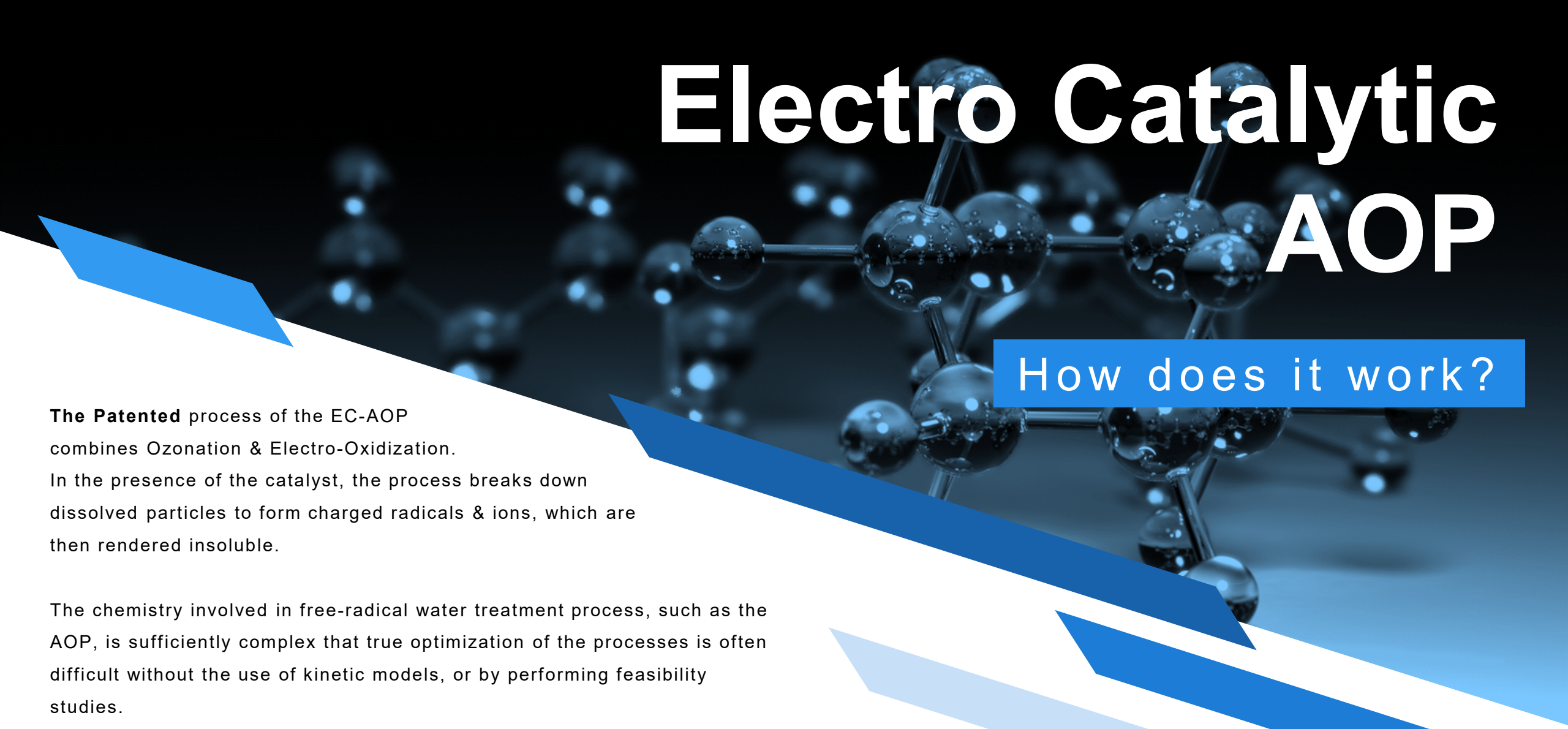
What are the advantages?

EC-AOP Units have a small footprint, are modular, and can be mobile.

This Product uses little-to-no-chemical, and requires zero hazardous clean-up or spill procedures. It can be used as a stand-alone system. Or can be used to enhance existing equipment, such as RO units and other filtration.

The EC-AOP system can decompose many hazardous chemical compounds found in water, without producing additional hazardous by-products, which requires additional handling. There are virtually no health, safety, spill or environmental concerns associated with the EC-AOP.

Electro Catalytic AOP



How does it work?

The Patented process of the EC-AOP combines Ozonation & Electro-Oxidization.
In the presence of the catalyst, the process breaks down dissolved particles to form charged radicals & ions, which are then rendered insoluble.

The chemistry involved in free-radical water treatment process, such as the AOP, is sufficiently complex that true optimization of the processes is often difficult without the use of kinetic models, or by performing feasibility studies.

The extremely high level of catalytic activity is comparable to related methods, such as supercritical water oxidization and wet-air oxidization.

Electro Catalytic AOP

How can it help?

The EC-AOP can help customers meet government compliance standards, and/or further reduce discharge fees.

Smaller volumes of sludge are produced, which are more shear resistant and easily dewatered. This is in contrast to chemically coagulated sludge, which generally have a high bound water content, and larger volume.

The sludge produced by EC-AOP units generally pass the US EPA's guidelines for Toxic Characteristic Leaching Protocol (TCLP). This is in contrast to chemically coagulated sludge which are generally unstable metal hydroxides that are classified as hazardous and must be disposed of in secure land-fills.

The Lotic EC-AOP Unit is

CUSTOM DESIGNED

Meeting Your Requirements

Custom-designed skid-mounted systems are made to fit space limitations. Specifications are manufactured according to the precise fluid chemistry. Fully automatic systems ensure simple operation, and easy service & maintenance.

Superior Results

The Lotic EC-AOP treats a wider range of organic pollutants than biological systems with no chemicals, has a faster reaction rate than biological systems, and treats inorganic pollutants while maintaining low energy consumption.

The Lotic AOP system can be customized for virtually any flow rate and volume of fluid.

HIGHLIGHTS

Of the EC-AOP Process

The Lotic EC-AOP requires minimal user manpower and service, since there are no moving parts. It also has the capability to treat fluid at a high volume & high rate capacity.

Recent tests have outperformed UV, chlorine dioxide, electrocoagulation and conventional biocides on cost vs. performance.

The Lotic EC-AOP unit allows a quick return on investment.

- Kills bacteria & pathogens by destroying cell walls
- Eliminates existing Hydrogen Sulfide (H2S)
- Oxidizes iron (Fe2) and heavy metals
- Reduces NORMS
- Eliminates or reduces BOD, COD & TOC
- Hydrocarbon & VOC removal
- Breaks down pharmaceuticals
- Breaks down pesticides
- Breaks down chlorocarbon, aromatics, phenolics, dyes, petroleum constituents
- Removal of suspended & colloidal solids
- Breaks oil/water emulsions – oxidizes and removes lower percentile oil constituents
- Removes fats, oils & greases
- Removes complex organics
- Reduces phosphates and nitrogen levels
- Achieves either total separation/precipitation of dissolved organics or achieves complete mineralization

The Main Objective of EC-AOP is to generate reactive Hydroxyl Radicals & Quasi Super-Critical conditions to enhance the oxidation and destruction of organic pollutants.

LET'S DIVE INTO SOME DETAIL

Electro Catalytic AOP

THE PROCESS

Electro Catalytic AOP

1. **Magnetohydrodynamic Pre-Treatment**
2. **Electro-Coagulation**
3. **Intense and Proficient Oxidation**

The Lotic EC-AOP unit manufactures its own ozone on-site. This is a necessity, since ozone has a half-life of 20 to 30 minutes.

Once created, the ozone is pumped into the AOP reactor, along with the fluid.

Ozone is a powerful oxidant

Oxidants can react with a variety of impurities such as metal salts, organic matter including micro organisms, hydrogen and hydroxide ions.

Creation of the key ingredient

Excess ozone is created in order to react with our electro catalyst in the reactor. The result of this reaction is the production of the main ingredient, hydroxyl radicals.

Oxidants break down

As reactions occur, the ozone and hydroxyl radicals naturally break down and produce hydrogen peroxide and atomic oxygen as by-products – two more oxidants. These components continue oxidation of the fluid.

Final Results

When reactions are complete, contaminants have been mineralized and oxidants have been degregated into H_2O, O_2 and CO_2.

Electro Catalytic AOP

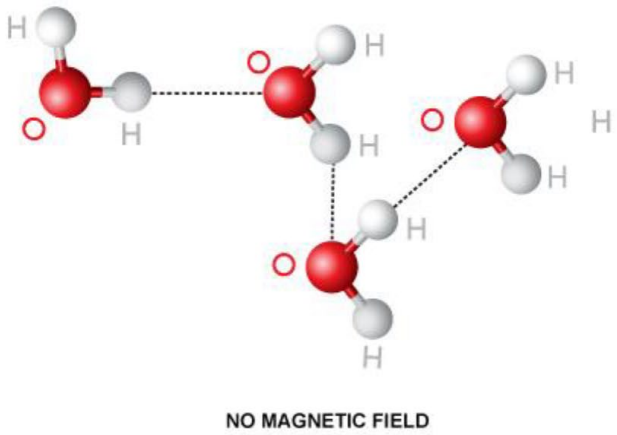
Magnetic Pre-Treatment

- **Increases Fluid Conductivity**
- **Alters Hydrogen Bonding**
- **Decreases Water Soluability**
- **Decreases Zeta Potential**

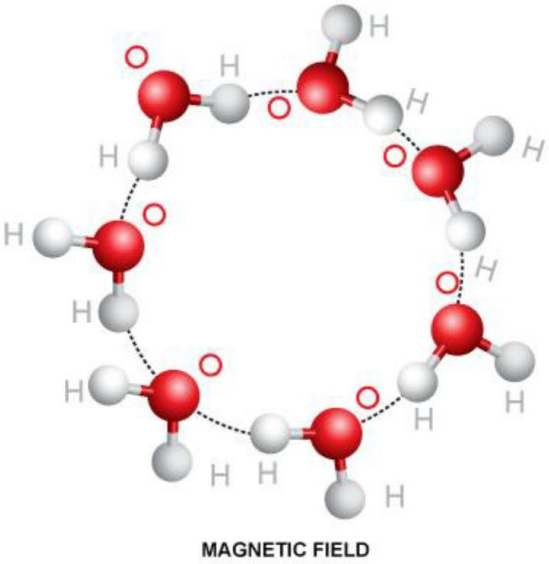
Magnetohydrodynamic Pre-Treatment allows significant changes to fluids on a molecular level.

