SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Aquifer Storage and Recovery (ASR) Science Plan

January 28, 2021

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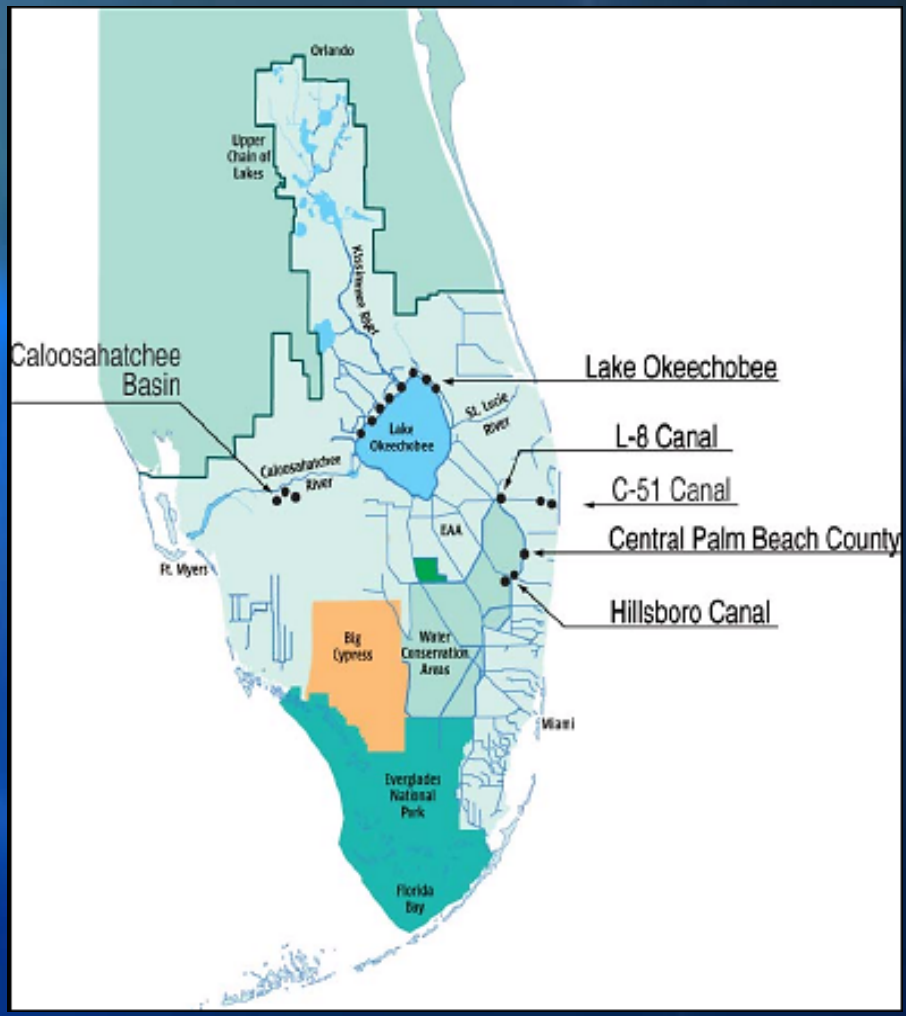
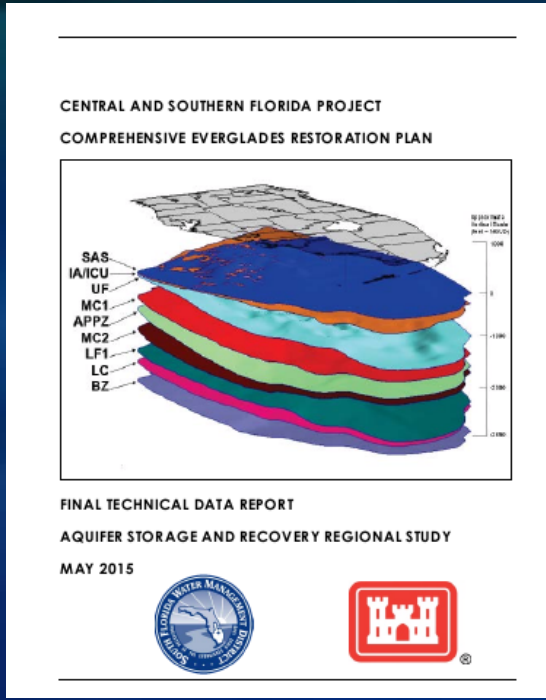
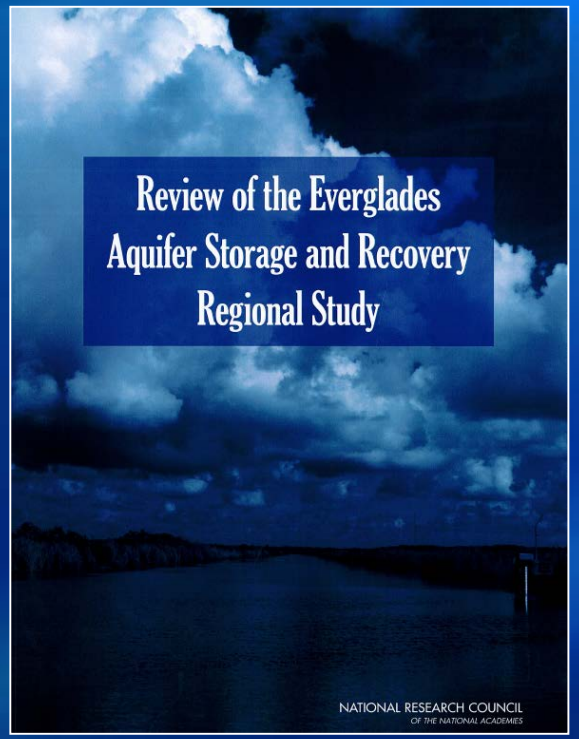
Essential Findings from the CERP ASR Studies

