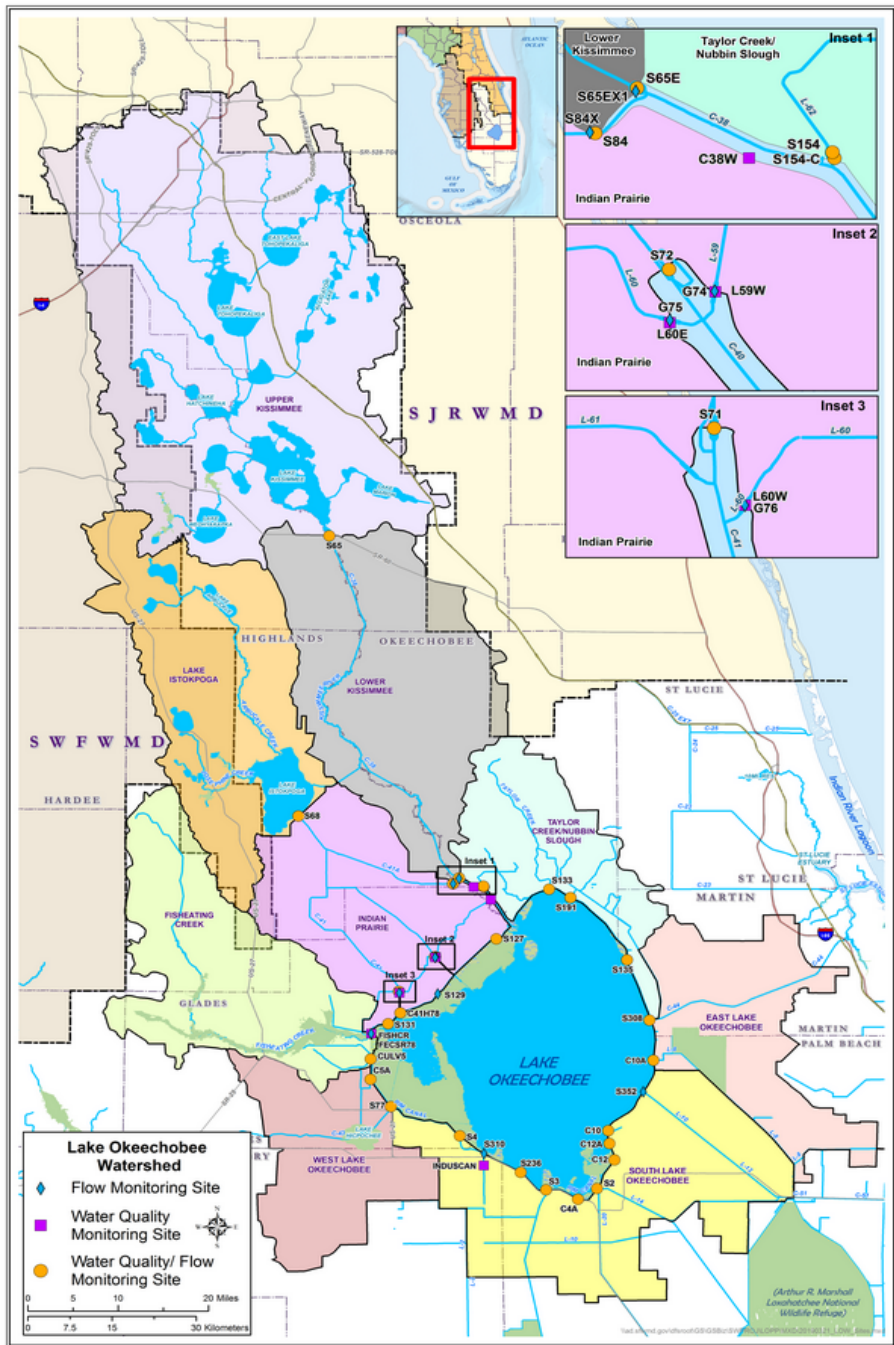


Update on the Lake Okeechobee Watershed Restoration ASR Program

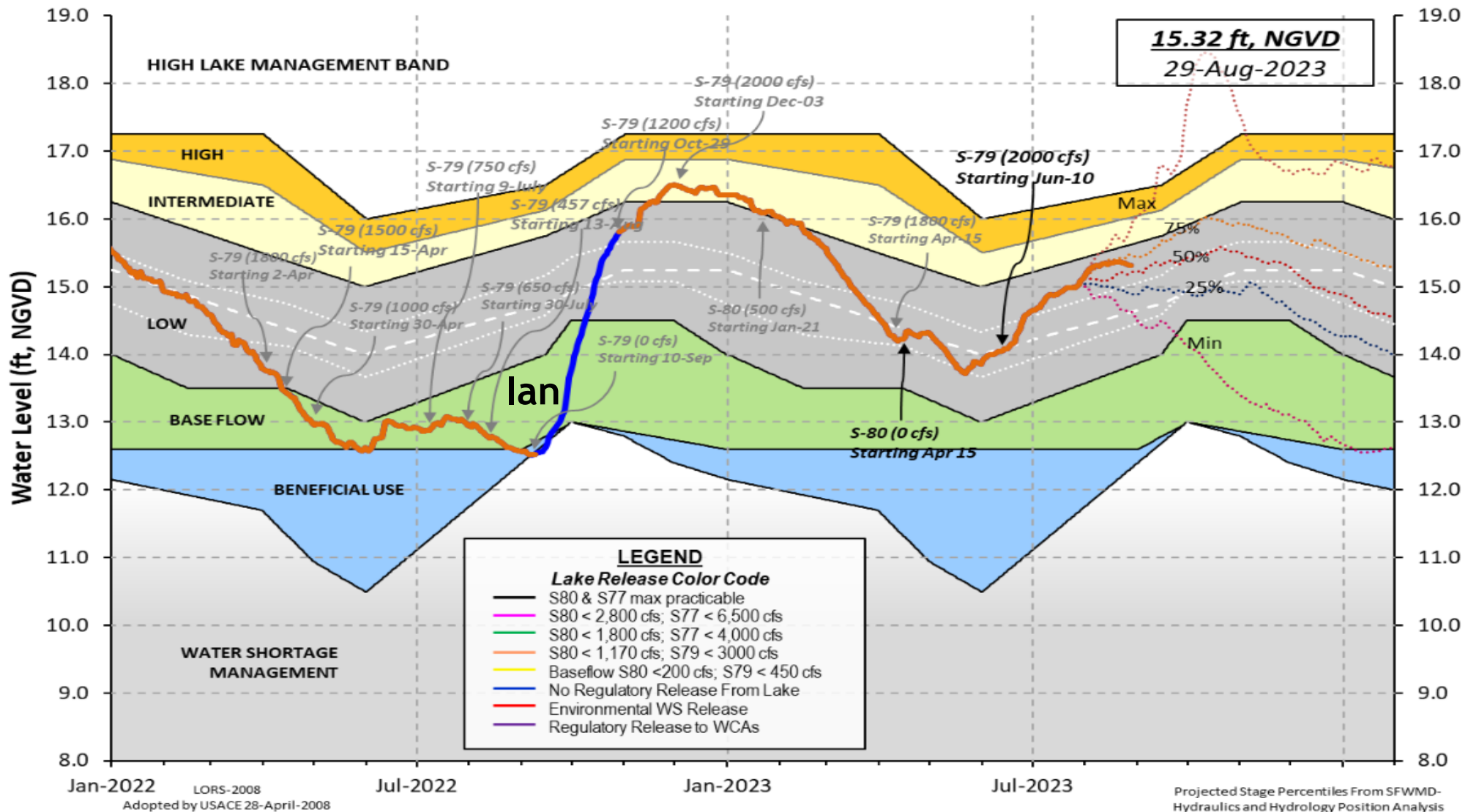
**Groundwater Protection Council Annual Forum
September 13, 2023**

Bob Verrastro, P.G.
Principal Hydrogeologist
South Florida Water Management District (Retired)



