# FAST Water Facilities: Piloting Technologies to De-Risk Innovation

Wednesday, May 17, 2017

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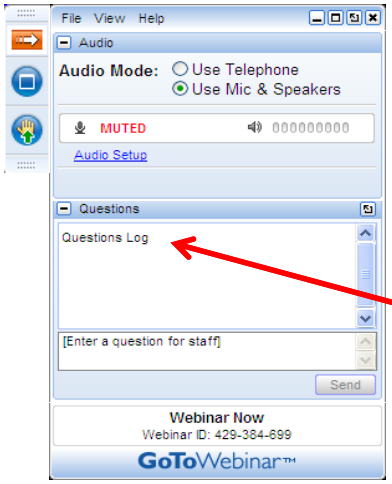
# How to Participate Today




- **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.**

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# Today's Moderator

**Dr. Aaron Fisher**
Water Environment &
Reuse Foundation

# Agenda

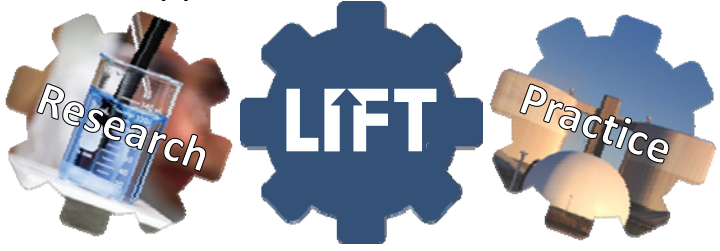
1:00 Welcome & Intro to LIFT and the FAST Water Network: Aaron Fisher, WE&RF
1:15 Randy Shaw, U.S. Bureau of Reclamation, Brackish Groundwater National Desalination Research Facility
1:30 Kristen Jenkins, Southern Research Institute, Water Research Center
1:45 Mike Carpenter, Idaho National Laboratory, 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

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

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# FAST WATER

Facilities Accelerating Science & Technology

www.werf.org/fastwaternetwork


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# National Test Bed Network: FAST Water

- Steering Committee

www.werf.org/fastwaternetwork

- Planning Partners

Argonne NATIONAL LABORATORY

Lawrence Livermore National Laboratory

NIST National Institute of Standards and Technology U.S. Department of Commerce

USDA

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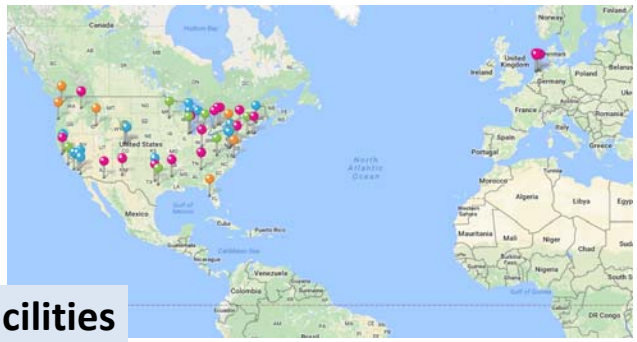
# FAST Water Directory



- Level 1
- Level 2
- Level 3
- Level 4

**70 Facilities**

www.werf.org/testbeddirectory

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# Facility Details



www.werf.org/testbeddirectory

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# Activities

guidance

matchmaking

validation


data library

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# Technology Scans Process


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# LIFT

Leaders Innovation Forum for Technology


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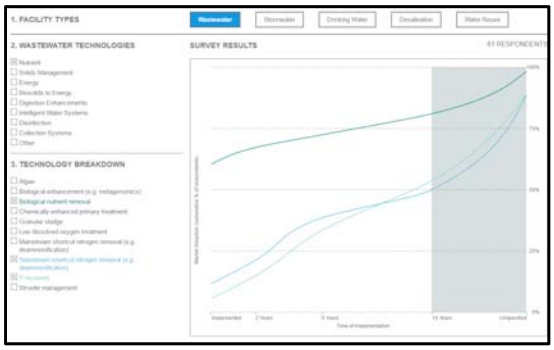
# 2017 Water Technology Survey

http://www.werf.org/lift/visualizationtool

****Just Released****

- Deeper understanding of industry direction and peer's activities
- 90 responses received to date regarding 100+ types of technology
- Survey to stay open through 2017