- No “fatal flaws” were uncovered
- Fewer wells (140) could be constructed – about 80 near Lake Okechobee
- Large capacity (5 mgd) ASR wells can be built; however, variability in hydrogeology makes it prudent to do exploratory programs first
- Water recovered did not show significant ecological effects, although analysis was based on limited testing
- Further implementation of CERP ASR should proceed in a phased approach



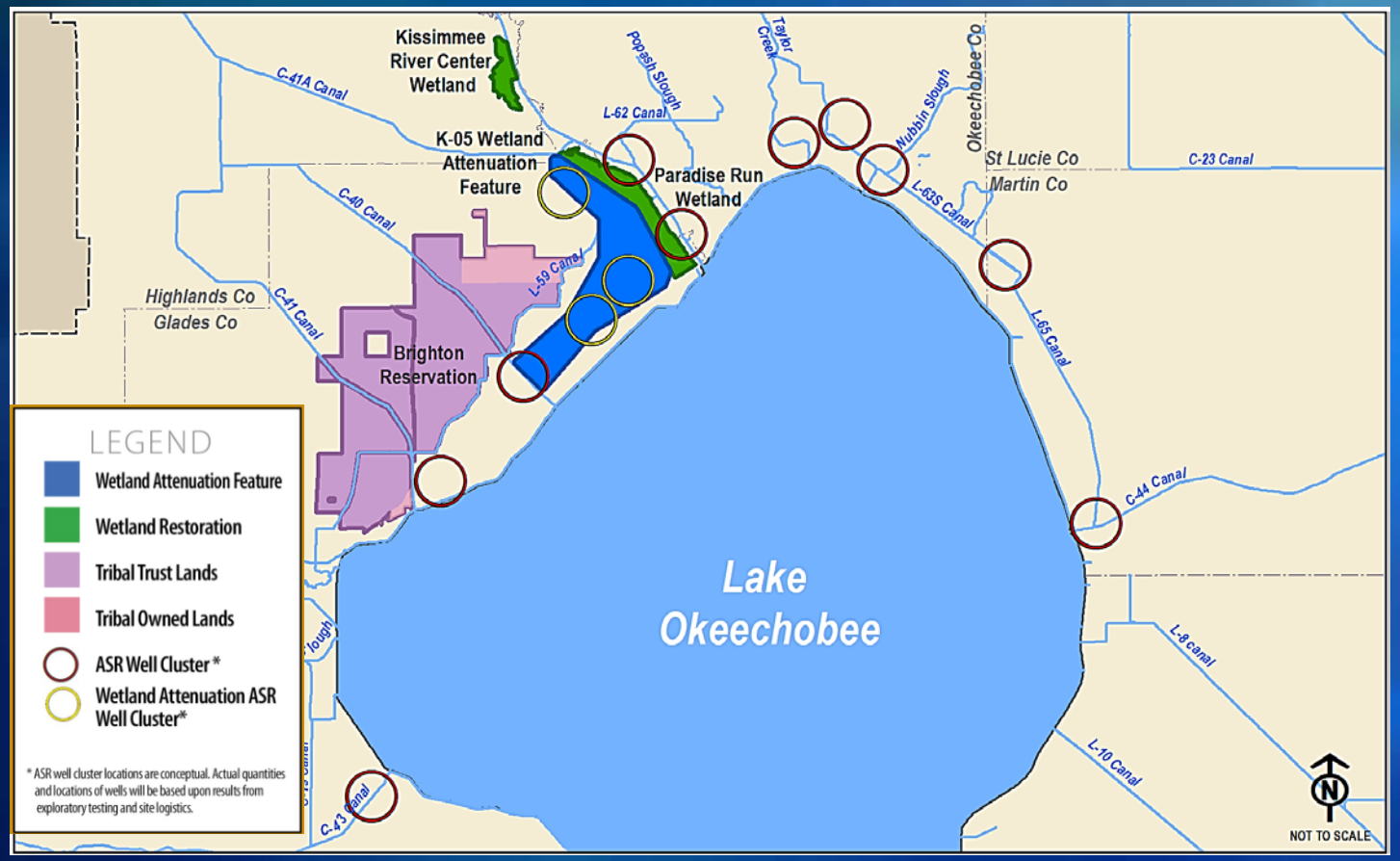
NRC Review of ASR Regional Study





- No “fatal flaws” preclude the use of ASR in CERP
- An incremental approach may involve phased clusters of ASR wells while providing some early benefits
- 6 Topics of Remaining Uncertainty
  - Future Construction and Testing
  - Understanding Phosphorus Reduction Potential
  - Operations to Maximize Recovery
  - Disinfection/Treatment Technology
  - Ecotoxicology and Ecological Risk Assessment
  - Water Quality