Current Lake Operational Schedule

Lake Okeechobee Water Level History and Projected Stages



LOWRP Objectives

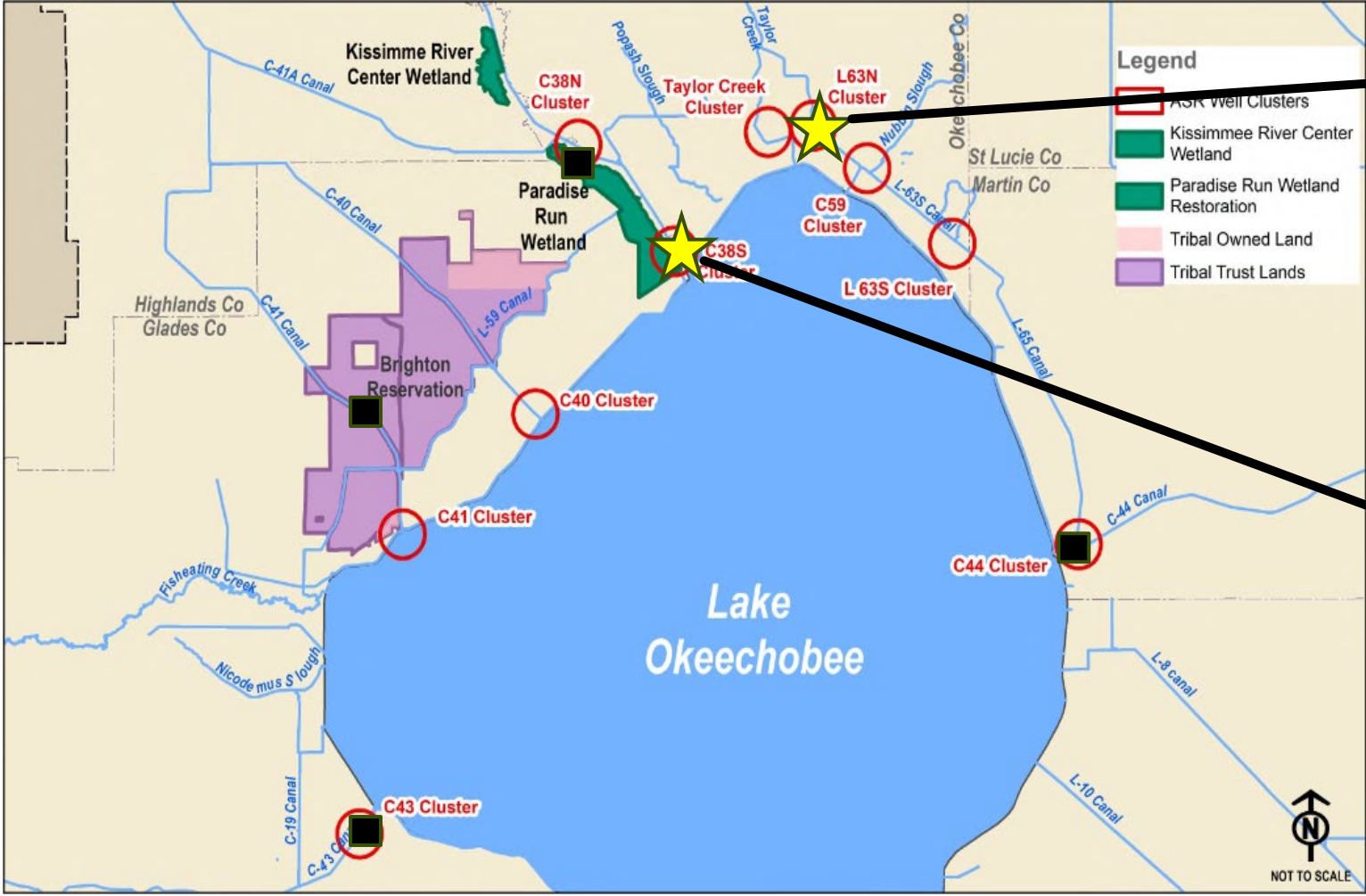
- ▶ Increase water storage in the watershed
- ▶ Better management of Lake Okeechobee water levels
- ▶ Improve the quantity and timing of discharges to the estuaries
- ▶ Restoring wetlands
- ▶ Provide water supply for existing legal users



The Evolution of Everglades ASR

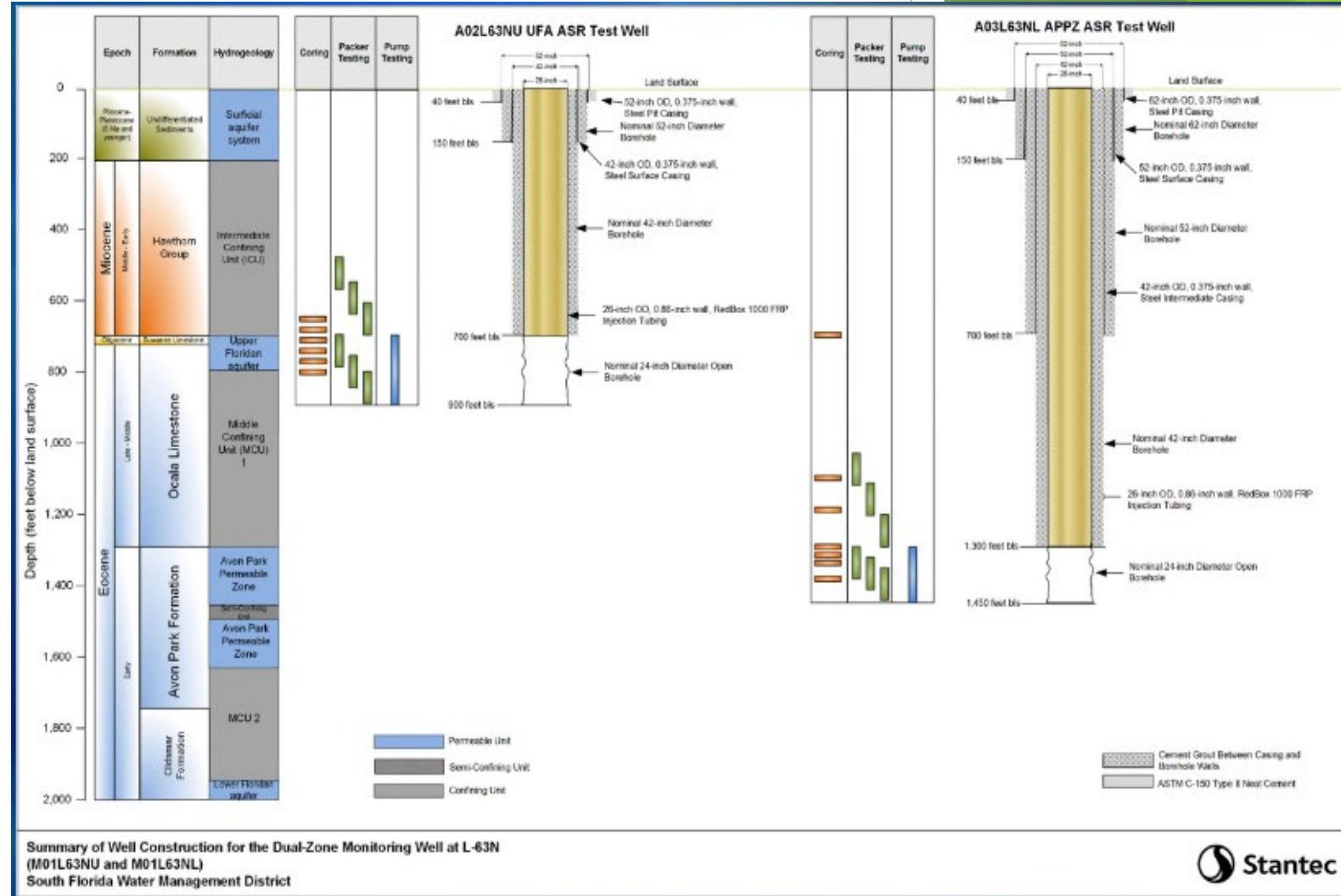
- ▶ 333 wells proposed in 1999 CERP Yellow Book
- ▶ 131 wells determined from ASR Regional Study (2015)
 - ▶ About 80 around Lake O
- ▶ Lake Okeechobee Watershed Restoration Plan (LOWRP - 2020)
 - ▶ 55 “regional” wells and 25 wells associated surface storage feature (WAF)
 - ▶ WAF eliminated due to tribal concerns
- ▶ In 2020, Florida State Legislature allocated \$50M to accelerate features
 - ▶ Additional \$50M allocated in 2021 up to ~\$450M
 - ▶ 55 wells currently under construction and evaluation

