Welcome and Progress Since the 2020 ASR Science Plan Workshop

Elizabeth Caneja
Lead Project Manager
South Florida Water Management District, West Palm Beach, FL
Welcome/Workshop Logistics

- Welcome/Meeting Purpose and Objectives
- Introductions
  - Panel members
  - ASR team members
- Meeting Format
  - June 15th – 9am - 4pm (Public Meeting)
  - June 16th – 9am - 3pm (Panelists and Project Team Only)
  - Panel discussion throughout the day
  - Public comment period prior to lunch and prior to closing remarks

Presenter: Elizabeth Caneja
# Workshop Agenda

## 2022 ASR Science Plan Peer Review Panel Meeting
June 15, 2022 at 9:00 am – 4:00 pm

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Presenter</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Welcome and Progress Since 2021</td>
<td>Elizabeth Caneja, Lead Project Manager, SFWMD – Ecosystem Restoration and Capital Projects Division</td>
<td>9:00 – 9:15 am</td>
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<tr>
<td>2.</td>
<td>LG3N Corhole Presentation</td>
<td>Hannah Rahman, GFT, Stantec</td>
<td>9:15 – 9:45 am</td>
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<td>3.</td>
<td>Geochemical Analysis of Corers</td>
<td>Dr. Jamie Macdonald, Provost Faculty Fellow and Professor, Florida Gulf Coast University – Environmental Geology Program</td>
<td>9:45 – 10:15 am</td>
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<td>4.</td>
<td>Assessment of Fracture Porosity of the Floridan Aquifer System</td>
<td>Dr. Kwon Cunningham and Victor Flora, USGS Caribbean-Florida Water Science Center</td>
<td>10:30 – 11:00 am</td>
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<td>5.</td>
<td>Characterization of Microbial and Geochemical Processes that Contribute to Nutrient Reduction and Potential Clogging</td>
<td>Dr. John Tolle, Research Microbiologist, USGS – St. Petersburg Coastal and Marine Science Center</td>
<td>11:00 – 11:30 am</td>
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<td>6.</td>
<td>Panel Discussion</td>
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<td>11:30 – 11:50 am</td>
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<td>7.</td>
<td>Public Comment</td>
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<td>11:50 – 12:00 am</td>
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<td>8.</td>
<td>Water Treatment Technology Evaluation</td>
<td>Heath Witze PC, Lead Environmental Engineer, Stantec</td>
<td>1:20 – 1:40 pm</td>
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</table>

**Break: 10:15 – 10:30 am**

**Lunch Break: 12:00 – 12:30 pm**

**Break: 2:00 – 2:15 pm**

<table>
<thead>
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<tbody>
<tr>
<td>9.</td>
<td>Ecological Risk Assessment</td>
<td>Joseph Allen M3, Senior Wildlife Biologist / Risk Assessor, Formation Environmental</td>
<td>1:00 – 1:30 pm</td>
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<tr>
<td>10.</td>
<td>Ecological Risk Assessment – Ecological Studies</td>
<td>Jennifer Mathie MMM, Senior Biologist, Environmental Consulting and Technology</td>
<td>1:30 – 2:00 pm</td>
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<tr>
<td>11.</td>
<td>ASR Programmatic Quality Assurance Plan</td>
<td>Steven Elliott M5, Senior Chemist, Stantec</td>
<td>2:15 – 2:35 pm</td>
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<tr>
<td>12.</td>
<td>ASR Projects in the Southwest Florida Water Management District</td>
<td>Samantha Smith, Hydrogeologist, SFWMD</td>
<td>2:35 – 3:00 pm</td>
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<tr>
<td>13.</td>
<td>Panel Discussion</td>
<td></td>
<td>3:00 – 3:30 pm</td>
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<td>14.</td>
<td>Public Comment</td>
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<td>3:30 – 3:40 pm</td>
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<td>15.</td>
<td>Closing Remarks and Expected Progress Over the Next Year</td>
<td>Dr. Anna Warherns, Lead Scientist, SFWMD – Applied Sciences Bureau</td>
<td>3:40 – 4:00 pm</td>
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<td>16.</td>
<td>Adjourn</td>
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**June 16, 2022**
PRP Meeting at SFWMD Headquarters, West Palm Beach 5:00 pm – 10:00 am
Optional PRP Tour of Kissimmee River ASR Facility 10:00 am – 3:00 pm

Second Zoom Workshop – September 2022

Presenter: Elizabeth Caneja
• **Aquifer storage and recovery**
  - 55 ASR wells
  - 308,000 ac-ft of storage per year

• **Wetland restoration**
  - Paradise Run
    ~ 4,700 acres
  - Kissimmee River Center
    ~ 1,200 acres

Presenter: Elizabeth Caneja
ASR Cluster Implementation as Recommended by the National Research Council

**Initial ASR Well Clusters**

  - Local scale model for heterogeneity, anisotropy, fracture, travel times
  - Test/exploratory multi-wells
  - Test/exploratory multi-wells
- **Wellfield Design, Permitting, and Construction (2021-2022)**
  - Local scale model for heterogeneity, anisotropy, fracture, travel times
  - Test/exploratory multi-wells
  - Test/exploratory multi-wells
- **Extended Testing and Wellfield Expansion (2026-2030)**
  - Improved bentonite columns
  - Establish buffer zones
  - Complete multi-wells and clusters
  - Evaluate clusters near large water bodies

**Expansion of L63N Cluster**

- Reactivate KRASR Well
  - Improve bentonite columns
  - Establish buffer zones
  - Complete multi-wells and clusters
  - Multi-cluster chronic toxicity testing
  - Community-level effects and bioaccumulation
  - Forecasting and concentration studies
  - Probabilistic, quantitative risk assessment
  - Source water effects on redox evolution of aquifer
  - Arsenic transport within aquifer using buffer zone
  - Nutrient uptake to reduce sulfate concentrations
  - Fate of sulfate in recovered water to form methanumary
  - Variability of geopressure and radium in recovered water

**Presenter:** Elizabeth Caneja
Continuous Coring and Monitoring Well Program

Presenter: Elizabeth Caneja
Test/Exploratory Wells at C-38N and C-38S
Treatment Technology Evaluation

Proof of Concept Testing

Water Samples - Raw and Treated
ASR Implementation Schedule and Near-Term Next Steps

Near-Term Next Steps:

- Complete Continuous Core at the C38S site – Dec 2022
- Initiate Treatment Design of C38S and C38N well cluster sites – Aug 2022
- Initiate first set of Test Wells at L63N – To be awarded in Aug 2022
- Complete Construction of first set of Test Wells at C38S and C38N sites – Aug and Nov 2022
- Aquifer Pump Tests at C38S and C38N sites – Sept and Dec 2022
- Request for Proposal for Drilling Contractors – To be awarded in Oct 2022
- Request for Proposal for Treatment Technology Vendors – To be awarded in Dec 2022
Progress towards addressing uncertainties:

- USGS Contracts – Bioclogging Analysis of the Aquifer, Multi-well Assessment Fracture Porosity, and Optical Borehole Logging
- Florida Gulf Coast University – Core analysis of L63N
- Huss Drilling – Continuous Core Program
- Florida Design Drilling – Exploratory/Test Well Drilling at C38N and C38S, Aquifer Pump Test, DEP NPDES Permitting
- ECT, PSI, Formation – Ecological Risk Studies (bench-scale bioconcentration and ecotoxicity studies, long-term ecological monitoring)
# 2022 ASR Science Plan Report Card

<table>
<thead>
<tr>
<th>National Research Council Uncertainties and ASR Peer Review Panel Recommendations</th>
<th>% Progress Towards Addressing the Topic</th>
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<tbody>
<tr>
<td><strong>2015 National Research Council Uncertainties</strong></td>
<td>10</td>
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<tr>
<td>Local scale information on attributes of AR P2</td>
<td>*</td>
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<tr>
<td>Research Phosphorus removal mechanisms</td>
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<td>Research pathogen inactivation in the aquifer</td>
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<tr>
<td>Couple pathogen inactivation with groundwater travel times</td>
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<tr>
<td>Analysis of injection pressures for fracture potential</td>
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<tr>
<td>Establish buffer zone</td>
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<td>Arsenic transport within aquifer using buffer zone</td>
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<tr>
<td>Buffer zone usage to reduce sulfate concentrations</td>
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<tr>
<td>Fate of sulfate in recovered water to form methylmercury</td>
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<tr>
<td>Local scale model for heterogeneity/anisotropy/fracturing/travel times</td>
<td>*</td>
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<tr>
<td>Pretreatment technologies to remove arsenic</td>
<td>*</td>
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<tr>
<td>Analysis of wellfield cluster for spacing and optimal recovery efficiency</td>
<td>*</td>
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<tr>
<td>Anisotropy analysis used for orienting wells</td>
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<td>Tracer studies for flow directions</td>
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<tr>
<td>Cross-well tomography and geophysics</td>
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<tr>
<td>Locate clusters near large water bodies</td>
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<tr>
<td>Examine technologies to meet regulatory requirements</td>
<td>*</td>
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<tr>
<td>Variability of gross alpha and radon in recovered water</td>
<td>*</td>
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<tr>
<td>Examine source water effects on redox evolution of aquifer</td>
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<td>Improve/extend cycle tests</td>
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<tr>
<td>Operate multi-well pairs and clusters</td>
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<tr>
<td>Continue chronic toxicity testing at multiple ASR locations</td>
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<tr>
<td>Long-term ecological monitoring and biocentrification studies, including examining community-level effects</td>
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<tr>
<td>Probabilistic, quantitative ecological risk assessment</td>
<td>*</td>
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<tr>
<td><strong>2021 ASR Peer Review Panel Recommendations</strong></td>
<td>*</td>
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<tr>
<td>Develop ASR Programmatic Quality Assurance Plan</td>
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<tr>
<td>Data Storage, Management, and Public Access</td>
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</table>

