Florida Fresh Water Demand and Use

Water Demand (bgd)

Year

Public Water Supply
Domestic and Small Public Supply
Agricultural Irrigation
Recreational Irrigation
Commercial/Industrial/Institutional
Floridan Aquifer Salinity

EXPLANATION
Chloride concentration, in milligrams per liter—Boundaries between concentration ranges are dashed where estimated:
- Less than 250
- 250 to less than 500
- 500 to less than 1,000
- 1,000 to less than 10,000
- 10,000 or more

Area where Lower Floridan aquifer does not occur

Limit of reliable chemical data

Modified from Sprinkle (1989)
Peninsular Florida

General setting
Florida Population
Groundwater Use Restrictions

- Water management districts (WMDs) regulate the use of water in Florida
- WMDs have restricted new water use permits as well as increased pumpage under existing permits
- To meet water needs for the future, non-traditional projects to store or reuse water are being implemented
### Tertiary Stratigraphy

#### Florida Hydrogeology

<table>
<thead>
<tr>
<th>Epoch</th>
<th>Unit</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Miocene</td>
<td>Hawthorn Group</td>
<td>Upper Confining Aquifer</td>
</tr>
<tr>
<td>Lower Oligocene</td>
<td>Suwannee Limestone</td>
<td>Upper Floridan Aquifer</td>
</tr>
<tr>
<td>Eocene</td>
<td>Ocala Limestone</td>
<td>Middle Confining Unit</td>
</tr>
<tr>
<td></td>
<td>Late</td>
<td>Middle Floridan Aquifer</td>
</tr>
<tr>
<td></td>
<td>Early</td>
<td>Lower Confining</td>
</tr>
<tr>
<td>Paleocene</td>
<td>Cedar Keys</td>
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*Subregional confining unit*
What is Aquifer Storage and Recovery (ASR)?

• ASR uses an aquifer for underground storage, recovering water as needed in the future

• ASR generally stores and recovers the same water

• ASR wellfields may include one or multiple wells
ASR Well in Subsurface
Aquifer recharge using wells is a method of replenishing an aquifer that is impaired due to overuse or water quality deterioration.

Aquifer recharge generally does not involve the recovery of recharged water.

Recharge wellfields may include one or multiple wells.
Aquifer Recharge
City of Clearwater

Benefits of Groundwater Replenishment
SW Florida Saltwater Intrusion

Approximate location of the saltwater interface (1,000 mg/l chloride) in the high-permeability zone of the Upper Floridan aquifer.
ASR Topics

• Purposes of ASR
• How ASR works
• Regulatory aspects
• Types of fluids stored
• Potential problems
  ○ Water quality
ASR Topics – 2

- Cycle testing
- Monitoring
- Interpretation of ASR data
- What makes for a successful project?
Purposes of ASR in Florida

- Store water in subsurface for future use
- Extend/augment existing freshwater supplies
- Reduce use of groundwater and the number of new wells
- Drought protection
Drought Protection
ASR Project Locations
How ASR Works

[Diagram showing ASR well and groundwater layers]
Water In, Water Out
Marco Lakes ASR, Collier County

Cumulative Volume

End Cycles 1 - 6 ASR-1

Cycle 6-E Begin Use of ASR

Cycle 5-E Begin Use of ASR

Volume (Million Gallons)

Date Range


Cumulative Volume

Cycle 5-E Begin Use of ASR

Cycle 6-E Begin Use of ASR

End Cycles 1 - 6 ASR-1

Volume (Million Gallons)
Class V Injection Wells

Permitting

- ASR and aquifer recharge wells are Class V injection wells
- All Class V wells first used after April 1, 1982 require UIC permits
- UIC rule can require up to Class I standards for well construction and operation
Other DEP Rules

- 62-520 – Groundwater
- 62-532 – Water Well Construction
- 62-550 – Drinking Water
- 62-600, 601 – Domestic Wastewater
- 62-610 – Reuse of Reclaimed Water
Class G-II

- Potable water use, groundwater in aquifers with a total dissolved solids content of less than 10,000 mg/L, unless otherwise classified by the Commission

- Injection of fluid into G-II groundwater (USDW) must meet the primary and secondary drinking water standards
ASR Fluids Stored