Previous ASR systems and explorations



Test Well Program

- ▶ Aquifer hydraulic properties
 - ▶ Evaluate "vertically stacked" storage zones
 - ▶ Confinement
 - ▶ Leakage
 - ▶ Pumping pressures
 - ▶ Fracture potential
 - ▶ Water quality
 - ▶ Aquifer performance tests
 - ▶ Groundwater model



Hydrogeology

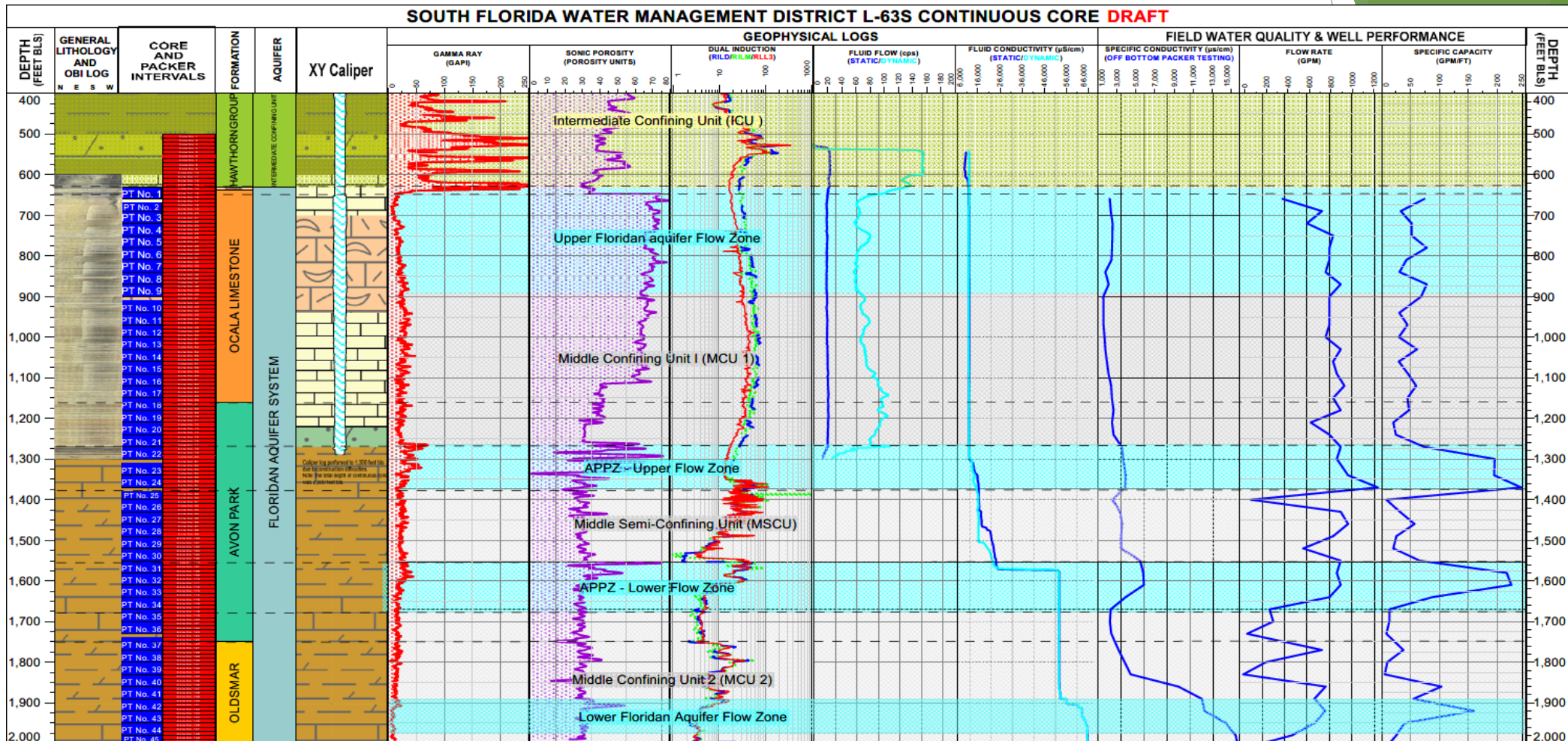


FIGURE TITLE:
 SOUTH FLORIDA WATER MANAGEMENT DISTRICT
 L-63S CONTINUOUS CORE M01L63SL
 GENERALIZED HYDROSTRATIGRAPHIC SECTION,
 LITHOLOGY, CONTINUOUS CORE CONSTRUCTION, AND GEOPHYSICAL LOGS

CORE and PACKER TESTING INTERVALS:

- Red bar: Cores Collected 30 feet
- Blue bar: Packer Tests Performed every 30 feet

LITHOLOGY LEGEND:

- SANDY CLAY
- DOLOSTONE
- FOSSILIFEROUS LIMESTONE
- LIMESTONE
- LIMESTONE TRACE DOLOSTONE
- SILTY LIMESTONE

Stantec
 DATE: 4/14/23
 SCALE: AS SHOWN
 PROJECT NO. 177311599
 FIGURE NO. 1
 VERSION NO: 1
 DRAWN BY: AA

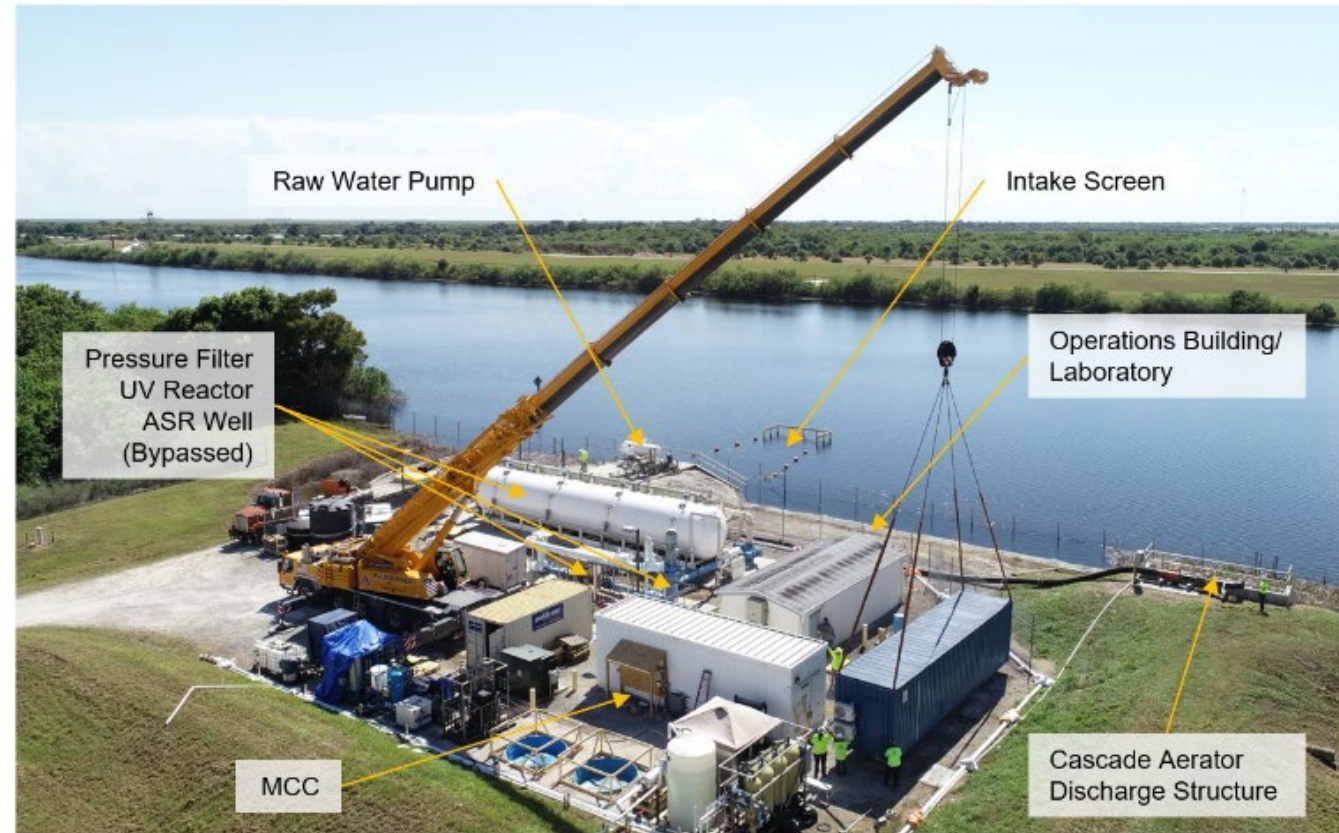
Local Scale Groundwater Model

- ▶ Using models developed during the ASR Regional Study
- ▶ Radius of influence (impacts to existing users)
- ▶ Wellfield design (how many wells at each cluster and pumping/recovery rates)
- ▶ Fracture potential (injection pressure)
- ▶ Buffer zone evaluation (recovery efficiency)
- ▶ Future Permitting
- ▶ Cycle testing plan formulation



Treatment Technology Evaluations

- ▶ Initial survey of all available treatment processes
- ▶ Proof of Concept Testing -2021-2022
 - ▶ 5 systems, side-by-side performance testing
- ▶ Designed to meet all primary and secondary water quality standards
- ▶ Moving forward 10 MGD demonstration facility for 2 wells at C-38S
 - ▶ Ceramic and polymeric membranes
 - ▶ Pretreatment to prevent arsenic mobilization
 - ▶ Degassing (stripper, membrane)
 - ▶ Sodium hydrosulfide (NaSH)
 - ▶ Investigating methods for PFAs removal



ASR Science Plan

- ▶ Developed to address uncertainties from the National Research Council
 - ▶ Project sequencing and reporting
 - ▶ Construction and testing
 - ▶ Understanding nutrient reduction
 - ▶ Operations to maximize recovery
 - ▶ Disinfection/treatment technology
 - ▶ Water quality/geochemistry
 - ▶ Quantitative/probabilistic risk assessment
- ▶ Inaugural version published in 2021



ASR Science Plan cont.

- ▶ Input from a Peer Review Panel
 - ▶ Recognized, independent experts
 - ▶ Dr. Rene Price - FIU (Chair)
 - ▶ Dr. Tom Missimer - FGCU
 - ▶ Dr. John Carriger - USEPA Risk Analyst
 - ▶ Mike Coates, P.E. - Peace River ASR
 - ▶ Reid Hyle - FFWC research biologist
- ▶ Findings should be helpful to all ASR projects
- ▶ Next Panel Workshop: January 2024



Continuous Coring Program

- ▶ Collected from 500' - 2,000' bls
- ▶ Water Quality (30' intervals)
- ▶ Specific Capacity (30' intervals)
- ▶ Petrography/mineralogy
- ▶ Geotechnical properties
- ▶ Fracture analysis (USGS)
- ▶ Column studies (USGS)
- ▶ Geochemical modeling



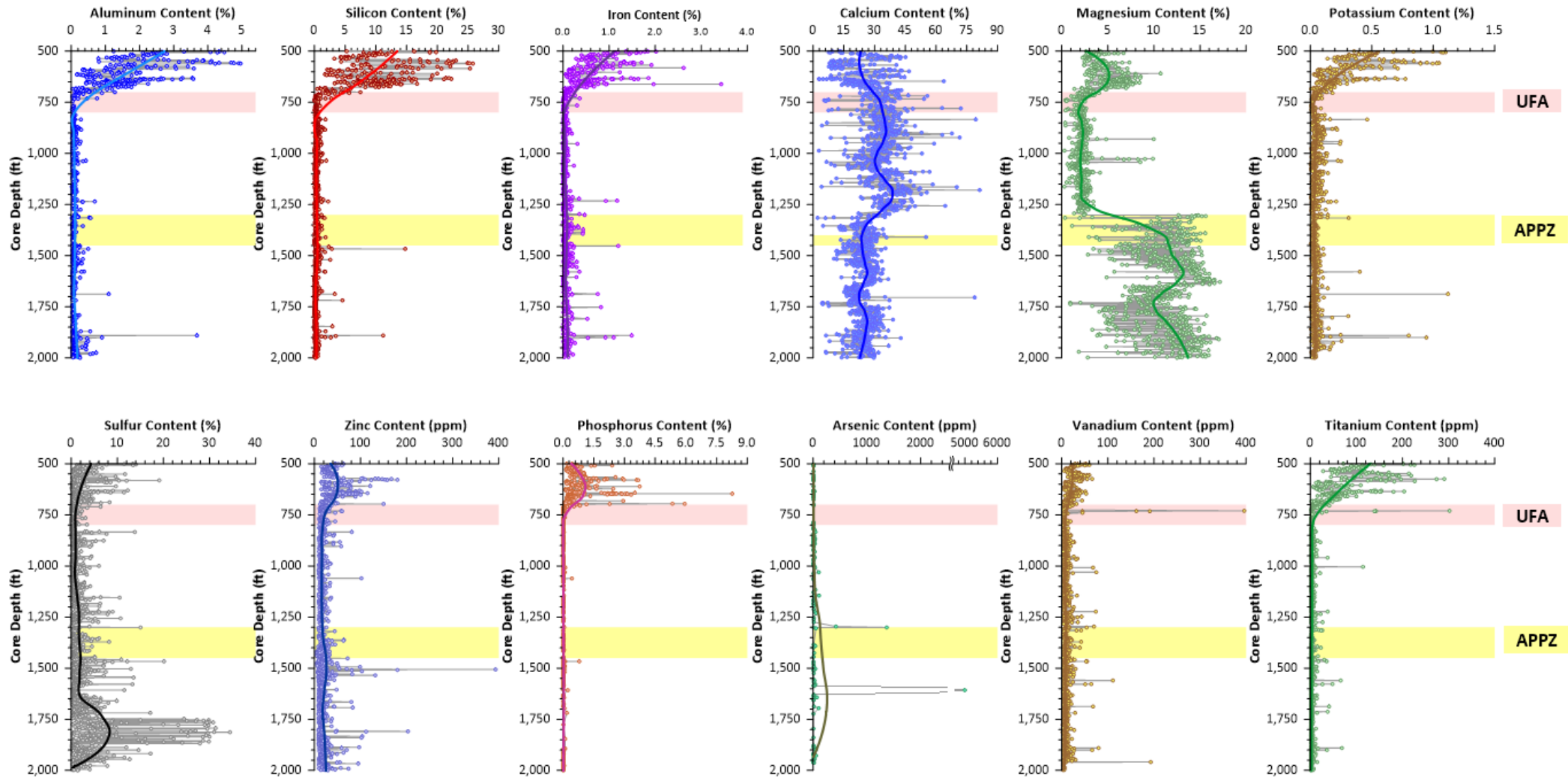
Florida Gulf Coast Univ. Core Study

- ▶ Portable X-ray fluorescence
 - ▶ 1-foot incremental hand measurements
 - ▶ Determination of mineralized zones/geochemical facies
 - ▶ Whole-rock composition
 - ▶ Organic layers
 - ▶ Elemental ratios
 - ▶ Useful in identifying zones that may be prone to metal mobilization?
 - ▶ Volcanic "Ash" layer at 1,466'