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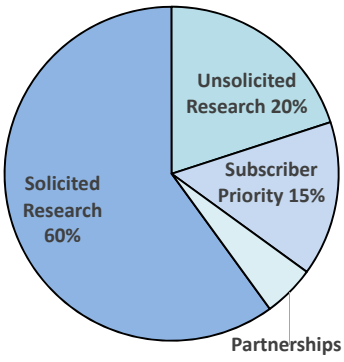
# WE&RF Research Funding




| |
|---|
| **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

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LIFT
Leaders Innovation Forum for Technology

# Thank You

Aaron Fisher
afisher@werf.org

**Randy Shaw**
Brackish Groundwater National Desalination Research Facility

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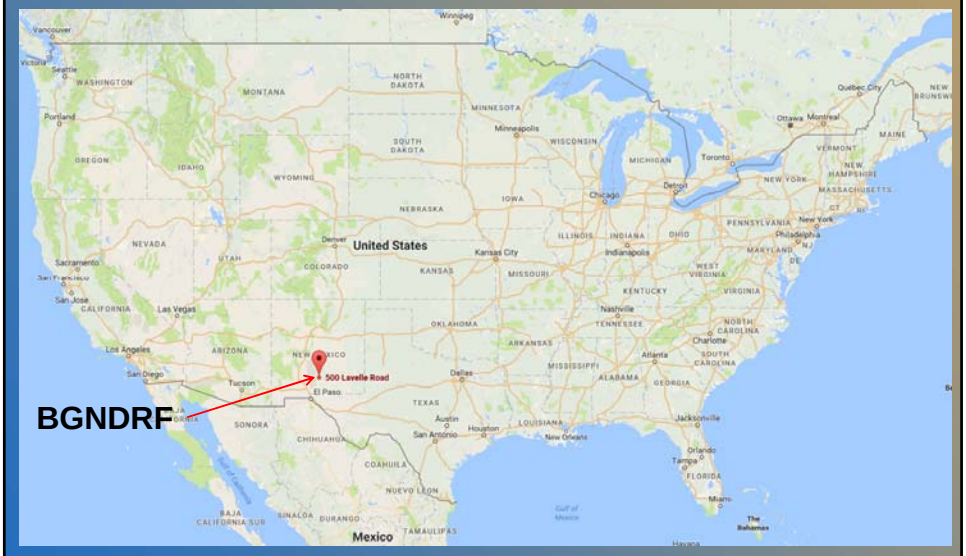
*Managing Water in the West*