LOWRP Recommended Plan

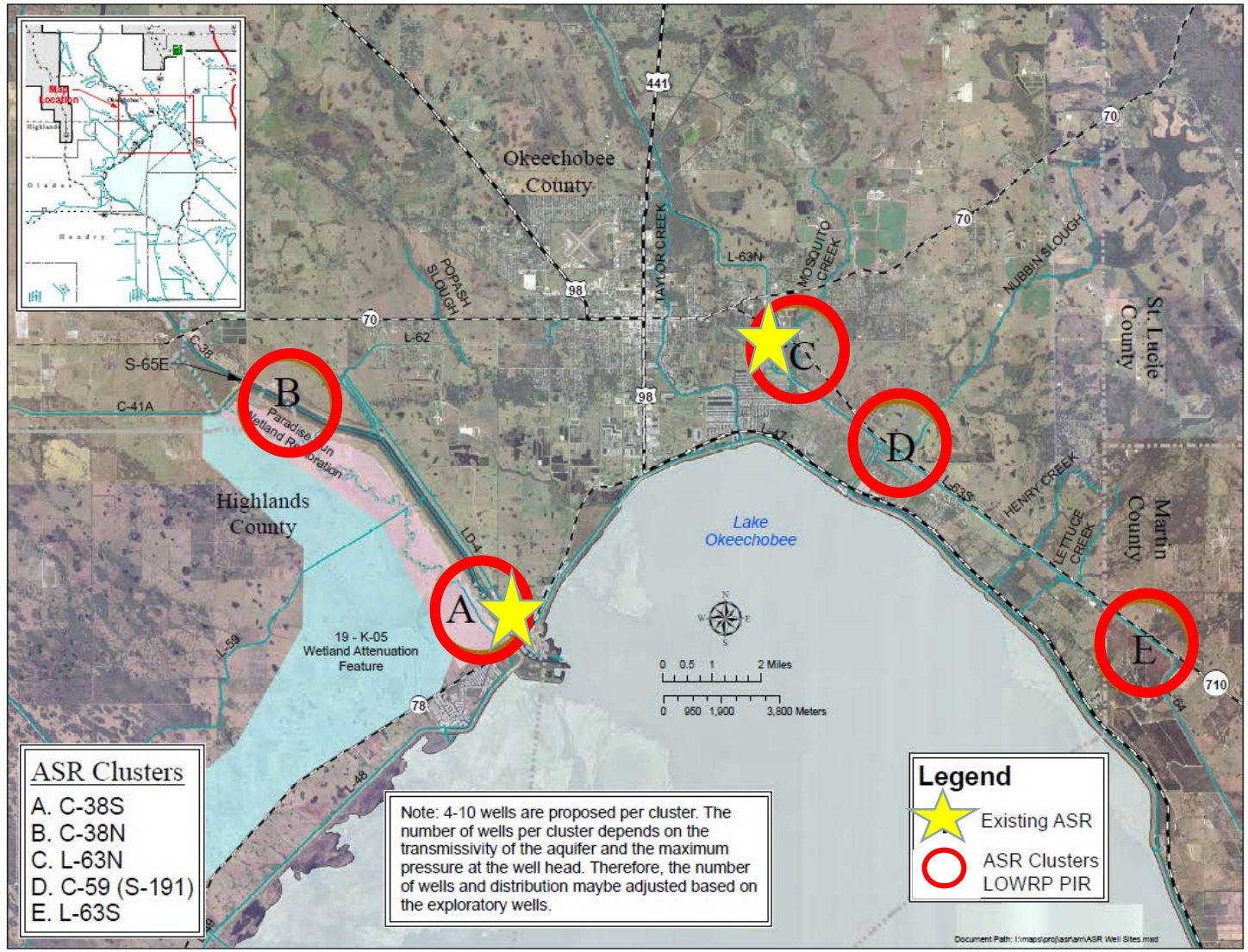


- **Recommended Plan components:**
- **Shallow aboveground storage**
  - Wetland Attenuation Feature (WAF)
  - ~ 13,600 acres
  - 46,000 ac-ft storage
- **Aquifer storage and recovery**
  - **80 ASR wells**
  - 448,000 ac-ft of storage per year (400 MG/day)
- **Wetland restoration**
  - Paradise Run ~ 3,600 acres
  - Kissimmee River – Center ~ 1,200 acres

LOWRP ASR Well Program

- **State Appropriations**
  - **Received $50M in FY19-20**
  - **Additional $50M in FY20-21**
- **“Design, engineering, and construction of specific project components designed to achieve greatest reductions in harmful discharges to the Caloosahatchee and St. Lucie Estuaries” (Specific Appropriation 1642A)**
- **Incremental, phased approach being implemented in the Program and the specific watershed ASR projects prioritized for these State Appropriations**

ASR Phased Implementation



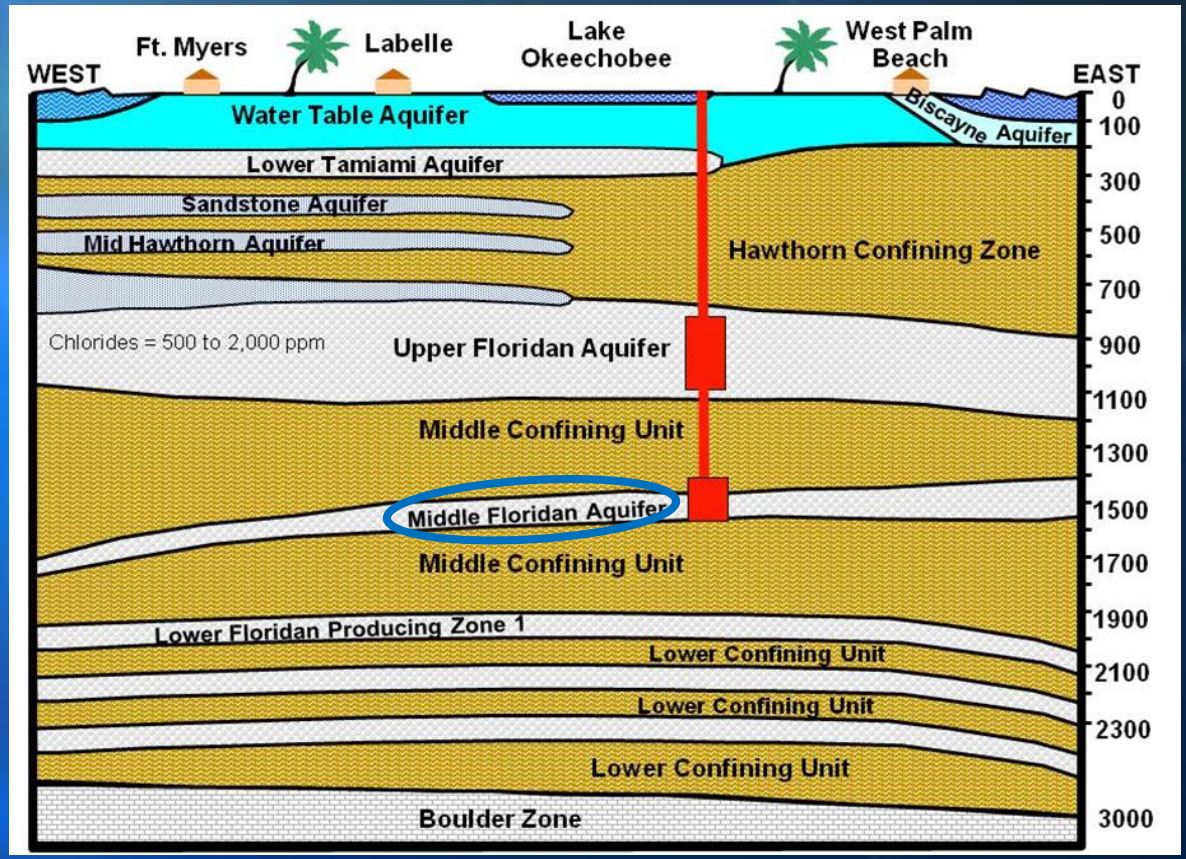
- Reactivate 2 existing systems
- Siting and constructability evaluations
- Continuous cores
- Permitting
- Exploratory wells at 2 proposed cluster locations
- Treatment technology evaluation
- Continuing USGS research