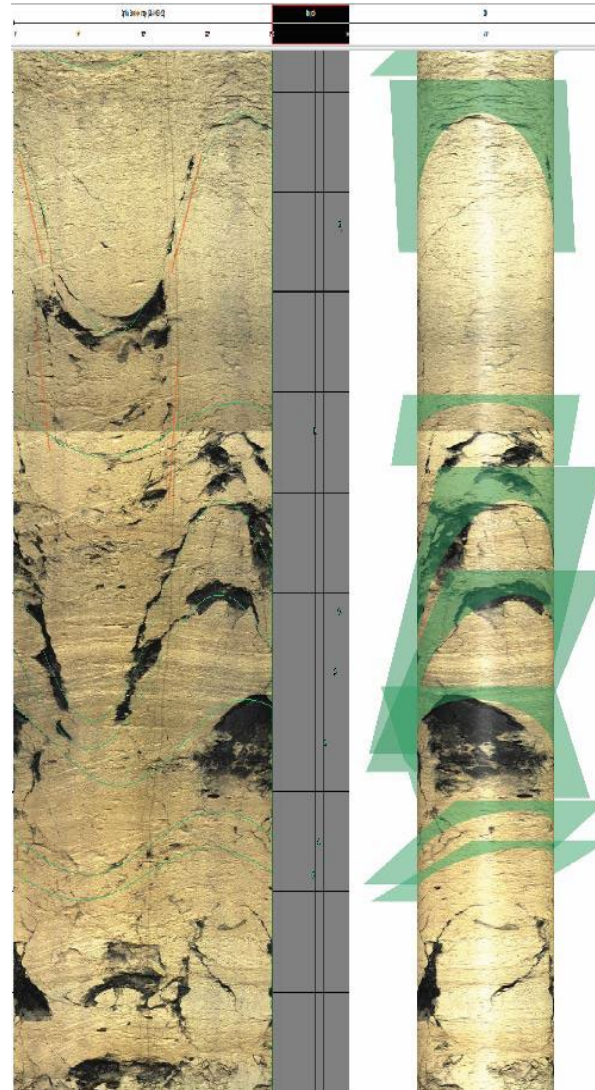
FGCU Core Analysis Cont.

L63N Core Profiles (500 – 2,000 ft)

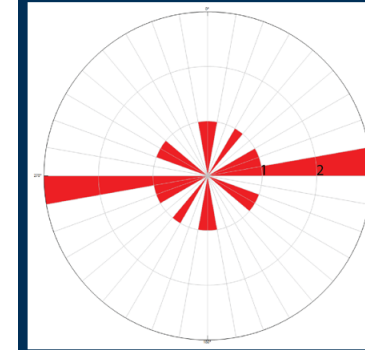


USGS Davie - Core Fracturing

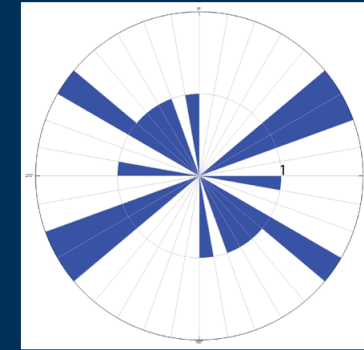
- ▶ Detailed lithologic and stratigraphic descriptions
- ▶ Secondary features (porosity, fractures)
- ▶ Trends of anisotropy within the aquifer
- ▶ Integration of results into the groundwater model



Rose Diagrams for L-63S Upper Floridan Aquifer

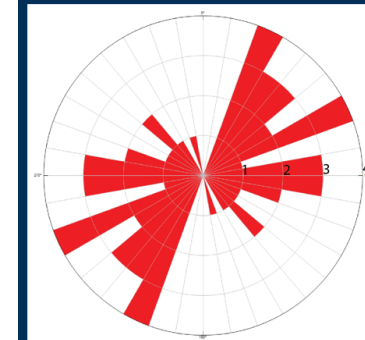


Total Natural Fractures: 10

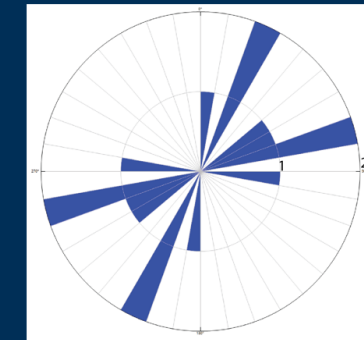


Total Bedding Plane Vugs: 11

Rose Diagrams for L-63S Avon Park Permeable Zone



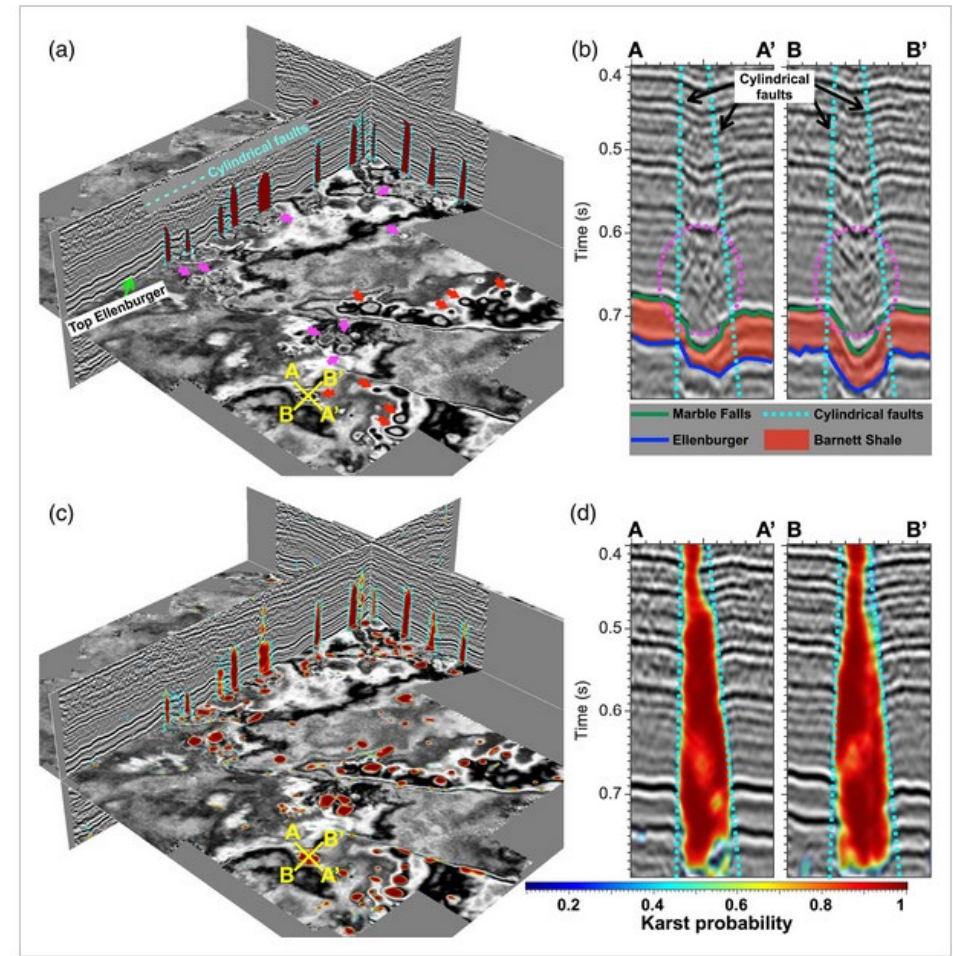
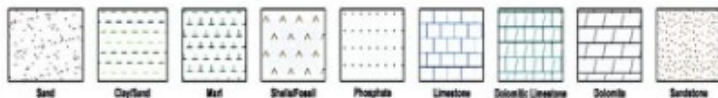
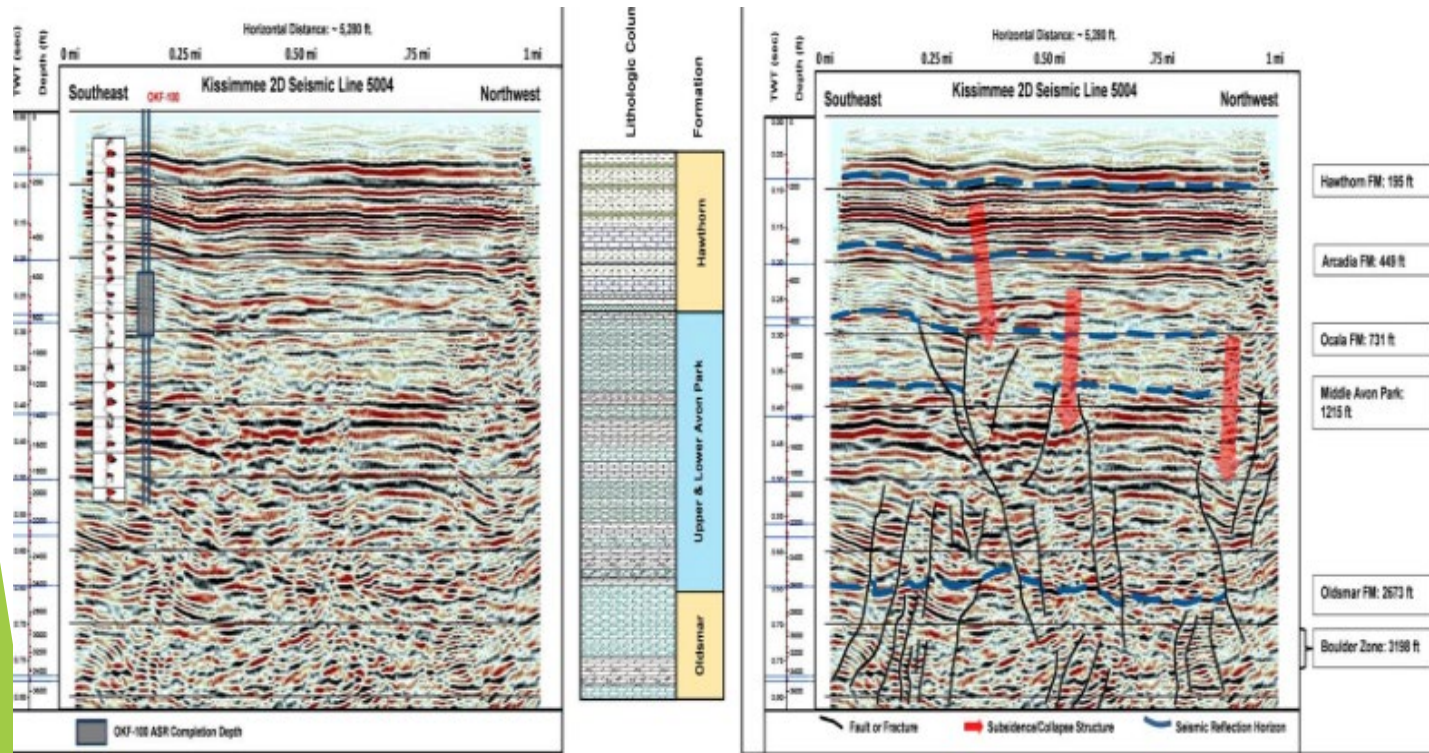
Total Natural Fractures: 31