These changes in fluid properties and behaviors as a result of exposure to magnetic fields is well documented, although our understanding remains superficial. Further in-depth study is ongoing with our Partners.

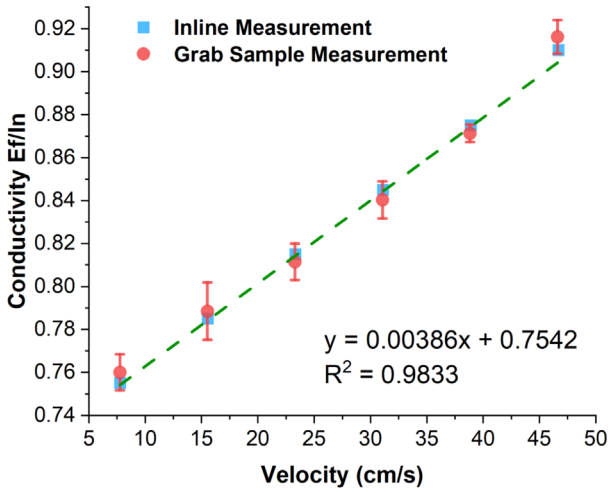
Effects from pre-treatment changes has persisted to at least 30 minutes from removal of the magnetic field.

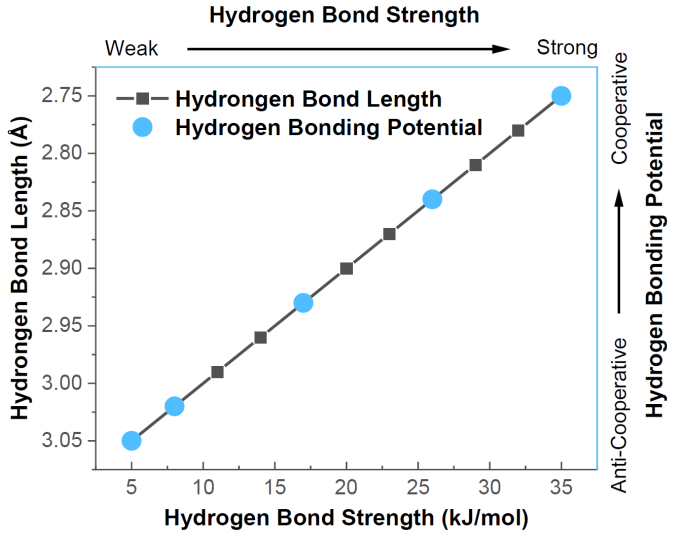


NO MAGNETIC FIELD



MAGNETIC FIELD



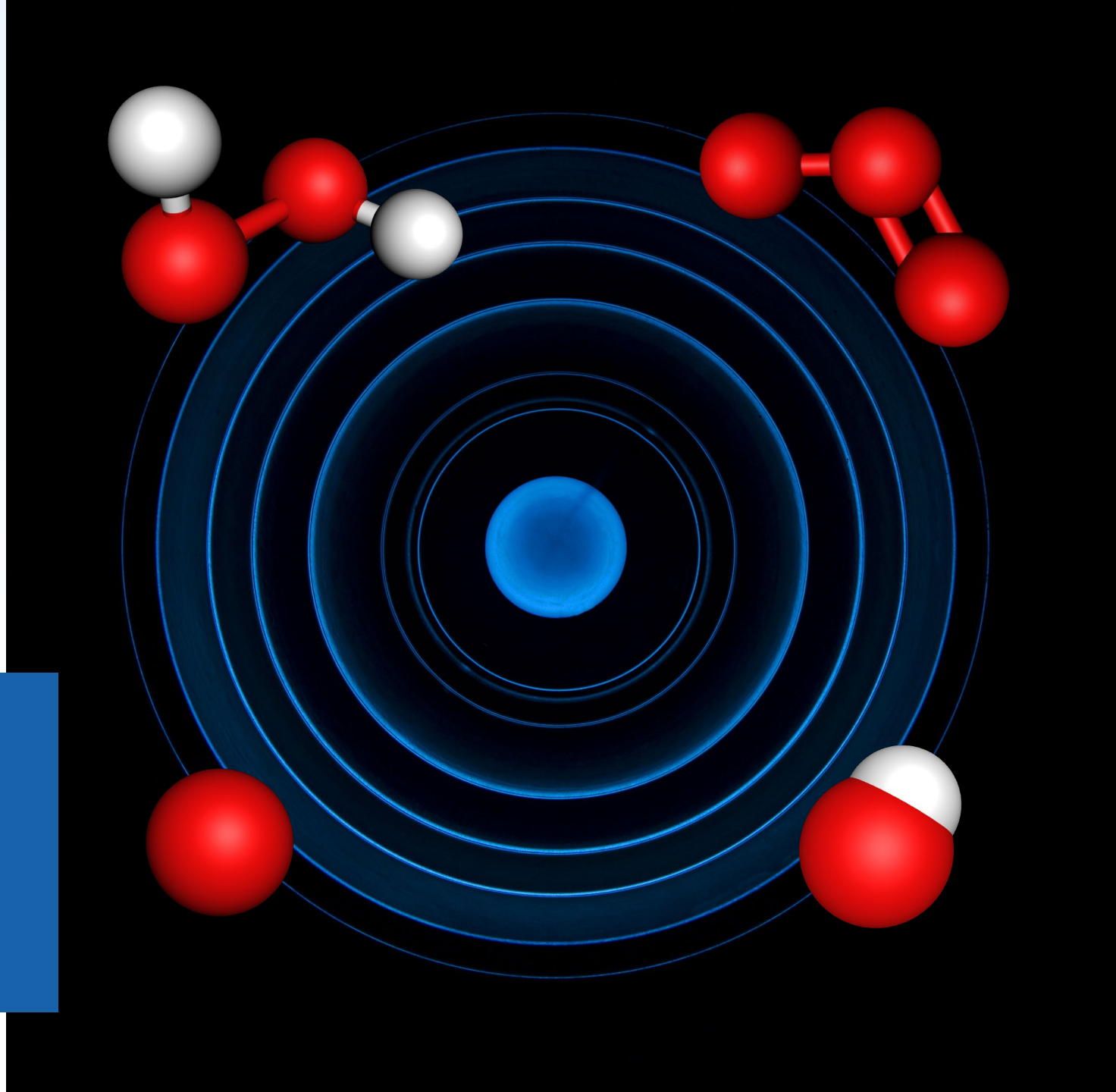


Electro Catalytic AOP

Oxidizing Agents

- **Atomic Oxygen**
- **Hydrogen Peroxide**
- **Ozone**
- **Hydroxyl Radicals**

These four powerful oxidizing agents are engaged in the EC-AOP reactor, breaking down contaminants in an environmentally friendly way, which results in a large decrease in organics, sludge, and other residual pollutants, toxins and chemicals.



WHY •OH RADICALS?

Electro Catalytic AOP

Oxidant	Redox (V)
•OH	2.80
O	2.42
O3	2.07
H2O2	0.87

The Hydroxyl Radical is one of nature's most powerful oxidizing agents. It easily & instantaneously reacts with surrounding dissolved chemicals, commencing a cascade of oxidation reactions which ultimately fully breaks down and mineralizes the molecule.

This reaction process can reduce the concentration of contaminants from hundreds of PPM to less than 5 PPB, which significantly lowers COD and TOC.

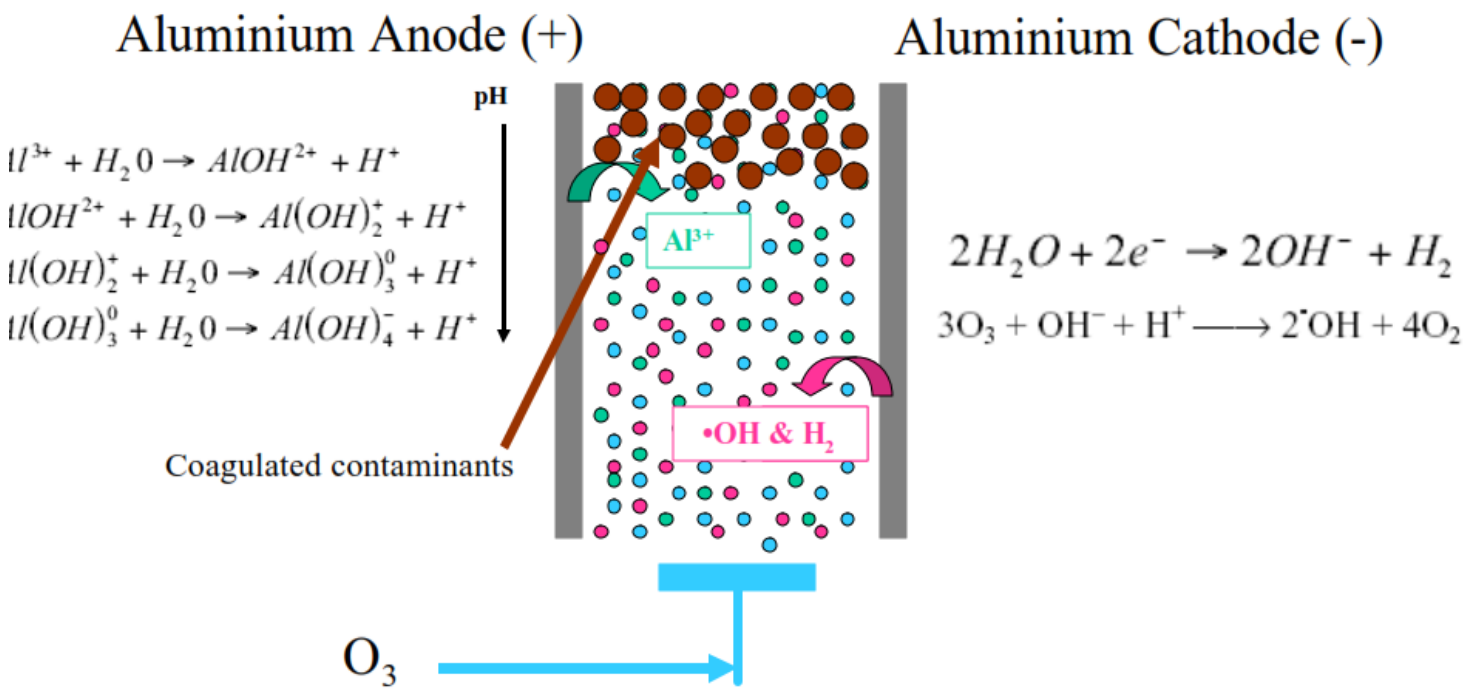
Hydroxyl Radicals are highly effective in the oxidative destruction of common organic pollutants, such as pesticides, pharmaceutical compounds, dyes, and petroleum based by-products.

