Optimizing Heavy Metal and Other Contaminants Removal from Mining and Waste Water Operations

Federal Remediation Technologies Roundtable

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CAVORTEX
TECHNOLOGIES
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Discussion Topics

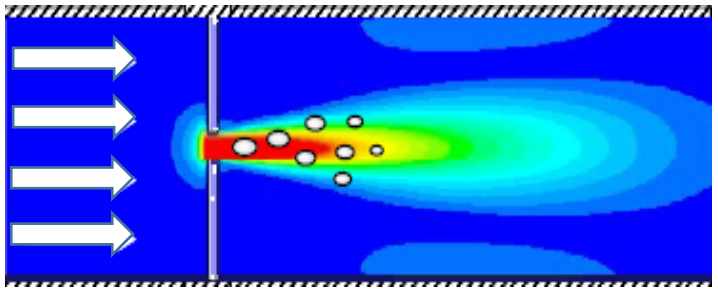
1. Overview of Hydrodynamic Cavitation
2. Results of Carpenter Snow Creek Trials
3. Process Advantages
4. Other Applications for the Cavortex Technology
5. Strategic Partnerships
6. Status/Next Steps

The Company

- Cavortex Technologies International, Inc.
  - Founded in 2014
  - Headquartered in Irvine, California
  - An American owned, Small Business
  - All products are proudly designed and manufactured in the USA
- Intellectual Property
  - Invented the Cavortex reactor for multiple water uses
  - International patent pending

Overview of Hydrodynamic Cavitation

Cavitation involves the formation and collapse of vapor cavities in a liquid. The collapse or implosion of these cavities creates localized zones of high temperature and pressure. Hydrodynamic cavitation occurs when liquid flow conditions create pressure variations. In aqueous streams, hydrodynamic cavitation results in formation of hydroxyl radicals, as well as transformations to dissolved salts and suspended minerals.



Hydrodynamic Cavitation Transformations

Physical Processes

Pathogen cell disruption
Mineral and salt transformations
Emulsification
Atomization
Generation of nano particles

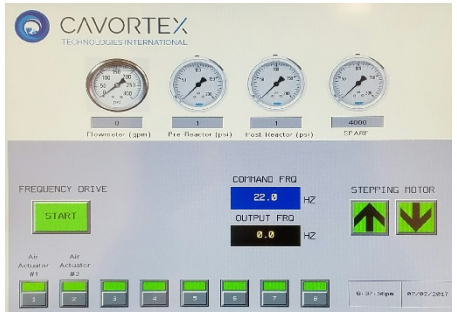
Chemical Processes

Increased transport coefficients
Increased interfacial area
Oxidation
Crystallization
Generation of extreme temperature and pressure

The Cavortex Reaction Process

Intake

Water is pumped into the Cavortex Reactor (pat. pending) at high pressure. Multiple units can be used in parallel to meet flow rate requirements.