Total Bedding Plane Vugs: 8

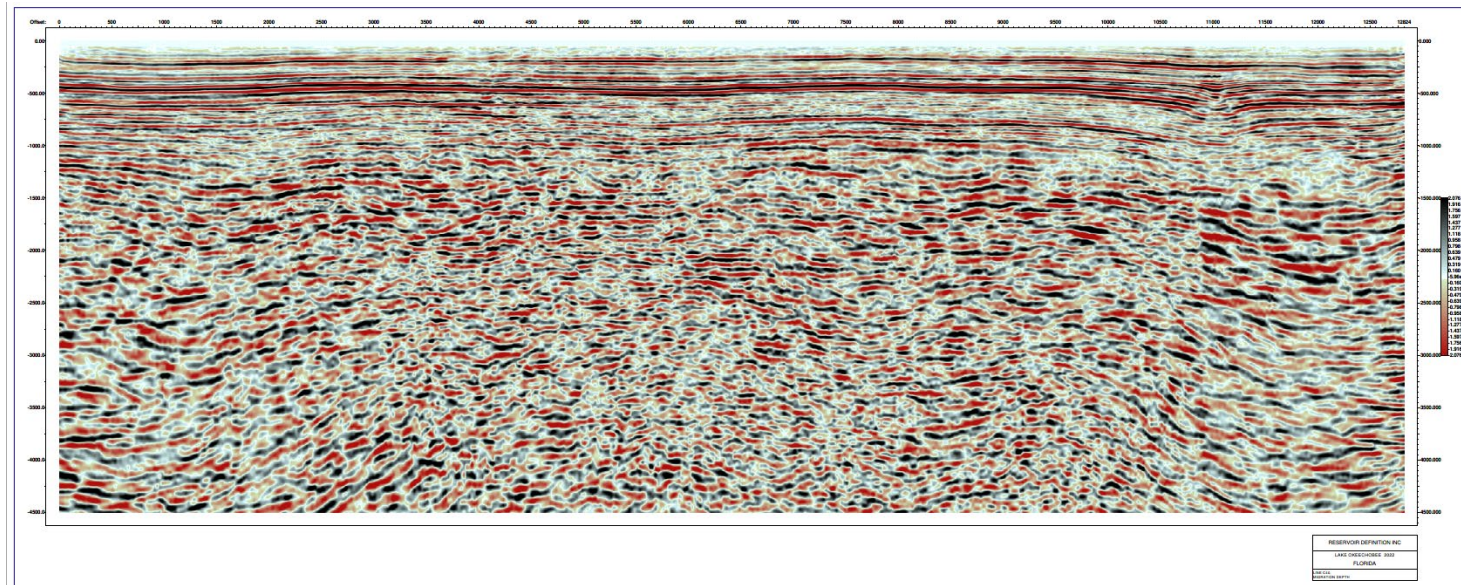
USGS Fracture Analysis cont.

- Phase 2: Expansion to regional/tectonic understanding of Florida paleokarst history