Hydroxyl Radicals do not discriminate, which allows it to react with almost every aqueous pollutant.

The final product of the reduction process of •OH is H20, which reduces by-product sludge and does not introduce new hazardous elements into the fluid.

Why we call it

Electro Catalytic



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EC-AOP Benefits

Polishing Step

- Lotic's EC-AOP system improves efficiencies of existing water treatment infrastructure such as Reverse Osmosis and Deionization.
- Inexpensive removal of Organics, Heavy Metals, Silica and Hardness results in a more cost effective selection for a desalination / polishing phase to obtain necessary water standards.
- Studies are also ongoing regarding Magnetic effects on soluble salts and resulting enhancement of water transport across RO Membranes.

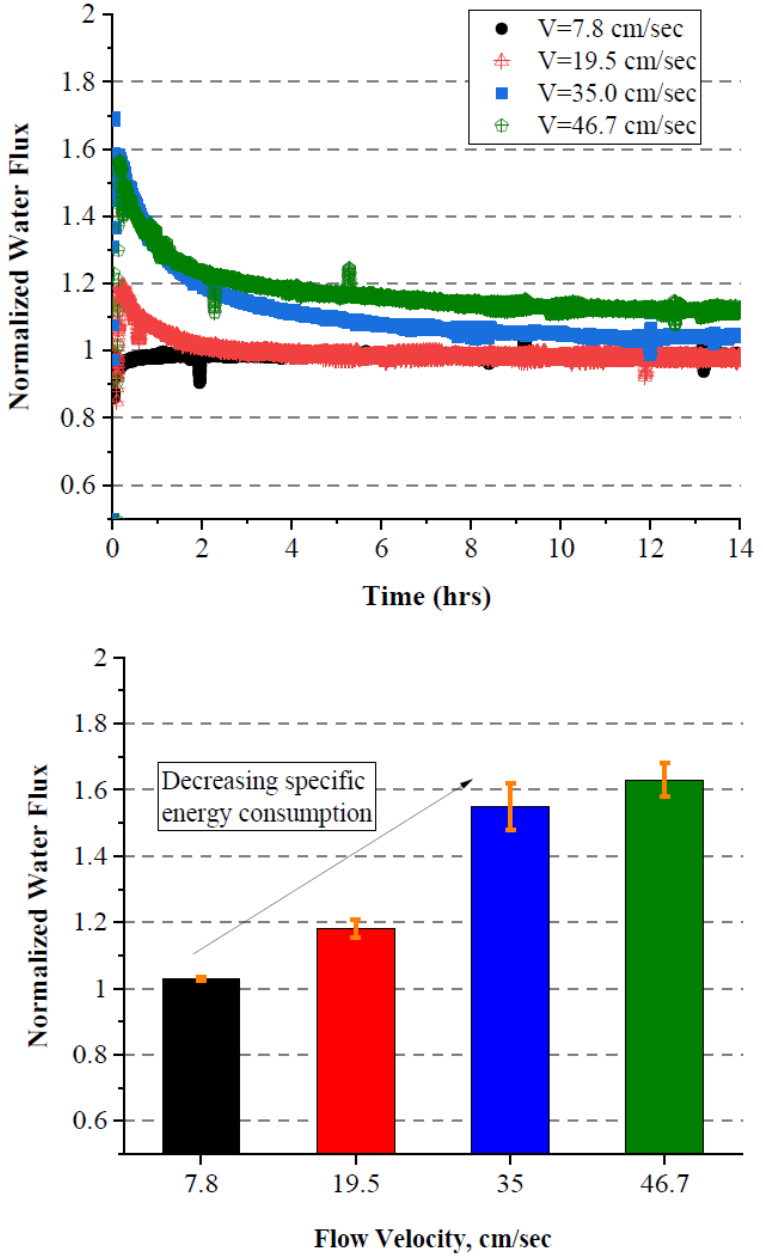


Fig. 1 Normalized flux through SW30HR membrane after pretreatment with magnetic field.

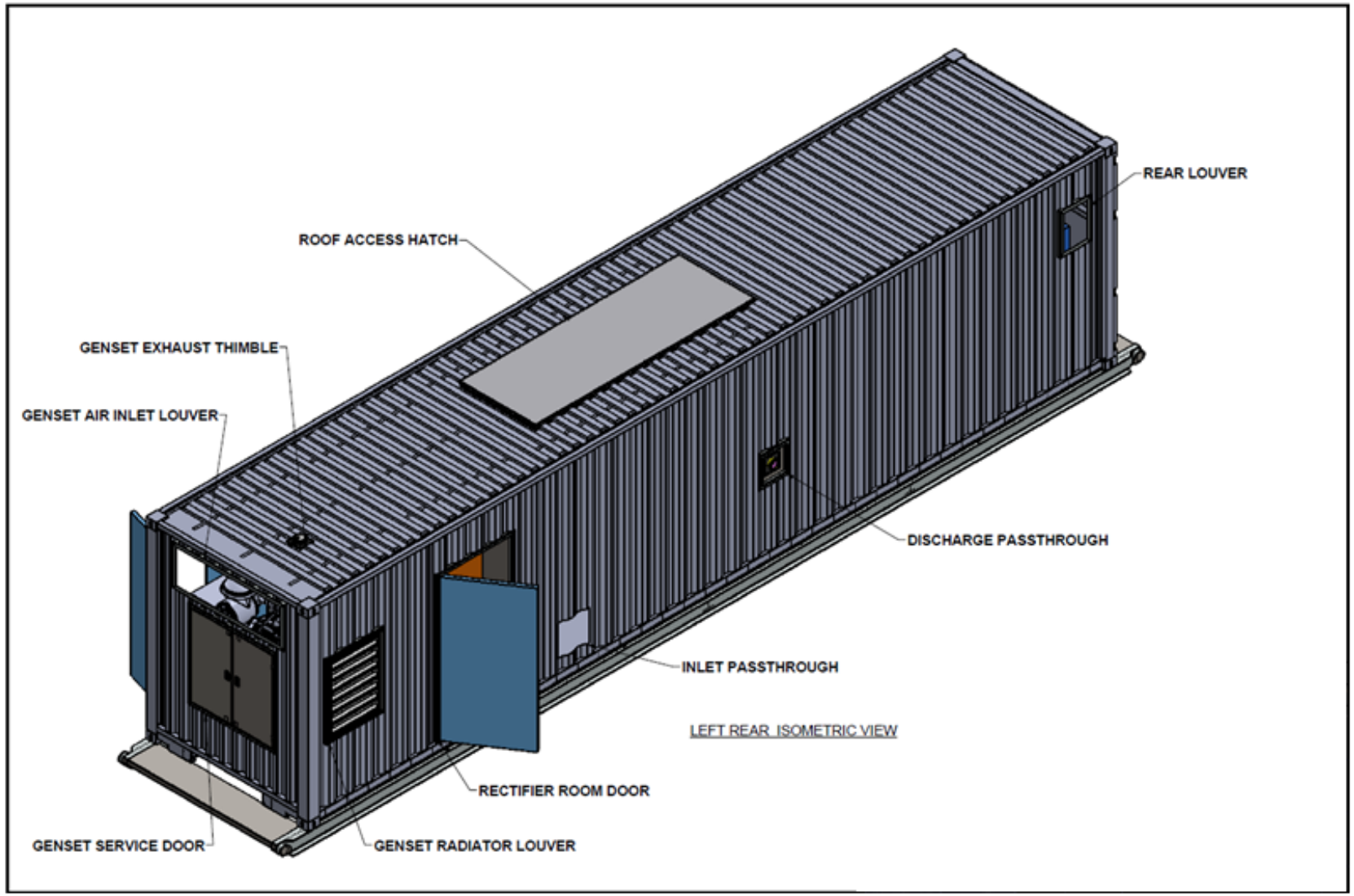
Manufacturing

Our Products

All products we engineer and manufacture are designed to the highest specifications, codes & industry standards. This allows our units to be safely operated in any industry and regulatory climate. Our products are manufactured in Canada internally by Lotic Technologies.