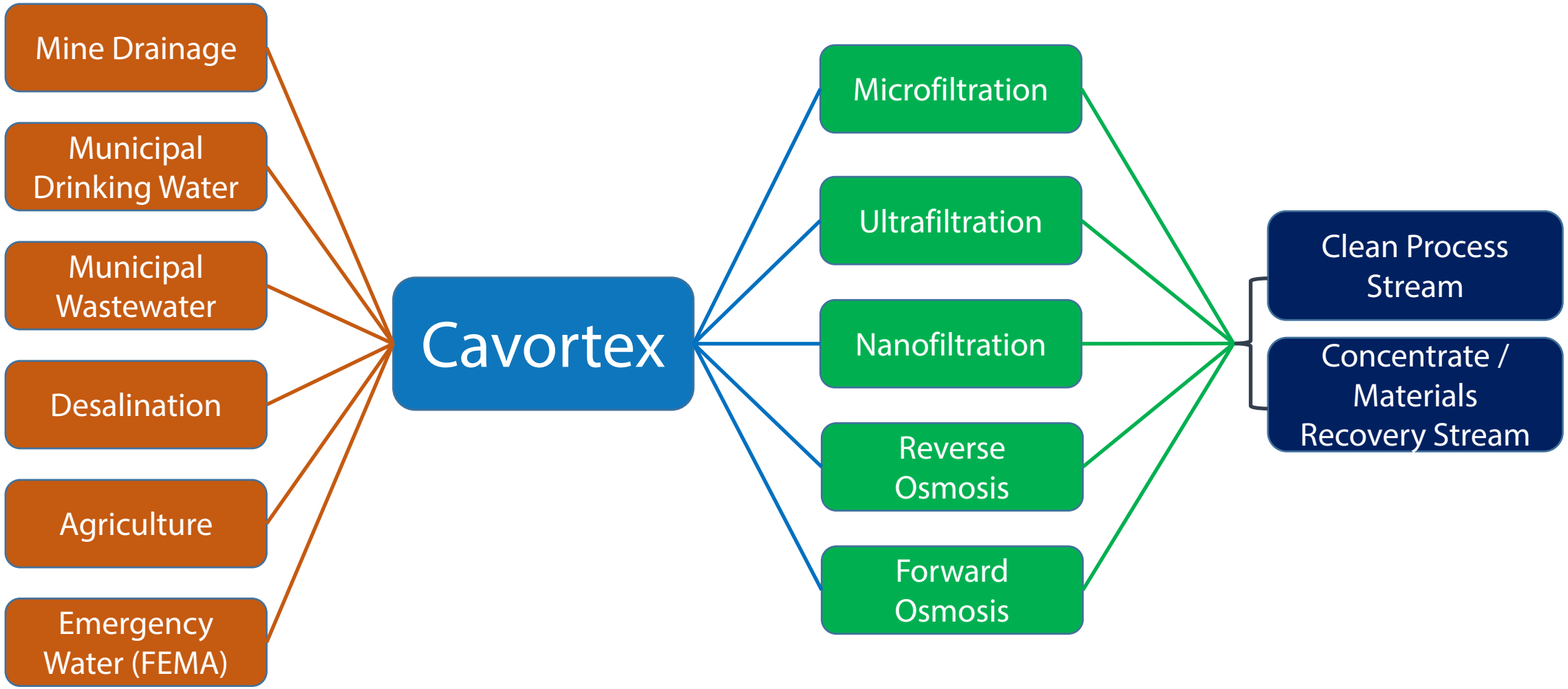
Cavitation Zone

In the Reactor, the process stream undergoes hydrodynamic cavitation, changing structural and charge characteristics of organic and inorganic species. Pathogens are destroyed.

Final Processing

The water stream can be used in tandem with separation and mitigation processes such as filtration or reverse osmosis.

Process Flow Diagram



Cavortex Trials at Carpenter Snow Creek

Site Description

- Carpenter Snow Creek Mining District Superfund Site (CSCMD), Cascade County, Montana ***(One of Hundreds of EPA designated Superfund Sites)***
- 9,000 acres with mine tailings, waste rock, and acid mine drainage
- 90 abandoned mines resulting in metal concentrations in surface water and soil at levels that are detrimental to human health and environment
- Added to Superfund Program's National Priorities List in 2001