# Brackish Groundwater National Desalination Research Facility (BGNDRF)

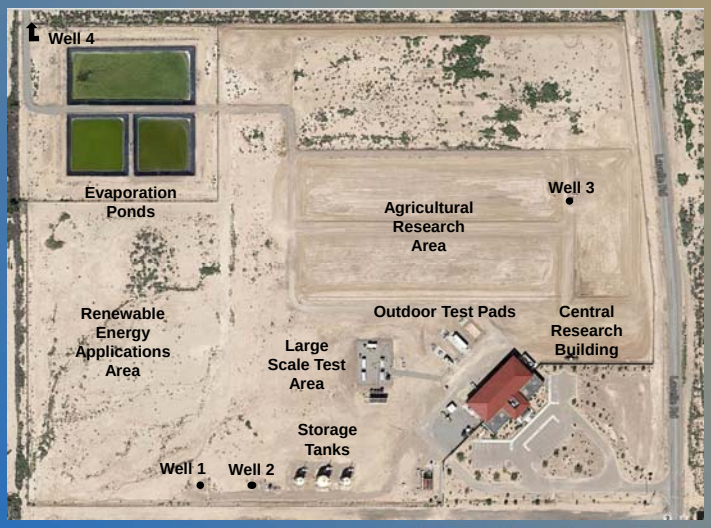
Randy Shaw, PE
BGNDRF Facility Manager

U.S. Department of the Interior
Bureau of Reclamation




RECLAMATION

# The BGNDRF Complex




RECLAMATION


RECLAMATION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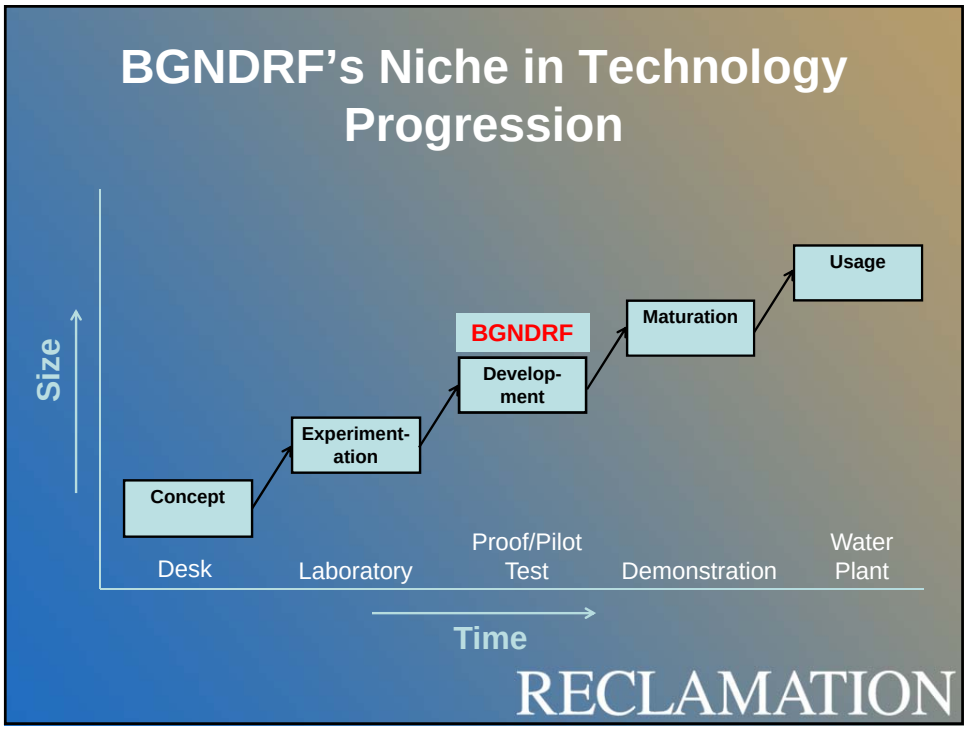
BGNDRF's Niche in Technology Progression
Size
Concept
Experiment-ation
BGNDRF
Develop-ment
Maturation
Usage
Desk
Laboratory
Proof/Pilot Test
Demonstration
Water Plant
Time
RECLAMATION

## BGNDRF Clients

- Government Agencies
- Universities
- Private Sector

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## Reverse Osmosis and Nanofiltration

NMSU

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## Capacitive Deionization


UTEP and Voltea

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## Radial Deionization

Danlin Industries and Atlantis Technologies

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## Reverse Osmosis (Patented Control)


Water Standard; Houston, TX

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## Solar Distillation

KII, Inc – Hill Kemp

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## Land Application of Concentrate

University of Arizona ⟶ NMSU

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## 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

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## 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**

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## What BGNDRF Has To Offer

1. 4 Brackish Water Wells with Varying Water Chemistries

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## 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 |

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## 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

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# 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

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## 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

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Randy Shaw
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http://hiddenunseen.blogspot.com/2012/04/top-9-unusual-deserts.html

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**Kristen Jenkins**
Associate Director
Water Research
Southern Research Institute

# The WRC

- $12M facility with investment from EPRI, Georgia Power Company, and Southern Research
- Co-located on the site of large coal-fired generating plant (Plant Bowen) in Cartersville, GA
- Concept – invest in infrastructure one time to cost-effectively research ways to treat, reuse, and conserve water. Heavy focus on flue gas desulfurization wastewater treatment.
- Active engagement from key members of US utility industry
- Extensive infrastructure
  - >10,000 ft$^2$ of space dedicated to water-related research
  - Weather enclosed environments, heavy equipment, utility vehicles, state-of-the-art analytical labs supporting fast-pace 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**