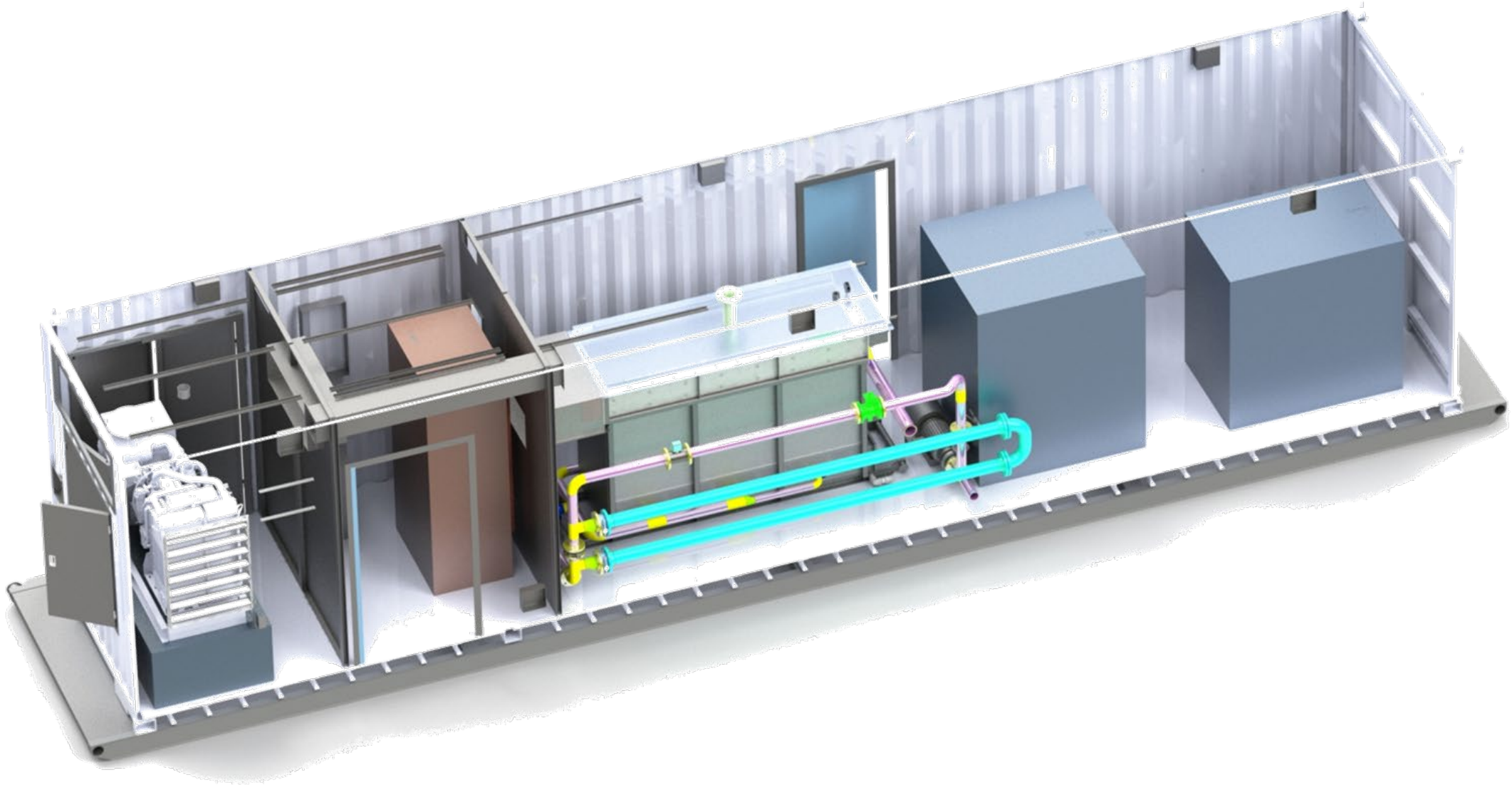
A Typical Configuration

Electro Catalytic AOP



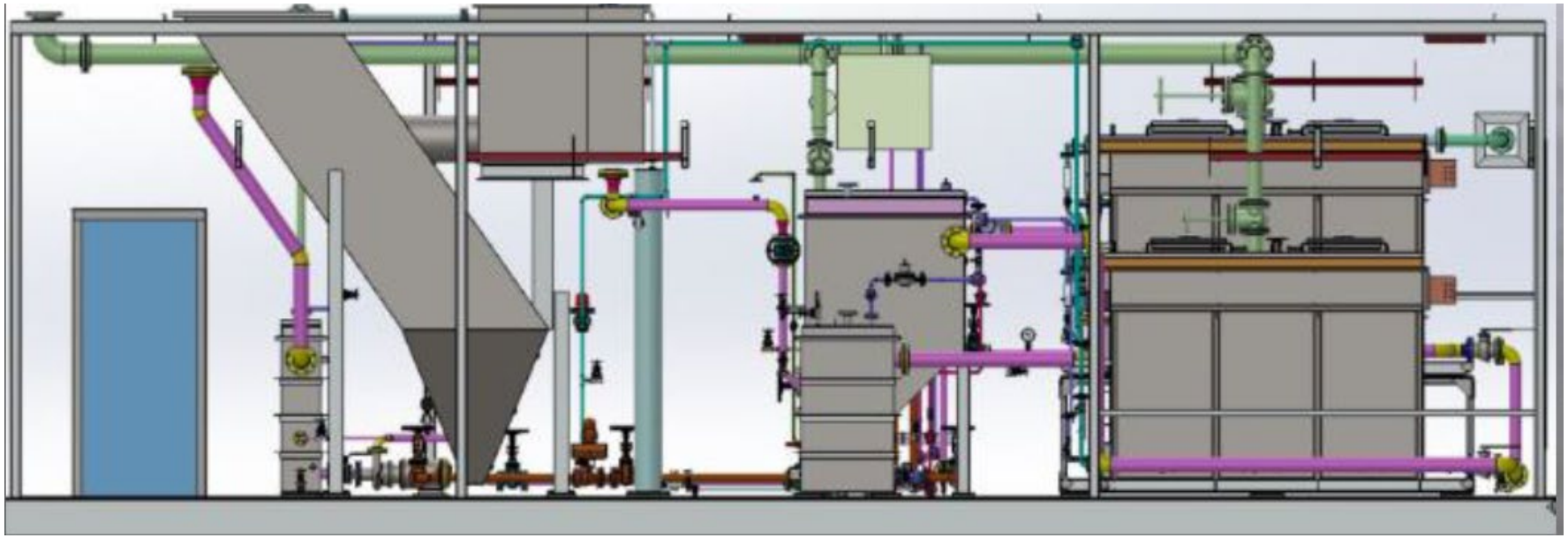
A Typical Configuration

Electro Catalytic AOP



A Typical Configuration

Electro Catalytic AOP



A typical set-up

Electro Catalytic AOP

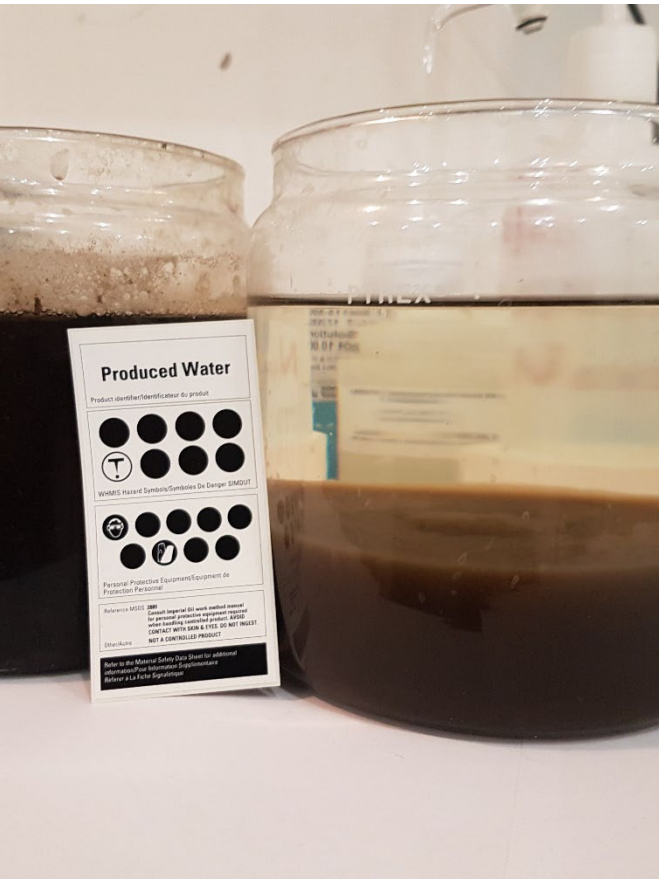
Basic Specifications

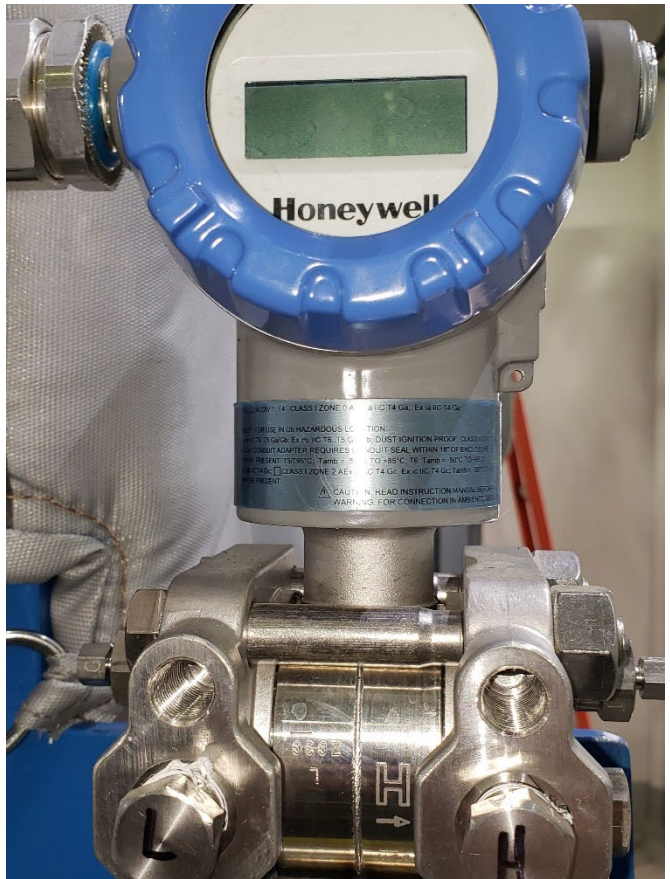
Portable Skid or Seacan mounted systems are typically 8’x40’x9.6’, 100gpm (22.71m3/hr), and 36,000lbs dry weight. Portable units can be daisy-chained together for increased flow rates, or large units can be built to achieve large flow rates.

Standard Product Line is 25gpm, 50gpm, 100gpm, and 650gpm. Custom Reactor tanks can be customized to tailor required flow rates. There are no limits to what custom flow rate equipment can be designed.

Product Cost is not outlined or estimated for a unit until a thorough pre-project scope is completed, including attaining a fluid pre-treatment report, and confirmation of desired flow rates. Lotic typically tests all water prior to determining a cost due to Reactor calculations and requirements.

- Reactor Tank sizes vary – a 650gpm reactor is generally 96” x 186”, and multiple tanks can work in tandem to achieve very large process volumes per day.
- The standard 40ft process center comes in 100gpm flow rate. This can also be customized to larger flow rates.