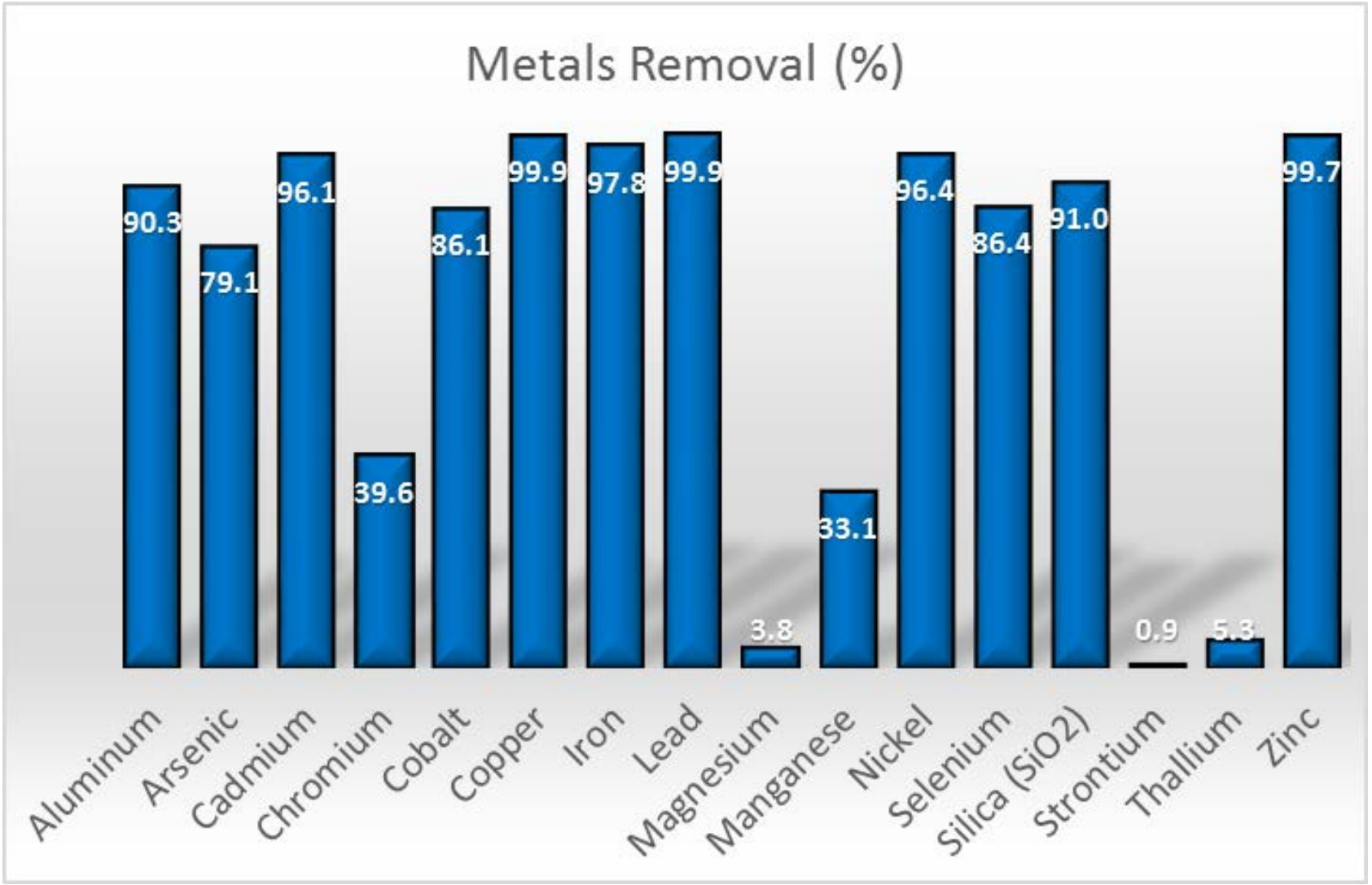
Cavortex Trials

- Cavortex trials conducted in Sep-2015. Objectives:
  - ➢ Reduce heavy metal concentrations
  - ➢ Demonstrate cost effectiveness
  - ➢ Demonstrate small footprint, rapid deployment, and low-maintenance operation

> "***We selected the toughest challenges facing CSCMD in 2015 for the reactor tests. Results were exceptional***"
> Environmental Protection Agency Project Manager

- Mine adit water was processed with the Cavortex system under several scenarios

Results of Cavortex Trials at Carpenter Snow Creek



Removal of Primary Contaminants of Concern

Primary COCs by % Driving Cleanup		Primary COCs Driving Cleanup at 540 Sites		Percent Removal at Carpenter Snow Creek	
Arsenic	28	Arsenic	149	Arsenic	79.1
Lead	24	Lead	129	Lead	99.9
Radium	11	Radium	61	Radium	
Cadmium	5	Cadmium	28	Cadmium	96.1
Cyanide	4	Cyanide	24	Cyanide	84
Copper	4	Copper	23	Copper	99.9
Zinc	4	Zinc	20	Zinc	99.6
Asbestos	3	Asbestos	17	Asbestos	
Chromium	2	Chromium	12	Chromium	39.6
TCE	2	TCE	10	TCE	
Uranium	2	Uranium	10	Uranium	
Mercury	2	Mercury	8	Mercury	
Fluoride	1	Fluoride	8	Fluoride	
Sulfate	1	Sulfate	6	Sulfate	
PCBs	1	PCBs	6	PCBs	
Iron	1	Iron	5	Iron	97.8
PAHs	1	PAHs	4	PAHs	
Molybdenum	1	Molybdenum	4	Molybdenum	
Lithium	1	Lithium	4	Lithium	
Aluminum	1	Aluminum	4	Aluminum	90.3
Organics	<1	Organics	2	Organics	
Beryllium	<1	Beryllium	2	Beryllium	
Radon	<1	Radon	1	Radon	
Selenium	<1	Selenium	1	Selenium	86.4
Nickel	<1	Nickel	1	Nickel	96.4
Manganese	<1	Manganese	1	Manganese	33
				Cobalt	86.1
				Silica	91