ASR Science Peer Review Panel (PRP)

- **Recognized, independent south Florida experts to assist in addressing remaining ASR uncertainties**
  - Dr. Jon Arthur, FGS
  - Dr. Tom Missimer, FGCU
  - Dr. Rene Price, FIU
  - Reid Hyle, FFWCC Research Institute
  - Dr. Sam Upchurch, retired USF
- **Workshops during July and November**
  - Reviewed the results of previous ASR studies
  - Provided a PRP report containing suggestions for addressing the NRC recommendations

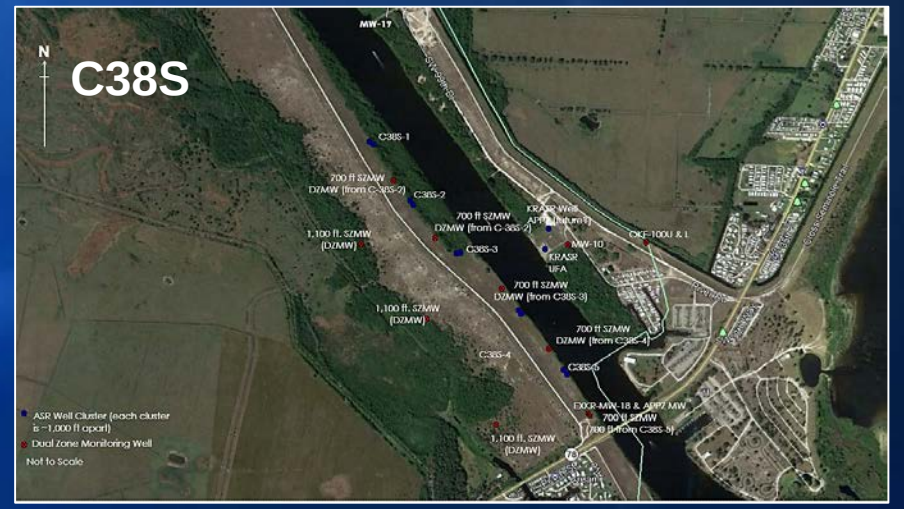
Future Construction and Testing

- More local scale information is needed on the attributes of the Avon Park Permeable Zone
  - Reactivate the L63N ASR well
    - Mechanical integrity test (2020)
    - Cycle testing (2023-2024)
  - Continuous cores at new locations (2021-2022)
    - Drilled to 2,000 feet bls
    - Water sampling at 30-foot intervals
    - Mineralogy, porosity, geotechnical and hydraulic properties
    - Geochemical modeling
    - Geophysical logging
    - Slabbed, described and stored by the USGS



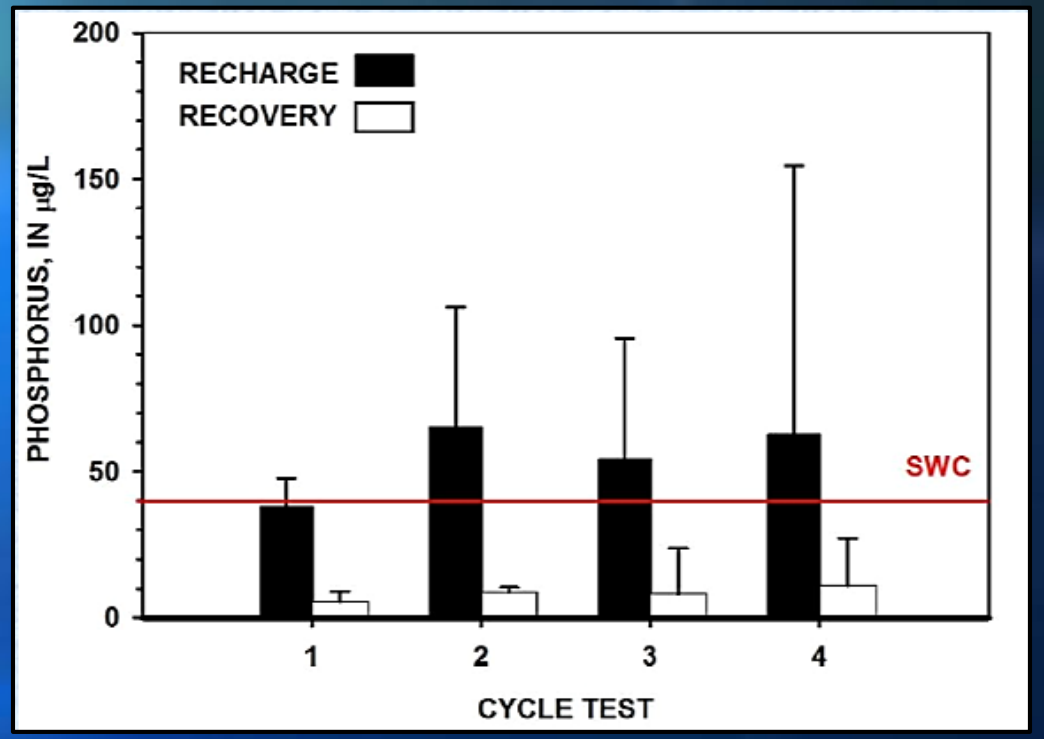
Future Construction and Testing (cont.)