**Presenter:** Elizabeth Caneja
Data Storage, Management, and Public Access

Inter-agency Collaboration
- Files
  - OneDrive/SharePoint
- Searchable Archive
  - Metadata
  - Documents
  - Data files
    - DataOne (MetacatUI/Metacat Hosted)
  - Data
    - DBHYDRO
- Project Management
  - Files
    - Documentum

Find Data
ASR

Contact: dimarley@sfwmd.gov

Presenter: Elizabeth Caneja
Panel Discussion
(5 min.)
Lake Okeechobee Watershed Restoration Project (LOWRP) Aquifer Storage and Recovery Wells Continuous Coring Program

Presenter: Hannah Rahman, GIT
Contributor: Rick Cowles, PG
Stantec Inc.
Lake Okeechobee Watershed Restoration Project (LOWRP) and ASR Well Sites

Aquifer Storage and Recovery (ASR) Wells
- ASR refers to the process of recharge, storage, and recovery of water in the aquifer
- Surface water is collected during times when water is plentiful, treated to meet applicable water standards, and then pumped into an aquifer through a well

Surface water level stabilization
Wetland restoration
Ongoing and Completed Work Over the Past 2.5 Years

- L-63N ASR MIT
- Hydrogeologic Assessment – C-38N, C-38S, L-63N, L-63S, C-59, C-40, and C-41
- Continuous Core Holes – three sites
- Treatment Evaluation
- Proof of Concept Treatment Technologies Evaluation
- Kissimmee ASR System Assessment
- FDEP UIC Permitting
- C-38N and C-38S ASR Test Well Design and Construction
- L-63N ASR Test Well Design and Construction Summery
- Upcoming Groundwater Modeling
Four drill rigs construction two UFA and two APPZ ASR Test Wells simultaneously – ASR well pairs

Currently permitting the second set of wells

Construction anticipated to start in late summer 2022

Construction 50 MGD wellfields at C-38N and C-38S sites
SFWMD Continuous Core Program

Presenter: Hannah Rahman
Continuous Coring Program L-63N Site

Legend
- L-63N Continuous Core Hole
- L-63N ASR (LKOKKE_ASRAPPZ)
- UFA MW (OKF-106)
- DZMW (TCRK_GW)

Presenter: Hannah Rahman
Continuous Coring Process

- Cuttings from 0 feet to 500 feet bls
- 10-foot cores from 500 feet to 2,000 feet bls
  - RQD and Recovery
- Off-bottom packer tests every 30 feet bls starting at 700 feet bls
  - Water quality
  - Isotope
  - Specific Capacity
- Geophysical Logging including OBI

Presenter: Hannah Rahman
Cores

Presenter: Hannah Rahman
### Fossils and Features

- **Lemon Shark Tooth** – 535 feet bls
- **Phosphate Nodule** - 565 feet bls
- **Sponge spicules** – 705 feet bls
- **Pyrite** - 925 feet bls
- **Lepidocyclina ocalana** - 715 feet bls

**Presenter:** Hannah Rahman
Fossils and Features

Limestone with grains comprised of mudstone rip up clasts – 1,078.5 feet bls

Glauconite - 1,118 feet bls

Presenter: Hannah Rahman
Fossils and Features

Bryozoan Fossil - 1,522.5 feet bls

Gypsum crystal - 1,745 feet bls
Ash Layer at 1,466.20 feet b.s.
Mineralogy, Inc.

- Scanning electron microscope
- X-ray diffraction
- Thin section analysis

8 Core Intervals chosen:

- 697.4 – 697.5 feet bls
- 755.5 – 755.7 feet bls
- 950.4 – 950.5 feet bls
- 1,154 – 1,155 feet bls
- 1,406.5 – 1,407.5 feet bls
- 1,450 – 1,451 feet bls
- 1,505 – 1,506 feet bls
- 1,603 – 1,604 feet bls

Presenter: Hannah Rahman
Packer Testing

Upper Floridan aquifer

Avon Park Permeable Zone (APPZ) – Flow Zone 1

APPZ – Flow Zone 2

Lower Floridan aquifer

Specific Capacity with Depth
- Specific Capacity (gpm/ft of drawdown)
- Questionable accuracy due to interference around packer

Field and Lab TDS, Specific Conductance, Chloride, and Salinity with Depth
- TDS – 10,000 mg/L Interface - 1,870 feet bls
- TDS 10,000 mg/L Interface - 1,870 feet bls

Salinity (ppt)

Depth (feet below land surface)

Specific Capacity (gpm/ft of drawdown)

Field and Lab TDS, Specific Conductance, Chloride, and Salinity with Depth
- Field TDS (mg/L)
- Lab TDS (mg/L)
- Field Chloride (mg/L)
- Lab Chloride (mg/L)
- Field Salinity (ppt)

Presenter: Hannah Rahman
### AQTESOLV Analysis

<table>
<thead>
<tr>
<th>Puckey Test Interval (Rainfall)</th>
<th>Extracted Transparenci (Typically Recovered) (g/l)</th>
<th>Extracted Transparenci (Copper, Acidic) (g/l)</th>
<th>Transparenci Equilal (a/kg)</th>
<th>Extracted Average (Typically Recovered, and Copper, Acidic) (g/l)</th>
<th>Average Extracted (Typically Recovered) (g/l)</th>
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<tr>
<td>PT (1.58-2.96)</td>
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<td>1.192.3</td>
<td>0.713.9</td>
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</tbody>
</table>

*Note: Values indicate the amount of copper in the solution obtained.*

**Note:** Values indicate the amount of copper in the solution obtained.
Isotopes - $\delta^{18}O$ vs $\delta D$
Isotopes - $\delta^{18}O$ vs $\deltaD$ - the Aquifers

Presenter: Hannah Rahman
Isotopes - $\delta^{18}O$ vs $\deltaD$ - The Confining Units

Presenter: Hannah Rahman
Isotopes - $\delta^{18}$O vs $\delta$D with Depth

Diagram showing the isotopes $\delta^{18}$O and $\delta$D at different depths. The depth ranges from 0 to 3400 meters. The data is compared against VSMOW standards. The presenter is Hannah Rahman.
Geophysical Logging

- XY Caliper/Gamma
- Flowmeter
- Borehole Compensated Sonic
- Dual-Induction with Variable Density
- Optical Borehole Imager
Geophysical Logging

Table: Specific Capacity

<table>
<thead>
<tr>
<th>Depth</th>
<th>Field and Lab TDS, Specific Conductance, Chloride, and Salinity with Depth</th>
<th>Specific Capacity</th>
<th>Existing ASR, UFA, and DNWV</th>
<th>Caliper &amp; Gamma</th>
<th>Sonic Interval Velocity and Sonic Porosity</th>
<th>Electric and Dual Induction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TDS, Chloride, and Specific Conductance (mg/L) and (ppm)</td>
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<tr>
<td></td>
<td>Specific Capacity (specific conductance)</td>
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<td>50000, 25000, 12000, 10000, 5000, 1000, 500, 100, 50, 20, 10, 5, 2</td>
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<td>500</td>
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</tbody>
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Graphs:
- UFA: Upper Flow Zone
- APPZ: Apparent Zone
- USDW: Unconfined Aquifer
- LFA: Lower Flow Area

Legend:
- TDS: Total Dissolved Solids
- Chloride
- Specific Conductance

Key:
- Specific Conductance
- Specific Capacity

Measurements:
- Electric and Dual Induction
- Sonic Interval Velocity
- Sonic Porosity
- Caliper & Gamma

Presenter: Hannah Rahman
Optical Borehole Imager
Continuous Coring Program – C-38S Site

- **Underground Injection Control (UIC) permit**
  - Permit allows the lawful option of disposal of appropriately treated fluids via the underground injection wells, while protecting Florida’s underground sources of drinking waters

- **APPZ Monitoring Well Construction**

Presenter: Hannah Rahman
Cores

Presenter: Hannah Rahman
Cores

1,242 feet b/s

1,376 feet b/s

Presenter: Hannah Rahman
Fossils and Features

- Bryozoan – 500-510 feet bls
- Oyster Shell – 514 feet bls
- *Lepidocyclina ocalana* – 560-570 feet bls

Presenter: Hannah Rahman
Fossils and Features

- Sand Dollar mold – 577 feet bls
- Possible *Oligopygus sp.* – 779 feet bls
- Possible Lignite – 1,204.75 feet bls
Water Quality and Specific Capacity Results

Specific Capacity (gpm/ft of drawdown)

Field and Lab TDS, Specific Conductance, Chloride, and Salinity with Depth

Salinity (ppt)

Specific Conductance (µS/cm)

Chloride (mg/l)

TDS (mg/l)

Field TDS (mg/l)

Field Specific Conductance (µS/cm)

Field Chloride (mg/l)

Lab Specific Conductance (µS/cm)

Lab Chloride (mg/l)

Lab TDS (mg/l)

Presenter: Hannah Rahman
Generalized Hydrostratigraphic Section
APPZ Monitoring Well Construction
Continuous Coring Program – L-63S Site
Panel Discussion
(5 min.)
Geochemical Analysis of a Continuous Core: Analysis of L63N Core and Refinement of Methodology

Presenter: Jamie MacDonald, Ph.D.
Contributors: Rachel Rotz, Ju Chou, Richard Molina, Zoie Kassis, Sophia Morejon, & Rachael Waldrop
Florida Gulf Coast University, Fort Myers, FL
ASR has been shown to potentially mobilize metals from the carbonate rock within Florida’s aquifers.

Example, As and U mobilization during three ARS cycle tests at Rome Ave. ASR, Hillsborough County, FL (Arthur et al., 2005).
Goal: to chemically analyze the core from ASR L63N to find areas of potentially high metal concentrations using a hand held X-Ray fluorescence (XRF).

Take one analyses every foot – when possible!

Concentrate additional analyses on areas of interest.
Geochemical Analysis of a Continuous Core

X-550 from SciAps.