Process Advantages

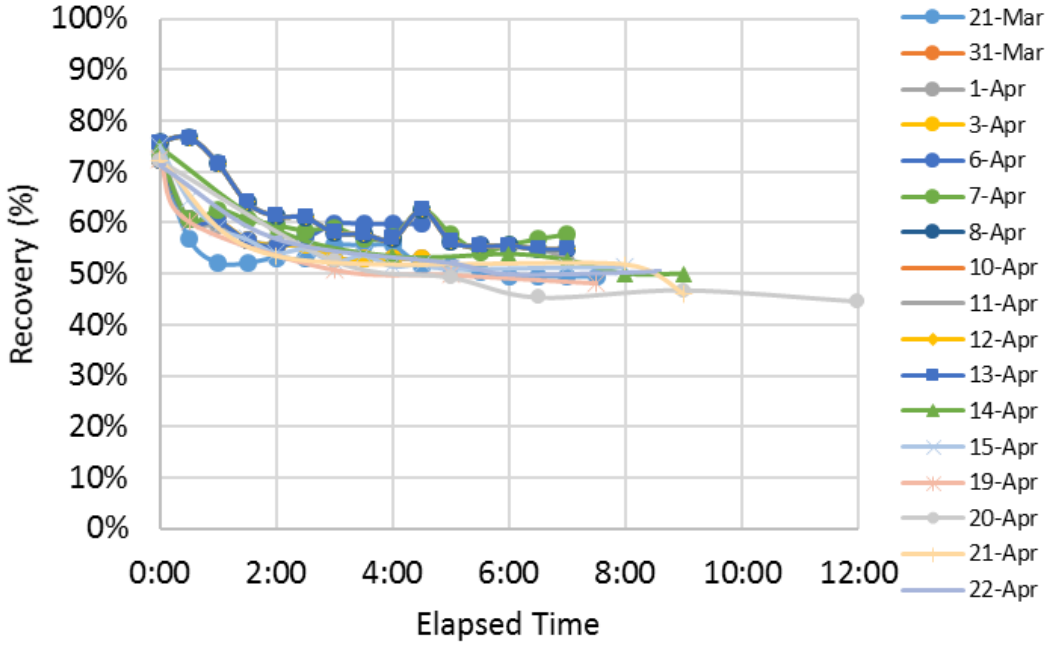
- Simple, robust process
  - Durable, wear-resistant components
  - No moving parts
  - Off-the-shelf auxiliaries: Pumps, valves, etc.
- Small footprint
  - Each 14" x 14" x 48" reactor processes 400 k gallons of water per day
  - Multiple units can be manifolded together: Economies of scale
- Economic Advantages
  - Low life cycle cost - No reagents or consumables
  - Extend life cycle for RO filters by minimum of 67% resulting in cost savings
  - Recovered brackish water generates additional revenue
  - Phosphates/Phosphorous generates fertilizer revenue
  - Separation of Precious Metals – generates revenue
  - Reduced waste (water, sludge, etc.) reduces other services resulting in cost savings

