Florida’s Diverse Use of Class I injection Wells

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Injection Well Classifications

- **Class I** – Wells Used for Disposal of Municipal and Industrial Wastewater below the USDW
- **Class II** – Oil and Gas Injection Wells
- **Class III** – Solution Mining Injection Wells
- **Class IV** – Hazardous Waste Injection Wells (banned in Florida)
- **Class V** – Other types of injection wells (e.g., ASR)
- **Class VI** – Carbon Sequestration

FDEP adopted EPA approved UIC regulations and FDEP has primacy in FL
Florida has a long Underground Injection history

- Florida relies on Class I deep well injection for municipal and industrial wastewater management more than any other state
  - Approximately 180 of the more than 550 Class I wells nationwide are located in Florida (nearly one-third)

- Municipal wells provide key backup to public access reuse systems during wet weather

- Industrial wells keep discharges out of our sensitive rivers and estuaries

- Elimination of ocean outfalls will likely result in even more dependence on Class I wells

Class I Injection Well Rehabilitation
City of St. Petersburg SW WRF
Pinellas County, FL
Operational History of Injection Wells has Demonstrated Few Problems

- Trillions of gallons of municipal and industrial wastewater injected in the last 40 years
- Over 125 large capacity injection wells at over 100 facilities
  - Up to 24 mgd permitted for a single well
- No public contact with injected water has been documented
- No potable drinking water supply has been affected
Class I Injection Well Drivers in Florida

- **Environmental**
  - Deep injection wells are an environmentally sound discharge option

- **Cost**
  - Lowest capital cost alternative in most instances
  - Comparably lower O&M costs in many cases

- **Regulatory**
  - Tighter air discharge regulations
  - More stringent surface water discharge criteria
Class I Injection Wells in Florida

- Injection of municipal or industrial wastewater below the base of the Underground Source of Drinking Water
  - A USDW is generally groundwater containing less than 10,000 mg/L Total Dissolved Solids (TDS) or otherwise being used for drinking water

- Injected fluid must be non-hazardous

- Confinement of the injection zone must be demonstrated – injected fluid cannot move into USDW (some exceptions with municipal wells)

- Well construction standards, mechanical integrity testing, and monitoring apply
Class I Injection Well Design

- Tubing and Packers required for real-time mechanical integrity demonstration for industrial wells
  - Annular pressure monitoring system
  - Cemented annulus options can be pursued
- Large diameter wells up to 30 inches
  - Flows limited to 10 ft/sec in final cemented casing
- Relatively deep
  - Current Florida Class I projects range from approximately 1,000 to 8,000 feet
Class I DIW Monitoring Requirements

- Class I injection wells require monitoring within 150 ft
- A lower zone (early warning) and upper zone (compliance) monitoring well are often constructed in a common dual-zone monitoring well
- Monthly sampling and reporting
- Injection well flow, wellhead pressure, and water levels in monitoring wells recorded
Mechanical Integrity Testing

- Required every five years, possibly as often as every 2.5 years with certain well completions

- External MI Demonstrations
  - Ensures no fluid movement in channels outside of the well in the annular space
  - Almost exclusively uses RTSs and temperature logging in Florida

- Internal MI Demonstrations
  - Ensures there are no leaks in the casing/tubing
  - Typically consists of packer testing and downhole television surveys
  - Alternative methodologies have been accepted

- Monitoring well data review also an important aspect of MI demonstrations
Injection and Floridan Monitoring Well Diagram
Multiple Proven Class I Injection Zones in Florida

- "Boulder Zone" of the LFA allows high capacity wells in south Florida (up to 18.6 mgd)
- The UFA Avon Park Permeable Zone allows high capacity injection wells in west central Florida (up to 24 mgd)
- Lower permeability zones in the LFA under investigation (approximately 2 to 3 mgd)
- Sub-Floridan aquifer injection wells in central FL where USDW is deep (generally 1 to 2 mgd or less)
- Other injection zones with lower capacities are under investigation throughout the state
### Table 2A-1. General Hydrogeological Framework for West-Central Florida