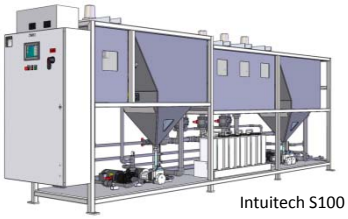
*Photo Courtesy of Oasys, Inc.*

# 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

# 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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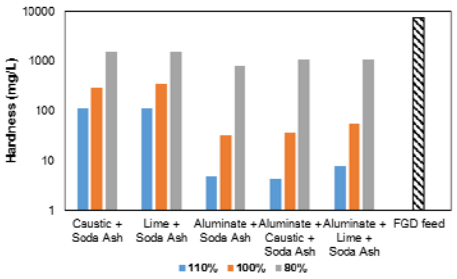
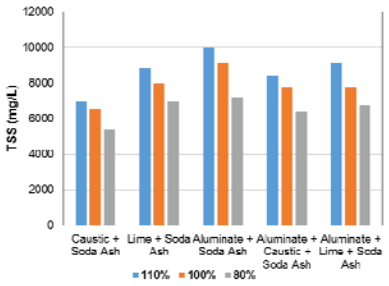
# Softening Findings

- Hardness reduction improved significantly with $NaAlO_2$
- TSS in sludge increase due to CaCO3 and Al(OH)3

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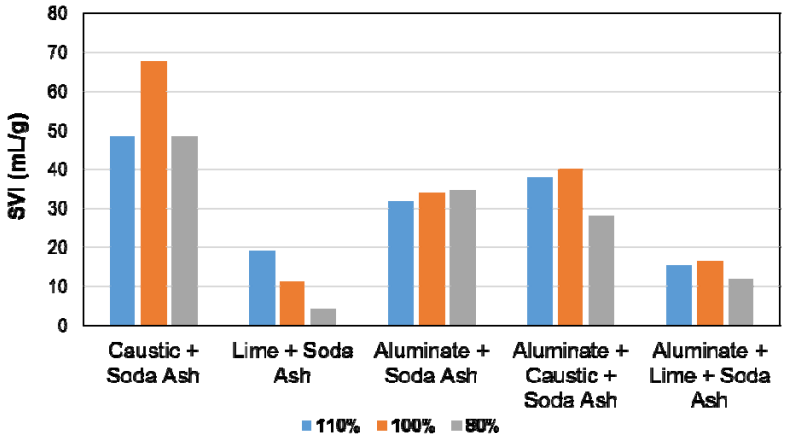
# Softening Findings

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

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# 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, $NO_3^-$, and Se.
- Develop design data for full scale system

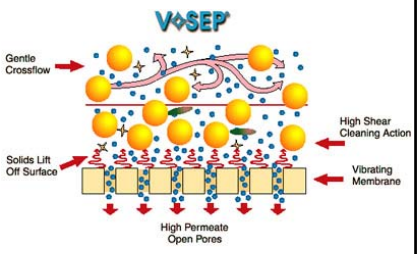
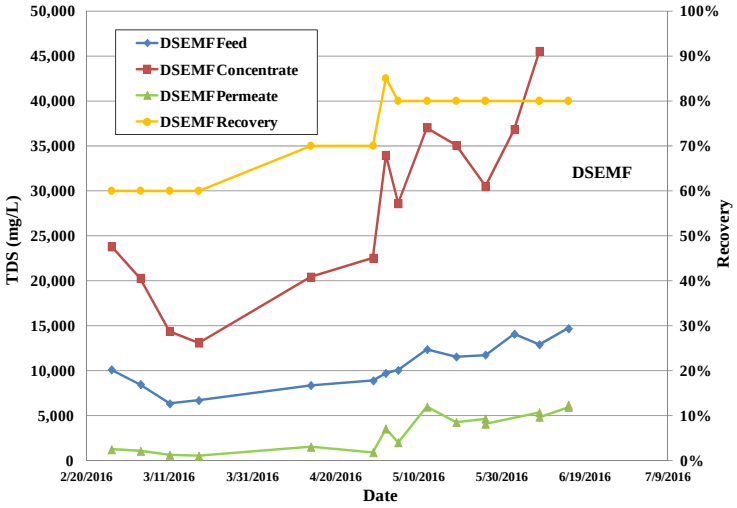



Figure Courtesy of New Logic, Inc.