- **Use groundwater models, geophysics, and tracer tests to anticipate heterogeneity, anisotropy, and travel times**
  - **Constructing multi-level, nested exploratory test wells at two locations along C38 canal (2021-2022)**
  - **Monitoring wells**
  - **Seismic surveys**
  - **Pumping (withdrawal) and tracer (injection) tests (2022)**
  - **Wellfield-scale groundwater models (2022)**



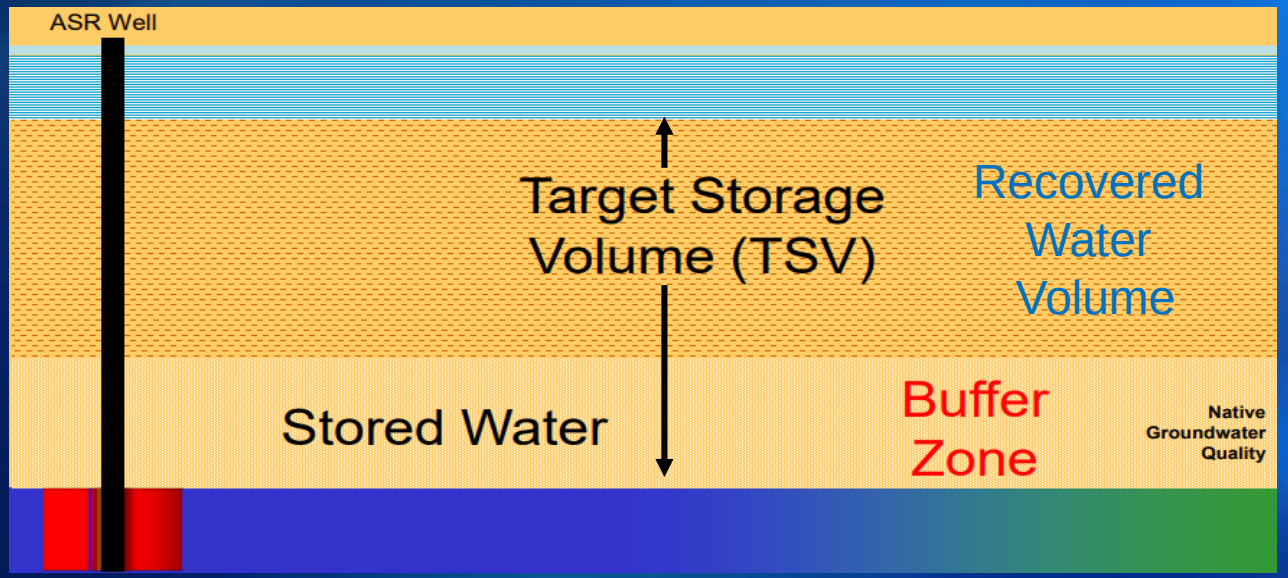
Understanding Phosphorous Reduction

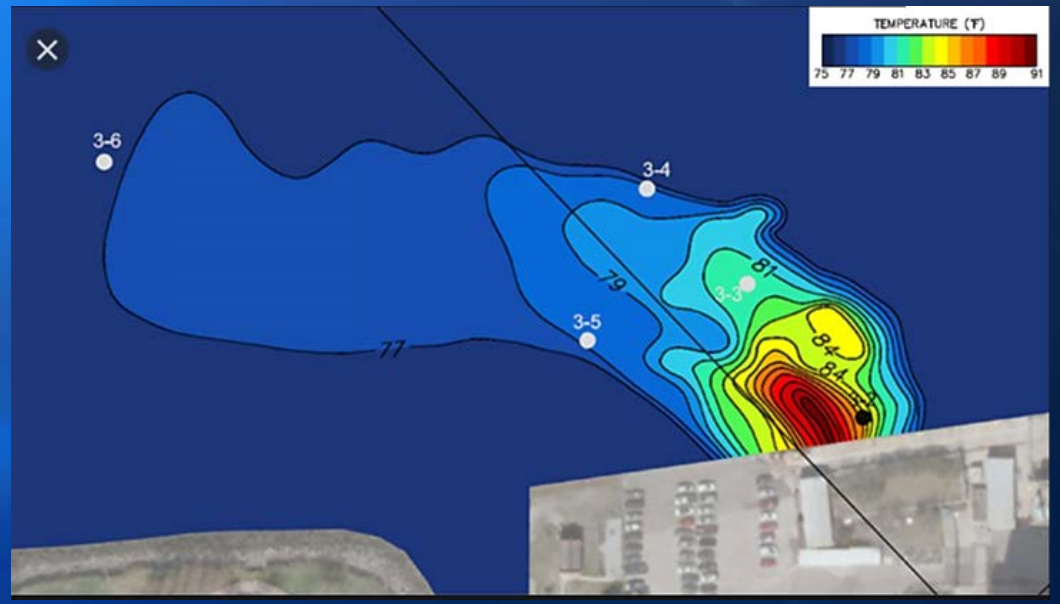
- **More research into the long-term nutrient removal mechanisms and rates should be undertaken**
  - **USGS to develop flow-through column experiments using continuous cores (2021)**
  - **Geochemical modeling from continuous core water quality data**
  - **Enhanced monitoring P and N species when Kissimmee and L63N systems are back up and running (2023)**
  - **Revision of the SFWMD Phosphorus Load Simulation Model**