- Drinking Water (potable)
- Reclaimed Water
  - Reclaimed water meets treatment requirements of Florida’s reuse rule, Chapter 62-610, F.A.C.
  - Higher treatment levels if warranted or if desired by utility
ASR Fluids Stored – 2

- Groundwater
- Surface Water
  - May need treatment or other measures to protect groundwater
Potable Water ASR

- Potable water treated at a permitted water treatment plant
- Meets all drinking water standards for recharge
- Recovered water is sent back to WTP for re-treatment prior to distribution
  - Normally blended with non-ASR source water at WTP
Reclaimed Water ASR

- Reclaimed (reuse) water quality
- Meets most drinking water standards for UIC recharge, but some secondary standards may not be met without extra treatment
• Florida domestic wastewater program has rules on the recharge of this water
• Recovered water used only for reuse supply
• Blended with other reclaimed water
Groundwater ASR

- Groundwater is the source water
- These ASR projects are for augmenting drinking water supplies in the dry season
- Meets most drinking water standards for UIC recharge, but some secondary standards may not be met without extra treatment (iron, color)
- Recovered water sent to WTP
Surface Water ASR

- Surface water is the source water
- Water quality more variable
- Treatment prior to injection is more likely to be needed
ASR Projects

- Large volume can be stored
- Little land area needed
- No evaporation losses
- Cost savings
- Contaminants may be introduced during injection
- Reactions may occur between injected fluid and aquifer material/formation fluids
Addressing Exceedance of Drinking Water Standards

- **Point of Injection Treatment**
  - Treatment of the injectate to reduce concentrations may be feasible for some systems

- **Point of Recovery Treatment**
  - Treatment used to render waters with high TDS levels potable will reduce other concentrations
  - Treatment includes blending and re-treating at WTP
Pyrite Crystals

Source of Arsenic
Pyrite Crystals - 2

Photos from FL Geological Survey
Treatment Prior to Injection

Arsenic Mobilization Reduction

- Dissolved oxygen removal – Degasification
  - Membranes
  - Oxygen stripping towers
- Chemical treatment – Sodium bisulfide or sodium hydrosulfide
Treatment Prior to Injection – 2

Disinfection

• Chlorine or chloramine

• Disinfection byproduct considerations

• Alternative disinfection for surface water
  - Ultraviolet (UV) light; color and suspended solids considerations
  - Ozone
Other Contaminants of Concern

• Coliform bacteria (surface water)

• Disinfection byproducts (reclaimed water)
  o Total trihalomethanes, 80 µg/L maximum
  o Total haloacetic acids, 60 µg/L maximum

• Secondary drinking water standards
  o Color, odor, iron
ASR – Other Concerns

• Poor recovery
  o ASR zone too saline
  o ASR zone permeability not conducive to recovery

• Poor economics, poor investment, poor project management
Operation Practices

• Injection pressure, flow rates, volumes recharged and recovered monitored continuously

• Report total volume in storage for wellfield

• Water samples of water recharged and recovered
• Monitor wells for water quality sampling, water levels

• Monthly operation reports are required with all required data, lab sheets

• The permit contains the facility requirements
Operational Limits

• Recharge volume limits
  o May be written per well or per wellfield

• Injection pressure
  o Limitations may be needed to prevent upward movement
• Water quality criteria
  o Injectate to meet groundwater standards

• Aquifer appropriateness
  o Use and type of aquifer, confinement
ASR Cycle Testing

- Cycles comprised of recharge, storage, recovery; multiple cycles run
- DEP requires a cycle testing plan
- Permittee evaluates results of each cycle
- Changes are allowed for cycles to improve performance or adjust to water supply situation
• Purpose is to demonstrate water recovery and repeatability

• Increase recovery percentage with successive cycles by “conditioning” the aquifer and creating a “bubble” of stored water
## Orange County ASR Cycle Testing Plan