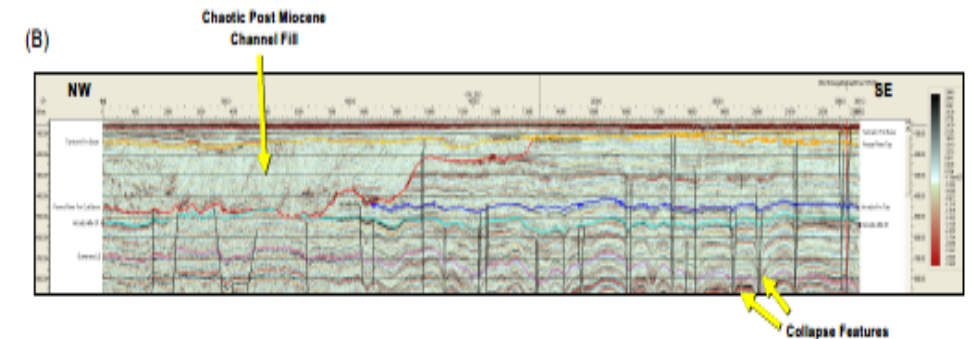
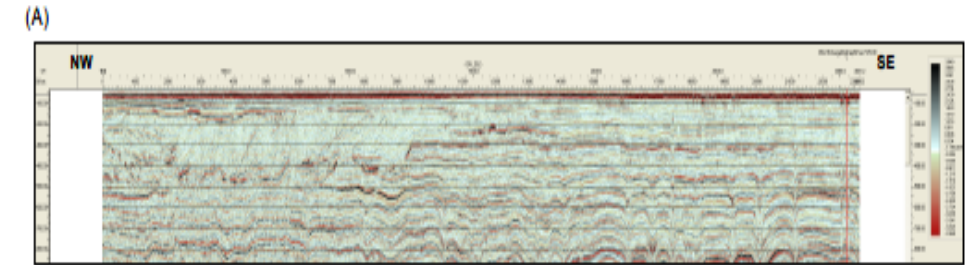
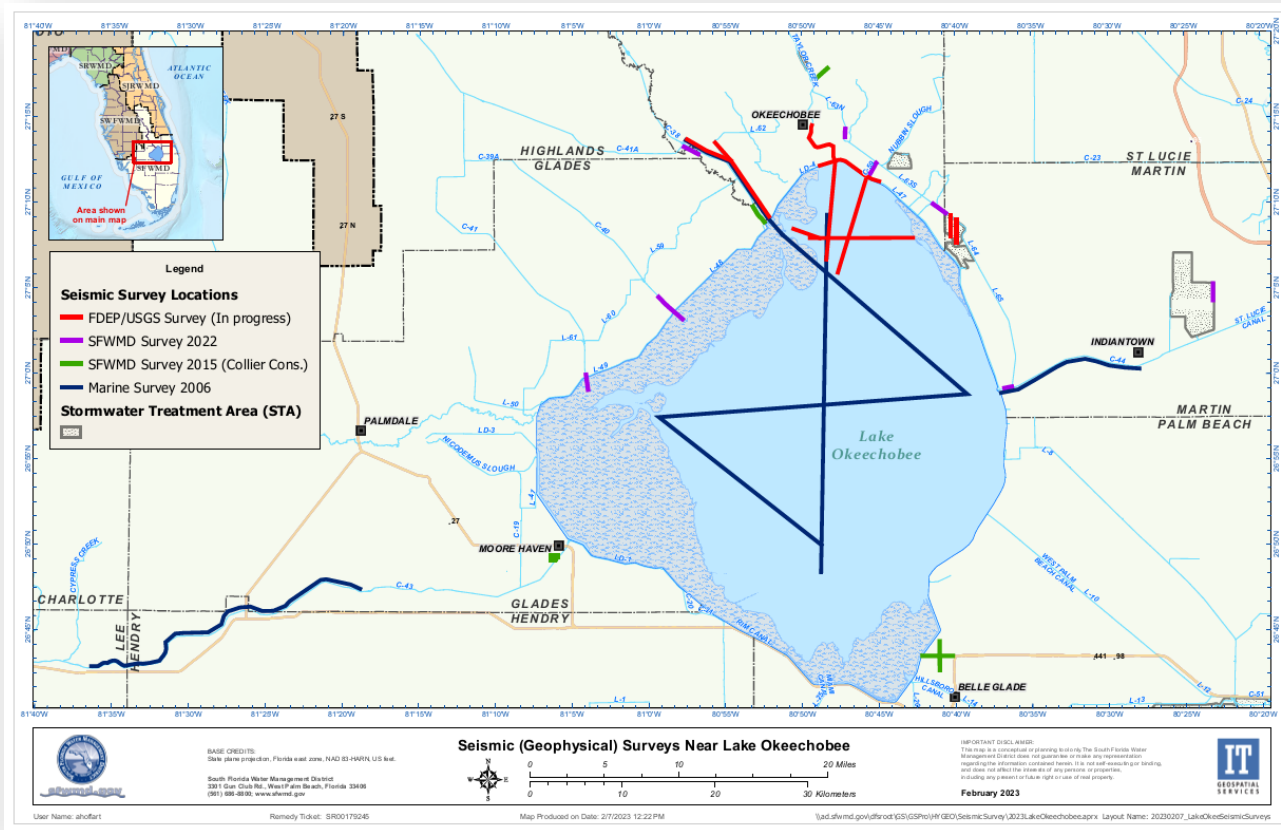


Seismic Surveys

- ▶ Reflection geophysics
- ▶ Non-invasive reconnaissance
- ▶ Comparative evaluation to assess risks at sites we know little about
- ▶ Obtain data without having to drill a well

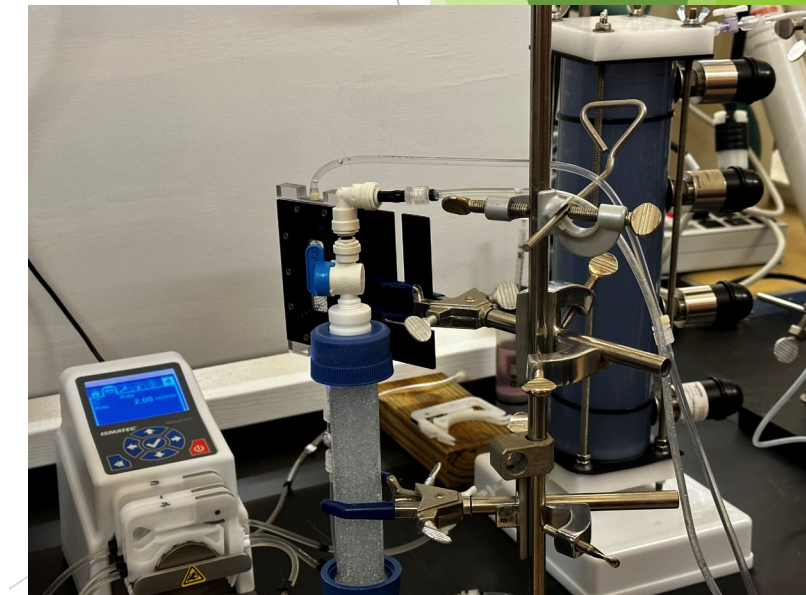
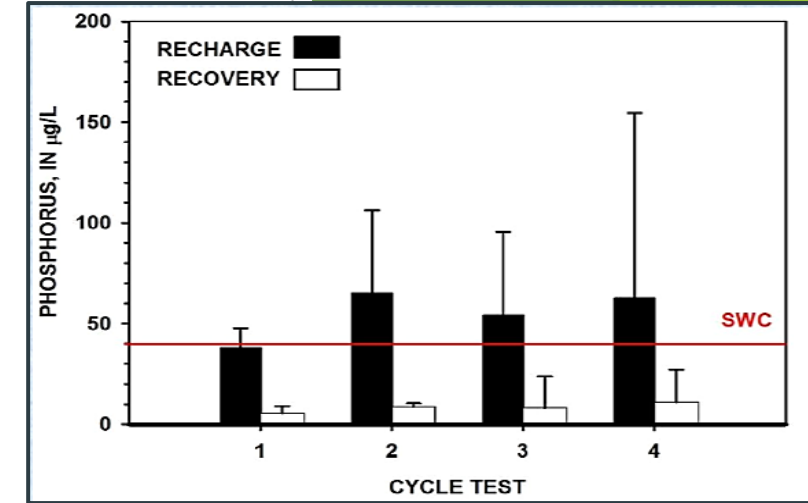
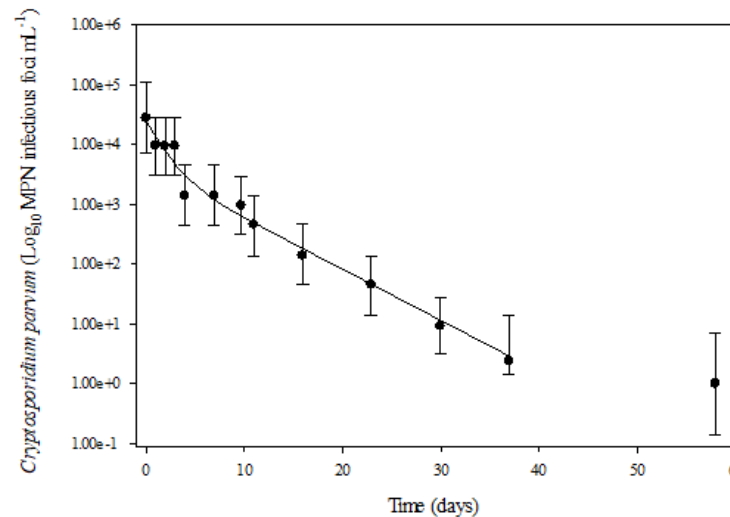
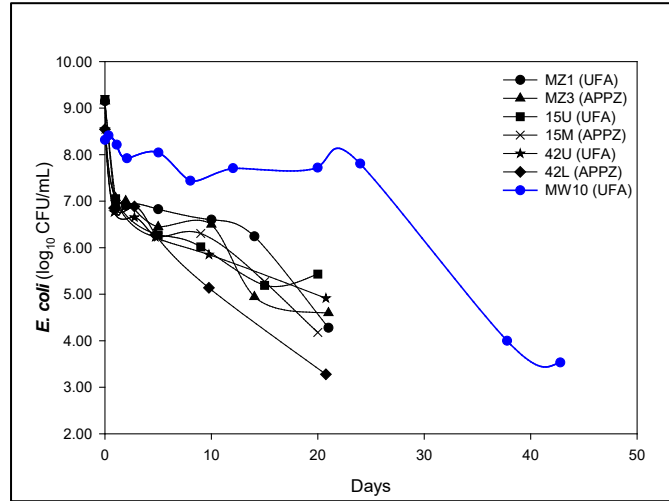


The Seismic Dream!



