Flowback Water Volume

- Over 1700 wells drilled in 2009
- If we reach 3000 wells in 2010 and generate 800,000 gallons each well = 2.4 billion gallons/yr
<table>
<thead>
<tr>
<th>Parameter</th>
<th>units</th>
<th>Barnett Shale</th>
<th>Fayetteville Shale</th>
<th>Marcellus Shale</th>
<th>Marcellus Shale</th>
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<td>GeoPure IPEC 2007</td>
<td>source unidentified</td>
<td>GRI/POGAM Data</td>
<td>GE/SRW Presentation Data</td>
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<td>pH</td>
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<td>8.7</td>
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<td>5.5 to 6.5</td>
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<tr>
<td>TSS</td>
<td>mg/L</td>
<td>4200</td>
<td>2580</td>
<td>9810</td>
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<tr>
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<td>TOC</td>
<td>mg/L</td>
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<td>4020</td>
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# Flowback Water Characteristics

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<thead>
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<th>Parameter</th>
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<th>First 1/3</th>
<th>Second 1/3</th>
<th>Last 1/3</th>
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<tbody>
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<td>Barium</td>
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<td>Benzene</td>
<td>ug/L</td>
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</tbody>
</table>
Typical Horizontal Well Flowback Curve
Flowback Water Management Options

- Discharge to Merchant Treatment Facility
- Truck to Disposal Wells
- Reuse with no treatment
- Treat and Reuse
Flowback Water Management Options

Discharge to Merchant Treatment Facility

- Limited number of facilities
- Facilities discharge will be limited by TDS and Chloride and other limits
- New facilities require long term commitment of water to keep amortization costs down
- May be best solution if designed as treat and reuse facility
Flowback Water Management Options

Truck to Disposal Wells

- Very few in PA, just over 40 in OH
- Trucking cost will be about $1/barrel/hr
- Current wells can handle about 4.5 million barrels/yr
- This is less than 10% of capacity to handle 57 million barrels/yr generated
Flowback Water Management Options

Reuse with no Treatment

- Trucking cost will be about $1/barrel/hr
- Can increase chemical usage to deal with scalants and other contaminants
- Typically want to remove suspended solids prior to reuse
Typical Treatment and Reuse scheme

Frac Water 4 MGD

Well No 1

Treatment

Well No 2

3.2 MGD Fresh Water

0.8 MGD

0.8 MGD
Treat and Reuse Options

- Precipitation of Iron
- Precipitation of Barium
- Precipitation of Strontium
- Softening Reactions
- Salt removal
Treat and Reuse Commercial Options

• Mobile treatment systems—many options available
• Modular reuse systems
• Central treatment plants managing water from multiple customers
Mobile Treatment systems

- Effluent is pumped/piped or trucked to next well site
- Mobilization/Demob must be considered
- Precipitation systems, thermal, sludge dewatering etc
- Can be contract operated
Modular Treatment systems

- Utilizes similar technologies as Mobile systems - centrally located to serve several producers
- Adds one additional transport step
- Mobilization/Demob costs are saved
- Gain some economy of scale
- Can be easily automated
Central Treatment systems

- Similar to Mobile and Modular but built to last 20+ years
- Would require long term service contracts
- Would provide optimum economy of scale, lowest operating cost and should provide highest quality