# VSEP/SRO SYSTEM

# TDS Results for VSEP

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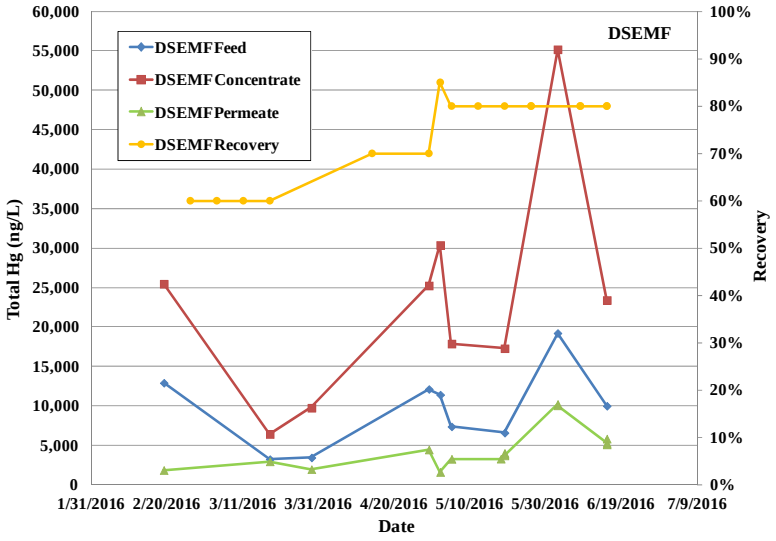
# Hg Results for VSEP

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205-704-3479

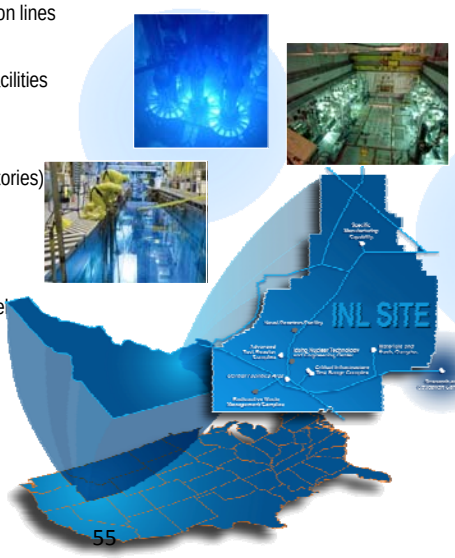
**Michael Carpenter**

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***

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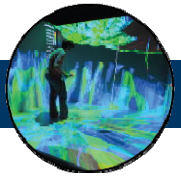
# INL Energy Environment Science & Technology Core Capabilities

**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

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# *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-user 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.*

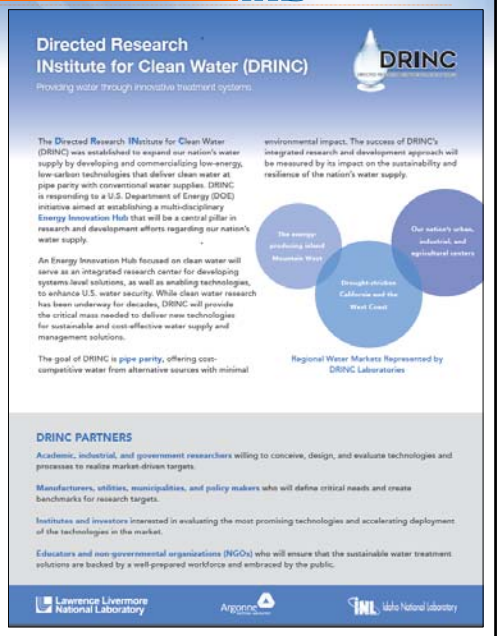
**WHAT IS AN ENERGY INNOVATION HUB?**

The U.S. Department of Energy funds several national Energy Innovation Hubs. DOE describes these Hubs as multi-disciplinary, 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.