Operations to Maximize Recovery

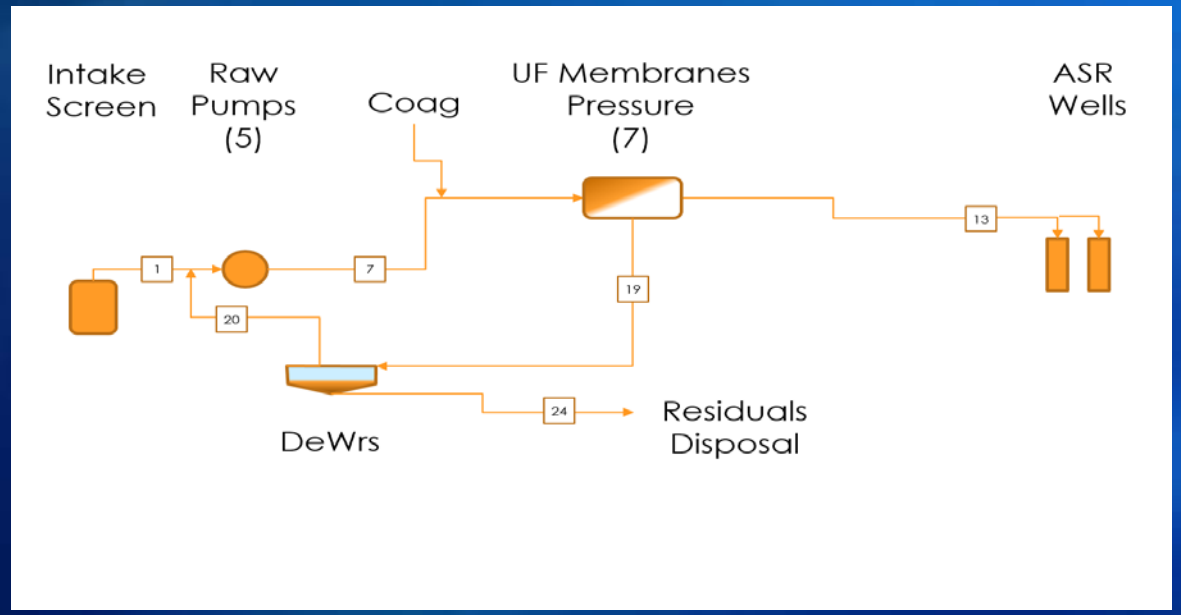
- **Establish and maintain a Buffer Zone (TSV = Recovery volume + Buffer Zone) during cycle testing**
- **Locate ASR systems adjacent to large water bodies to allow for adequate mixing zones**