All handheld XRF operate on multiple settings to correct for overlaps in elements.

Soil setting for trace elements with <10 wt. %.

Mining setting for major elements – or elements that occur in higher wt. %.

5 channels operating at different kV and uA to limit overlap of elements during detection.

Presenter: Jamie MacDonald
These are example of calibration curves for Mo, Hg, and Pb. Working with SciAps we modified the calibrations to fit our needs.
Debris and rust were cleaned off of the core surface using a wire brush before every analysis.

Far left is a “before” picture of a core segment in the upper confining unit. The near left is the same core “after” cleaning.
Geochemical Analysis of a Continuous Core

Elements measured with Soil setting:
As, Cu, Cd, Hg, Mo, Pb, U, Na, Ti, V, Cr, Co, Ni, Zn, Be, Rb, Zr, Nb, Ag, Sn, Sb, Ba, and Ra

Elements measured with Mining setting:
Al, Si, P, S, K, Ca, Mn, Mg, and Fe
9 samples from core L63N were each analyzed twice – i.e., run 1 and run 2. This was to test for the ability of the handheld XRF to duplicate an analysis. Slopes range from 0.66 for S to 1.51 for Mo. Ideal slope should be 1.
9 samples from core L63N were each analyzed twice – i.e., run 1 and run 2.

This was to test for the ability of the handheld XRF to duplicate an analysis.

Precision was consistently high as all elements have a correlation coefficient close to 1.

### Table: Correlation coefficient of select elements using handheld XRF

<table>
<thead>
<tr>
<th>Element</th>
<th>Number of samples analyzed*</th>
<th>Correlation coefficient (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>5</td>
<td>0.989421</td>
</tr>
<tr>
<td>As</td>
<td>4</td>
<td>0.999998</td>
</tr>
<tr>
<td>Ca</td>
<td>7</td>
<td>0.940640</td>
</tr>
<tr>
<td>Hg</td>
<td>9</td>
<td>0.986544</td>
</tr>
<tr>
<td>Mg</td>
<td>7</td>
<td>0.971302</td>
</tr>
<tr>
<td>Mo</td>
<td>5</td>
<td>0.995687</td>
</tr>
<tr>
<td>Ni</td>
<td>4</td>
<td>0.978713</td>
</tr>
<tr>
<td>S</td>
<td>7</td>
<td>0.945692</td>
</tr>
<tr>
<td>Si</td>
<td>7</td>
<td>0.999729</td>
</tr>
<tr>
<td>Sr</td>
<td>8</td>
<td>0.999969</td>
</tr>
<tr>
<td>Ti</td>
<td>9</td>
<td>0.991525</td>
</tr>
<tr>
<td>V</td>
<td>9</td>
<td>0.990723</td>
</tr>
</tbody>
</table>

*one sample was only run using Soil setting.
Data integrity Tests

Four standards were run as knowns to also test the precision and accuracy of the instrument.

All elements were within 10% of the standard known values except Ag, Cd, Mg, and P, which needed corrections based on the standards.

To correct these elements, a linear equation $Y = fx$, where $Y$ is known value and $x$ is the measured value. The correction factor, $f$, was generated by dividing the known standard value by the instrument measured value for the standard ($f = Y/x$).

Example for silver (Ag) $f = Y/x = 1.04/35 = 0.0297$
1339 Analyses of Core L63N!

Presenter: Jamie MacDonald

**Calcium (%)**

- Core Depth (ft): 2,000 to 0
- Calcium concentration range: 0 to 1,000

**Magnesium (%)**

- Core Depth (ft): 2,000 to 0
- Magnesium concentration range: 0 to 1,000

**Silicon (%)**

- Core Depth (ft): 2,000 to 0
- Silicon concentration range: 0 to 1,000
1339 Analyses of Core L63N!
1339 Analyses of Core L63N!

- Arsenic (ppm)
- Copper (ppm)
- Molybdenum (%)

Presenter: Jamie MacDonald
1339 Analyses of Core L63N!

**Mercury (ppm)**

- Core Depth (ft): 500 to 2,000
- **Chromium (ppm)**
  - Core Depth (ft): 500 to 2,000
- **Nickel (ppm)**
  - Core Depth (ft): 500 to 2,000
The metals within the Upper Floridan Aquifer (UFA) Dual Zone Monitoring Well (DZMW) Upper Monitoring Zone (UMZ) can be illuminated by plotting from 700 to 800 feet below surface. Mo graph is semi-log.
The metals within the Avon Park Permeable Zone (APPZ) Dual Zone Monitoring Well (DZMW) Lower Monitoring Zone (LMZ) can be illuminated by plotting from 1300 to 1450 feet below surface. Mo graph is semi-log.
Clay constitutes a large portion of 500-700 foot section of the cores, as seen in the high Al:Ca ratio (McMillan and Verrastro, 2008).

500-510 ft.
232 samples between 500 feet and 700 feet.

Chemistry suggests clays may be a mixture of montmorillonite and Illite.
Element ratios can help identify facies changes.

@ 700 foot depth Si:Ca and other ratios greatly decrease, suggesting a facies change to limestone.

@ 1300 foot depth Mg:Ca ratio increases to dolostone levels of 0.8 (Prothero and Schwab, 2014) suggesting facies change.
Massive and Nodular Gypsum in Avon Park Fm.

Figure Raman: Raman analysis of gypsum from core L63N. This sample, along with another sample, are a ≥ 97% match to gypsum’s Raman wave number positions.
Massive and Nodular Gypsum in Avon Park Fm.

Figure S/Ca: S vs. Ca ratios for core intervals where massive and nodular gypsum occurs. S/Ca ratio for pure gypsum = 1. Change et al. (1998) report a S/Ca ratio of gypsum from limestone of approximately 0.8.
Organic-rich Layers Between 956 & 1958 Feet

1607 ft. depth

1795.5 ft. depth

1917.58 ft. depth

Presenter: Jamie MacDonald
Organic-rich Layers Between 956 & 1958 Feet

On average, As is 10.8 times higher; Sr is 9.3 times higher; Mo is 13.7 times higher; Hg is 4.8 times higher; Cu is 3.8 times higher; and Ni is 3.5 times higher in the organic layers than the average for these elements in the entire core.

Presenter: Jamie MacDonald
Occurs around 1466 foot depth. Disruption of stratigraphy. Elevated Si, S, Sr, Al, P, and Mo.
A handheld XRF can be used to rapidly and accurately analyze hundreds of samples from the ASR project.

Metal concentrations can be identified within the potential zones for ASR at site L63N. For example, most metals are higher at the top of the APPZ.

Additionally, other important information can be revealed with the geochemistry. Such as facies changes, possible composition of clays, and areas of high sulfate minerals.

High organic content layers should be avoided.
Break
10:15 AM – 10:30 AM
Multi-Well Assessment of Fracture Porosity of the Floridian Aquifer System in Support of Future ASR Wells in Northern Lake Okeechobee

Presenter: Victor Flores
Researcher and Analyst

Contributor: Kevin Cunningham (Technical Lead)
U.S. Geological Survey, Davie, FL
Carbonate Aquifer Characterization Laboratory
Core Analysis

Low Flow

High Flow

Presenter: Victor Flores
Core to OBI Depth Calibration

Core Box

OBI Log

Presenter: Victor Flores
## Vuggy Pore Space Classification

### VUGGY PORE SPACE

<table>
<thead>
<tr>
<th>SEPARATE-VUG PORES (Vug-to-matrix-to-vug connection)</th>
<th>TOUCHING-VUG PORES (Vug-to-vug connection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAIN-DOMINATED FABRIC</td>
<td>MUD-DOMINATED FABRIC</td>
</tr>
<tr>
<td>Example types</td>
<td>Example types</td>
</tr>
</tbody>
</table>

- **Mouldic pores**
- **Intrafossil pores**
- **Intragrain micropores**
- **Mouldic pores**
- **Intrafossil pores**
- **Shelter pores**
- **Cavernous**
- **Breccia**
- **Fenestral**
- **Fractures**
- **Solution-enlarged fractures**
- **Microfractures connect mouldic pores**

*Lucia (2007)*
Carbonate Fracture Classification

Vuggy pore space in carbonate rocks

- Bedding Plane Vug
- Cavernous Pore Space
- Ichnologic Pore Space
- Fracture Pore Space
- Touching-Vug pore space
- Separate-Vug pore space

Natural Fractures

- Extension (2 rock masses pulled apart)
- Shear (2 rock masses slide past each other)
- Tension (produced in response to minimum stress)
- Pedogenic breccia
- Stylolites
- Roots
- Freezing
- Others.....

Vug Porosity

Induced Fracture

Natural Fracture

Presenter: Victor Flores
Fracture Classification

- Fractures or bedding planes can be identified by outlining the sinusoidal features on the OBI image.
- Natural Fracture: Created by geologic forces and processes
- Induced Fracture: Created by drilling, coring and handling processes
Fracture Picking
Induced Fractures

Common Characteristics of Induced Fractures
• Rough, unmineralized, fresh breaks
• Lips at the core edge
• Plumes that interact with the core edge and that follow a core axis
• Fracture planes that are consistently normal or parallel to the core axis

Common Characteristics of Natural Fractures
• Mineralization/cementation
• No interaction with the core surface
• Similar orientations and geometries to mineralized fractures
• Plumes, steps, or slickenlines that have axes that are unrelated to the core axes
• Generally, are more planar than induced fractures
• Petal shaped parallel cracks
• Closely spaced
• Nested
• Concave propagation
• Rib surfaces
• Difficult recovery
• Rainbow arcs (core sample)
• May form on one side of the core only
• Data collected for this project could be used in a USGS phase II study
Phase II Project Could Investigate Karst Origin of Fractures Through Analog Studies

Highly fractured evaporite solution collapse breccia, Kirschberg Dolomite, Cretaceous, Central Texas

Outcrop Analogy

Evaporite-capped ideal cycle, Avon Park Formation

Evaporites

Sabkha

Microbial Laminites

Tidal flat (Humid)

Platform interior (Subtidal)

Grainstone & Packstone

Fractures in Cretaceous Dolomite, Texas

Predissolution of Evaporite Unit

Postdissolution of Evaporite Unit

Loucks & Zahm (2014)

"Preliminary Information-Subject to Revision. Not for Citation or Distribution."

