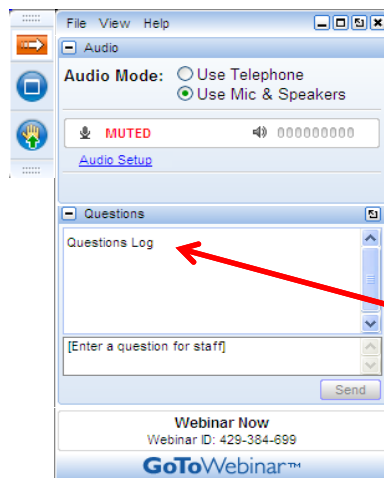


FAST Water Facilities: Piloting Technologies to De-Risk Innovation

Wednesday, May 17, 2017



How to Participate Today



- **Audio Modes**
 - Listen using Mic & Speakers
 - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this web seminar.**



Today's Moderator



Dr. Aaron Fisher
Water Environment &
Reuse Foundation



Agenda

- 1:00 Welcome & Intro to LIFT and the FAST Water Network: Aaron Fisher, WE&RF
- 1:15 Randy Shaw, U.S. Bureau of Reclamation, Brackish Groundwater National Desalination Research Facility
- 1:30 Kristen Jenkins, Southern Research Institute, Water Research Center
- 1:45 Mike Carpenter, Idaho National Laboratory, Water Security Test Bed & Jim Goodrich, U.S. EPA
- 2:00 Matt Magruder, Milwaukee Metropolitan Sewerage District
- 2:15 Questions
- 2:30 Adjourn



Introduction to LIFT and the FAST Water Network






LIFT
Leaders Innovation Forum
for Technology

Dr. Aaron Fisher
Technology and Innovation Manager
afisher@werf.org





LIFT's Mission

LIFT is a WEF/WE&RF initiative to encourage and support innovation in water




LIFT 101







Utility Peer Network




Technology Scans




LIFT Link




FAST Water Network




Technology Survey





SEE IT



University-Utility Partnership




Hubs, Partners, and Affiliates

FAST WATER

Facilities Accelerating Science & Technology



www.werf.org/fastwaternetwork

THE LIFT WATER RESOURCE RECOVERY TEST BED FACILITY NETWORK


The LIFT Water Resource Recovery Test Bed Facility Network (LIFT TRB) assesses, develops and pilots technologies for the water sector. It works to connect researchers, new technology providers, and other innovators in the water resource recovery industry with test facilities appropriate for their needs. It also aims to manage risk and accelerate the adoption of innovation by engaging the broader water community.

The test bed network was developed as a result of recommendations from stakeholder meetings and discussions organized by the National Science Foundation (NSF), the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the Water Environment & Reuse Foundation (WERF), and the Water Environment Foundation (WEF).

The LIFT TRB aims to employ work being done at Test Bed Facilities, by addressing three barriers: (1) connecting the right partners for testing; (2) ensuring applicability of test results beyond a small geographic region, or a highly specific facility setup; and (3) acceptance of the testing data to generate market demand. The LIFT TRB does not manage these facilities, but serves as a neutral party helping to coordinate their work and efforts to limit redundancy and wasted efforts.


Funding Opportunities
Numerous sources offer funding for proving and demonstrating water technologies. Please visit our [Funding Opportunities](#) page for more information. We are always open to assistance in this effort. If you are interested in engaging with the network and are not sure, how please contact Dr. Aaron Fisher, afisher@werf.org

Find a Test Bed Facility





Learn about Innovations & Connect with Innovators


LIFT Link
Discover. Connect. Collaborate.



LIFT SEE IT





National Test Bed Network: FAST Water



- Steering Committee

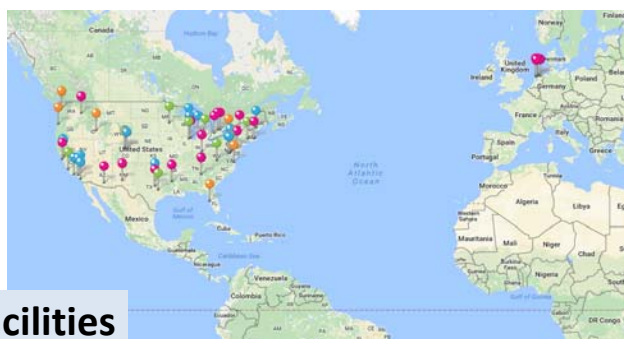
www.werf.org/fastwaternetwork



- Planning Partners



FAST Water Directory



70 Facilities

www.werf.org/testbeddirectory



Facility Details



FACILITY FILTER

Level 1
 Level 2
 Level 3
 Level 4

Click a pin to download its Facility Summary

Brackish Groundwater National Desalination Research Facility
Bureau of Reclamation

Type of Facility: Level 4 - A full-scale facility designed solely for R&D/testing of new technologies (not for treatment of a drinking water system).

Facility Contact: Randy Hahn, PE
Facility Manager
(505) 441-4334
rha@brwf.gov
<http://www.werf.org/center/US/US/Brackish/index.html>

Facility Address: 588 Lincoln Road
Alamogordo, NM 88310
United States

Facility Partners: The Brackish Groundwater National Desalination Research Facility (BRWF) is a 4.8-acre complex comprised of a central research building, auxiliary test ponds, 2-acre agricultural research area, wastewater storage, test area with 8 desalination units (including a central and source water delivery system, Research, Development and demonstration work are conducted by a variety of organizations including universities, private sector companies, congressional, and government agencies. Facility test beds are being wetted through September 2017.

The BRWF staff operates and maintain the facility. The Water Treatment Group in the Denver Reclamation office provides desalination technical assistance upon request. The