Produced Water
Product identifier/Identificateur du produit
WHMIS Hazard Symbols/Symboles De Danger SIMDUT
Personal Protective Equipment/Equipment de Protection Personnel
Refer to the Material Safety Data Sheet for additional information/Pour Information Supplementaire Referer a La Fiche Signalitique


Honeywell
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TRIAD

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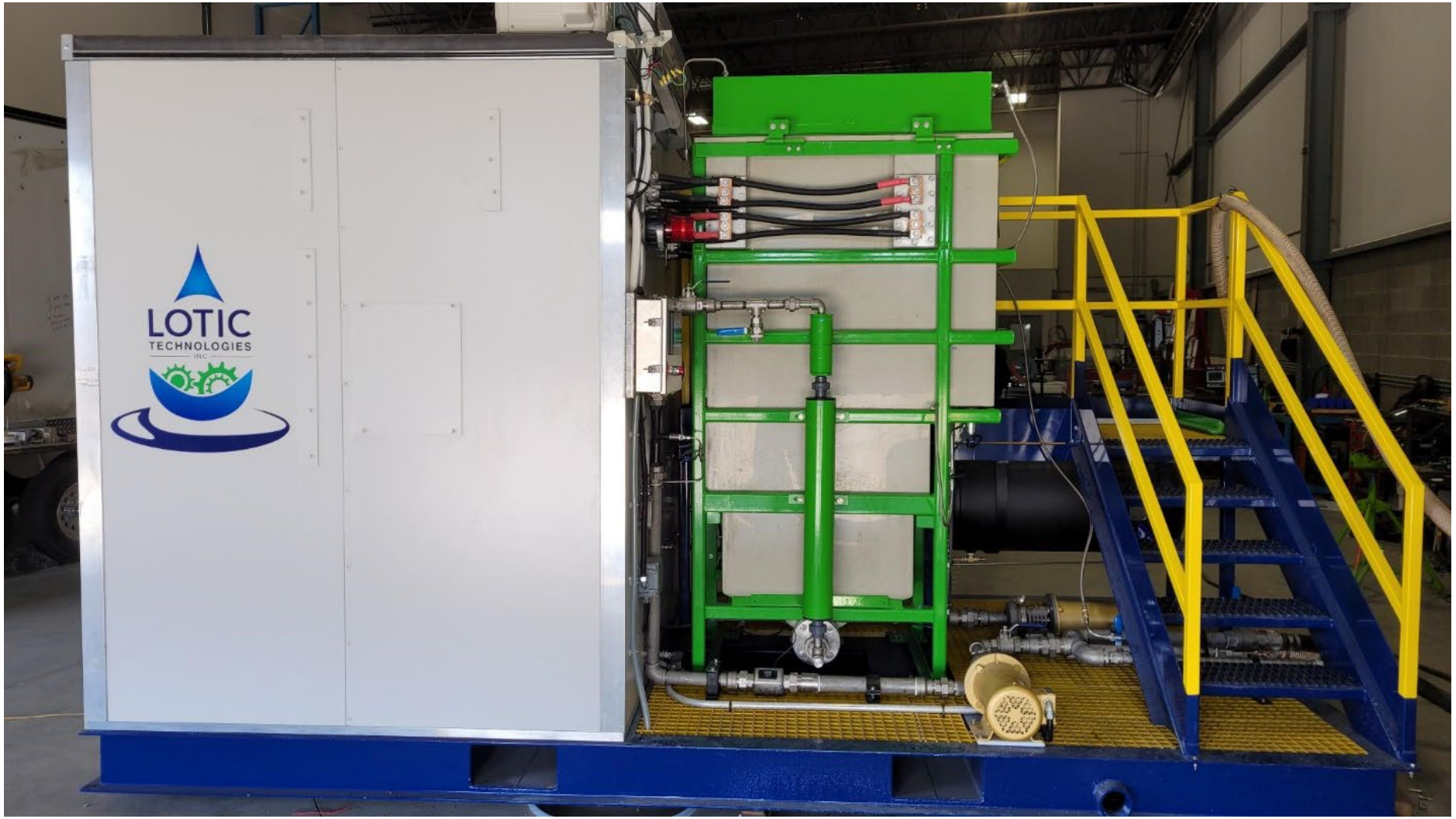
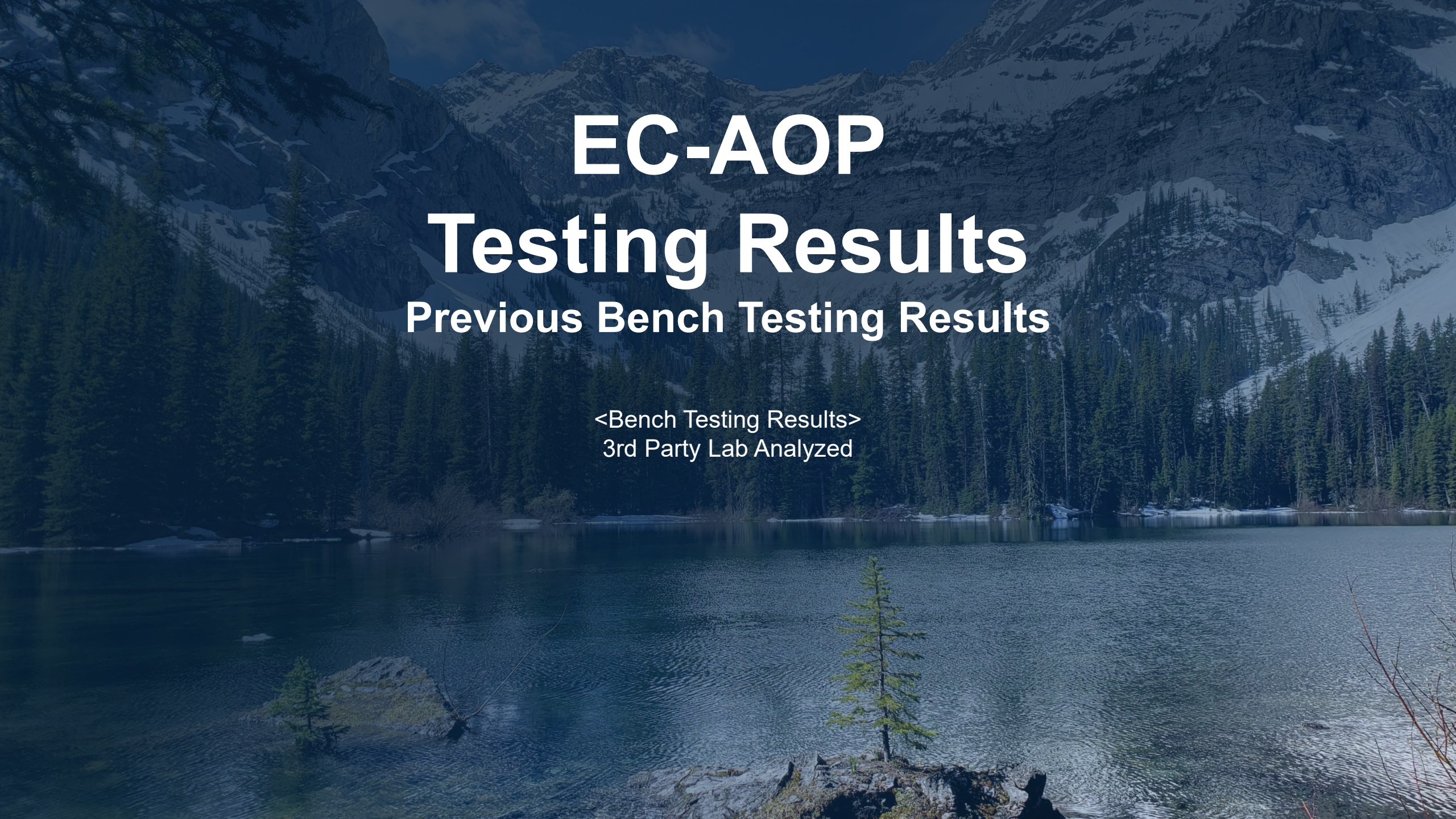
WT-2 Pilot Unit