Presenter: Victor Flores
Phase II Project Could Investigate Tectonic Origin of Fractures

"Preliminary Information-Subject to Revision. Not for Citation or Distribution."

Presenter: Victor Flores
Phase II Project Could Investigate Tectonic Origin Of Fractures With 3D Seismic

Assuming left-lateral transform fault parallel to Florida Transfer Fault at basement

"Preliminary Information-Subject to Revision. Not for Citation or Distribution."

Presenter: Victor Flores
Panel Discussion (5 min.)
Characterization of Microbial & Geochemical Processes Contributing to Nutrient Reduction & Potential Clogging

Presenter: John Lisle
Research Microbiologist
USGS/St. Petersburg Coastal & Marine Science Center
U.S. Geological Survey, St. Petersburg, FL
**Project Overview**

**USGS ASR Well Biocebogging & Nutrient Reduction Project Summary**

- At each well drilling site, 2 lengths of the same core depth (i.e., UFA) will be collected immediately by USGS.
- Second core sent to commercial company to crush & sieve to size.
- Crushed & sieved core used to pack biofilm growth reactor and attached to native GW flow to grow native bacterial biofilm.
- Effluents from all columns were analyzed for growth, nutrient & biofilm-related variables.
- Whole core storage at 4°C for months.

Presenter: John Lisle
Aquifer Cores Sites

- Cores collected from 3 well sites
- Cores for column studies from 2 zones per well
  - UFA
  - APPZ
- From each zone, recovered cores will be used for:
  - Solid core segments for permeameter
  - Crushed core for
    - Packing experimental column with no native biofilm
    - Packing experimental column with native biofilm

* 3 wells x 2 zones x 2 experimental crushed core columns per zone = 12 experimental columns using crushed core
Core Collection, Stabilization & Processing

Presenter: John Lisle
Types of Experimental Columns

- Glass beads (2.0mm)
- Crushed core (no biofilm at $T_0$)
- Crushed core (native biofilm at $T_0$)

* All columns are 3”(ID) x 12”(L)
Growing Native Biofilms on Experimental Columns

Presenter: John Lisle
Bioclogging Experimental System

- YSI 556 MPS & sensors
- Sensor flow cell
- Surface water source for columns
- Inflow bubble trap
- Peristaltic pump
- Packed experimental column
- Pressure loggers
- Column effluent sample bottle

Presenter: John Lisle
Experimental Data Types & Collection Points

**Data Types:**
- Temperature
- Sp conductance
- Conductivity
- TDS
- Salinity
- DO
- pH
- ORP

**Collection Points:**
- Nutrients (CNP)
- Cations
- Anions
- Redox sensitive metals

**Presenter:** John Lisle
Nutrient & Geochemical Analytes

Carbon
- Biodegradable DOC
- TOC
- DOC
- SUV

Nitrogen
- NO₃
- NO₂
- NH₄

Phosphorus
- PO₄

Geochemical
- Cations
- Anions
- Redox sensitive metals

Dr. John Kominoski, FIU

Dr. Rob Masserini, University of Tampa

Eurofins Test America, Tampa
To date, 1 core has been retrieved from the first site, C38S, at the upper storage zone.

- The solid core has been stabilized and is in storage.
- The core section for crushing is currently being processed.

All laboratory systems are set up and trial experiments have been conducted for optimization.

- Example: Biofilm development assay
Biofilm Production Rate System

- Kissimmee River water (300µm filtered)
- Bubble trap
- Peristaltic pump
- Biofilm flow cell
- 2.0mm glass beads

Presenter: John Lisle
Biofilm Development on Glass Beads

$T_0$ (visible light)  $T_{14}$ (visible light)  $T_{14}$ (SYBR Gold)  $T_{14}$ (crystal violet)

Presenter: John Lisle
Panel Discussion
(5 min.)
Public Comment
11:50 AM – 12:00 PM
Lunch Break
12:00 PM – 12:30 PM
Aquifer Storage And Recovery (ASR)
Treatment Technology Proof-of-Concept Testing Update

Presenter: Heath Wintz, PE
Stantec Inc
Contributors: Mohini Nemade, EI; Stefani Harrison, PE
Megan Patterson, EI; Michael Price, PE
Proof of Concept Testing
Performance Summary
  - Media Filtration + UV
  - Membrane Filtration
Backwash and Solids
Non-Economic Evaluation
Recovered Water Considerations
Schedule
Next Steps
Proof-of-Concept testing was intended to test and demonstrate treatment systems that can produce water suitable for aquifer recharge, per Rule 62-520.410(1), F.A.C., including:

- coliform removal to 4 CFU/100 mL, and
- assess potential for removal of color and dissolved organic carbon (DOC).
POC Testing

- Test up to two (2) coagulants
- Test membrane filtration including two (2) ceramic and two (2) polymeric membranes
- Test dual-media filtration as pretreatment to UV.
- Evaluate the ability of pressurized UV reactor technology to meet disinfection criteria
- Characterize backwash waste from pilot operation for dewaterability analysis
POC Testing Facility Layout

- Existing raw water pump
- Strainer
- Membrane System 1
- Membrane System 2
- Membrane System 3
- Membrane System 4
- Backwash Treatment
- Media/UV System
- Treated Water Discharge

Presenter: Heath Wintz
Membranes:

- Microfiltration/ultrafiltration (MF/UF, ALT 2A) removed coliform bacteria by size exclusion and removed significant amounts of color with the aid of a coagulant.

- Ceramic membranes used a greater amount of coagulant than polymeric membranes and would correspondingly produce a greater volume of solids for management.

- However, ceramic membranes demonstrated the ability to reduce color by 93-95% to approximately 7.5-5 PCU. Ceramic membranes would meet secondary drinking water standard for color (15 PCU).
Membranes, cont:

- Polymeric membranes reduced color by 50-53% to approximately 50 PCU, which would not meet the secondary drinking water standard for color.

Media Filtration + UV:

- Media filtration prior to UV helps with solids and turbidity reduction but was unable to reduce color to meet secondary drinking water standards and would require a water quality criteria exemption.

- UV treatment (Alternative 1A/B) does not rely on chemicals for disinfection. However, high color surface water (and coincident low UVT) requires significant doses UV light to remove coliform bacteria.
Media filters did not remove coagulated DOC, Particle sizes 10-100 x smaller than could be captured by sand media.

Aluminum in media filter effluent was 80% of coagulant dose.

This represents what would be passed downstream for storage.

Presenter: Heath Wintz
Media filtration will not remove DOC and would require a Water Quality Criteria Exemption for Color.

Low filtration rate for media filters translates to a large facility footprint. Backwash ponds require significant land.

Even at low filtration rate, media filters minimally reduce turbidity/solids, resulting in high UV dose requirement.

UV can reliably disinfect but requires up to a 30 mJ dose during poor water quality events (as opposed to 21 mJ dosed at KRASR previously)

Clean water source strongly recommended for backwashing, but utility water may not be available from OUA.
### Performance: Ceramic Membranes

<table>
<thead>
<tr>
<th>NANOSTONE</th>
<th>Trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Success Criteria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runtime</td>
<td>&gt;12 days</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fouling</td>
<td>&lt;50% decline in specific flux (30d extrapolation)</td>
<td>N/A</td>
<td>N/A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Treated water turbidity</td>
<td>95th %ile &lt;0.100 NTU</td>
<td>N/A</td>
<td>N/A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Treated water coliform</td>
<td>&lt;4 CFU/100mL</td>
<td>N/A</td>
<td>N/A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CIP recovery</td>
<td>&gt;80% recovery of clean membrane specific flux</td>
<td>N/A</td>
<td>N/A</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- **AQUA AEROBIC**

<table>
<thead>
<tr>
<th>AQUA AEROBIC</th>
<th>Trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Success Criteria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runtime</td>
<td>&gt;12 days</td>
<td>10.6 (equipment issues)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fouling</td>
<td>&lt;50% decline in specific flux (30d extrapolation)</td>
<td>N/A</td>
<td>56% decline (coagulant delivery issues, tubing)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Treated water turbidity</td>
<td>95th %ile &lt;0.100 NTU</td>
<td>N/A</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Treated water coliform</td>
<td>Treated water &lt;4 CFU/100mL</td>
<td>N/A</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CIP recovery</td>
<td>&gt;80% recovery of clean membrane specific flux</td>
<td>N/A</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- **After a shaky start, Nanostone’s nominal flowrate was not sustainable during Trial 4, though the cause is undetermined (e.g. equipment vs. fouling).**

- **Aqua Aerobic had very sustainable operations throughout the POC test, including Trial 4.**
## Performance: Polymeric Membranes

### FILMTEC

<table>
<thead>
<tr>
<th>Success Criteria</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runtime</td>
<td>&gt;12 days</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Fouling</td>
<td>&lt;50% decline in specific flux (30d extrapolation)</td>
<td>N/A</td>
<td>100% decline (coagulant dose too high)</td>
<td>94% decline (maintenance chemicals insufficient)</td>
</tr>
<tr>
<td>Treated water turbidity</td>
<td>95th %ile &lt;0.100 NTU</td>
<td>N/A</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Treated water coliform</td>
<td>Treated water &lt;4 CFU/100mL</td>
<td>N/A</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>CIP recovery</td>
<td>&gt;80% recovery of clean membrane specific flux</td>
<td>N/A</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

- **FilmTec had very sustainable operations** during Trial 4, once chemicals were optimized.