<table>
<thead>
<tr>
<th>System</th>
<th>Series</th>
<th>Stratigraphic Unit</th>
<th>General Lithology</th>
<th>Major Lithologic Unit</th>
<th>Hydrogeological Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td>Holocene and Pliocene</td>
<td>Undifferentiated surficial deposits</td>
<td>Predominantly fine quartz sand; shell interbedded clay, marl, peat, dolostone, sandstone, and phosphorite Shelly quartz sand, unfossiliferous quartz sand, and thin limestone beds Shelly quartz sand, thin, shelly limestone beds, and marl</td>
<td>Sand</td>
<td>Surficial aquifer system</td>
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<td>Fort Thompson Formation</td>
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<td>Caloosahatchee Formation</td>
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<td></td>
<td>Pliocene</td>
<td>Tamiami Formation</td>
<td>Sandy limestone, clayey and pebbly sand, clay, marl, shell, phosphatic</td>
<td>Clastic</td>
<td>Confining unit</td>
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<td></td>
<td></td>
<td>Peace River Formation*</td>
<td>Clayey, phosphatic, sandy beds, silty and sandy phosphatic clay beds, and clayey phosphatic quartz sand</td>
<td>Carbonate and clastic</td>
<td>Aquifer</td>
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<td></td>
<td>Miocene</td>
<td>Hawthorn Group</td>
<td>Dolomite and clay, and limestone, silty, phosphatic</td>
<td>Carbonate</td>
<td>Confining unit</td>
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<td>Arcadia Formation†</td>
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<td>Neocene</td>
<td>Suwannee Limestone†</td>
<td>Limestone, sandy limestone, fossiliferous</td>
<td>Carbonate</td>
<td>Upper Floridan aquifer</td>
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<td>Ocala Group</td>
<td>Limestone, chalky, foraminiferal, dolomitic, near-bottom</td>
<td>Carbonates</td>
<td>Middle confining unit</td>
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<td>Paleocene</td>
<td>Cedar Key Formation</td>
<td>Limestones, fine crystalline, slightly porous to porous</td>
<td>Carbonates with evaporites</td>
<td>Sub-Floridan confining unit</td>
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<tr>
<td></td>
<td></td>
<td>Upper Unit</td>
<td>Interbedded anhydrites and gysiferous dolomites</td>
<td>Carbonates with evaporites</td>
<td>Sub-injection zone confining unit</td>
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<td>Middle Unit</td>
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<td>Lower Unit</td>
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<td>Lawson Formation</td>
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<td>Taylor Formation</td>
<td>Limestone, soft chalky, with some anhydrite</td>
<td>Carbonates</td>
<td>Sub-injection zone confining unit</td>
</tr>
</tbody>
</table>

**Notes:**
*Peace River Formation includes Bone Valley Member and undifferentiated deposits.*
†Arcadia Formation includes undifferentiated deposits, Tampa Member, and Nocatee Member.

**Sources:** Ryder, 1985; Johnson, 1989; Chen, 1965; ECT 2009
Class I Municipal Injection Wells

- Municipal wells are the vast majority of Class I injection wells in Florida
- Reuse is preferred, but injection wells are a necessary backup during wet weather conditions
  - Typically reuse systems are “built out” at about 50 percent reuse due to the seasonal variations in demand

- Tubing and packer and fluid-filled annulus not required
- Fluid movement allowed if high level disinfection is utilized
St. Petersburg has had a Successful Class I Injection Well Program for over 35 Years

Albert Whitted WRF (Plant No. 1)
Northeast WRF (Plant No. 2)
Northwest WRF (Plant No. 3)
Southwest WRF (Plant No. 4)