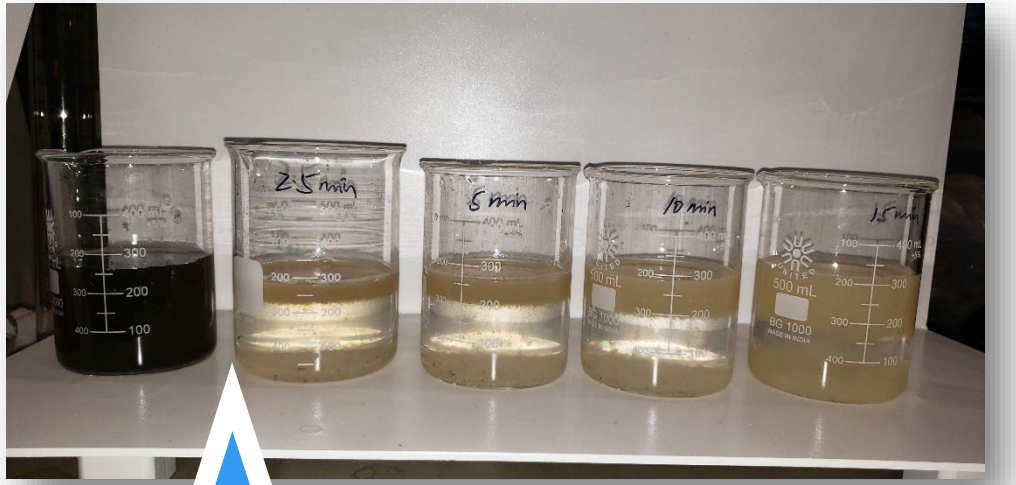
EC-AOP Testing Results

Previous Bench Testing Results

<Bench Testing Results>
3rd Party Lab Analyzed

EC-AOP Bench Testing

Lotic Technologies

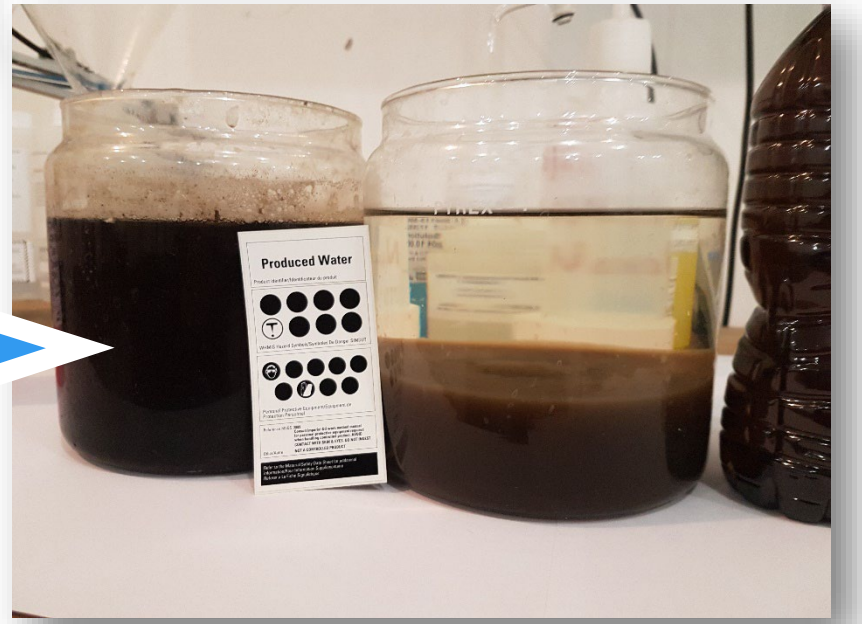


Landfill Leachate

- High Bacteria Removal
- High Organic Removal

Produced Oilfield Water

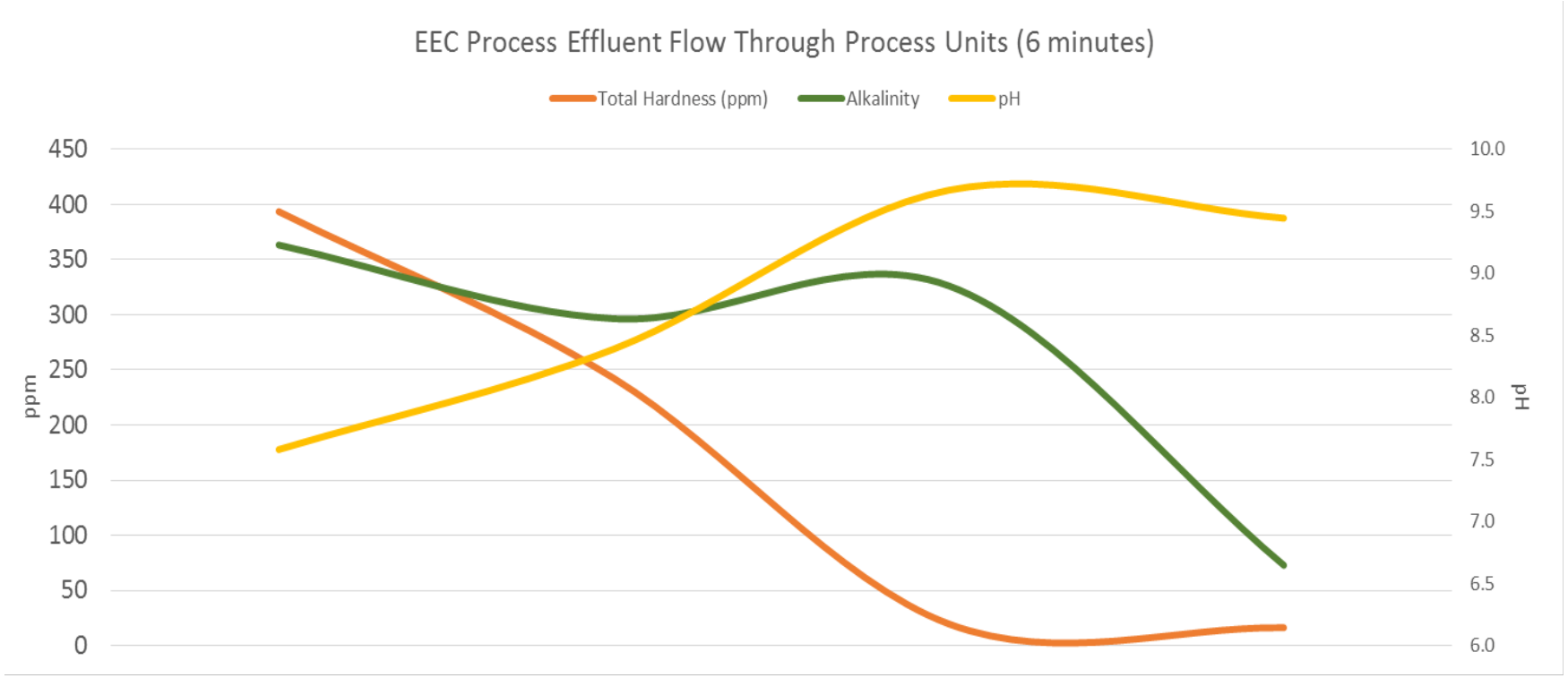
- High Silica Removal
- Hardness Reduction
- Immediate Sludge Flocculation

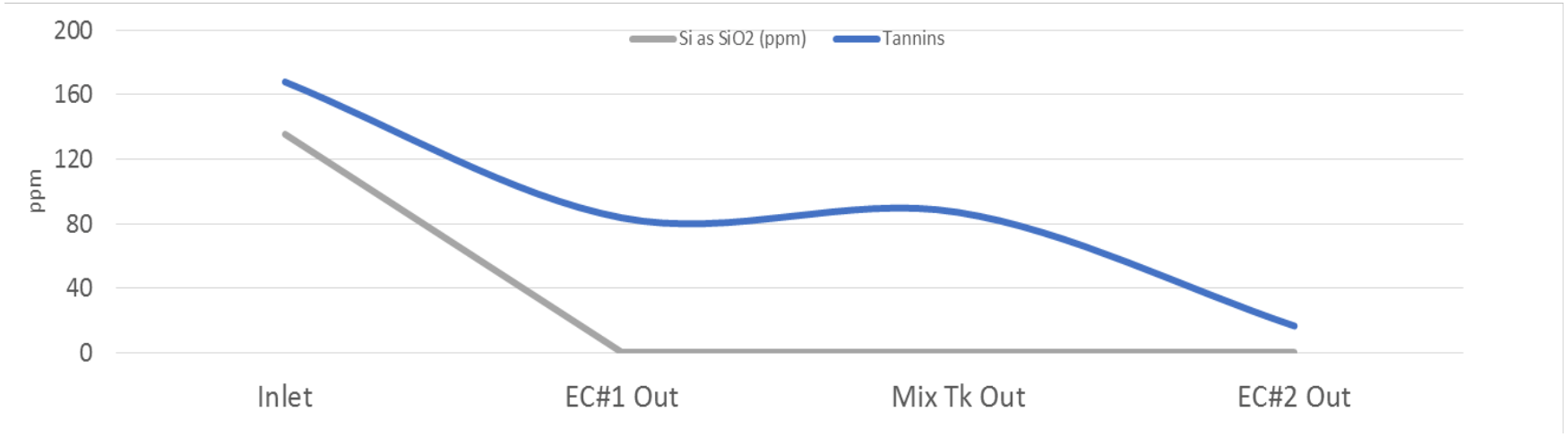


Municipal Wastewater

- TSS Reduction of 96.3%
- High Metal Removal Efficiencies
- Immediate Sludge Flocculation

EEC Bench Pilot Results





Bench-Test Results

Oilsands Tailings Fluid

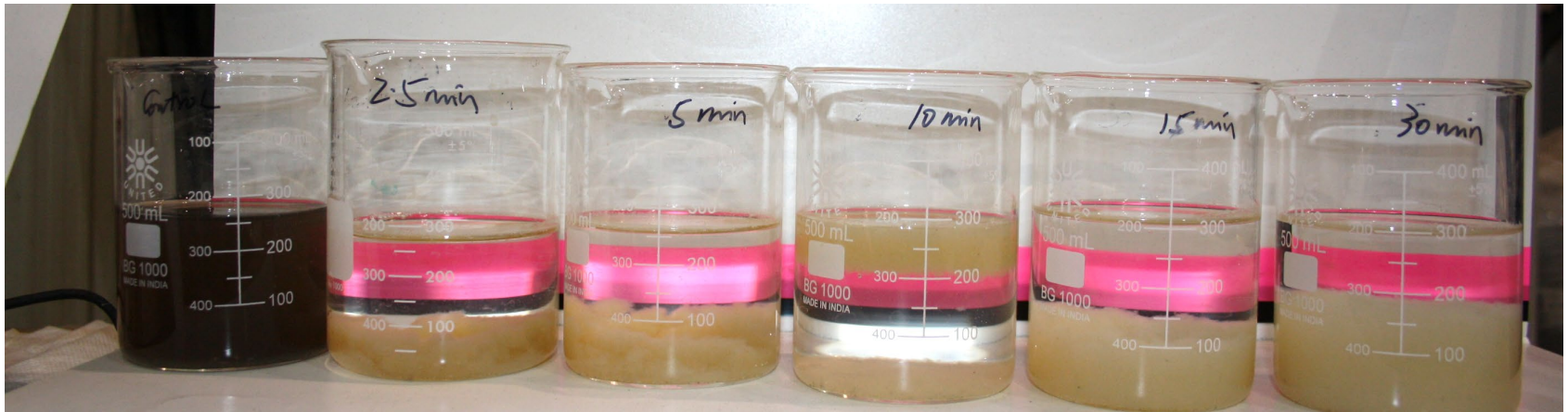
Parameters	Influent (mg/L)	Effluent (mg/L)	Removal efficiency (%)
pH	8.01	8.34	NA
Conductivity	1790	1680	6.1
Alkalinity	343	342	0.3
Hardness	86	63	26.7
TSS	821	30	96.3
TDS	1130	1030	8.8
Chloride	140	122	12.9
Sulfate	362	304	16.0
Metals-Total Trace			
Al	24	2.1	91.0
Ca	25.4	13.0	49.0
Fe	12.7	0.07	99.0
Mg	10.6	7.3	31.0
Mn	0.613	0.01	98.0
K	17.6	13.9	21.0
Si	18.4	0.33	98.0
Na	362	345	5.0
S	122	98.7	19.0
Metals-Total ICP-MS			
Ar	0.0066	0.0011	83.0
Ba	0.461	0.036	92.0
Cd	0.00016	0.00002	88.0
Co	0.0133	0.0009	93.0
Cu	0.091	0.01	89.0
Pb	0.008	0.00003	96.0

Testing Results

Electro Catalytic AOP

Landfill Leachate – Meadow Lake, Saskatchewan

Parameter	Control	Treated sample	Removal
COD (mg/L)	626	315	49.7%
TSS (mg/L)	505	8	98.4%
EC (µs/cm)	3130	1600	48.9%
TDS (mg/L)	1700	747	56.1%
Hardness (mg/L)	812	212	73.9%
Alkalinity (mg/L)	1110	253	77.2%

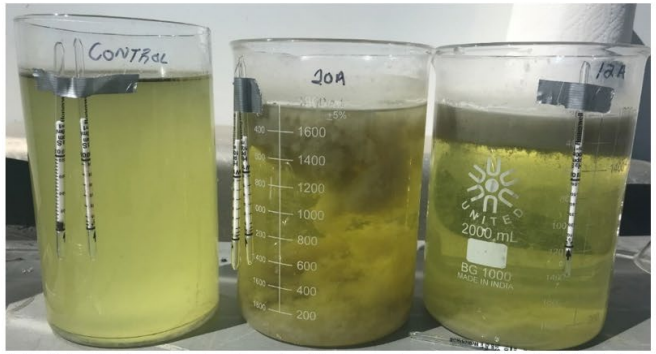


Testing Results

Electro Catalytic AOP

Produced Oilfield Water – H2S Mitigation

Sample Description			Trucked Out Water 14-17-070-08W6M	Produced Water 1st Run 14-17-070-08W6M	Produced Water 2nd Run 14-17-070-08W6M
Date Sampled			07/28/2021	07/29/2021	07/29/2021
Parameter	Unit	RDL	2794370	2799602	2799603
Acid Producing Bacteria	cfU/mL		82000	2	1
Iron Reducing Bacteria	cfU/mL		9000	2200	8
Sulphur Reducing Bacteria	cfU/mL		2200000	2200000	1
COMPLETE WATER					
Parameter	Unit	RDL	2794370	2799602	2799603
H2S	mg/L		1185.69	155.58	n/d



Left: Untreated produced water set aside as a control sample. Middle + right: two different samples that were collected under different electrocatalytic parameters. Both tested at approximately 20 ppm H2S, but had different rates of solid separation. Both also retained a yellowish color seen in the control sample.