### SUEZ

<table>
<thead>
<tr>
<th>Success Criteria</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runtime</td>
<td>&gt;12 days</td>
<td>✔️</td>
<td>6.4 (coagulant pump not delivering)</td>
<td>✔️</td>
</tr>
<tr>
<td>Fouling</td>
<td>&lt;50% decline in specific flux (30d extrapolation)</td>
<td>N/A</td>
<td>N/A</td>
<td>✔️</td>
</tr>
<tr>
<td>Treated water turbidity</td>
<td>95th %ile &lt;0.100 NTU</td>
<td>N/A</td>
<td>N/A</td>
<td>✔️</td>
</tr>
<tr>
<td>Treated water coliform</td>
<td>Treated water &lt;4 CFU/100mL</td>
<td>N/A</td>
<td>✔️</td>
<td>persistent coliform</td>
</tr>
<tr>
<td>CIP recovery</td>
<td>&gt;80% recovery of clean membrane specific flux</td>
<td>N/A</td>
<td>N/A</td>
<td>✔️</td>
</tr>
</tbody>
</table>

- **Suez had persistent high coliform** throughout Trial 4, despite many attempts to chlorinate the sample tap, membrane housing, piping, etc. Operations were otherwise very steady.

Presenter: Heath Wintz
Water quality summary

<table>
<thead>
<tr>
<th>ANALYTE</th>
<th>UNITS</th>
<th>RAW</th>
<th>MEDIA FILTER / UV</th>
<th>NANOSTONE</th>
<th>FILMTEC</th>
<th>AQUA AEROBIC</th>
<th>SUEZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>PCU</td>
<td>100</td>
<td>4%</td>
<td>95%</td>
<td>53%</td>
<td>93%</td>
<td>50%</td>
</tr>
<tr>
<td>DOC</td>
<td>mg/L</td>
<td>18.7</td>
<td>11%</td>
<td>66%</td>
<td>22%</td>
<td>59%</td>
<td>20%</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>mg/L</td>
<td>0.0705</td>
<td>26%</td>
<td>93%</td>
<td>86%</td>
<td>93%</td>
<td>86%</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/L</td>
<td>1.25</td>
<td>12%</td>
<td>54%</td>
<td>26%</td>
<td>50%</td>
<td>27%</td>
</tr>
<tr>
<td>Aluminum</td>
<td>ug/L</td>
<td>67.5</td>
<td>43%</td>
<td>92%</td>
<td>0%</td>
<td>91%</td>
<td>78%</td>
</tr>
</tbody>
</table>

**% REDUCTION**

*green results indicate favorable treatment (greater removal than red results)*

Presenter: Heath Wintz
Primary drinking water standards were met for all treatment trains*

*Disinfection standards were not met for Suez during extended trial #4

Secondary Standards were met by ceramic membrane manufacturers: Aqua Aerobic & Nanostone
Laboratory analysis quantified the solids remaining in the treated effluent of each treatment process.

Maximum dry solids production from each process is the sum of: DOC removed, TSS removed, and coagulant added.

Higher doses of coagulant yield greater solids production.

green results indicate lower solids removed than red results
Water from POC testing was NOT used to recharge the aquifer.

However, the difference between solids in the raw water and solids in the backwash stream gives us the amount of solids in the recharge water.

Higher solids in recharge water to the Aquifer indicate a higher potential for fouling (or more frequent need for maintenance acidization).

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Alternative 1A/B</th>
<th>Alternative 2A</th>
<th>Alternative 2A</th>
<th>Alternative 2A</th>
<th>Alternative 2A</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recharge Water / Well Maint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow</td>
<td>50.0</td>
<td>50.0</td>
<td>60.0</td>
<td>50.6</td>
<td>50.0</td>
<td>mgd</td>
</tr>
<tr>
<td>DOC, Effluent (median)</td>
<td>16.6</td>
<td>6.3</td>
<td>14.6</td>
<td>7.8</td>
<td>14.9</td>
<td>mg/L</td>
</tr>
<tr>
<td>Turbidity, Effluent (95th percentile)</td>
<td>3.5</td>
<td>0.011</td>
<td>0.049</td>
<td>0.018</td>
<td>0.043</td>
<td>NTU</td>
</tr>
<tr>
<td>TS, Effluent</td>
<td>5.3</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>mg/L</td>
</tr>
<tr>
<td>Total Solids to Aquifer</td>
<td>9,117</td>
<td>2,652</td>
<td>6,102</td>
<td>3,245</td>
<td>6,244</td>
<td>lb/yr</td>
</tr>
</tbody>
</table>

**Results:**
- **Red** results indicate greater solids in recharge water than **green** results.
Membrane solids content and BW settleability was highly variable

- Polymeric membrane BW did not settle
- Additional coagulant dosed to BW to thicken solids, based on jar testing
- Thickened samples sent offsite for laboratory dewaterability analysis
Membrane Backwash and Solids

- Samples were sent to Andritz laboratory for a Centrifuge dewatering evaluation with the following objectives:
  - Analyze the physical properties of the sludge samples received
  - Conduct a polymer evaluation with the sludge sample received
  - Conduct Centrifuge spin-down testing

- 2% solids is the target concentration for centrifuge dewatering

<table>
<thead>
<tr>
<th>Lab Number</th>
<th>Sample Type</th>
<th>L-14730</th>
<th>L-14731</th>
<th>L-14732</th>
<th>L-14733</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids* (%TS @ 105°C)</td>
<td>Aqua</td>
<td>1.36</td>
<td>0.23</td>
<td>0.07</td>
<td>0.45</td>
</tr>
<tr>
<td>Suspended Solids** (%SS @ 105°C)</td>
<td>Dupont</td>
<td>1.36</td>
<td>0.23</td>
<td>0.07</td>
<td>0.45</td>
</tr>
</tbody>
</table>

EPA Methods: *1684, **160.2
Conclusions: Membrane Filtration

- Coliform was reliably removed without additional disinfection technology.
- Excellent removal of solids and turbidity results in greater solids content in backwash.
- Operations are sensitive to coagulant dose.
- Parameters vary significantly by vendor:
  - Membrane life
  - Chemical use
  - Settleability and dewaterability of backwash waste
How do treatment technologies compare?
<table>
<thead>
<tr>
<th>PROCESS/AREA DESCRIPTION</th>
<th>ALT 1A/B</th>
<th>ALT 2A</th>
<th>ALT 2A</th>
<th>ALT 2A</th>
<th>ALT 2A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granular Media Filtration, UV Vessel</td>
<td>3,400</td>
<td>3,400</td>
<td>3,400</td>
<td>3,400</td>
<td>3,400</td>
</tr>
<tr>
<td>Raw Water Pump Station</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydroburst Mechanical Room</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Strainers &amp; Access Way for Pumps</td>
<td>3,000</td>
<td>3,400</td>
<td>3,400</td>
<td>3,400</td>
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<tr>
<td>Pressure Media Filters</td>
<td>26,000</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>UV Disinfection</td>
<td>8,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>MF/UF membrane</td>
<td>N/A</td>
<td>54,000</td>
<td>20,000</td>
<td>37,000</td>
<td>40,000</td>
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<tr>
<td>Ground Storage Tank</td>
<td>8,100</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Floc/Sedimentation Basin</td>
<td>N/A</td>
<td>2,600</td>
<td>N/A</td>
<td>N/A</td>
<td>4,500</td>
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<tr>
<td>2nd Stage Membranes</td>
<td>N/A</td>
<td>N/A</td>
<td>7,400</td>
<td>9,700</td>
<td>N/A</td>
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<tr>
<td>Settling Pond or Gravity Thickening</td>
<td>12,200</td>
<td>10,052</td>
<td>N/A</td>
<td>N/A</td>
<td>7,297</td>
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<tr>
<td>Sludge Holding Tank</td>
<td>N/A</td>
<td>5,655</td>
<td>4,000</td>
<td>5,600</td>
<td>3,927</td>
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<td>Solids Dewatering</td>
<td>N/A</td>
<td>2,023</td>
<td>1,550</td>
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<td>Polymer</td>
<td>N/A</td>
<td>1,350</td>
<td>1,489</td>
<td>1,205</td>
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<tr>
<td>Coagulation</td>
<td>N/A</td>
<td>1,549</td>
<td>990</td>
<td>1,600</td>
<td>1,067</td>
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<tr>
<td>Hypochlorite</td>
<td>N/A</td>
<td>1,063</td>
<td>215</td>
<td>1,174</td>
<td>461</td>
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<tr>
<td>Sulfuric Acid</td>
<td>N/A</td>
<td>N/A</td>
<td>373</td>
<td>1,180</td>
<td>N/A</td>
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<tr>
<td>Hydrochloric Acid</td>
<td>N/A</td>
<td>879</td>
<td>N/A</td>
<td>N/A</td>
<td>357</td>
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<tr>
<td>Citric Acid</td>
<td>N/A</td>
<td>N/A</td>
<td>373</td>
<td>500</td>
<td>369</td>
</tr>
<tr>
<td>Sodium Hydroxide (Caustic)</td>
<td>N/A</td>
<td>360</td>
<td>360</td>
<td>360</td>
<td>248</td>
</tr>
<tr>
<td>Sodium Metabisulfite (SMBS)</td>
<td>N/A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Process Area Subtotal</td>
<td>69,700</td>
<td>86,800</td>
<td>44,100</td>
<td>67,200</td>
<td>68,400</td>
</tr>
<tr>
<td>Overall Site Total</td>
<td>195,000</td>
<td>200,000</td>
<td>150,000</td>
<td>165,000</td>
<td>175,000</td>
</tr>
<tr>
<td>Total Area, Ac</td>
<td>4.5</td>
<td>4.6</td>
<td>3.4</td>
<td>3.8</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Facility Footprint

Presenter: Heath Wintz
Weighting of categories based on previous study
Organics removal, operational considerations and reliability carried greatest weighting

<table>
<thead>
<tr>
<th>Non-Economic Criteria</th>
<th>Weighting</th>
<th>ALT 1A/B</th>
<th>ALT 2A</th>
<th>ALT 2A</th>
<th>ALT 2A</th>
<th>ALT 2A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color/Organics Removal</td>
<td>15</td>
<td>0</td>
<td>15</td>
<td>6</td>
<td>15</td>
<td>6</td>
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<tr>
<td>Waste Disposal</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Operational Considerations</td>
<td>25</td>
<td>20</td>
<td>16</td>
<td>15</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Staffing Requirements</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Minimal Risk for Aquifer Plugging</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>4</td>
<td>10</td>
<td>4</td>
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<tr>
<td>Process Reliability</td>
<td>20</td>
<td>6</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Environmental, Health and Safety</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Constructability</td>
<td>10</td>
<td>9</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Footprint</td>
<td>10</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>110</strong></td>
<td><strong>61</strong></td>
<td><strong>79</strong></td>
<td><strong>63</strong></td>
<td><strong>86</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>
How do we handle potential arsenic issues during recovery?