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Recharge</th>
<th>Storage</th>
<th>Recovery</th>
<th>Buffer Volume</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Days</td>
<td>Volume (MG)</td>
<td>Days</td>
<td>Volume (G)</td>
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<tr>
<td>Pre-Cycle Injection</td>
<td>60</td>
<td>180</td>
<td>0</td>
<td>180</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>30</td>
<td>14</td>
<td>210</td>
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<tr>
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<td>35</td>
<td>105</td>
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<td>270</td>
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<td>555</td>
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<td>4</td>
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<td>225</td>
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<td>5</td>
<td>60-120</td>
<td>225</td>
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<td>6</td>
<td>30-90</td>
<td>90-215</td>
<td>20</td>
<td>406-531</td>
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<tr>
<td>7</td>
<td>30-90</td>
<td>60-90</td>
<td>20-60</td>
<td>502-532</td>
</tr>
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</table>
Cycle Testing – Marco Lakes ASR

Cumulative Volume

Volume (Million Gallons)

Date Range

End Cycles 1 - 6 ASR-1
Cycle 5-E Begin Use of ASR
Cycle 6-E Begin Use of ASR
Cycle 5-E Begin Use of ASR
Cumulative Volume

Flow

End Cycles 1 - 6 ASR-1
Cycle 5-E Begin Use of ASR
Cycle 6-E Begin Use of ASR
Cumulative Volume

Flow

End Cycles 1 - 6 ASR-1
Cycle 5-E Begin Use of ASR
Cycle 6-E Begin Use of ASR
Cumulative Volume

Flow

End Cycles 1 - 6 ASR-1
Cycle 5-E Begin Use of ASR
Cycle 6-E Begin Use of ASR
Cumulative Volume

Flow
ASR Monitoring Plan

Figure 2-3
ASR System Well Construction Details
Monitor points

• Injected water
• Recovered water
• Monitor wells in ASR zone
• Monitor wells above ASR zone
• Annual full wastestream analyses
ASR Cross Section View

- ASR Well
- Shallow Monitoring Well
- ASR Storage Zone Monitoring Well

Overlying Aquifer

Confining

ASR Storage Zone

Confining
ASR Data Interpretation

- Interpretation is best done with graphs of the collected data
- Identify the periods of recharge, storage, and recovery
- Compare with cumulative water volumes in storage
Orange County ASR
Orange County ASR - 2

Monitor Wells

ASR Well
Orange County ASR Well Chloride

Figure 2.4.1. Chloride Concentration
LFASR-1

Cumulative Volume (MG)
Orange County, Nearby SZMW, Chloride

Figure 2.4.3. Chloride Concentration
LFMW-1 (Near)

Cumulative Volume (MG)
Orange County, Distant SZMW, Chloride

Figure 2.4.4. Chloride Concentration
LMFW-2 (Far)

Cumulative Volume (MG)
Orange County, Overlying MW, Chloride

Figure 2.4.2. Chloride Concentration
CZMW-1

Cumulative Volume (MG)
Orange County ASR
Well Arsenic

Cumulative Volume (MG)
Orange County, Nearby SZMW, Arsenic
Orange County, Distant SZMW, Arsenic
Orange County, Distant SZMW, Dissolved Oxygen
Orange County, Nearby SZMW Oxidation Reduction Potential (ORP)
Orange County, ASR
Well Total Trihalomethanes (TTHM)
Regulatory Hurdles for ASR

- Arsenic mobilization
- Coliform bacteria, trihalomethanes
- Movement of water off-site, with or without contaminants
- Public perception
What Makes a Successful ASR Project?

- Does not endanger water resources, does not pose health risks
- Meets applicable water quality standards
- Is financially viable for the owner
- Meets goals of water supply planning
  - Recovery efficiency
# Table 7-2- ASR System Cycle Test Volumes

<table>
<thead>
<tr>
<th>Cycle No.</th>
<th>Recharge Period</th>
<th>Recharge Volume (MG)</th>
<th>Storage Period (Days)</th>
<th>Recovery Period</th>
<th>Recovery Volume (MG)</th>
<th>Recovery Efficiency (%)</th>
<th>Chloride Conc. (mg/L)</th>
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<td>1</td>
<td>09/09/2014 to 10/09/2014</td>
<td>44.6</td>
<td>18</td>
<td>10/28/2014</td>
<td>0.024</td>
<td>&lt;1</td>
<td>12,400</td>
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<tr>
<td>2</td>
<td>01/04/2015 to 04/09/2015</td>
<td>143.7</td>
<td>60</td>
<td>06/09/2015</td>
<td>0.021</td>
<td>&lt;1</td>
<td>11,500</td>
</tr>
<tr>
<td>3</td>
<td>10/04/2015 to 03/16/2016</td>
<td>240</td>
<td>58</td>
<td>05/25/2016</td>
<td>0.018</td>
<td>&lt;1</td>
<td>13,500</td>
</tr>
</tbody>
</table>