www.werf.org/testbeddirectory



Activities



guidance



matchmaking

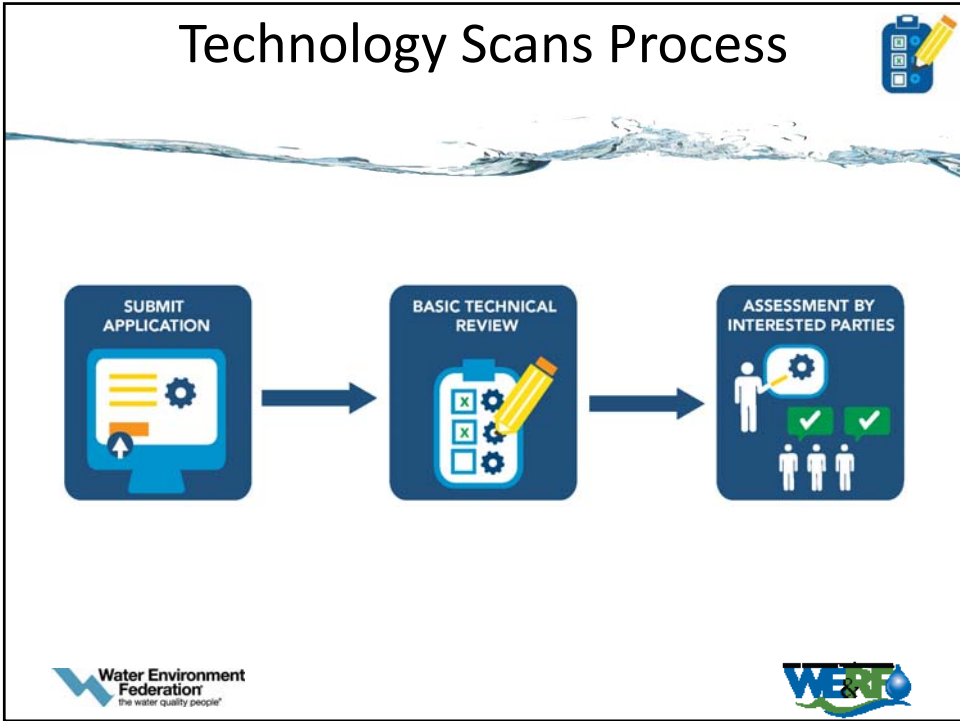


validation



data library





LIFT

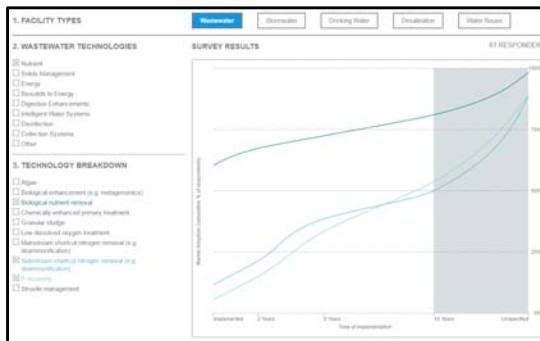
Leaders Innovation Forum
for Technology

105 Technologies
97 Companies

Water Environment Federation
the water quality people®

2017 Water Technology Survey

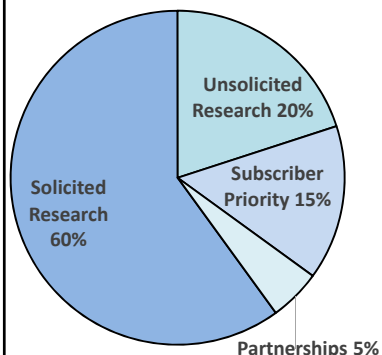
- Deeper understanding of industry direction and peer's activities
- 90 responses received to date regarding 100+ types of technology
- Visualization to be publically available Spring 2017



<http://www.surveymoz.com/s3/2952785/LIFT-Water-Tech-Survey-2016>



WE&RF Research Funding



Solicited Research - specific RFPs; targeted areas
Unsolicited Research - annual RFP; any area
Subscriber Priority - annual RFP; any area; requires matching funds
Research Partnership - board-advised fund for collaborations; rolling deadline
Tailored Collaborative - no dedicated budget; rolling deadline; WE&RF provides fundraising support and management

See all opportunities: <http://www.werf.org/a/o/Funding.aspx>





Thank You

Aaron Fisher

afisher@werf.org



Randy Shaw
Brackish Groundwater National
Desalination Research Facility



RECLAMATION

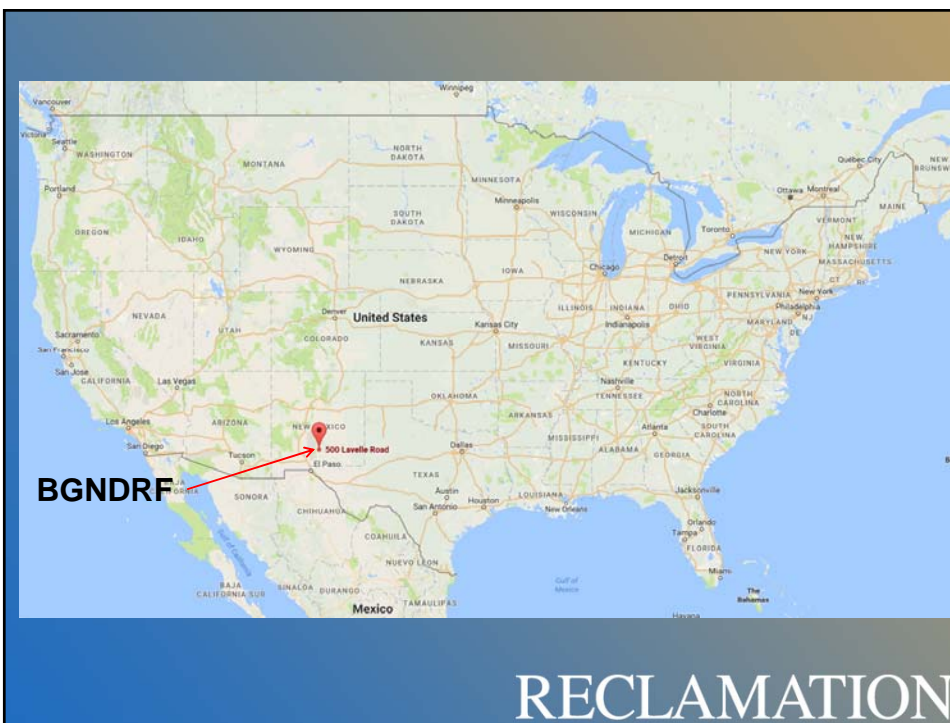
Managing Water in the West

Brackish Groundwater National Desalination Research Facility (BGNDRF)