Presenter: Heath Wintz
During cycle testing at KRASR, Arsenic was present in recovered water. Arsenic was 7x the MCL during cycle 1.

Based on data from the 2013 CERP report, this situation appears to be short-term (commissioning) in nature rather than long-term.

Characteristics of POC treated water (conductivity, ORP) are similar to that of Kissimmee River surface water, and similar to that used for KRASR testing.

2013 CERP ASR Final Tech Data Report
During previous KRASR testing, a “first flush” of recovered water was directed to a retention pond.

For full-scale facilities, allocating large areas of land for retention ponds to address a short-term issue does not appear productive.

- A regulatory approach to addressing Arsenic in recovered water could involve establishing a mixing zone, and could be discussed further with FDEP.

However, if there is a desire to treat and remove Arsenic during cycle testing, membranes could be used to accomplish this.

- With piping and sodium hypochlorite, recovered water could be oxidized from Arsenite (III) to Arsenate (V), precipitated, coagulated and removed using micro or ultrafiltration membranes.
Schedule – Poc Testing Report

- SFWMD & USACE review draft report: 5/27/22 - 6/21/22
- Conceptual Discipline Design: 4/27/22 – 6/23/22,
- Final report: 7/20/22    TRB mid-August.
Next Steps

- Develop conceptual design drawings based on an apparent preferred technology.
- Develop MCASES detailed cost estimate for USACE
- Final Proof-of-Concept report / TRB
- Treatment technology procurement / pre-selection
- Facility pre-design (survey, geotech investigation)
- Design overall facility around pre-selected technology
Next Steps - Technology Procurement

- Equipment Preselection RFP package
- Competitive Solicitation
- Evaluation
Panel Discussion (5 min.)
Aquifer Storage and Recovery (ASR)
Quantitative Ecological Risk Assessment

Presenter: Joe Allen
Senior Wildlife Biologist / Risk Assessor
Formation Environmental LLC
ASR Ecological Risk Assessment History

- Original ERA completed in 2015 as part of the ASR Regional Study
- Utilized data from 2 ASR Pilot Facilities
  - Kissimmee River ASR (KRASR)
  - Hillsborough ASR (HASR)
ASR ERA Conclusions

- Low likelihood of risk to Lake Okeechobee and the Everglades
  - Highest - Larval fish due to impingement/entrainment
  - Low – Hg methylation
  - Limited toxicity
  - Minimal bioconcentration

- ASR systems should be constructed where sufficient dilution can occur
Comments received from NRC and PRP

- Look at longer storage times and larger recovery volumes.
- Toxicity testing with adjustments to water parameters.
- Look at effects of hardness adjustments.
- Additional *in situ* bioaccumulation studies.
- More quantitative risk assessment.
Public process with multiple stakeholders

- Many different approaches for analyses and data needs
- Responsive to stakeholders, but as efficient and cost-effective as possible
- Utilize comments from NRC and PRP
ASR Ecological Risk Assessment Path Forward

Development of ASR ERA Work Plan

Build from 2015 ASR ERA

Use USEPA Guidance

Quantitative Use of 2015 Data

Chemical Stressors

Physical Stressors

Presenter: Joe Allen
ASR Ecological Risk Assessment Path Forward

- Risk-Based Analysis of Historical ASR ERA Data
  - Quantitative Analysis of 2015 Data
    - Bioconcentration.
      - Aquatic-Feeding Wildlife
      - Fish and Mussels
    - Causal Analysis of Toxicity Testing
ASR Ecological Risk Assessment Path Forward

Using 2015 Data to Fill Data Gaps

Bioconcentration Data

Aquatic Feeding Wildlife

Toxic Effects

Toxicity Data

Causative Analysis

Birds

Mammals

Reptiles

Fish

Invertebrates

Presenter: Joe Allen
Historical Data Analysis

- Utilized available tissue data.
  - Conservative estimate of risk to birds, mammals, and reptiles feeding downstream of the ASR discharge.

\[
\text{Exposure}_{\text{Total}} = (SUF) \cdot \left[ \frac{(C_{\text{water}} \cdot IR_{\text{water}}) + \sum (C_{\text{prey}} \cdot IR_{\text{prey}})}{BW} \right]
\]
Historical Data Analysis

- **Aquatic-Dependent Wildlife**
  - 10 bird species
  - 2 mammals
  - 1 reptiles

- **Screening-Level**
  - Maximum concentrations
  - No effect toxicity reference values used.
  - Radiological exposure screened using USDOE Level 1 Biota Concentration Guidelines

\[
HQ = \frac{Exposure_{total}}{TRV}
\]
No HQs > 1.

- Likelihood of risk very low
- Ra-226 and Ra-228 < Level 1 BCGs
- Focus Wildlife ERA on bioaccumulative metals.
Historical Data Analysis

- **Risk to Fish/Mussels Assessed**
  - Max concentrations and no effect TRVs
  - Risks to fish *de minimis*.
  - Several metals had HQs > 1 for mussels.
    - Aluminum (upstream and downstream)
    - Manganese (all samples exceeded)
    - Molybdenum (upstream and downstream)

- **Very low potential for risk to mussels and fish.**
  - Should continue to be monitored in future studies.
Historical Data Analysis

Causal Analysis of Toxicity Test Results

- 2015 ASR ERA only presented results of tests.
- Water collected at each location on date of toxicity test sample.
- Compare to water quality benchmarks (WQB) and toxicity test results.
  - Limited overlap of toxicity in sample and exceedance of WQB (4 of 80 tests).
  - Data did not support toxicity based on water quality parameters alone.
  - Recommend paired water analyses and toxicity tests for new data.

Presenter: Joe Allen
2022 ASR ERA Tasks

- Development of a comprehensive ERA Work Plan
  - Reassemble the Working Group
  - Step-wise process to build the Work Plan with input from stakeholders.
  - Incorporate 2021 analyses.
  - Currently beginning the problem formulation step.

Presented by: Joe Allen
Updated Ecological Conceptual Site Model

- **Stressors**
  - Chemical
  - Physical
  - Physio-chemical.

- **Exposure pathways**

- **Generic receptor groups (will be finalized in meeting #2)**

---

2022 ASR ERA Tasks – Work Plan Development

**Stressor Category**
- Physical Stressors
  - Groundwater Recharge
  - Localized Pumping Operations to Store Water In ASR Wells
  - Localized and Regional Changes to Water Temperature
  - Direct Exposure to Released Water
  - Impingement and Entrainment of Ichthyoplankton
- Physio-Chemical Stressors
  - ASR Discharge
  - Localized and Regional Changes to Water Quality (DO, pH, TDS, etc.)
  - Potential Effects to Fish and Non-Fish Populations Temperature Dependent Wildlife Populations
  - Potential Effects to Fish and Non-Fish Aquatic Populations
- Chemical Stressors
  - ASR Discharge
  - Localized and Regional Effects on Water Quality
  - Direct Exposure (Contact with or ingestion of water)
  - Exposure via Food Web Exposure via Bioconcentration and/or Bioaccumulation
  - Ingestion of Surface Water by Fish and Wildlife Populations

**Stressor/Release Mechanism**
- Groundwater Recharge
- Chemical Stressors
  - ASR Discharge
- Physical Stressors
  - Groundwater Recharge
- Physio-Chemical Stressors
  - ASR Discharge
- Localized and Regional Changes to Water Quality (DO, pH, TDS, etc.)
- Direct Exposure to Released Water
- Impingement and Entrainment of Ichthyoplankton
- Potential Effects to Fish and Non-Fish Populations Temperature Dependent Wildlife Populations
- Potential Effects to Fish and Non-Fish Aquatic Populations
Goals of the ASR ERA Work Plan

- Expand/Improve ERA
- Incorporate comments on 2015 ERA
- Consensus from Working Group
- Regional applicability
  - First ASR Well Cluster (C-38)
    - Vicinity of the discharge point
    - Potential risks also assessed regionally
  - Results should be scalable to future ASR Well Clusters
    - Similar Conditions/Similar Risk
    - Focus on unique attributes (if any) at future sites
Panel Discussion
(5 min.)
ASR ERA – Pre-Operational Studies and Mobile Laboratory

Presenter: Jennifer Mathia
Senior Biologist
Environmental Consulting and Technology, Inc.
2022 to 2024

2022
- Pre-operational Studies
- Mobile Lab Construction
- ERA Work Plan Development

2023
- Pre-operational Studies
- Toxicity Studies
- Bioconcentration Studies

2024
- Mesocosm Studies

Presenter: Jennifer Mathia
Pre-Operational Studies

- QA/QC
- General Data Collection
- Survey Areas
- Survey Initiation and Timing
- Water Quality
- Periphyton
- Submerged Aquatic Vegetation
- Benthic Macroinvertebrates
- Sediments
- Apple Snails
- Mussels
- Fish and Ichthyoplankton
Pre-Operational Studies