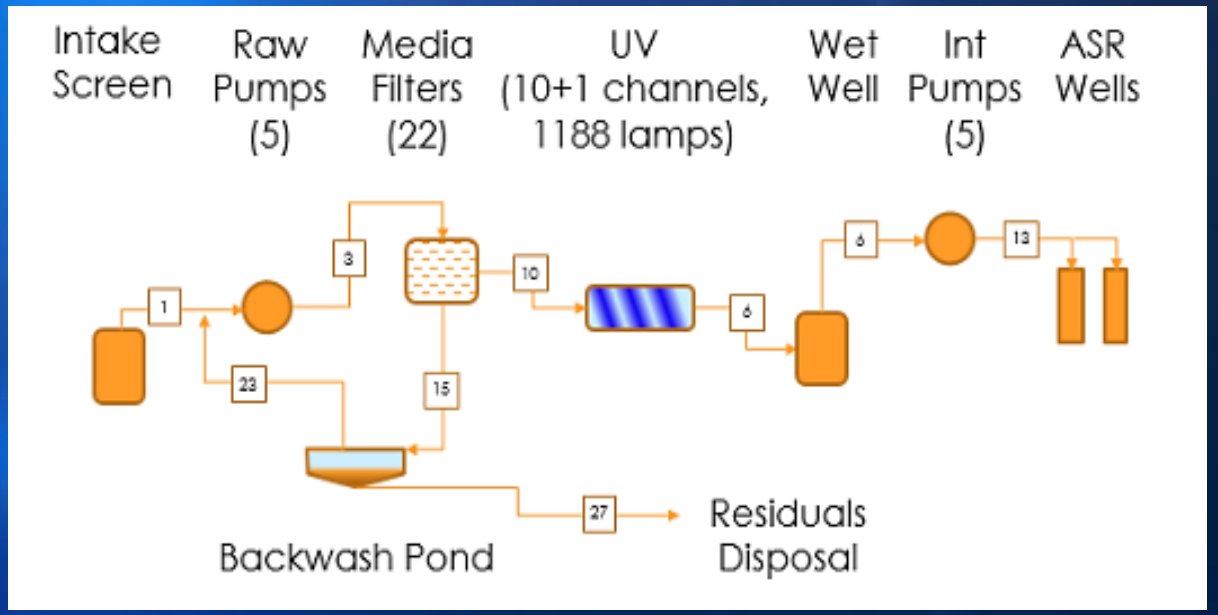




Disinfection/Treatment Technology

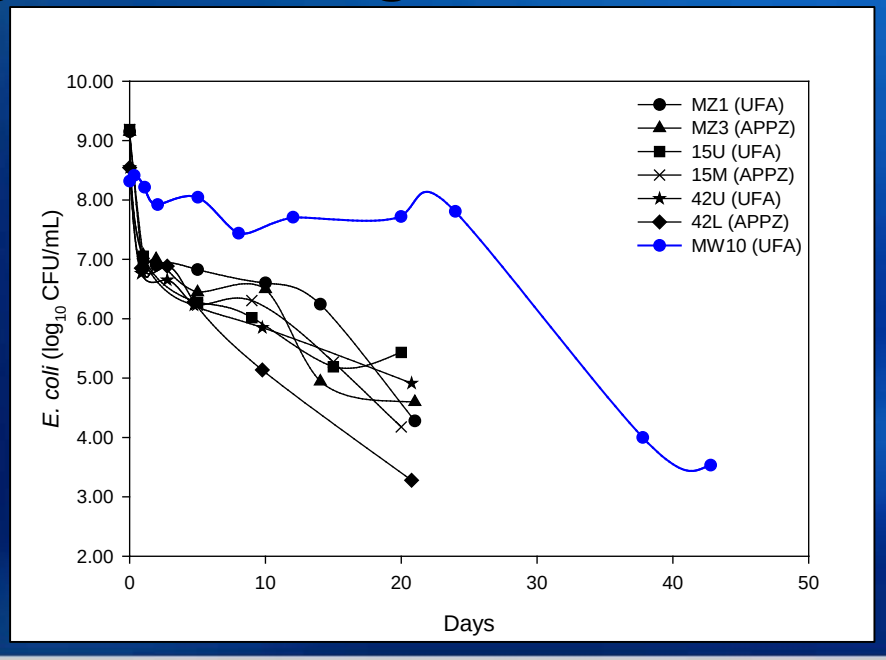
- **Develop appropriate pretreatment strategies to consistently meet regulatory requirements**
- **Develop strategies to attenuate arsenic mobilization**

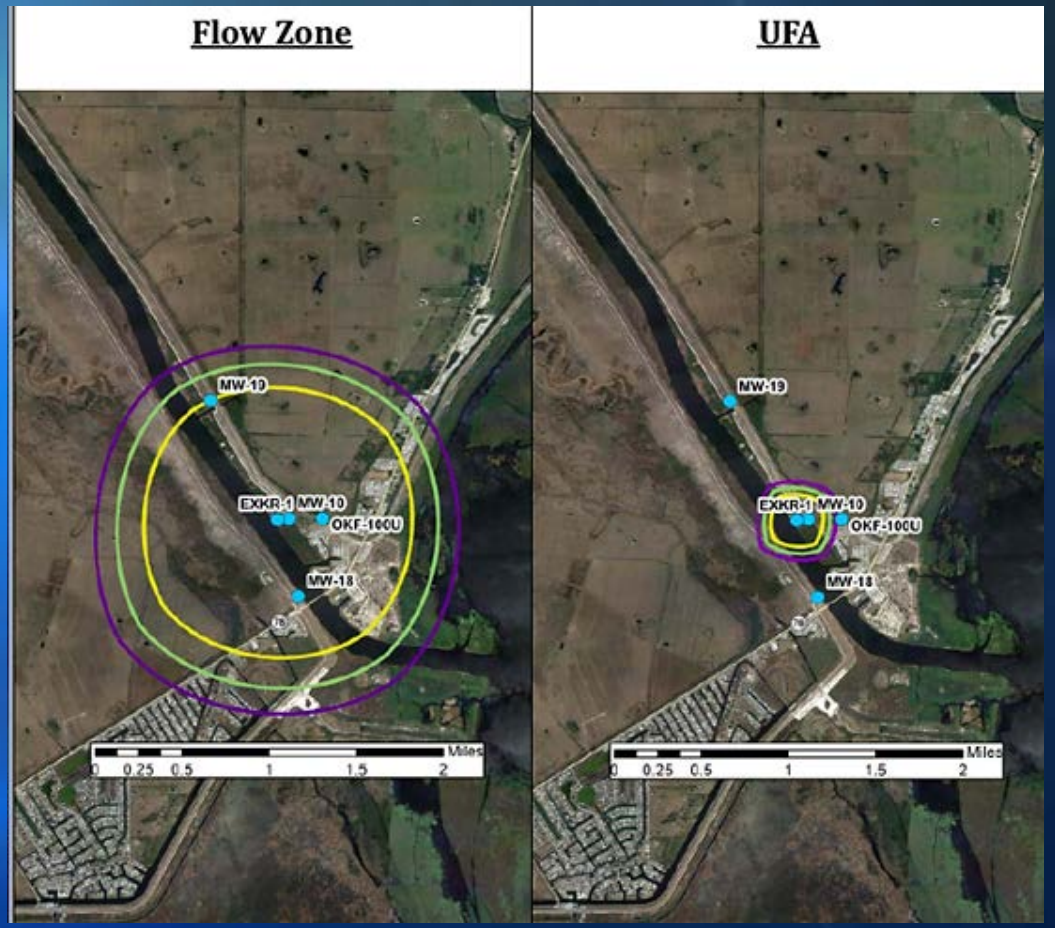




Disinfection/Treatment Technology (cont.)