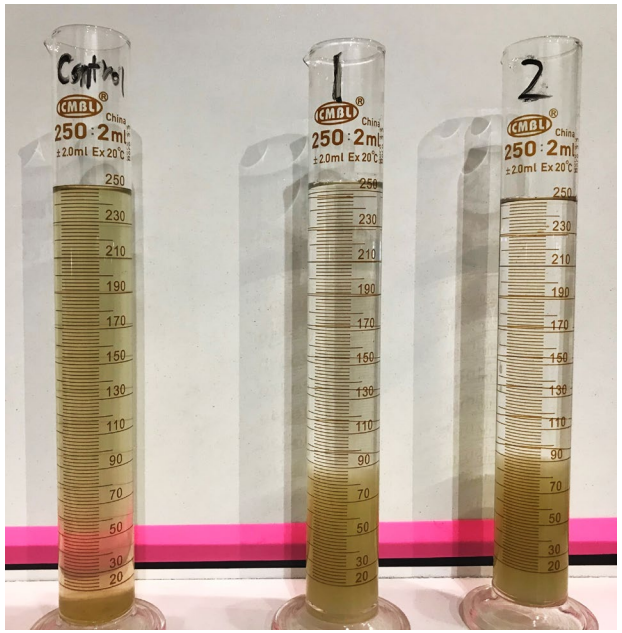
1-First pass sample, unfiltered; 2- First pass, filtered; 3- Second pass, filtered, 4- Second pass solids removed from over 60 L of water.

Testing Results

Electro Catalytic AOP

Municipal Wastewater – Camrose, Alberta

Parameter	Control	Treated sample	Removal
COD (mg/L)	149	35	76.5%
BOD (mg/L)	13	6	53.8%
TSS (mg/L)	41	9	78.0%
Ammonia (mg/L)	12.8	12.4	3.1%
TKN (mg/L)	17.3	13.5	22.0%
Phosphorus (mg/L)	2.37	<0.05	>97.9%
Calcium (mg/L)	77.2	34.5	55.3%
Magnesium (mg/L)	44.2	21.7	50.9%
Hardness (mg/L)	375	176	53.1%
Alkalinity (mg/L)	300	178	40.7%
Total Coliform (CFU/100mL)	20	1	>95.0%
E.Coli (CFU/100mL)	10	1	>90.0%



Testing Results

Electro Catalytic AOP

SAGD Oilfield Production Water

Parameter	Control	Treated sample	Removal
Hardness (mg/L)	351	87	75%
Alkalinity (mg/L)	634	350	45%
Calcium (mg/L)	307	80	74%
Magnesium (mg/L)	48	5	89%
Silica (mg/L)	142	1	99%
Tannin (mg/L)	158	0	100%

Testing Results

Electro Catalytic AOP

SAGD Production Water – 2nd Client

Parameter	Control	Treated sample	Removal %
Hardness (mg/L)	393	36	90.9%
Alkalinity (mg/L)	363	97	73.3%
Calcium (mg/L)	349	17	95.2%
Magnesium (mg/L)	45	19	58.1%
Silica (mg/L)	136	2	98.5%
Tannin (mg/L)	168	32	80.9%

Testing Results

Electro Catalytic AOP

Oilfield Produced Water (California)

Sample Description			Trucked Out Water 14-17-070-08W6M	Produced Water 1st Run 14-17-070-08W6M	Produced Water 2nd Run 14-17-070-08W6M
Date Sampled			07/28/2021	07/29/2021	07/29/2021
Parameter	Unit	RDL	2794370	2799602	2799603
Benzene	mg/L	0.0005	3.15	0.132	0.0021
Toluene	mg/L	0.0003	9.29	0.437	0.0066
Ethylbenzene	mg/L	0.0005	0.680	0.0135	<0.0005
Xylenes	mg/L	0.0005	9.01	0.225	0.0036
C6 - C10 (F1)	mg/L	0.1	119	1.0	0.1
C6 - C10 (F1 minus BTEX)	mg/L	0.1	97.1	0.1	0.1
C10 - C16 (F2)	mg/L	0.1	334	0.4	0.3
Toluene-d8 (BTEX)	%		125	126	119
o-Terphenyl (F2)	%		129	101	102
Sediment			Not Present	Trace	Not Present

Testing Results

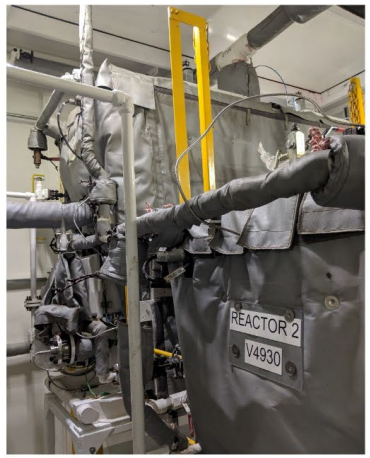
Electro Catalytic AOP

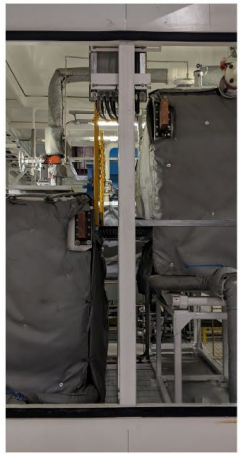
Oilfield Frac Fluid – Bacteria Reduction

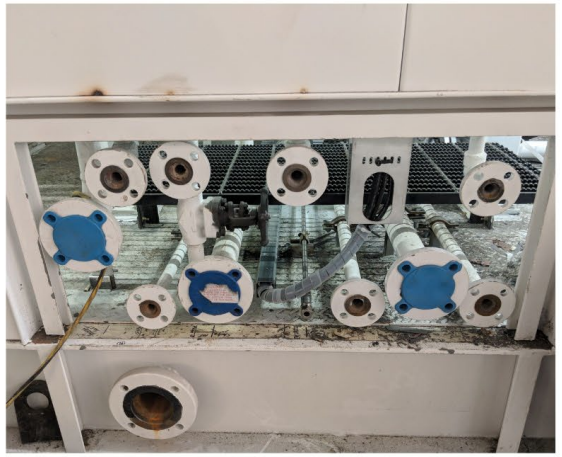
Company: Lotic Technologies

		Reference Number	1369368-1	1369368-2		
		Sample Date	Aug 09, 2019	Aug 09, 2019		
		Sample Time	NA	NA		
		Sample Location				
		Sample Description	Control / 4.1C	EC-A0P / 4.1C		
		Matrix	Water	Water		
Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
Microbiological Analysis						
Approximate Sulfate Reducing Bacteria Population	BART Kit	CFU/mL	27000	<1.0		

Recent Projects







ExxonMobil – Maskwa Plant Pilot Project

Project:	Maskwa Pilot Project
Client:	ExxonMobil
Location:	Cold Lake, Alberta, Canada

Purpose/Scope:

Prime objective for ExxonMobil was to identify technologies that would meet their goals for Water Recycling reliability. In the Cold Lake Maskwa region, ExxonMobil generates steam which is injected into their heavy oil reservoirs. The heavy oil is heated by the steam in order for it to be pumped to surface. At surface, the Maskwa Plant separates the water from the oil. ExxonMobil's goal is to re-use this water, rather than utilizing fresh water from the surface. Lotic's EC-AOP was identified as a candidate technology that would work to reach this goal.

After extensive Bench-Testing, ExxonMobil also identified that the fluid clarification from the EC-AOP was extensive enough that a unit could also be an alternative replacement to their current Hot Lime Softeners – at a much lower CAPEX and OPEX.

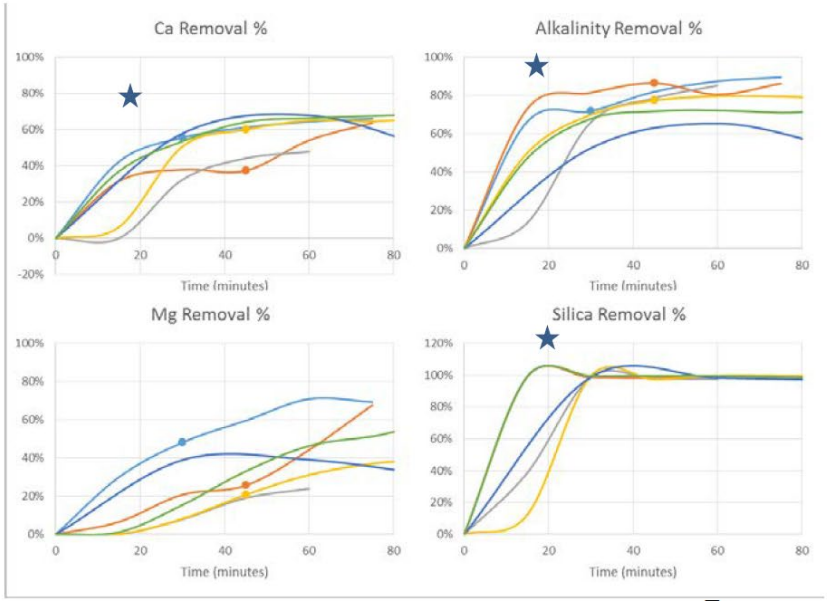
Additional advantages of the EC-AOP determined by ExxonMobil, in respect to their specific project, includes:

- Less Chemical Utilization – no more requirements for Lime or Mag-Ox; considerable reduction of Caustic Soda
- Less Solids Waste – up to 1/10th. OPEX and land usage for landfills and sludge ponds were reduced.
- Reduction in GHG intensity, since the EC-AOP allows the process to require less heat energy.
- Estimated to reduce their Bitumen Lifting Cost by as much as $0.55 per barrel.
- Increased Water Quality: less contaminants in their boiler feed water, reduced scaling, improved reliability, potential for higher steam qualities and subsequently higher oil production.