- QA/QC
  - Survey Specific Work Plans
  - Follow Programmatic Quality Assurance Plan (PQAP)
  - FDEP SOP or SFWMD specific, where appropriate
Pre-Operational Studies

- **General Data Collection**
  - Data will be collected to support the surveys and provide back up for peer review
    - Data logs
    - Field notebooks
    - SOPs
    - Methods
    - Data Forms
    - Calibration logs (YSI Pro DSS, Hach Chlorine Test kit CN-70)
  - Each collection will include record of:
    - In-situ water quality
    - Temperature (air and water)
    - Weather (wind direction, wind speed, cloud cover, precipitation)
  - Scientific Collector’s Permit

Presenter: Jennifer Mathia
Pre-Operational Studies

- **Monitoring Sites**

  - Study Area: Lake Okeechobee

  - ASR C-38N
  - KRASR
  - ASR C-38S
  - Survey locations
  - Survey Area
  - ASR Discharge

Presenter: Jennifer Mathia
Pre-Operational Studies

- **Schedule**
  - Semi-annual minimum frequency
  - Focused sampling during peak growing season/spawning season

**Table 4. Proposed sampling frequencies for 2022-2023 sampling period.**

<table>
<thead>
<tr>
<th></th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality (grab sample analysis per Appendix A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Periphyton</td>
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<td></td>
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</tr>
<tr>
<td>Benthic Macros</td>
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<td>Mussels</td>
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</tbody>
</table>

Presenter: Jennifer Mathia
Pre-Operational Studies

- **Water Quality**
  - SFWMD current water quality program is extensive
  - No separate water quality study for ASR ERA proposed
  - Water quality will be collected in parallel with each study described next to characterize water at time sampling
  - Analyzed for metals and nutrients in laboratory
  - QA/QC sample collections will follow DEP-SOP FS 2100 and PQAP
  - Field measurements

Presenter: Jennifer Mathia
Pre-Operational Studies

- **Periphyton**
  - FIU Institute of Environment Periphyton Analysis Laboratory
  - Field Surveys
    - Epiphytic evaluated using periphytometers
    - Metaphyton grabs
  - Data Analysis
    - Taxonomy, cell density, abundance, ash-free dry mass, chlorophyll-a
    - Shannon-Weiner diversity index, taxa richness, evenness
    - Chemical and nutrient analysis (descriptive statistics)

Presenter: Jennifer Mathia
Submerged Aquatic Vegetation (SAV)

- Canals are poor habitat
- Lake Okeechobee heavily studied

Field Studies

- Desktop Assessment
- Reconnaissance Surveys
- Mapping and Characterization Field Surveys

Data Analysis

- Frequency of occurrence, density, abundance
- Statistical analyses
Pre-Operational Studies

Benthic Macroinvertebrates
- Desktop Review
- Field surveys
  - Hester-Dendy per FDEP SOP FS-7430
  - 28-day deployment
  - Deployed concurrent with periphytometers
- Data Analysis
  - Taxonomy
  - Taxa richness, Shannon-Weiner Diversity, Pielou’s evenness, EPT
  - Statistical analyses

Source: Wisconsin DNR
Presenter: Jennifer Mathia
Pre-Operational Studies

- **Sediment**
  - Field sampling
    - Three grabs per sample station
    - Sediment cores proposed, with ponar dredge as contingency
    - Sediment depth, water column depth, water quality
  - Data Analysis
    - Metals, nutrients, pH, grain size, water content, ash content
    - Statistical Analyses
Pre-Operational Studies

- **Apple Snails**
  - Important relationship to snail kite
  - Field surveys
    - Tissue collection
    - Submitted intact to laboratory
  - Data analysis
    - Metals analysis
    - Statistical analysis
Pre-Operational Studies

- **Mussels**
  - Sensitive to bioconcentration in regional ASR ERA studies

- **Field Surveys**
  - Native Florida mussels (*Elliptio jayenis*) targeted
  - Mussel tissue collection
  - 30 mussels per sample station
  - Shucked prior to shipping

- **Data Analysis**
  - Tissues analyzed for metals
  - Statistical analysis

Presenter: Jennifer Mathia
Pre-Operational Studies

- Fish
  - Desktop Assessment
  - Field Surveys
    - Canal focused
    - Fish Community Characterization
    - Fish Tissue Collection
      - Three trophic levels/feeding guilds (i.e., bluegill, crappie, and largemouth bass)
      - Analyzed for metals
Pre-Operational Studies

- Ichthyoplankton
  - Entrainable size organisms
  - Field Surveys
    - Plankton tows
      - 0.3-mm mesh plankton net with 1 L cod end
      - Target spawning period of local fish (March to June)
    - Three depths
  - Qualitative Assessment of nursery habitats along shoreline
Pre-Operational Studies

➢ Fish and Ichthyoplankton

▪ Data Analysis
  ▪ Taxa richness, Shannon-Weiner diversity index, Pielou’s evenness
  ▪ Catch-per-unit-effort (CPUE)
  ▪ Metals tissue concentrations
  ▪ Descriptive statistics
  ▪ ANOSIM
  ▪ Ordination diagrams
Data Management and Reporting

- Bi-monthly progress reports following field collections
- Survey specific annual reports
- Comprehensive pre-operational report for C-38 ASRs
- Data provided as reports, graphs, electronic, databases, ArcGIS, etc.
Mobile Laboratory

- Designed for future on-site bioconcentration studies
Bioconcentration Studies

- Bioconcentration vs bioaccumulation
- Test organisms
  - Bluegill (*Lepomis macrochirus*)-Osage Farms
  - Freshwater mussel (*Elliptio jayenis*)-Lake McMeekin
  - Pretreatment
- Water quality
  - Grab samples
  - Metals and nutrients
  - Ambient conditions

![Bioaccumulation and Bioconcentration Process](chart)

Bioaccumulation = bioconcentration + food chain transfer – (elimination + growth dilution)
Bioconcentration Studies

- ASTM method “Standard Guide for Conducting Bioconcentration Test with Fishes and Saltwater Bivalve Mollusks, ASTM: E 1002-94” used as guide

- Mobile laboratory
  - Construction to be completed late 2022
  - Flow through
  - 2 different water supply options for three different treatments:
    - Background surface water or recharge (BSW)
    - Recovered ASR Water (RCV)
    - 50/50 mixture of BSW and RCV (MW)
Bioconcentration Studies

- Study recharge and recovery cycles
- Fish and Mussels
- Monitoring
  - Water quality
  - Mortality
  - Anomalies
- Tissue Analysis
  - Metals

Presenter: Jennifer Mathia
Bioconcentration Studies

- **In-situ Bioaccumulation**
  - Sample survey areas, locations, and sample stations per baseline studies
  - Mussels
  - Periphyton
  - Data analysis follows pre-operational studies
Toxicity Studies

Ecotoxicity Test

- Tests
  - 7-day *Ceriodaphnia* survival and reproduction study
  - 21-day *Daphnia magna* survival and reproduction study
  - 7-day fathead minnow embryo-larval survival and teratogenicity study
  - FETAX (frog embryo assay)
  - 96-hour bannerfin shiner test
  - 96-hour *Ceriodaphnia* test

- Recharge and Recovery
- Multiple cycles of varying durations
Toxicity Studies

NDPES and CERP Permits

- Additional toxicity testing will likely be required as part of the NPDES and CERP permits for operation of the ASR wells.
- Whole Effluent Toxicity Testing
Longer-Term chronic Toxicity Study

- Fathead minnow (*Pimephales promelas*)
- Evaluate reproduction success
Panel Discussion (5 min.)
Break
2:00 PM – 2:15 PM
Aquifer Storage and Recovery
Programmatic Quality Assurance Plan

Presenter: Steven Elliott
Chemist
Stantec
What is a Quality Assurance Project Plan?

- QAPPs describe *HOW* project elements are done
- The EPA has established basic guidelines for QAPP development
- The steps include:
  - Project Management
  - Data Generation and Acquisition
  - Assessment and Oversight
  - Data Validation and Usability
What is a “Programmatic” QA Plan?

- The ASR PQAP uses a broader approach and tries to address all anticipated activities.
- Individual project Work Plans will either reference procedures detailed in the PQAP or will have to provide sufficient detail about variances or items not addressed in the PQAP.
- The PQAP is designed to be a “living” document.
Work Plans that address water quality, biological, and ecological data collection and management must:

- Define project scope and purpose
- Reference standardized procedures and guidelines
- Justify design strategy and sampling locations
- Discuss DQOs
- Define parameters and analytical requirements
- Reference or define equipment and procedures
Criteria

- USEPA Primary and Secondary Drinking Water Standards
- Florida MCLs for drinking water and CTLs for groundwater and surface water
- Additional Permit parameters

Table 1-1. ASR Science Plan Groundwater and Surface Water Parameters and Applicable Criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FDEP DW MCLs $^1$</th>
<th>FDEP CTLs (ug/L)$^2$</th>
<th>USEPA Drinking Water Standards (ug/L)$^3$</th>
<th>Recommended Project MDL (ug/L)</th>
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<td>GW</td>
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Field Sampling

- Forms and Logs
- Equipment requirements, calibration, decontamination
- Quality Control Samples
- Sample Collection Techniques
  - Groundwater
  - Surface Water
  - Sediment
  - Tissue
- Preservation and Holding Times
- Chain of Custody
Chemical Analysis

- Laboratory Certification
- Detection and Reporting Limits
- Quality Control Requirements
- Reporting Requirements
- Storage Requirements

Presenter: Steven Elliott
Data Assessment

- Literature Assessment
- Field Data Validation
- Laboratory Data Assessment
  - Validation
  - Data Usability Summaries
  - ADaPT
Well Construction

- ASR Well Construction and Testing
- Continuous Coring
- Post-Construction Pump Tests
- Construction Oversight