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

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# 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/olCs_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

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# Operational Pictures

***Triggered Flushing***

***Injection Point***

***Chlorine and UV Sensors with Cellular Modem***

**8" Ductile Iron**

***4" Cast Iron***

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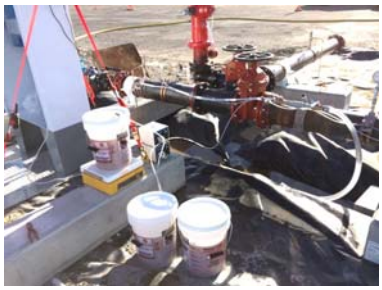
# Microbial Decontamination

- 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



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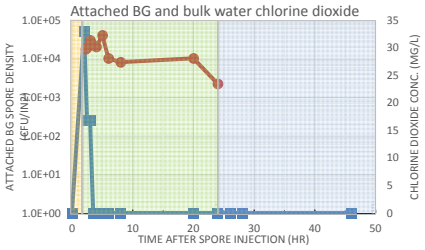
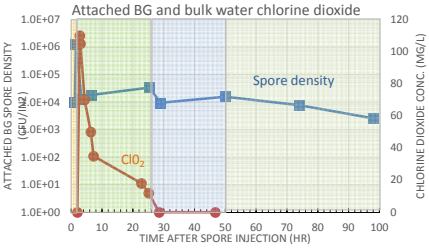
# *Bacillus Globigii* Experiments




***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 $ClO_2$




***Data from WSTB at INL***

- Spores persisted on cement-mortar in the presence of up to 100 mg/L $ClO_2$
- Pipe demand, temperature fluctuation and de end spaces impacted decontamination

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# 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

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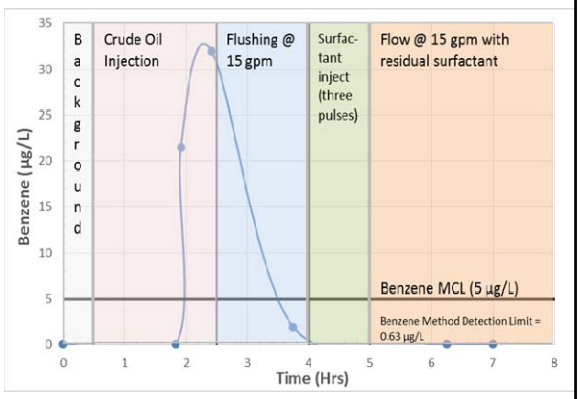
# Bakken Crude Oil in the WSTB




- 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)

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# Service Line to the Indoor Plumbing


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# WSTB Indoor Plumbing

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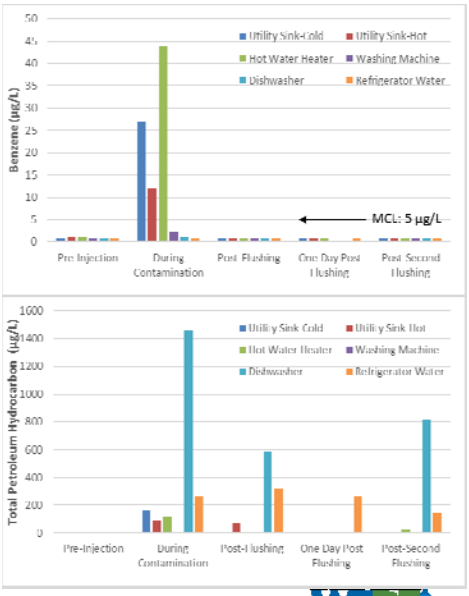
# Plumbing Decontamination Data

- Bakken crude oil injected in the same manner as in the big pipe previously (subnatent 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