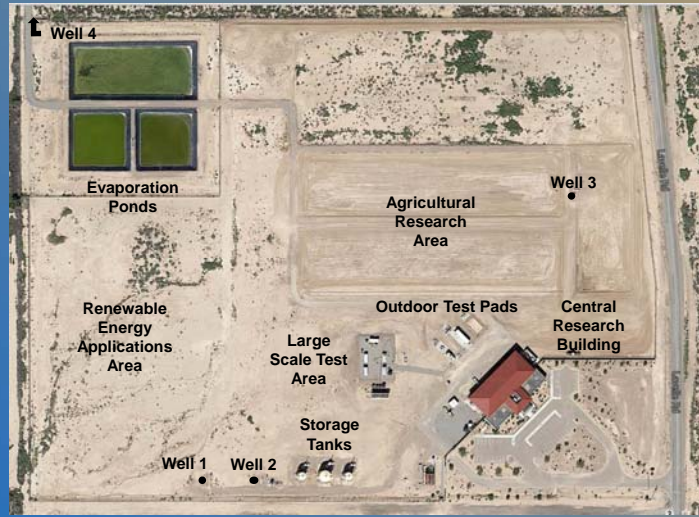
Randy Shaw, PE
BGNDRF Facility Manager



U.S. Department of the Interior
Bureau of Reclamation



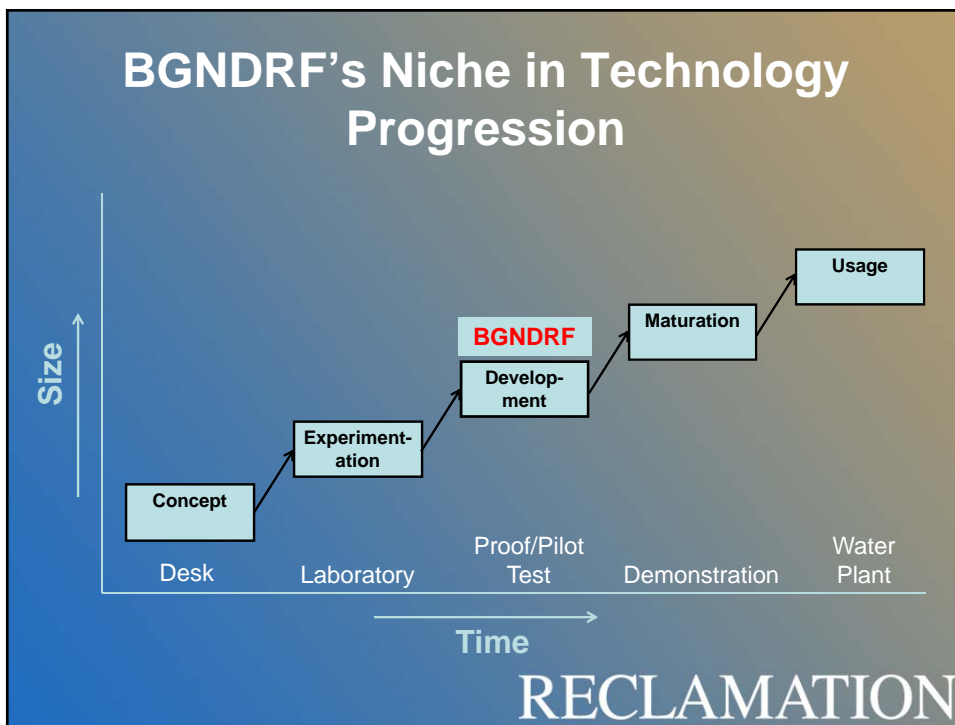
The BGDRF Complex



RECLAMATION



RECLAMATION



BGNDRF Clients

- Government Agencies
- Universities
- Private Sector



RECLAMATION

Reverse Osmosis and Nanofiltration



NMSU

RECLAMATION

Capacitive Deionization



UTEP and Voltea

RECLAMATION

Radial Deionization



Danlin Industries and Atlantis Technologies

RECLAMATION

Reverse Osmosis (Patented Control)



Water Standard; Houston, TX

RECLAMATION

Solar Distillation



KII, Inc – Hill Kemp

RECLAMATION

Land Application of Concentrate



University of Arizona → NMSU

RECLAMATION

Current and Upcoming Research

1. University of Arizona and NMSU: Irrigation of Halophytes with RO Concentrate
2. NMSU: Crop Salt Sensitivity Study
3. University of North Texas: Wind and Solar Powered Desalination for Potable Water and Agriculture Irrig.
4. LG Chem: 8-inch BWRO Membrane Characterization
5. NMSU: Ion-Selective Electrodialysis (ED)
6. NMSU: A Novel Approach for Pretreating RO Feedwater Using High Frequency Electrical Charges
7. Lehigh University: Hybrid Ion Exchange for Enhanced Recovery from Impaired Waters

RECLAMATION

Current and Upcoming Research (Continued)

8. Pacific Advanced Civil Engineering: Novel Photobiological Process to Improve Water Recovery in Brackish Groundwater Desalination
9. Global Environmental Legacy Foundation: Nano-magnets for Selective Removal of Selenium and Algae
10. NMSU: Developing Alternative Water Sources for Bioenergy Crops Production on Marginal Lands

RECLAMATION

What BGNDRF Has To Offer

1. 4 Brackish Water Wells with Varying Water Chemistries

RECLAMATION

Source Water Chemistry

Parameter	Unit	Well 1	Well 2	Well 3	Well 4
Total Dissolved Solids	mg/L	1,300	5,500	3,900	4,100
Specific Conductance	µmhos/cm	1,800	6,000	4,700	4,800
pH	---	7.88	7.27	7.32	7.29
Total Alkalinity (as CaCO ₃)	mg/L	151	248	199	210
Calcium	mg/L	63	539	440	501
Magnesium	mg/L	16	325	220	224
Sodium	mg/L	324	649	425	431
Chloride	mg/L	34	589	660	644
Sulfate	mg/L	725	3,062	1,810	1,944
Silica	mg/L	25	23	21	19

RECLAMATION

What BGNDRF Has To Offer

1. 4 Brackish Water Wells with Varying Water Chemistries
2. Discharge Permit for Concentrate Discharge to Ponds and Land Application of Concentrate
3. Currently Waiving Facility Use Fees

RECLAMATION

BGNDRF Fee Schedule

2012 Fee Schedule (subject to change)	Price	Unit
Level 3 Engineer/Scientist	976	\$/Staff Day
Level 2 Engineer/Scientist	800	\$/ Staff Day
Level 1 Technicians	592	\$/ Staff Day
Interior Bay Rental	250	\$/week
Exterior Bay Rental	400	\$/week
Power	0.15	\$/kWhr
Water RO Permeate (Set up fees vary) +	10	\$/kgal
On-site groundwater	2	\$/kgal
Imported (Depends on source)		TBD
ETV Testing Coordination with NSF International	~\$100,000	Per report
Potable Water	TBD	

Water quality analysis available for staff time charge: conductivity, pH, ORP, Temperature, Colorimetric analyses, Particle counts, Turbidity, Silt Density Index

RECLAMATION

What BGNDRF Has To Offer

1. 4 Brackish Water Wells with Varying Water Chemistries
2. Discharge Permit for Concentrate Discharge to Ponds and Land Application of Concentrate
3. Currently Waiving Facility Use Fees
4. 24 hr/day; 7 days/week
5. Local Technician Pool
6. TOC Analyzer, UV Vis Spectrophotometer, Furnace etc
7. Mobile 7.2 KW Photovoltaic Array
8. Greenhouse and Agriculture Research Area
9. "Research Friendly" Philosophy