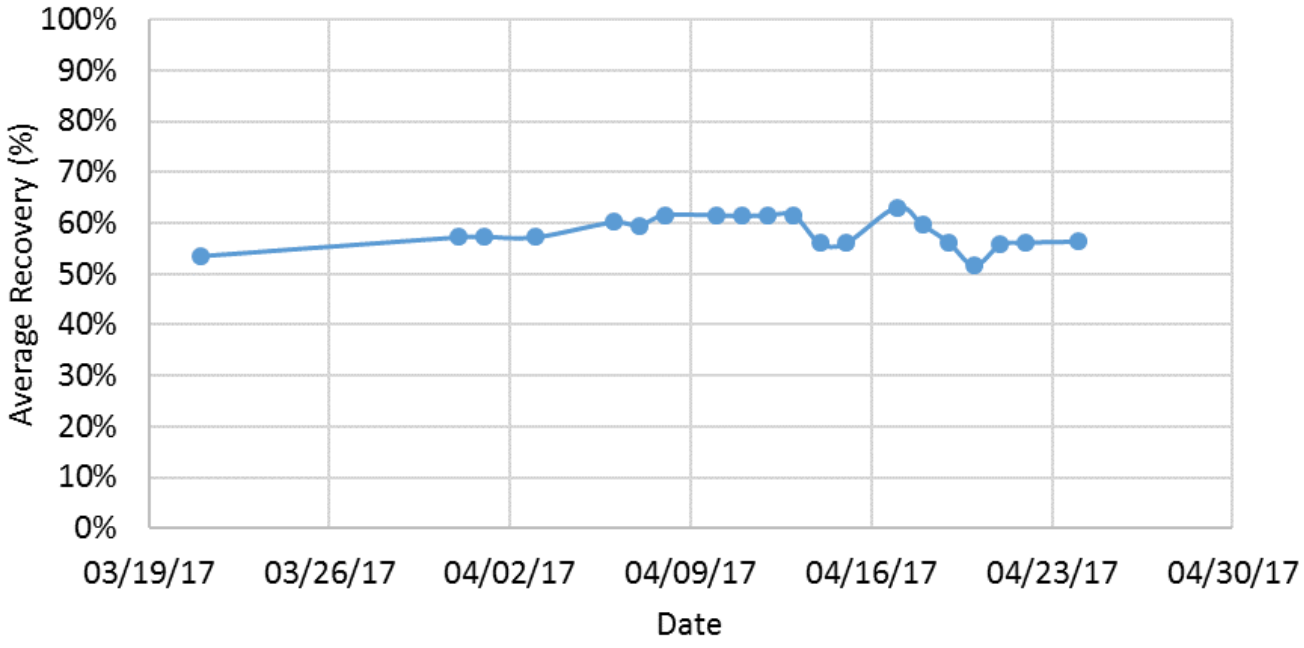
Other Applications for the Cavortex Technology

- Recovery of reverse osmosis concentrate: 2017 municipal desalter tests: Significant impact on brackish water
- Portable potable water systems: Emergency and backup use
- Humanitarian: Water treatment in developing countries
- Fracking water
- Coal ash pond treatment
- Irrigation and agricultural water

Results of 2017 Municipal Desalter Tests

- Facility: Calif. desalter processing 7 MG per day of brackish well water into drinking water
- Pilot test program conducted involving processing a stream of reverse osmosis concentrate through the Cavortex system and then back through RO membranes
- Goal is to recover 50% of RO concentrate without fouling membranes





Strategic Partnerships

- Technology can be integrated with existing treatment processes for operational and financial savings
- Cavortex strategically aligns with certified service delivery partners providing "one-stop" for implementation, support, and complementary technology integration as required
- Cavortex Strategic Partners include:
  - Seasoned EPC Contractors, Geological Engineers
  - Third Party EPA qualified Testing Labs
  - Schneider Electric
  - Misc. Suppliers US made products, Pumps, Plumbing, Valves ETC.
  - R&D, complex design, 100+ years combined experience in advanced water treatment design

Technology Status and Next Steps

- Proof-of-concept and piloting complete for initial capability
- Full-scale demonstration projects
  - Mine waste - EPA select three challenge sites
  - Municipal water – Approach city planners for East Coast beta site (Loudoun/Fairfax Co, VA)
  - Emergency water supplies – Approach DHS (FEMA), NGB, USAID
- Commercialization

Conclusions

- The Cavortex process employs hydrodynamic cavitation to transform process water stream characteristics
- The process is robust, low-maintenance, and has a small footprint
- Carpenter Snow Creek trials showed high levels of metals removal
- Next steps are full-scale demonstration and commercial deployment

Cavortex can provide solutions to reduce the time it takes to clean up existing Superfund Projects making it possible to transfer projects earlier to the States that have responsibility for the affected areas.

Contacts

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