Ozone and UV AOP Mobile Trailer

Solstreme UV Flow Through System

***Wash Water Treatment after Pipe Decontamination***

Granular Activated Carbon Drums

WaterStep Mobile Emergency Water Treatment System

Hayward Swimming Pool Chlorinator

# WSTB Current and Future Experiments

**Accomplished**

- Persistence of *Bg* spores
- Efficacy of Chlorine dioxide
- Efficacy of flushing
- Mobile Water Treatment
- Preliminary plumbing testing

**Planned**

- Detection/Decontamination of radionuclides
- PFAS Decontamination
- Physical pipe scouring
- Cyber attack on system instrumentation and communications

**Future**

- Build a larger distribution grid
- Additional treatment and infrastructure decontamination experiments
- Homeowner and small system Self-help clean up
- Testing sensors and models (dead ends)
- First responder training exercises
- *Collaborations*

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# Thank You!

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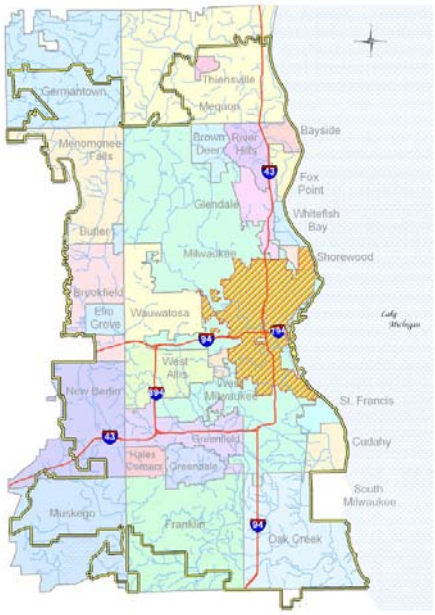
## MMSD Overview

- Provide water reclamation and flood management services
- Serve ~1.1 million people from 28 municipalities in the Greater Milwaukee Area
- Planning area spans 411 $mi^2$ 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 | |
|---|---|---|
| In | Out | *Increase* |
| % | % | % |
| 56.6 | 86 | 52% |
| 58.7 | 71 | 20% |
| 66.3 | 77 | 15% |
| 66.1 | 83 | 25% |
| 66.00 | 60 | -9% |
| 66.3 | 82 | 24% |
| 65.9 | 69 | 5% |
| 61.3 | 87 | 42% |
| 65.8 | 63.6 | -3% |
| **64** | **75** | **18%** |

| | CO2 | |
|---|---|---|
| In | Out | *Removal* |
| % | % | % |
| 29.3 | 6.35 | 78% |
| 29.2 | 4.17 | 86% |
| 33.1 | 17.7 | 47% |
| 32.7 | 8.34 | 74% |
| 32.5 | 3.14 | 90% |
| 32.6 | 4.42 | 86% |
| 33.4 | 4.1 | 88% |
| 31.8 | 5.12 | 84% |
| 33.7 | 3.51 | 90% |
| **32** | **6** | **80%** |

| | H2S | |
|---|---|---|
| In | Out | *Removal* |
| *ppm* | *ppm* | *%* |
| 87 | 0.076 | 99.9% |
| 69 | 0.042 | 99.9% |
| 95 | 0.18 | 99.8% |
| 160 | 0.120 | 99.9% |
| 74 | 0.088 | 99.9% |
| 100 | 0.3 | 99.7% |
| 73 | 0.13 | 99.8% |
| 29 | 0.29 | 99% |
| 120 | 0.044 | 99.96% |
| **90** | **0** | **99.8%** |

| | Siloxane | |
|---|---|---|
| In | Out | *Removal* |
| *µg/m3 as Si* | *µg/m3 as Si* | *%* |
| 1600 | 890 | 44% |
| 2300 | 1200 | 48% |
| 2300 | 1400 | 39% |
| 3700 | 970 | 74% |
| 5300 | 1600 | 70% |
| 5300 | 1600 | 70% |
| 2300 | 680 | 70% |
| 3200 | 850 | 73% |
| 3200 | 1100 | 66% |
| **3244** | **1143** | **65%** |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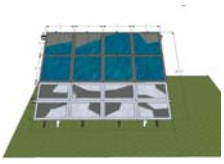
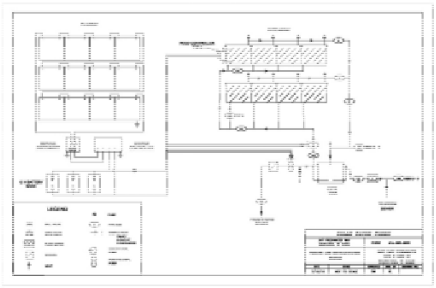
## PECO System