RECLAMATION

General Process for New Client

- Initial Inquiry
- Tour of the Facility
- Complete Facility Use Forms (7 ea; 3 hrs)
- Safety Orientation (2 hrs)
- Commence Work at BGNDRF

RECLAMATION



Randy Shaw
Facility Manager
Rshaw@usbr.gov
(575) 443-6553

<http://hiddenunseen.blogspot.com/2012/04/top-9-unusual-deserts.html>

RECLAMATION



Kristen Jenkins
 Associate Director
 Water Research
 Southern Research Institute



The WRC

- \$12M facility with investment from EPRI, Georgia Power Company, and Southern Research
- Co-located on the site of large coal-fired generating plant (Plant Bowen) in Cartersville, GA
- Concept – invest in infrastructure one time to cost-effectively research ways to treat, reuse, and conserve water. Heavy focus on flue gas desulfurization wastewater treatment.
- Active engagement from key members of US utility industry
- Extensive infrastructure
 - >10,000 ft² of space dedicated to water-related research
 - Weather enclosed environments, heavy equipment, utility vehicles, state-of-the-art analytical labs supporting fast-paced R&D, office space, process equipment



Georgia Power's Plant Bowen



Key Services to Selected Clients

Consulting Services

- Independent evaluation of wastewater treatment (WWT) technology and techno-economic analysis
- Technical support throughout the development process
- Trouble-shooting existing systems and enhancing treatment

Process Testing and Validation Services

- Lab and field validation of WWT processes and equipment
- Lab analytical testing services
- Method development

Technology Development

- New to the world technology to treat, reuse, and conserve water; focused on electricity and oil & gas sectors
- Intellectual property creation



WRC Treatability Testing Infrastructure

- Physical/chemical pilot
 - Clarification
 - Dissolved Air Flotation
- Membrane Filtration
 - Flat sheet bench scale test unit
 - Pilot Reverse Osmosis
- Membrane Distillation Bench Unit
- Evaporator and Crystallizer
- Granular Media Reactors
- Filter Press
- 6-Port Jar Stirrer

6,000 ft² Dedicated to Pilot Testing - Indoor



Plug and Play Space



Photo Courtesy of Oasys, Inc.



WRC Analytical Capabilities

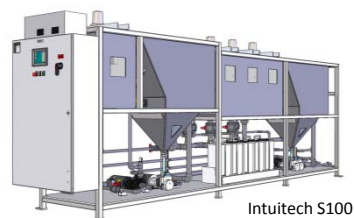
- Ion Chromatography
- ICP-MS
 - Trace metals/metalloids
 - Speciation
- GC-MS
- Trace Mercury – Liquid and Solid
- Specialized Instruments/Expertise in Solids Analyses and Leaching
- Multiple Instruments for Wet Chemistry
- Method Development

Analytical Lab



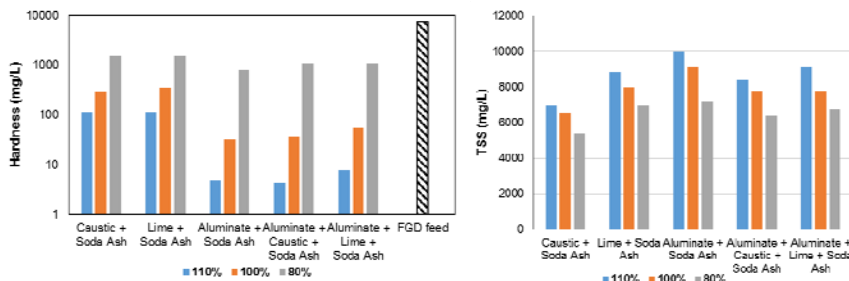
Case Study - Chemical Softening of FGD Wastewater

- Pilot test required chemical softening followed by media filtration and ion exchange
- Short term comparison of lime/soda ash softening to caustic/soda ash favored lime over caustic
- Bench testing performed to evaluate chemical doses required and enhancements with the addition of aluminate
- Funding from EPRI



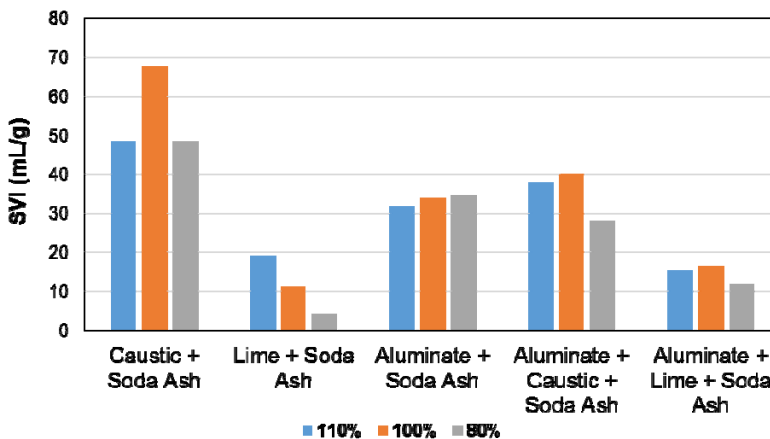
Softening Findings

- Hardness reduction improved significantly with NaAlO_2
- TSS in sludge increase due to CaCO_3 and $\text{Al}(\text{OH})_3$



Softening Findings

- Improved compaction with lime over caustic
- Adding lime to aluminate improved sludge compaction



VSEP Case Study



- Operate full-scale pilot combined New Logic's Vibratory Shear-Enhanced Process (VSEP) (also called Dynamic Shear Enhanced Membrane Filtration or DSEMF) on FGD blowdown
 - Create high shear rate at membrane surface to reduce fouling
 - Fouling control very important for treatment of highly scaling waters.
- Evaluate removal of dissolved solids, Hg, NO₃⁻, and Se.
- Develop design data for full scale system