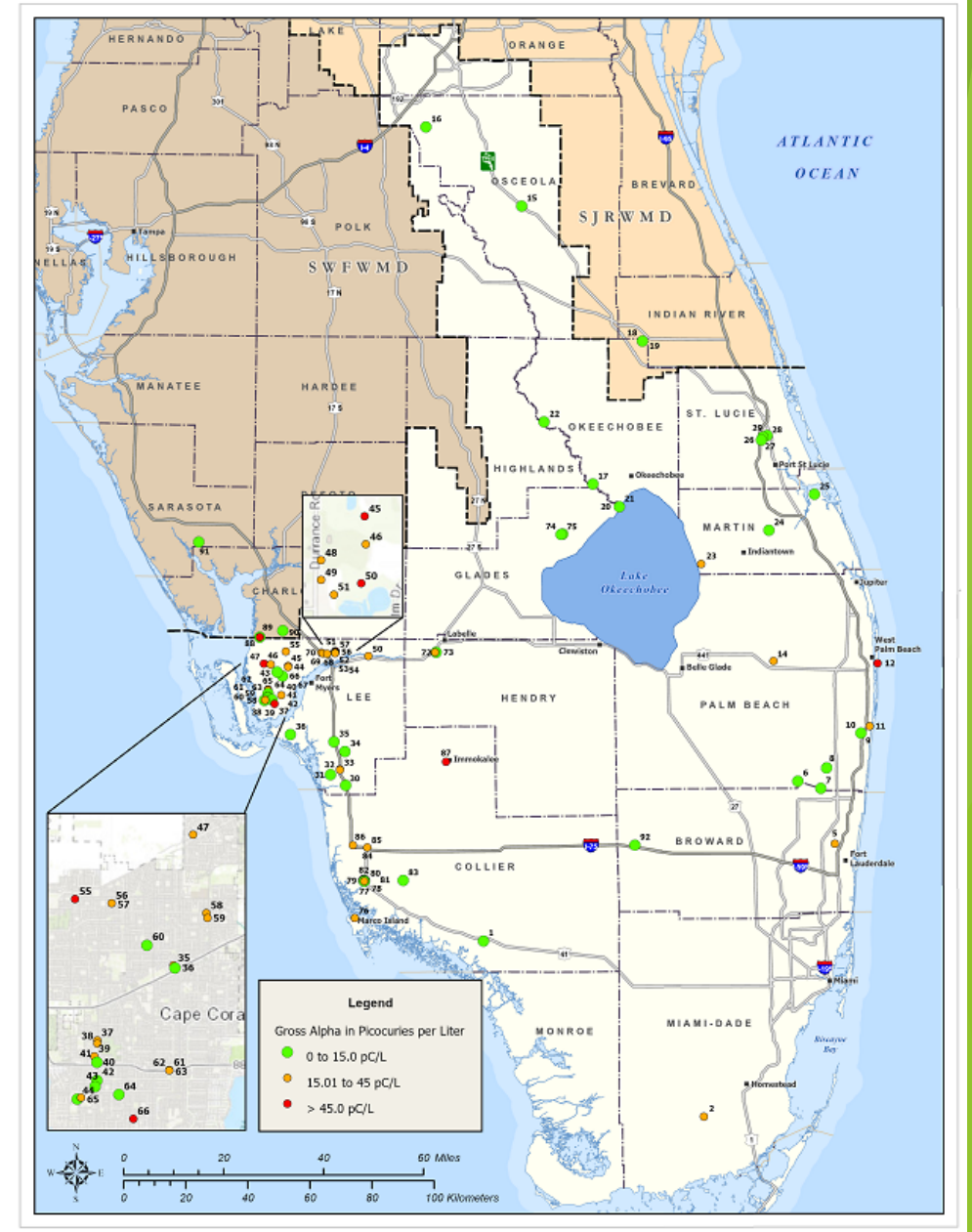
USGS St. Pete - Microbiology

- ▶ Pathogen inactivation - most inactivated after 30 to 60 days when subjected to anoxic, aphotic
 - ▶ *Pseudomonas aeruginosa*
 - ▶ *Cryptosporidium*
 - ▶ *E. Coli*
 - ▶ Bacteriophage MS2
 - ▶ Poliovirus Type 1
- ▶ Nutrient (P and N) reduction - conditions exist for native biofilms and surface area to capture and retain
- ▶ Clogging potential



Geochemical Evaluations

- ▶ Arsenic and sulfate control via a “buffer zone”
- ▶ Survey of radium/gross alpha occurrences using existing data
- ▶ Benchtop geochemical "mixing" model (PHREEQC 3.2)
 - ▶ Probability of arsenic mobilization
 - ▶ Reactions between recharge water and rock mineralogy
 - ▶ Could be useful in determining a treatment process



Gross alpha concentrations in UFA

ERDC (USACE) Participation

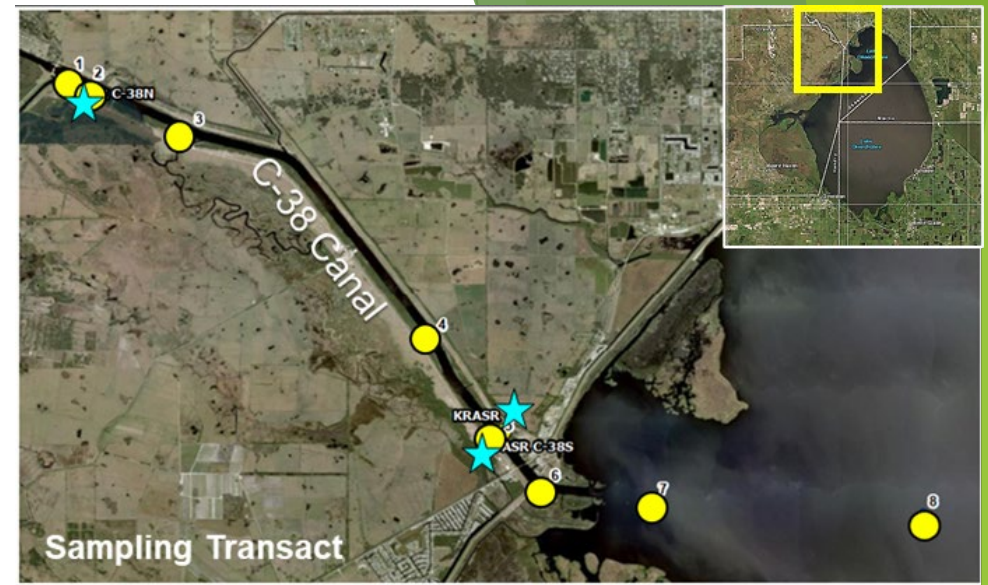
- ▶ Characterize arsenic speciation in FAS rocks
- ▶ Arsenic dissolution reactions when subjected to recharge water
- ▶ Reactive transport groundwater model
 - ▶ Using the local scale model as a platform
- ▶ Pretreatment of recharge water eliminate arsenic mobilization



DISCOVER | DEVELOP | DELIVER

Ecological Studies

- ▶ Recovered water effect on the Lake O and greater Everglades Ecosystem
- ▶ Initiated Baseline Environmental Monitoring
 - ▶ Water quality
 - ▶ Sediments
 - ▶ Aquatic vegetation
 - ▶ Fish
 - ▶ Periphyton
 - ▶ Benthic macrofuana
- ▶ Mobil environmental testing laboratory
- ▶ Studies to develop a quantitative, probabilistic risk assessment (per NRC)



Data Quality, Storage and Access

- A curated, validated, publicly-accessible information management system.
- Programmatic Quality Assurance Plan
 - Audits
- Reports can be found on DBHYDRO or DataOne
 - cerp-sfwmd.dataone.org/data
- Information pertaining to ASR Science Plan can be found on SFWMD website
 - <https://www.sfwmd.gov/our-work/alternative-water-supply/asr>

Aquifer Storage and Recovery Programmatic Quality Assurance Plan



South Florida
Water Management District

Version: 1.0
Date Prepared: January 2022
Effective Date: Upon Final Approval

Questions?