Irrigation with Produced Water in Texas Beneficial Use Case Study

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February 24, 2016

GWPC Conference “Aquifer Management and Underground Injection”

http://www.gwpc.org/events/2016-uic-conference
Irrigation with Produced Water in Texas

Outline

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I. Management Options for Produced Water
US onshore - in the modern era

Option A

Class II UIC disposal wells

Option B

Treatment and Reuse in Operations

......... aside from CBM operations ..........

Option C varies depending on many things
II. Givens

- Legacy oil and gas area with multiple producing formations, plus resource play potential
- No groundwater and very little surface water in most of the county with an ongoing drought
- Original plan was to use produced water for developing our new resource plays
II. Givens (continued)

- One particular producing zone from legacy ops had very fresh water chemistry
  - 1,500 to 3,500 mg/l TDS
  - Lined storage pit was an aquarium
- Things changed in 2013, our resource play did not work
III. Regulatory Landscape

- Federal and State jurisdiction if this is a NPDES discharge, or spills and violates water quality standards
- Federal jurisdiction if it creates a wetland or enters Waters of the United States “WOTUS”
- No “off the shelf” State beneficial use permit, closest was RRC land farming for muds and cuttings
- This became a science project considering
  - Topography, proximity to wetlands and WOTUS
  - Soil characterization and baseline chemistry
  - Soil loading and native plant tolerance predictions
IV. Site Assessment and Permitting Process

- Topography, WOTUS, Soil Characterization, Plant and Animal Survey
IV. Site Assessment and Permitting Process

- Site Assessment led to specific area selection and system design
V. Irrigation System Design

- Pump, Filter, Underground Pipeline to the Irrigation Area, then PVC Distribution System
VI. Monitoring for Soil Chemistry

- One Acre Monitoring Grid, all Sampling Locations Recorded and Tracked

Approx 60 acre site

Sample each acre then composite into “quadrants” of 5 for both shallow zone (0”-12”) and deep (12”-24”) every quarter, analyze for 11 parameters, if an exceedance then isolate the quadrant and increase sampling to monthly
## VII. Baseline Testing Results and Permit Limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Shallow Soils -0” to -12”</th>
<th>Deep Soils -12” to -24”</th>
<th>RRC Permit Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>Chloride (Total)</td>
<td>ND</td>
<td>ND</td>
<td>10</td>
</tr>
<tr>
<td>Chloride (Saturation Extract, mg/L)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Arsenic</td>
<td>4.9</td>
<td>14.0</td>
<td>6.2</td>
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<tr>
<td>Barium</td>
<td>170</td>
<td>770</td>
<td>220</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.17</td>
<td>0.33</td>
<td>0.20</td>
</tr>
<tr>
<td>Calcium (Saturation Extract, mg/L)</td>
<td>120</td>
<td>220</td>
<td>66</td>
</tr>
<tr>
<td>Chromium</td>
<td>3.6</td>
<td>24</td>
<td>8.9</td>
</tr>
<tr>
<td>Exchangeable Sodium Percentage</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Lead</td>
<td>5.3</td>
<td>52</td>
<td>3.2</td>
</tr>
<tr>
<td>Magnesium (Saturation Extract, mg/L)</td>
<td>2.3</td>
<td>5.9</td>
<td>1.2</td>
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<tr>
<td>Mercury</td>
<td>ND</td>
<td>0.096</td>
<td>ND</td>
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<tr>
<td>% Moisture</td>
<td>9.4</td>
<td>31</td>
<td>8.3</td>
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<tr>
<td>% Solids</td>
<td>69</td>
<td>91</td>
<td>67</td>
</tr>
<tr>
<td>Selenium</td>
<td>ND</td>
<td>2.6</td>
<td>ND</td>
</tr>
<tr>
<td>Silver</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Sodium (Saturation Extract, mg/L)</td>
<td>2.7</td>
<td>7.3</td>
<td>20</td>
</tr>
<tr>
<td>Sodium Adsorption Ratio</td>
<td>ND</td>
<td>0.17</td>
<td>ND</td>
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<tr>
<td>Temperature (°F)</td>
<td>21.1</td>
<td>21.3</td>
<td>21.1</td>
</tr>
<tr>
<td>Specific Conductance (Sat Extract, mmho/cm)</td>
<td>0.55</td>
<td>1.10</td>
<td>0.61</td>
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<tr>
<td>Field pH (pH units)</td>
<td>7.11</td>
<td>8.64</td>
<td>7.35</td>
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<tr>
<td>Field PID (ppm)</td>
<td>0</td>
<td>0.14</td>
<td>0.02</td>
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<tr>
<td>Field Conductivity (mmho/cm)</td>
<td>0</td>
<td>0.6</td>
<td>ND</td>
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<tr>
<td>TPH (C6-C12)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>TPH (C12-C28)</td>
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<td>ND</td>
<td>ND</td>
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<tr>
<td>TPH (C28-C40)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>TPH (C6-C40 Summary)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Metal concentrations are total metal and units are (mg/kg) unless otherwise noted; ND – Non Detect
VIII. Additional Assurances

- No discharge or run-off by constructing a perimeter berm

- Prove the absence of groundwater by records search and (later) by a 100’ test well

- Had program logic in the control system for max daily rate of 10,000 bbls

- Had program logic in control system to not operate at night or during rain
IX. Snapshot at 8 months and 500k bbls

pre operations

approx 8 months and 500,000 bbls later
X. Snapshot at 15 months and 1M bbls

pre operations

approx 15 months and 1M bbls later (drone pic taken on a hazy day)
XI. Lessons Learned

- Things that went well:
  - Extensive pre permitting field reconnaissance work and agency interaction
  - Baseline soil sampling that matched the permitting protocols
  - Field monitoring each quarter with same field biologist and hydrogeologist
  - Drone pics were very useful for internal and external communications

- Things that we would improve on:
  - Additional soil sampling after the exact site was selected to establish a better range of soil chemistry and lab method variability
  - Take drone pics during same time of day, perspective, and hopefully sunny conditions