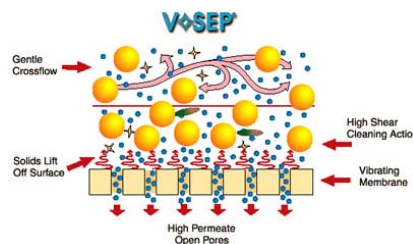
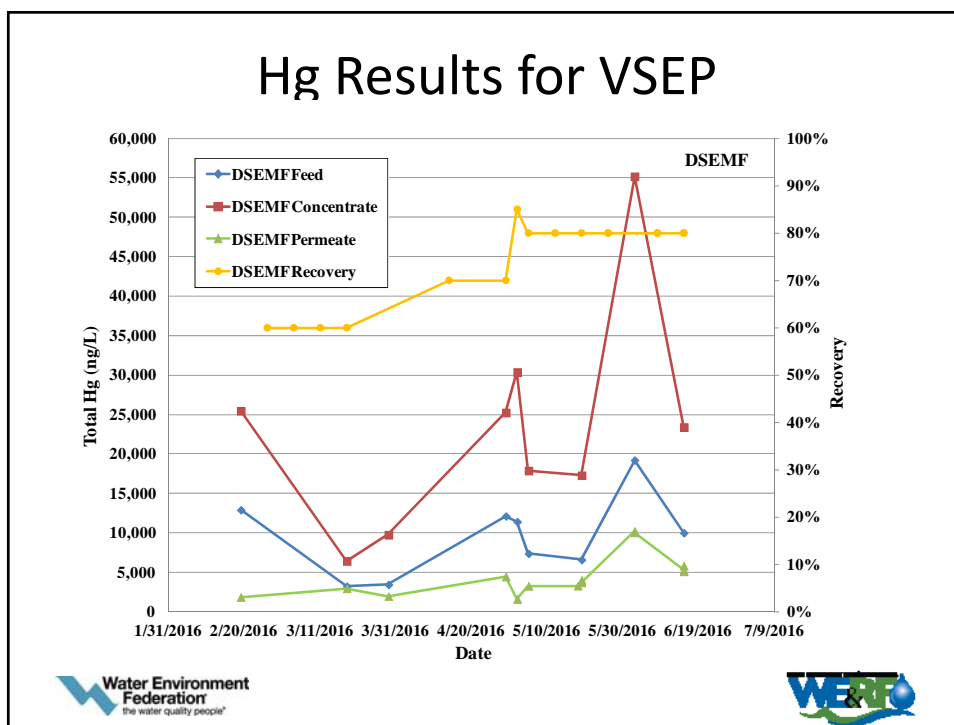
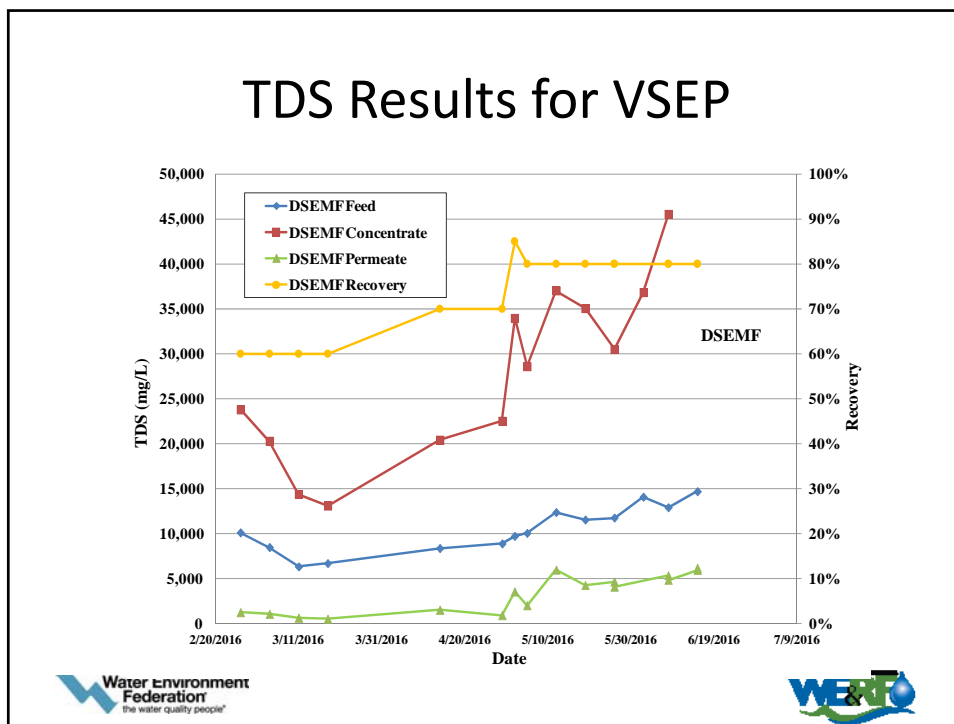


Figure Courtesy of New Logic, Inc.



VSEP/SRO SYSTEM







Kristen Jenkins, PE
kjenkins@southernresearch.org
Associate Director, Southern Research
Water Research Center
317 Covered Bridge Road
Cartersville, GA 30120
205-704-3479




Michael Carpenter
Relationship Manager, Energy Water Nexus
and Water Security
Idaho National Laboratory





INL Snapshot

- 890 square miles
- 111 miles of electrical transmission and distribution lines
- 3 reactors
- Nuclear and radiological facilities
- Classified space
- Explosive range
- 579 buildings (120 Laboratories)
- 177 miles of paved roads
- 14 miles of railroad lines
- 2 spent fuel pools
- 300 metric tons of used fuel
- Mass transit system
- 3 fire stations
- Security
- Museum
- Landfills




We resemble a “reconfigurable city/region” in which energy and security questions can be addressed at scale

Unique geography and assets provide a competitive advantage for INL and Partners





INL Energy Environment Science & Technology Core Capabilities

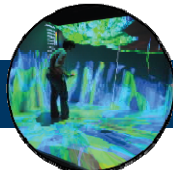
Key Market Differentiators: Performance science at-scale; Systems integration at-scale; Systems analyses




Materials Properties and Performance




Systems Science and Engineering




Geosciences





Chemical Process Science and Technology



Power and Energy Systems



Sensing, Measurement, and Data Sciences



Directed Research INstitute For Clean Water (DRINC)

OUR MISSION

DRINC delivers sustainable and secure clean water supplies for the nation by integrating world-class science and engineering.

Together, DRINC partners will accelerate development and transfer of promising technologies to market through scale-up, demonstration, and close collaboration with private companies and public entities. Our solutions will be tailored to the water-use requirements and source water qualities in each application.

WHAT IS PIPE PARITY?

Pipe parity is the ability to deliver water to consumers at the same (or higher) quality, and at the same (or reduced) cost and environmental impact, as existing freshwater sources.

WHAT IS AN ENERGY INNOVATION HUB?

The U.S. Department of Energy funds several national Energy Innovation Hubs. DOE describes these Hubs as multidisciplinary, multi-investigator, multi-institutional integrated research centers. The Hubs bring together top researchers from academia, industry, and government laboratories, with expertise that spans multiple scientific and engineering disciplines, as well as energy policy, economics, and market analysis. Learn more about DOE Energy Innovation Hubs at energy.gov/science-innovation/innovation-hubs.

CONTACT US

For more information, contact A.J. Simon at simon19@inl.gov.