Technology Screening

Nov/17

- Started screening the static unit with ozone at Lotic shop using Imperial's Cold Lake raw produced water.
- Results were interesting:
  - Retention time 20 minutes showed to be optimal
  - Hardness reduced by ~50%
  - Alkalinity reduced by ~80%
  - Silica & Tannin reduced to near zero with O_3
  - Coagulation of solids very good, effluent water at <3 ntu



Lotic Technologies Inc. Bench Pilot

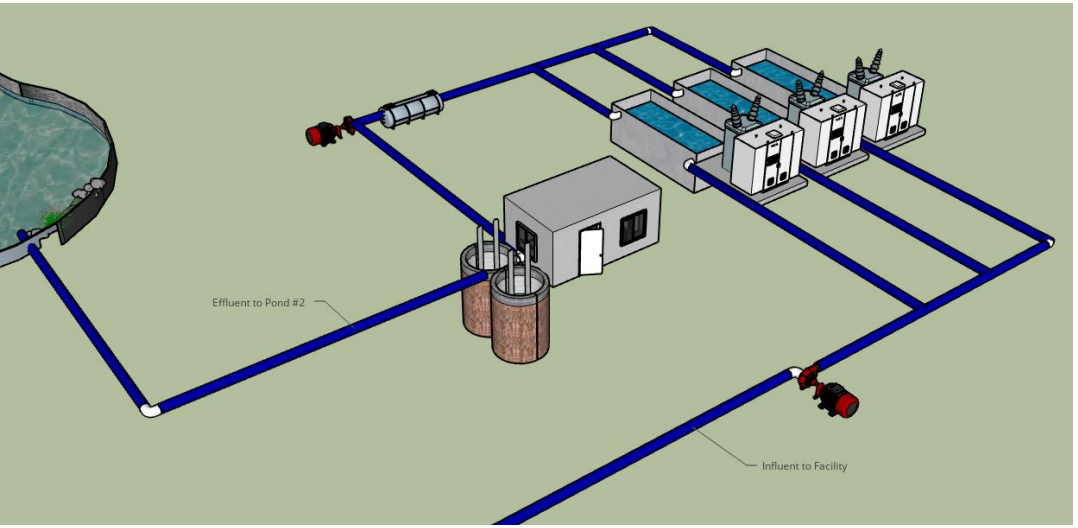
EC only

ExxonMobil

Technical Validation

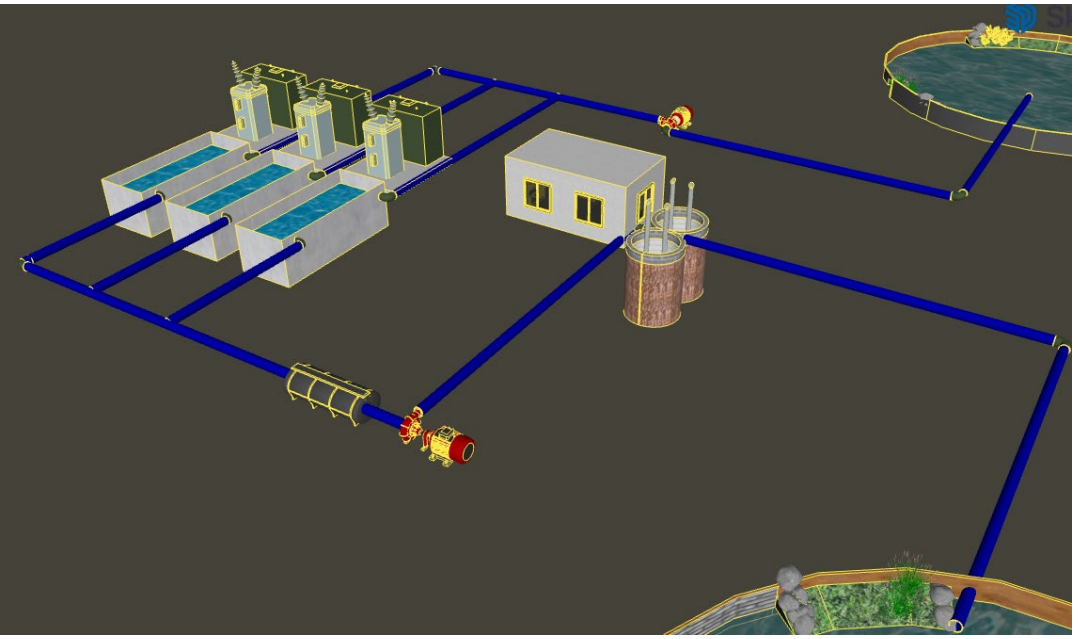
Imperial

Bench Pilot		Commercial Pilot
$0.25/m3	Operating Cost	$0.25/m3
0.68 gpm (183 L/hr)	Flow Rate	100 gpm (27 m3/hr)
80ºC	Temperature	70-85ºC
Atmospheric	Pressure	1-2 kPag
1.5-2.2 Kw-H/m3	Power	<3.0 Kw-H/m3 (~0.03-0.5$/m3)
Air	Sparge Medium	Gas
None	Solid Separation	Coagulant & Clarifier
0-3000 ppm	Feed TSO	0-3000 ppm
99% (<2 ppm)	Silica Reduction	>75% (<85 ppm)
91% (~30 ppm)	TH Reduction	91% (<30 ppm)
73% (~100 ppm)	Alkalinity Reduction	73% (<120 ppm)
70% (~50 ppm)	Tannin Reduction	70% (>50 ppm)
~2-3 ntu	Effluent Turbidity	<10 ntu (prefer <1 to bypass filters)
Unknown	**EC Plate Fouling**	Manageable with electrical clean cycle
EC1 foam managed by vacuum	Reactor Foaming	EC1 foam managed by H2O spray
Unknown	EC Plate consumption	0.1 lbs./1,000 gallon
As tested with air @max solubility	Dissolved Oxygen	Feed H2O ~15 ppb, pilot <50 ppb
Typical BFW ICP <1 ppm	Aluminum in Effluent	<1 ppm



Municipality of Calmar – Municipal Wastewater Treatment

Project:	Calmar Wastewater Treatment
Client:	Municipality of Calmar
Location:	Calmar, Alberta, Canada



Purpose/Scope:

The Municipality of Calmar currently treats their municipal wastewater in large wastewater lagoons.

Due to a rapidly increasing population, and the introduction of stricter environmental disposal standards and regulations, Calmar has reached the maximum capacity of their current lagoons.

With the requirement of purchasing more land in order to construct additional lagoon capacity, Calmar's Public Works reached out to Lotic Technologies to determine if there was a feasible economic alternative.

Lotic Technologies bench tested Calmar's Municipal Wastewater on several occasions throughout the year to determine if EC-AOP would be a feasible alternative to the construction of further lagoon capacity.

Following the successful bench-testing phase, Lotic submitted a Commercial Proposal with the scope of clarifying Calmar's current maximum wastewater volumes, with a 20% increase, with EC-AOP technology infrastructure rather than additional lagoon infrastructure. This proposal offered Calmar a largely advantageous economic alternative.

Bench-testing had proven that the EC-AOP system that Lotic has proposed would clarify their wastewater to WSER standards as requested, and would eliminate the need to purchase land and construct additional lagoons.

Shell Offshore / PMI – Port Fourchon Barge Wastewater

Project:	Port Fourchon Barge Wastewater
Client:	Shell Offshore / PMI
Location:	Port Fourchon, Louisiana, USA

Purpose/Scope:

Production Management Industries (PMI) is Shell Exploration and Production's preferred Barge Cleaning vendor.

Oilfield waste from Gulf of Mexico Offshore Oil/Gas drilling and production activities is barged to land for disposal. PMI cleans these barges out, which utilizes a significant amount of wash-water. Once utilized for cleaning the barges, this wash-water is then considered a contaminated Oilfield Waste, and these large volumes must be shipped to Disposal Wells for disposal.

Shell and PMI had inquired into the possibility of utilizing EC-AOP to recycle and reuse this wash-water in order to greatly reduce the costly burden of shipping large volumes of fluid for disposal.

Shell performed a formal Technology Screening Program for this endeavor. Six different companies from the US and internationally, along with their AOP technologies, were chosen and forwarded fluid samples for bench-testing. From those group of six, Lotic's EC-AOP had vastly outperformed in terms of clarification and cost-effectiveness.

Shell and PMI then proceeded in renting a Pilot Unit from Lotic Technologies, and performed a thorough 6 month Pilot Program on-site in Port Fourchon, Louisiana.

Lotic's EC-AOP succeeded in the Pilot Program, and PMI promptly ordered and purchased a commercial EC-AOP unit for their permanent use on-site.

GWI – California Natural Resources Group – Irrigation Project

Project:	CAL-NRG Irrigation Pilot
Client:	GWI / CAL-NRG
Location:	Ventura County, California, USA

Purpose/Scope:

Global Water Innovations (GWI) is developing a project whereas they propose to clarify Oilfield Produced Water to the extent that it can be safely utilized as agricultural irrigation.

GWI has identified that this endeavor is impossible with any one specific technology that is currently on the market today. Due to this, GWI had set-out to determine and design a multi-technology facility in order to obtain the clarification that they require.

GWI has developed a three-technology train that will effectively and economically clarify this oilfield waste to the extent that it can be utilized as agricultural irrigation both safely, and according to strict governmental regulations.

The three-technology train that GWI has developed includes:

- Lotic Technologies' EC-AOP Technology
- A De-Ionization Technology
- A Zero-Liquid-Discharge Technology

It can be noted that Lotic's EC-AOP is effectively doing the "heavy-lifting" for the clarification facility, by removing the majority of the contaminates. The remaining two technologies are essentially removing the residual salts, and performing a final polishing to the effluent.

GWI has recently partnered with California Natural Resources Group (CAL-NRG), one of California's leading Oil/Gas producers. GWI and CAL-NRG are moving forward with Bench-Testing and on-site Pilot Projects to further prove feasibility of utilizing GWI's proposed facility to clarify CAL-NRG's produced water to irrigation standards.

Lotic's EC-AOP is an integrated key part of the Pilot Project.

Contact Us

For More Information

www.lotictech.ca

PO Box 1084
Nisku AB,
T9E 8A8

Brett Erickson
berickson@lotictech.ca

Greg Bend
gbend@lotictech.ca