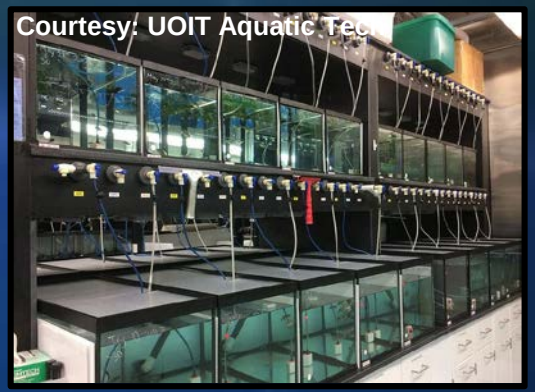
- **Continue research on subsurface pathogen inactivation using a wider array of pathogens**
- **Couple pathogen inactivation studies to groundwater travel times and distances using local scale groundwater modeling**





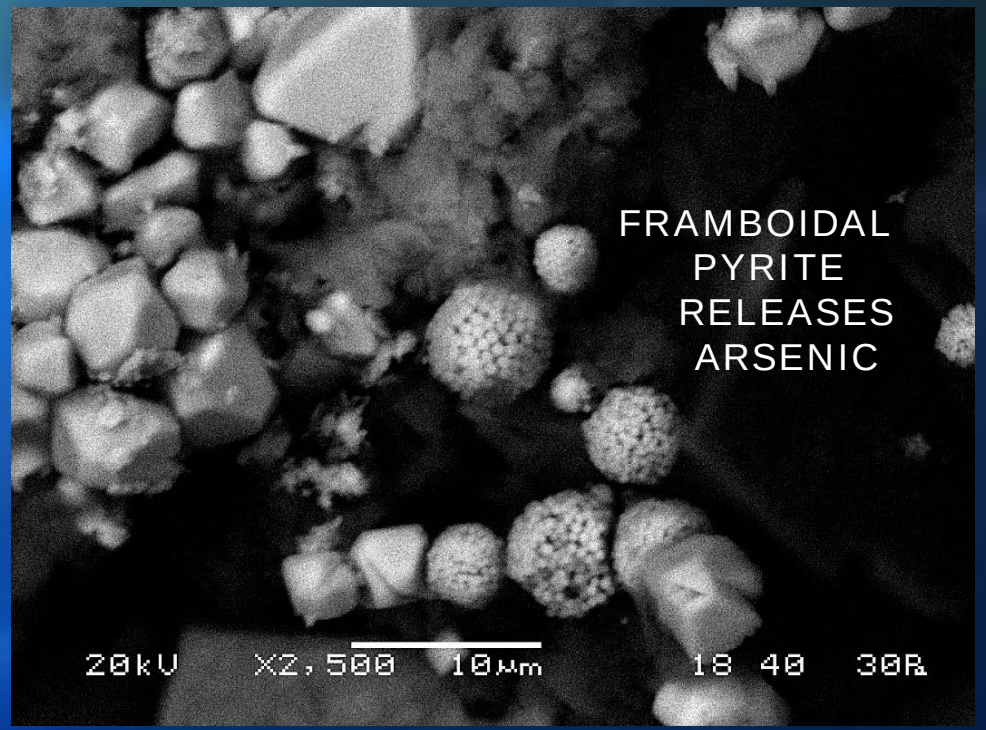
Ecotoxicology and Risk Assessment

- **Longer-term recovery periods will allow for extended duration of chronic and bioaccumulation evaluations and mesocosms**
- **Quantitative, probabilistic Ecological Risk Assessment using updated EPA methodology to incorporate all of the chemical, toxicity, bioaccumulation, and other data collected throughout the project into a comprehensive assessment**



Water Quality

- More research is needed to understand the impacts of different source water qualities on the long-term redox evolution of the aquifer and its effect on arsenic mobilization
- Need to determine how development of a buffer zone can be utilized to reduce sulfate concentrations in recovered water
- Need to determine how far arsenic can be transported within the aquifer using extended cycles
- More understanding on the spatial variability of gross alpha and radium at future locations should be addressed



Science Plan Study Schedule

	2021 Continuous Cores	2021-22 Reactivation of Existing Wells	2021-22 Test/Exploratory Multiple Wells	2021-24 Design, Permitting, and Construction	2024-26 Initial Cycle Testing	2026-30 Extended Testing and Wellfield Expansion
Local scale information on APPZ attributes	■	■	■			
P removal mechanisms	■	■			■	
Pathogen inactivation	■	■		■		
Injection pressures for fracture potential	■		■	■	■	
Chronic toxicity testing		■			■	
Arsenic transport within aquifer using buffer zone		■			■	■
Buffer zone usage to reduce sulfate concentrations		■			■	■
Fate of sulfate in recovered water to form methylmercury		■			■	■
Groundwater travel times		■	■	■		
Local scale model for heterogeneity, anisotropy, fracturing, travel times		■	■	■		
Pretreatment technologies to remove arsenic		■		■	■	
Well spacing and optimal recovery efficiency			■	■	■	
Anisotropy analysis used for orienting wells			■	■		
Tracer studies for flow directions			■	■		
Cross-well tomography and geophysics			■	■		
Locate clusters near large water bodies				■	■	
Technologies to meet regulatory requirements				■		
Multi-cluster chronic toxicity testing					■	■
Community-level effects and bioaccumulation					■	■
Prolonged bioconcentration studies					■	■
Probabilistic, quantitative risk assessment					■	■
Variability of gross alpha and radium in recovered water					■	■
Source water effects on redox evolution of aquifer					■	■
Improve/extend cycle tests					■	■
Establish buffer zone					■	■
Operate multi-well pairs and clusters					■	■

Next Steps

- Agency Technical Review by USACE
- Construction of continuous cores at two or more locations
- Analysis of cores for mineralogic and geotechnical properties
- Continuing the next phase of treatment technology evaluation
- USGS column studies of nutrient reduction/plugging potential
- Construction of exploratory wells at C38S and C38N locations
- Reactivation of Kissimmee and L63N ASR systems
- Early start tasks for ecological assessments
- Draft Plan will be available for public review in February

Discussion

www.sfwmd.gov/asr