Directed Research Institute for Clean Water (DRINC)

Providing water through innovative treatment systems.



The Directed Research Institute for Clean Water (DRINC) was established to expand our nation's water supply by developing and commercializing low-energy, low-carbon technologies that deliver clean water at pipe parity with conventional water supplies. DRINC is responding to a U.S. Department of Energy (DOE) initiative aimed at establishing a multi-disciplinary Energy Innovation Hub that will be a central pillar in research and development efforts regarding our nation's water supply.

environmental impact. The success of DRINC's integrated research and development approach will be measured by its impact on the sustainability and resilience of the nation's water supply.

The energy-producing Midwest Mountain West

Our nation's urban, industrial, and agricultural centers

Through utilities California and the West Coast

Regional Water Markets Represented by DRINC Laboratories

An Energy Innovation Hub focused on clean water will serve as an integrated research center for developing systems-level solutions, as well as enabling technologies, to enhance U.S. water security. While clean water research has been underway for decades, DRINC will provide the critical mass needed to deliver new technologies for sustainable and cost-effective water supply and management solutions.

The goal of DRINC is pipe parity, offering cost-competitive water from alternative sources with minimal

DRINC PARTNERS

Academic, industrial, and government researchers willing to conceive, design, and evaluate technologies and processes to realize market-driven targets.

Manufacturers, utilities, municipalities, and policy makers who will define critical needs and create benchmarks for research targets.


Institutes and investors interested in evaluating the most promising technologies and accelerating deployment of the technologies in the market.

Educators and non-governmental organizations (NGOs) who will ensure that the sustainable water treatment solutions are backed by a well-prepared workforce and embraced by the public.







STIMS INL/MIS-17-41237



James A. Goodrich Ph.D.
Senior Research Advisor, Water Infrastructure Protection Division
National Homeland Security Research Center
Office of Research and Development - U.S. EPA

U.S. EPA's Full Scale Water Security Test Bed

How will these technologies perform in full-scale systems?

Water Security Test Bed:

- Simulates intentional and inadvertent distribution system contamination (chem, bio, rad) and disruptions (cyber-attacks)
- Supports diverse applied research
- Located at Idaho National Lab (INL) (near Idaho Falls, Idaho)

[Water Security Test Bed Video: https://youtu.be/oICs_kbegBA](https://youtu.be/oICs_kbegBA)



Phase I of the test bed is a once through system:

- ~445' of 8" cement mortar lined, ductile iron pipe (water main), 2 hydrants, 6 sample ports
- ~200' of 1" Cu service line to building
- 15' pipe material coupon section for sampling the interior of the pipe surface
- Above ground system, underlined by secondary containment
- 28,000 gallon lagoon/high rate groundwater pump/storage tank



Operational Pictures

Triggered Flushing



Injection Point



Chlorine and UV Sensors with Cellular Modem



8" Ductile Iron

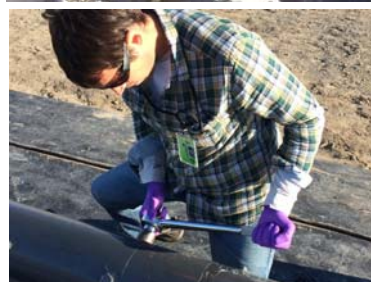


4" Cast Iron

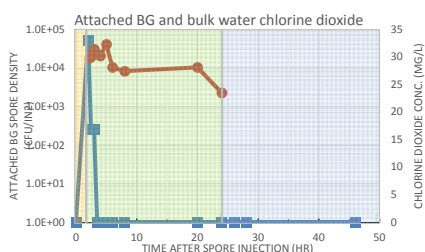


Microbial Decontamination

- WSTB pipe was contaminated with *Bacillus globigii* spores
- Decontamination was undertaken with chlorine dioxide
 - Target concentration was 25 mg/L, but we hit 100 mg/L
 - Chlorine dioxide concentration dropped precipitously due to heat and demand
 - 2-log reduction of attached spores was observed, which was less than in the pilot scale experiments
- Re-sampled for *B. globigii* in the water and re-decontaminated the pipe
The water sample concentrator helped find low levels of spores

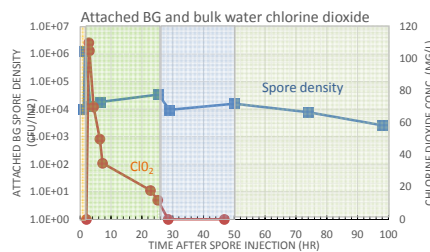


Bacillus Globigii Experiments



Data from Pilot Scale Decontamination Loop at EPA's T&E Facility

- No spores detected on cement-mortar after treatment with 25-30 mg/L ClO₂



Data from WSTB at INL

- Spores persisted on cement-mortar in the presence of up to 100 mg/L ClO₂
- Pipe demand, temperature fluctuation and dead end spaces impacted decontamination

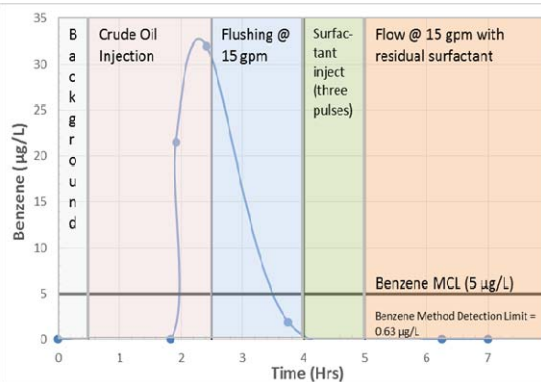


Response to Oil Spills

- Contaminated the WSTB pipe with Bakken crude oil components
 - Examined flushing and adding a surfactant as decontamination methods
 - Coupons and water samples were analyzed for BTEX, ORO, GRO and DRO



Bakken Crude Oil in the WSTB



- Bakken Crude oil components (Benzene) were not detected on the coupon surfaces
- Flushing clean water was enough to lower benzene below the MCL in the water phase
- Surfactant addition was unnecessary, and could be counterproductive as it did persist (surfactant may be needed for higher petroleum product loading)