Presenter: Steven Elliott
Hydrogeological Monitoring

- Surface geophysical surveys
- Tracer testing
- Pathogen inactivation studies
- Nutrient reduction studies
Ecological Monitoring

- Mobile Lab Construction
- Operational Considerations
- Ecotoxicological Testing
- Bioconcentration Studies
- Lake Okeechobee Environmental Model
- Baseline Ecological Studies
- Mesocosm Studies
Data Management

- Storage
- Custody
- Security
- Access
- Archiving
Audits

- Field Audits
  - FDEP Audit Checklists
- Laboratory Audits
- Data Management Audits
- Corrective Actions

Presenter: Steven Elliott
Conclusion

- The PQAP is designed to guide future Work Plans
- A “living” document
- Covers:
  - Potential parameters and criteria
  - Sampling
  - Analysis
  - Well construction and oversight
  - Hydrogeological Modeling
  - Ecological Assessment
Panel Discussion
(5 min.)
Recharge Projects in the SWFWMD

June 15, 2022
Cooperative Funding Initiative

- This program allows local governments and private entities (within our District) to share costs for projects that assist in creating sustainable water resources, provide flood protection and enhance conservation efforts.
- Do Projects Align with District Strategic Plan?
- The CFI covers up to 50% of total project cost
CFI Recharge Projects

Direct Recharge:
- Q246 (City of Tampa)
- Q088 (Hillsborough County)
- Q142 (Pinellas County)
- Q159 (Sarasota County)
- N855 (Hillsborough County)
- N287 (Hillsborough County)
- N665 (City of Clearwater)

Aquifer Storage & Recovery:
- Q050 (City of Venice)
- Q142 (Pinellas County)
- N833 & K120 (City of North Port)
- N398 (City of Oldsmar)
- N435 & K114 (City of Bradenton)
- L608 (City of Palmetto)
- N024 (Polk County)
- K269 (Sarasota County)
- K509 (Hillsborough County)
- P787 & K424 (City of St. Petersburg)
- K257 (City of Englewood)
- F007 (Manatee County)

Presenter: Sammy Smith
N833 – The City of North Port (ASR)

Presenter: Sammy Smith
N833 – The City of North Port (ASR)

**Total Coliform (Idexx Quantitray)**

- **Day 0 (Recharge):** 7,270 units/mL
- **3 Days Storage:** 30 units/mL
- **7 Days Storage:** 2 units/mL
- **14 Days Storage:** 30 units/mL
- **30 Days Storage:** 30 units/mL

Figure 1. Cycle Test 6C ASR-1 Well Total Coliform Results.

**E-Colli (Idexx Quantitray)**

- **3 Days Storage:** 56 units/mL
- **7 Days Storage:** 3 units/mL
- **14 Days Storage:** 3 units/mL
- **30 Days Storage:** 3 units/mL

Figure 3. Cycle Test 6C ASR-1 Well E-Colli Results.

**Fecal Coliform**

- **Day 0 (Recharge):** 370 units/mL
- **3 Days Storage:** 3 units/mL
- **7 Days Storage:** 2 units/mL
- **14 Days Storage:** 2 units/mL
- **30 Days Storage:** 2 units/mL

Figure 2. Cycle Test 6C ASR-1 Well Fecal Coliform Results.

**Heterotrophic Plate Count (HPC)**

- **3 Days Storage:** 5000 units/mL
- **7 Days Storage:** 63 units/mL
- **14 Days Storage:** 250 units/mL
- **30 Days Storage:** 85 units/mL

Figure 4. Cycle Test 6C ASR-1 Well HPC Results.

Presenter: Sammy Smith
N833 – The City of North Port (ASR)

Figure 5. Cycle Test 6C ASR-1 Well Virus Results.
Q142 – Chesnut Park AR/ASR (Pinellas County)

Scope:

30% design/TPR of an ASR system to store and recover excess surface water from Lake Tarpon, as well as an AR system designed to help restore water level elevations in the NTBWUCA and aid in aquifer freshening.

Shared intake structure for both wells

Minimum 5-year total recovery quantity of 300MG for the ASR portion

1 BG minimum recharge volume over a 5-year period for the AR portion

Presenter: Sammy Smith
N287/N855 SHARP (Hillsborough County)
N287/N855 - SHARP (Hillsborough County)

Groundwater Level vs Recharge Volume

Presenter: Sammy Smith
N287/N855 - SHARP (Hillsborough County)

TDS vs Recharge Volume
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

Southern Water Use Caution Area (SWUCA)
Most Impacted Area (MIA)
Flatford Swamp

Presenter: Sammy Smith
Geomorphology (Hardpan):

Well-drained deep sands

Poorly-drained sands with organic hardpan

Poorly-drained sands with subsurface clay

Continuous Percolation into Aquifer

Impeded Percolation into Aquifer
Multiple Benefits

- Trend back toward historic hydroperiod
- Improve aquifer level in the Southern Water Use Caution Area (SWUCA)
- Saltwater Intrusion (mitigation)
Panel Discussion
3:00 PM – 3:30 PM
Public Comment
3:30 PM – 3:40 PM
Closing Remarks and Expected Progress Over the Next Year

Presenter: Anna Wachnicka, Ph.D.
Lead Scientist/ASR Science Plan Project Manager
Contributor: Robert Verrastro, PG and Elizabeth Caneja
South Florida Water Management District, West Palm Beach, FL
### Expected Progress Over the Next Year

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<th>Cal Year 2021</th>
<th>Cal Year 2022</th>
<th>Cal Year 2023</th>
<th>Cal Year 2024</th>
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<td>Mobile Lab Design and Bench-Scale, Mesocosm and Toxicity Study Plans</td>
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<td>Pre-Operational Monitoring along C-38 Canal</td>
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- **Completed**
- **Ongoing**
- **In Prep**

Presenter: Anna Wachnicka
ASR Ecological Risk Assessment

Phase 1: Planning & Scoping
- **Goal:** Development of scoping document outlining planning and implementation of ERA & formulating Subject Matter Expert Working Group

Phase 2: Problem Formulation
- **Goal:** Identify data gaps (what and where is at risk? What is the hazard of concern?) & develop a Work Plan for completion of the Quantitative ASR ERA

Phase 3: Data Collection
- **Goal:** Collect data identified in the ERA Work Plan to complete Quantitative ASR ERA

Phase 4: Quantitative Ecological Risk Assessment
- **Goal:** Provide a technically defensible assessment of ecological risks (local and regional) from the operation of the planned ASR wells

EPA Ecological Risk Assessment Framework
- **Problem Formulation**
- **Risk Characterization**
  - Exposure Analysis
  - Effects Analysis
- **Risk Analysis**
- **Communicate Risk Results to Risk Manager**
- **Risk Management**

Presenter: Anna Wachnicka
Enclosed Experiments and Field Studies

Toxicity, bioaccumulation and changes in community structure studies will be conducted at different temporal and spatial scales.

Studies will be designed based on additional modeling (landscape, hydrological) scenario outcomes.

Simulation models will use data from the studies (bench-scale, mesocosms, field) to predict responses to different spatial and temporal scales.
Bench-Scale Chronic Toxicity Tests and Bioconcentration Studies

- Construction of mobile, temperature-controlled lab in 2022
- Lab experiments under variety of conditions using source, recovered and mixed water in 2023 - 2024
- Bioconcentration Studies
  - At multiple ASR locations (C-38 KRASR first in 2022 – 2024)
  - Accumulation of contaminants within tissue of selected organisms
- Bench-Scale toxicity Testing in 2023
  - Laboratory controlled setting
  - Chronic tests (Survival, Growth, Reproduction)
Evaluation of long-term bioaccumulation and community-level responses at different temporal and spatial scales

Before-After-Control-Impact (BACI) study designs under low flow conditions and during different recovery periods
  • 1-year Pre-Operational monitoring (2022 - 2023)
  • 2 – 3-year Post-Operational monitoring once cycling begins (2023 - 2026)

Examples of Planned Monitoring: periphyton, caged mussels, invertebrates, fish
Construction of mesocosm facility at KRASR in 2023 for conducting bioaccumulation experiments in 2024 - 2025

Experiments designed in light of the fact that water from ASR operations will be recovered during dry, low-flow conditions

Planned Studies

- Effect of changes in water hardness on soft water Everglades organisms
- Effect of recovered water on freshwater community structure and bioaccumulation (e.g. periphyton, vegetation)
Mixing Zone Modeling (2022)

Modeling Goals

- Support SFWMD ASR permitting
- Support ASR Ecological Risk Assessment
- Support ASR outfall design/blending/pre-treatment and engineering specifications

Ecological Risk Assessment Support

- Evaluate Discharge Scenarios
- Evaluate Blending Recovered Water and River Water
Predictive Evaluation of Arsenic Mobilization

- Mineral components will be “reacted” with treated surface water
- Utilizing core analysis from FGS and newly-completed wells
- Benchtop analysis using PHREEQC version 3.2
Evaluation of “Buffer Zone” to Control Sulfate in Recovered Water

- Mixing zone model will be developed to approximate sulfate concentrations in the bubble
- Calibration using data from KRASR cycle testing
- Operational strategies can be tested to maximize recovery while minimizing sulfate
Utilizing isotopic lithologic and groundwater quality data from existing and previous monitoring networks

Maps will be developed to designate areas of further evaluation in vicinity of LOWRP

Will be augmented with data from newly constructed test wells
Expectations from Peer Review Panel and ASR Science Plan Next Steps

- Each panelist to prepare a memorandum – June 30th
- Chair to compile memos into the 2022 Peer Review Panel Report – July 15th
- SFWMD/USACE to revise the Draft 2022 ASR Science Plan Report – August 30th
- Reconvene with the Peer Review Panel – early September
- Release Draft Report for 30-day public review – mid-September through mid-October
- Finalize Comment/Response Matrix and release Final 2022 ASR Science Plan in November 2022
Thank You!

www.sfwmd.gov/lowrp or www.sfwmd.gov/asr