Note: Recovery Efficiency calculated based on volume pumped where recovered water quality exceeded a chloride concentration of 1,500 mg/L.
Well Spacing
Tampa Tippin WTP
WELL ASR-1

Arsenic Concentration, in mg/L

Volume Recovered, in MGal

MCL 10 ppb
Bradenton ASR

May-05 Aug-05 Nov-05 Feb-06 May-06 Aug-06

Arsenic ug/l

Cumulative Storage Volume mg

- asr1
- SZMW
- Cumulative Storage Volume mg
Peace River ASR Site Map
Lee County Corkscrew ASR

Key:
- Injected Water
- Arsenic Mobilization

Legend:
- Alkalinity (mg/l) - C.I. 50 mg/l
- ASR Well
- Storage Zone Monitoring Well
- Underlying Zone Monitoring Well
- Overlying Zone Monitoring Well

FIGURE 5-20. MAP SHOWING LOCATION OF SIMULATED ASR INJECTED WATER AT THE END OF INJECTION OF CYCLE 9.
Aquifer Recharge Topics

- Purposes of AR
- Comparison with ASR
- Potential problems
- Monitoring
- Class V wells under the UIC rule, Chapter 62-528, F.A.C.
Aquifer Recharge Goals in Florida

• Extend/augment existing freshwater supplies

• Reduce use of groundwater and the number of new wells

• Restore aquifer water levels to offset drawdowns

• Help offset effects of over-pumping near coasts and saltwater intrusion

• In Miami-Dade and Broward counties, Aquifer Recharge can help replace ocean outfall
Waters Used for Aquifer Recharge

Fluids permitted

• Reclaimed water
• Surface water
• Groundwater
Water Level Declines

Declines represent the difference between predevelopment and 1980 water levels.
Hillsborough County Aquifer Recharge
City of Clearwater Aquifer Recharge

Benefits of Groundwater Replenishment

- hydrologic cycle
- water treatment plant
- advanced water purification plant
- recharge wells
- water level
- sands
- fresh water
- brackish water
- salt water

Upper Floridan aquifer

Bay
Regulatory Hurdles for Aquifer Recharge

- Arsenic mobilization
- Coliform bacteria, disinfection byproducts
- Movement of water off-site, with or without contaminants
- Public perception
Reclaimed Water Aquifer Recharge Projects

• Requires full treatment & disinfection for aquifer recharge in G-II aquifer < 3000 mg/L TDS

• Total organic carbon and total organic halogen limitations

• Other requirements
Aquifer Recharge Monitoring

- Monitor wells in the recharge zone at greater distance than for ASR wells
- Monitor wells in overlying aquifer within 150 feet of recharge well
- Recharge water and monitor well well sampling
- Pressure/water level and injected volume monitoring
Aquifer Recharge

Potential Problems

- Contaminants introduced during injection
- Reactions between injected fluid and aquifer material/formation fluids
- Well location not effective to recharge aquifer
- Recharge zone too deep or shallow
- May adversely affect springs
- Poor economics, poor investment
Potable Reuse and Aquifer Recharge

- Recharge aquifer with treated domestic wastewater
  - Levels of treatment – reclaimed vs. “purified”
  - Recharged water may be a portion of water produced by public supply wells
• Indirect potable reuse
  o Treated water is blended or has intermediate steps before it goes to WTP

• Direct potable reuse
  o Treated water is sent directly to WTP or potable distribution system

• Demonstration projects have not involved recharge wells
Overlap With Other DEP Programs

ASR and Aquifer Recharge

- Domestic Wastewater – ASR, aquifer recharge
- Drinking Water – ASR
- Groundwater Programs (springs) – aquifer recharge
Working With Other Agencies

ASR and Aquifer Recharge

- U.S. Environmental Protection Agency
- Florida’s Water Management Districts
- Florida Department of Health
- Florida Department of Transportation
- U.S. Geological Survey
- Local Governments
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