Service Line to the Indoor Plumbing

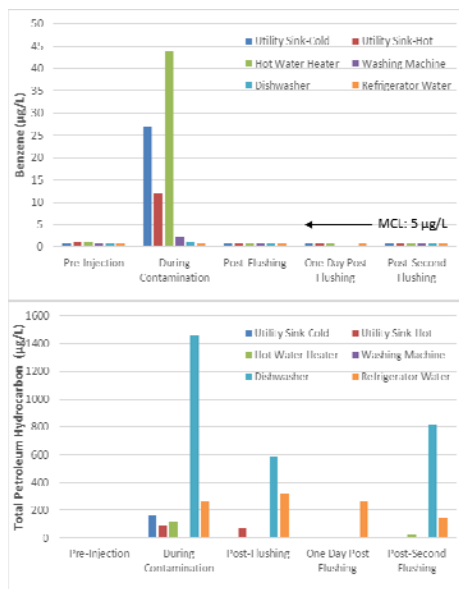


WSTB Indoor Plumbing



Plumbing Decontamination Data

- Bakken crude oil injected in the same manner as in the big pipe previously (subnantent containing dissolved compounds)
- Flushing:
 - Cold water and refrigerator flushed for 20 min (hot water off)
 - Hot water heater drained, refilled, then hot water flushed for 75 min
 - The flushing process was repeated the next day



Portable Decon Water Treatment Technologies

Wash Water Treatment after Pipe Decontamination



Ozone and UV AOP Mobile Trailer



Solstreme UV Flow Through System



Granular Activated Carbon Drums

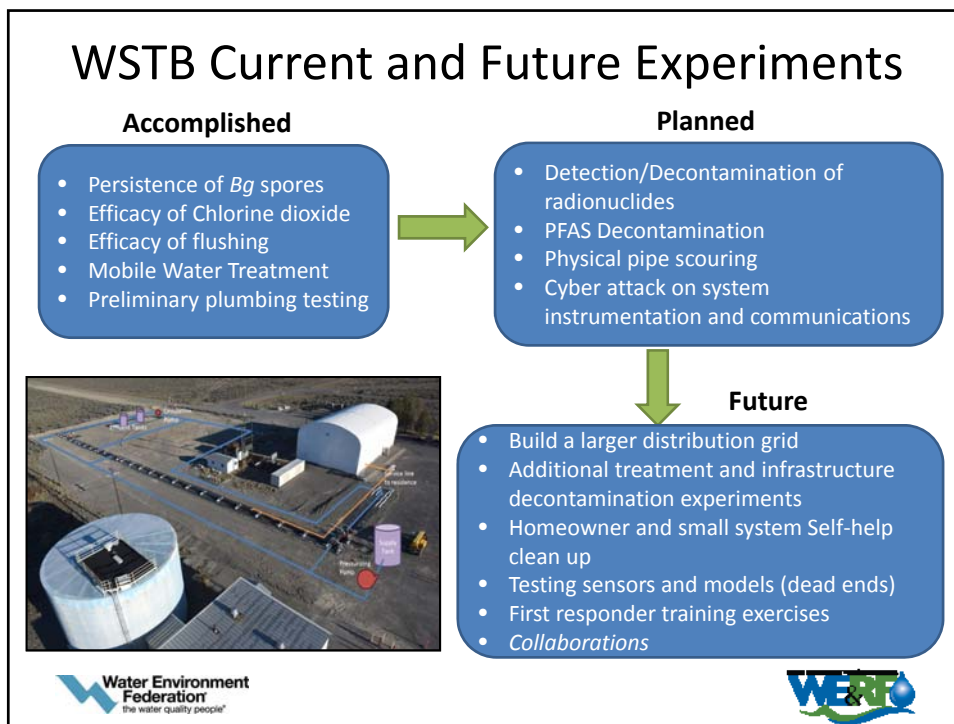


WaterStep Mobile Emergency Water Treatment System



Hayward Swimming Pool Chlorinator







Thank You!

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 Water Infrastructure Protection Division
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Matt Magruder
 Environmental Research Manager
 Milwaukee Metropolitan Sewerage
 District

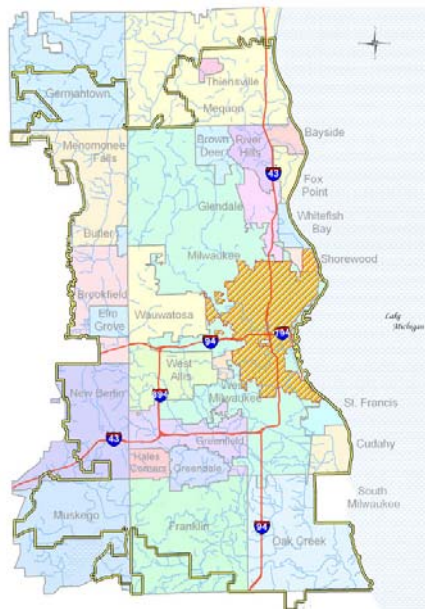


Kevin Jankowski, P.E.
 Senior Project Manager
 Milwaukee Metropolitan Sewerage
 District



MMSD Overview

- ▶ Provide water reclamation and flood management services
- ▶ Serve ~1.1 million people from 28 municipalities in the Greater Milwaukee Area
- ▶ Planning area spans 411 mi² that covers all, or segments of six watersheds.
- ▶ 300 Miles of MMSD Sewers
- ▶ 3,000 Miles of Municipally Owned Sewers
- ▶ 3,000 Miles of Private Laterals



What MMSD Facilities Offer

- ▶ Ample Space
- ▶ Power
- ▶ Lab Space
- ▶ Sample Points
- ▶ On-site Technical Assistance



Environmental Lab Tests Offered

▶ Conventional

- ▶ BOD (5 day)
- ▶ BOD (20 day)
- ▶ Turbidity, Total Solids
- ▶ Total Suspended Solids
- ▶ Volatile Suspended Solids
- ▶ Alkalinity, Hardness
- ▶ Temperature, Depth, pH
- ▶ Dissolved Oxygen
- ▶ Conductance, Chloride
- ▶ Secchi disc, Photometer

▶ Biological

- ▶ Fecal Coliform Bacteria
- ▶ E. Coli Bacteria
- ▶ Chlorophyll a

▶ Metals

- ▶ Cadmium, Chromium
- ▶ Zinc, Lead, Nickel
- ▶ Calcium, Magnesium
- ▶ Mercury, Selenium
- ▶ Silver, Copper, Arsenic

▶ Nutrients

- ▶ Total Kjeldahl Nitrogen
- ▶ Ammonia Nitrogen
- ▶ Total Organic Carbon
- ▶ Dissolved Organic Carbon
- ▶ Total Inorganic Carbon
- ▶ Total Phosphorus
- ▶ Soluble Phosphorus
- ▶ Soluble Silica
- ▶ Nitrite
- ▶ Nitrate