| Date | Configuration | Flowrate (GPM) | Inlet Bacteria (CFU/100 ml) | Outlet Bacteria (CFU/100 ml) | Removal (%) | Log Reduction ($10^x$) | 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 |

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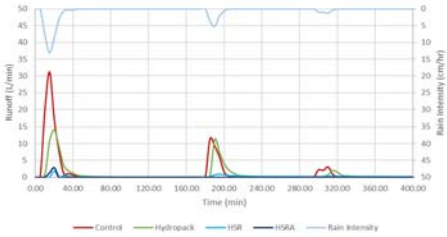
## Green Infrastructure Piloting

| *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 |

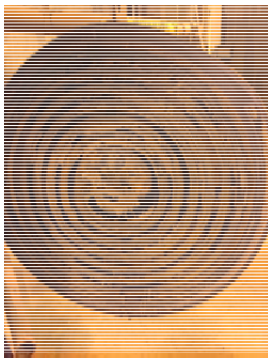
**Table 4.1 Runoff reduction, or retention in (%)**

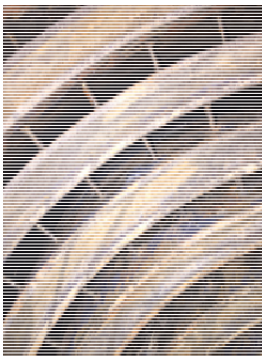



| *Storm Event* | *Peak Storm Intensity (cm/hr)* | *Hydropack* | *HSR* | *HSRA* |
|---|---|---|---|---|
| *4/19/2015* | 1.5 | 36.6 | 94.3 | - - - |
| *5/25/2015* | 2.4 | 97.6 | - - - | 98.3 |
| *7/18/2015* | 6.7 | 23.5 | 92.5 | 87.6 |
| *8/10/2015* | 13.1 | 55.1 | 94.0 | 90.8 |
| *8/18/2015* | 6.7 | 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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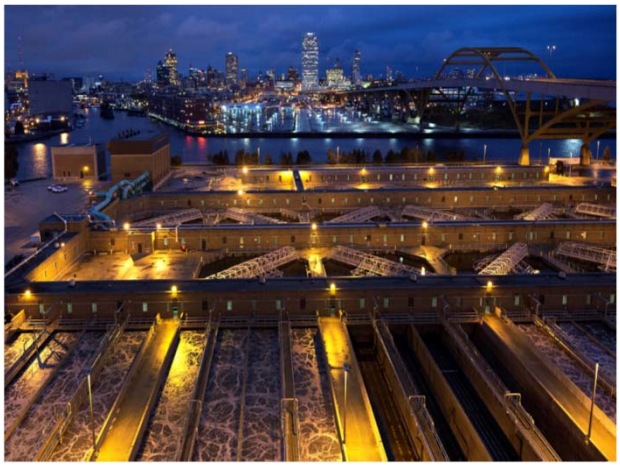

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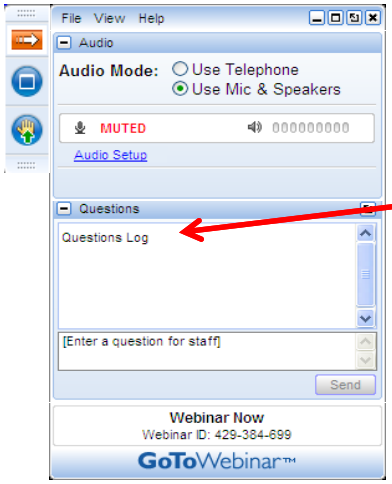
# How to Ask a Question




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

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# Thank You