Facilitating Shale Play Development in Pennsylvania - Meeting the Need for Nearby Brine Disposal Wells*

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Abstract

Marcellus Shale exploration and production operations in Pennsylvania generate large quantities of flowback and produced water. Although there is a strong increasing trend in recycling, not all flowback and produced waters can be cost-effectively recycled due to water chemistry, lack of a nearby new well at which the water can be recycled and other factors. Brine disposal wells have an important role to play in managing such waters in a cost-effective and environmentally protective manner. The need for brine disposal wells in Pennsylvania is expected to increase as the Marcellus and Utica Shale Plays mature and tens of thousands of new wells begin generating produced water on a daily basis. Although currently there are only five permitted brine disposal wells operating in Pennsylvania and no commercial wells, there is potential to develop many additional brine disposal wells within or near Marcellus and Utica Shale producing areas.

The presentation will provide an overview of the status of currently permitted brine disposal wells in Pennsylvania and nearby states, most of which have substantially more wells than Pennsylvania. Potential target formations for brine disposal in Pennsylvania will be discussed along with procedures for identifying and evaluating specific candidate injection well sites. An overview of EPA brine disposal well permit application procedures will also be presented along with a summary of well construction and operating requirements. Ranges in capital and Operation and Maintenance (O&M) costs and the economics of utilizing brine disposal wells relative to other available options (e.g., water treatment plants) will also be discussed.
Facilitating Shale Play Development in Pennsylvania - Meeting The Need for Nearby Brine Disposal Wells

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Identifying Target Areas and Formations

- Determine Viable Transportation Distances (via truck, rail, barge or pipeline) from Your Water Sources.
- Identify Potential Target Formations.
  - Existing brine disposal wells in the area?
  - Depleted oil and gas wells / fields in the area?
  - Drilling depths, Disposal depths and Cost considerations?
- Identify Existing Production. Or, Avoidance of Watering Out Existing Production
- Injectivity Testing to Confirm Viability.

Marcellus Shale activity in the Appalachian Basin mapped with Current Brine Disposal Wells

Marcellus Shale activity in the Appalachian Basin mapped with Current Commercial Brine Disposal Wells

Possible Formations for Brine Disposal Wells in Pennsylvania

- Upper Devonian Sandstones*
- Huntersville Chert*
- Oriskany Sandstone*
- Bass Islands
- Lockport Dolomite
- Medina – Tuscarora Sandstones*
- Queenston Shale
- Bald Eagle Sandstone
- Trenton – Black River
- Gatesburg Formation*
- Basal Cambrian Sandstones (e.g. Potsdam)

*Existing injection well in PA
Source: Stratigraphic Column from PADEP
**Comparison of PA, OH and WV UIC Class II Well Permitting**

<table>
<thead>
<tr>
<th>State</th>
<th>Primacy</th>
<th>Area of Review (AOR)</th>
<th>Maximum Injection Pressure (MIP) Basis</th>
<th>Seismicity Evaluation</th>
<th>Approx. Timeframe*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>EPA</td>
<td>Calculated based on 10 year injection scenario. Default 1/4 mi.</td>
<td>ISIP From Frac; consider SG of brine; Frac gradient of 0.733 if no ISIP</td>
<td>Considered in EPA review.</td>
<td>8 months to 16 months</td>
</tr>
<tr>
<td>OH</td>
<td>State</td>
<td>≤200 bbl/d - 1/4 mi; &gt;200 bbl/d - 1/2 mi</td>
<td>Frac gradient of 0.75 psi/ft</td>
<td>Yes</td>
<td>2 to 3 months</td>
</tr>
<tr>
<td>WV</td>
<td>State</td>
<td>1/4 mi</td>
<td>Frac gradient of 0.8 psi/ft; 90% of breakdown pressure may be approved</td>
<td>Yes</td>
<td>2 to 3 months</td>
</tr>
</tbody>
</table>

*From application submittal to final permit

**EPA UIC Well Permit Application**
- Define Area of Review/Zone of Endangerment
- USDW Description
- Injection well construction
- Well operation including maximum injection pressure and rates
- Plugging and abandonment
- Financial Responsibility

**UIC Permit - Area of Review**

Plan View of Area of Review

Source: EPA January 2009

**Lowest Most Underground Source of Drinking Water (USDW)**

Underground Source of Drinking Water Include: Drinkable Quality Water (<3,000 TDS) And Usable Quality Water (3,000-10,000 TDS)

Brine - Salt Water (>10,000 TDS)

Source: EPA April 2002

**Typical UIC Class II Well Construction**

Casing Cemented to Surface

**Injectivity Testing**

- Step-Rate Test
  -- Establish optimal rate for constant rate test
  -- ISIP data can help regarding Maximum Injection Pressure (MIP)
- Constant Rate Test
  -- Injection – establish radial flow
  -- Pressure Falloff monitoring
  -- Data Evaluation - permeability, injection pressures, rates, AOR, boundaries, etc.
- Valuable tool but may have limitations in predicting long term performance

**Brine Disposal Wells - $/Bbl Cost**

<table>
<thead>
<tr>
<th>Capital Cost ($1000s)</th>
<th>O&amp;M ($1000s)</th>
<th>Total Cost 15 years ($1000s)</th>
<th>Approx. $/Bbl by Injection Rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>150</td>
<td>3250</td>
<td>500 Bbl/d</td>
</tr>
<tr>
<td>1500</td>
<td>150</td>
<td>3750</td>
<td>1000 Bbl/d</td>
</tr>
<tr>
<td>2000</td>
<td>150</td>
<td>4250</td>
<td>2000 Bbl/d</td>
</tr>
</tbody>
</table>

$Assumes 260 operating days per year
Case Study: Bear Lake Properties Brine Disposal Permits
Warren County, Pennsylvania

Summary of Bear Lake Brine Disposal Properties

• Depleted Medina gas well field
• Over 11,000 acres
• 2 Commercial UIC Well permits, currently accepting brine for disposal
• 30,000 bbl/mo/well
• Approx. 20 wells could potentially be converted to injection
• Est. 300 million bbls. capacity within the potential injection field

SUMMARY OF BEAR LAKE SWD FIELD

• The two-well field is conveniently located within the Marcellus and Utica Shale fields.
• Injection interval includes the Medina and Whirlpool Sandstones.
• The Silurian Salina Group (salts and anhydrites) serve as a confining interval for disposal.
• The field is currently in operation, taking flowback and produced brines from local operators.

CONCLUSIONS

• Strong understanding of the reservoir system is key to geologic siting of a possible SWD project.
• Can be a very cost-effective and safe option for brine disposal management
• Underutilized in PA – only 7 wells permitted with many additional wells needed
• There are various potential injection targets which may vary locally/regionally
• Depleted oil or gas wells/fields can be “low hanging fruit”
• Siting and public education strategies may help in addressing public opposition issues

THANKS

• Thanks to Bear Lakes Properties and Karl Kimmich for allowing us to use their data as our case study
• Special thanks to Suzanne Paxton and Steve Hughes of Tetra Tech