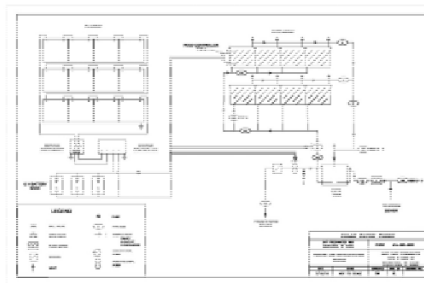
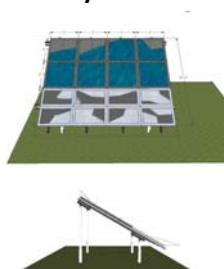
Digester Gas Water Scrubber

Methane			CO2		
In	Out	Increase	In	Out	Removal
%	%	%	%	%	%
56.6	86	52%	29.3	6.35	78%
58.7	71	20%	29.2	4.17	86%
66.3	77	15%	33.1	17.7	47%
66.1	83	25%	32.7	8.34	74%
66.00	60	-9%	32.5	3.14	90%
66.3	82	24%	32.6	4.42	86%
65.9	69	5%	33.4	4.1	88%
61.3	87	42%	31.8	5.12	84%
65.8	63.6	-3%	33.7	3.51	90%
64	75	18%	32	6	80%

H2S			Siloxane		
In	Out	Removal	In	Out	Removal
ppm	ppm	%	µg/m3 as Si	µg/m3 as Si	%
87	0.076	99.9%	1600	890	44%
69	0.042	99.9%	2300	1200	48%
95	0.18	99.8%	2300	1400	39%
160	0.120	99.9%	3700	970	74%
74	0.088	99.9%	5300	1600	70%
100	0.3	99.7%	5300	1600	70%
73	0.13	99.8%	2300	680	70%
29	0.29	99%	3200	850	73%
120	0.044	99.96%	3200	1100	66%
90	0	99.8%	3244	1143	65%



PECO System



Date	Configuration	Flowrate (GPM)	Inlet Bacteria (CFU/100 ml)	Outlet Bacteria (CFU/100 ml)	Removal (%)	Log Reduction (10 ¹)	Reaction Rate Constant (min ⁻¹)
8/17/16	8 panels, single pass, parallel connection	3.8	1085	182	83.2	0.78	0.8
8/26/16	8 panels, single pass, parallel connection	5.8	6200	2400	61.3	0.41	0.5
8/31/16	4 panels, single pass, series connection	1.2	13900	1050	92.4	1.12	0.6
9/1/16	5 panels, single pass, series conn, light	1.2	1858	4	99.8	2.67	1.5



Green Infrastructure Piloting

Storm Event	Total Rain Depth (cm)	Hydropack	HSR	HSRA
4/19/2015	2.59	48.3	85.1	---
5/25/2015	1.04	97.0	---	97.8
7/18/2015	1.70	14.0	75.0	86.4
8/10/2015	4.04	30.7	79.9	96.4
8/18/2015	1.75	75.3	92.3	94.2
8/28/2015	2.87	63.4	88.8	96.2
9/18/2015	3.66	40.3	83.4	90.5
9/29/2015	2.21	82.4	83.0	95.6

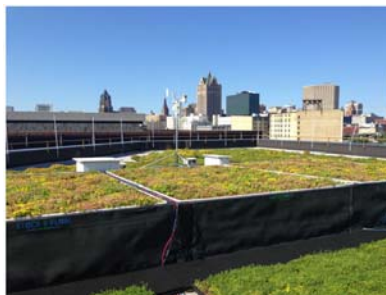
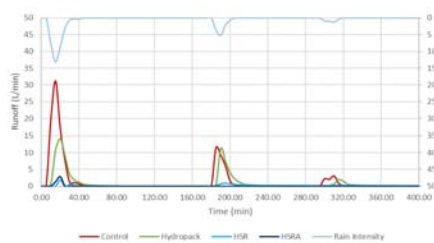


Table 4.1 Runoff reduction, or retention in (%)

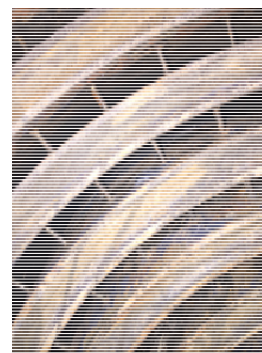
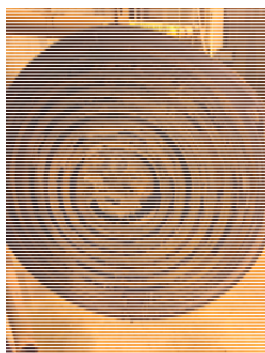


Storm Event	Peak Storm Intensity (cm/hr)	Hydropack	HSR	HSRA
4/19/2015	1.5	36.6	94.3	---
5/25/2015	2.4	97.6	---	98.3
7/18/2015	6.7	23.5	92.5	87.6
8/10/2015	13.1	55.1	94.0	90.8
8/18/2015	6.7	92.0	97.1	97.3
8/28/2015	1.5	-6.6	94.4	96.2
9/18/2015	5.2	19.3	89.7	87.2
9/29/2015	2.1	90.0	95.9	98.4

Table 4.2 Peak runoff reduction in (%)



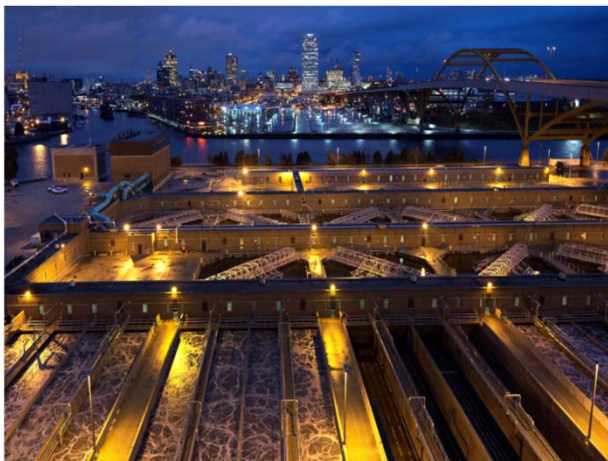
Advanced Materials for Improved Performance



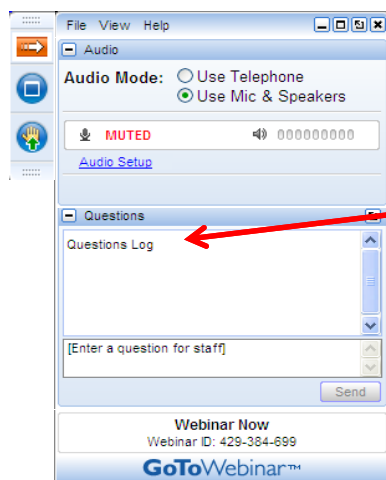
Thank You!

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How to Ask a Question



- Submit your questions using the Questions pane.
- A recording will be available for replay shortly after this web seminar.



Thank You