Approximately 175 BG Injected
Class I Industrial Injection Wells

- Concentrate by-product from membrane water treatment plants
- Use at power plants is emerging in FL
  - Cooling water and other blowdown
  - Concentrate from treated reclaimed water
  - Other non-hazardous wastestreams
- Other Industry such as manufacturing, chemical production, landfills, etc.
- A single Class I injection well “grandfathered in” that allows hazardous waste discharge below the Floridan aquifer system
Central Florida
Tampa Electric Company
Polk Power Station

- Class I Industrial injection wells to 8,000 feet in depth
- RO concentrate from reclaimed water and other wastestreams
- Limestone/dolostone injection zone with dolostone/anhydrite confinement above
- Second Injection Well designed as Carbon Capture and Sequestration (CCS) Demonstration Project
  - Initially pursued Class V Experimental Well for pilot testing
  - Class VI Injection Well for Long-term Operation
Two Class I Injection Wells Have Been Successfully Constructed at the PPS

Note: Injection Wells are approximately 2,300 ft apart
Considerable Coring of Confinement and Injection Zone

- Excellent confinement between the lower Floridan aquifer and the Cretaceous injection zone
- Appears to be adequate to contain wastewater or CO₂ as needed

Photos courtesy of MWH
Tampa Electric Company
Polk Power Station

- IW-1 and IW-2 both have CO₂ resistant cement for 500 feet above injection zone
- IW-2 was designed to safely store CO₂ as a demonstration project but was terminated
- Injection Zone MW was cancelled once CO₂ program shelved
- Unique pilot program included wastewater then CO₂ then return to wastewater
- Tremendous buffering capacity in carbonate aquifer
- Uniquely designed, including removable Tubing and Packer following CO₂ pilot project
Southeast Florida

- Florida’s “Boulder Zone” is extremely permeable
- Highly fractured dolomite injection zone with limestone/dolomite confinement
- Disposal of cooling tower blowdown, reverse osmosis concentrate, other non-hazardous waste streams
Gulf Power Plant Crist, Pensacola

– Treatment includes gypsum settling pond, coagulation, filtration and pH adjustment, effluent storage tank and injection system pumping station

– Two injection wells with 7-in FRP tubing
  • Injecting Chiyoda scrubber blow-down and stormwater
  • Average 250 gpm at <250 psi
  • Provided geochemical modeling of the injectate and native groundwater
  • Minor pressure increases have resulted after two years of operation
  • Two monitoring wells completed above confinement
Gulf Power Plant
Crist Injection
Well Diagram

- Primary injection zone is the Ocala Limestone of the Lower Floridan Aquifer
  - ~1,600 to 1,800 ft
- Little additional capacity to 2,800 ft
- Other nearby class I Industrial injection wells compete for capacity
Fabricated Tubing Packer Fits Into a Machined Receptacle to Make a Metal to Metal Seal

• Tubing and Casing Materials Selected for Capacity, Depth, Pressure, and Corrosiveness
  FRP is compatible with highly corrosive fluids
Gulf Power Plant Crist Injection Wellheads
Pensacola, FL

IW-1

IW-2
Gulf Power
Plant Smith, Panama City

- Plan to inject cooling tower blowdown from municipal reclaimed water source and/or ash pond water
  - Exploratory injection well drilled to 7,000 ft with 5.5-in FRP tubing
  - Primary injection zone (Tuscaloosa Fm) contains 150,000 mg/L at 170°F
  - Well designed to access three potential injection zones
  - Expected average flow of 500 gpm at <500 psi
  - Well designed for up to 1,500 psi
  - One monitoring well completed above confinement
Narrow Site Successfully Avoided Wetland Impacts
Cost Considerations

- **Injection Well Capital Costs**
  - Dependent on well depth/diameter/design
  - Typically $3M to $8M per well
  - $200k to $6M per mgd disposal capacity depending largely on injection zone

- **Operation and Maintenance Costs**
  - Lower O&M Costs than other disposal technologies such as surface water discharge and ZLD
  - O&M includes power, sampling, equipment maintenance, mechanical integrity testing, analytical, well rehabilitation
  - Estimated O&M Costs – 2 to 10% / year of well construction costs
Questions?

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