Aquifer Storage and Recovery: A Management Tool for Upstream Operators

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Outline

- Water Management Lifecycle in Unconventional E&P
- Incorporate ASR into Water Management Tools
- ASR Definition
- Feasibility Considerations
- Two Example Projects
Water Management is Required Throughout the Unconventional Oil and Natural Gas Exploration Lifecycle

- Excess produced water is recycled/reused, treated for surface water discharge, disposed of via injection wells
- Water production varies by region and play
Aquifer Storage and Recovery (ASR) Can Be Incorporated into the Water Management Tools

• Increase available water supply
• Reduce dependence on disposal wells
• Potentially increase existing groundwater supply well yields
What is ASR?

• Storage of a water resource in a suitable underground aquifer during periods of excess supply for recovery during periods of excess demand.
• Recharge aquifer using wells or infiltration basins
• Storage in a fresh groundwater or brackish
Typical Project Elements

Recharge Basin

ASR Well

NGWA 2014
Feasibility is Dependent on Many Factors

• Aquifer suitability including:
  – Basin characteristics for storage and recovery
  – Geochemical characteristics of recharge water and storage zone
  – Hydraulic characteristics for flow rate

• Plugging /maintenance

• Permitting
Suitable Characteristics for Fresh Groundwater Aquifer

• Aquifer Geometry
  – Closed basin is ideal

• High transmissivity

• Low groundwater gradient
End of Recharge Cycle
End of Usable Recovery
Suitable Characteristics for Brackish Aquifer

• Recharge water displaces brackish native groundwater
• Aquifer Geometry
  – Confined aquifers ideal
• Thinner, lower permeable zones
• Low groundwater gradient
Use Geochemical Modeling to Predict Chemical Reactions of Concern

- Mineral precipitation
- Mineral reactions
- Clay dispersion or swelling

Pyrite
\( \text{FeS}_2 \)

Mineral Surface

\( \text{O}_2^{-2} \)  \( \rightarrow \)  \( \text{Fe}^{+3} \)

\( \rightarrow \)  \( \text{Fe}^{+2} \)

\( \rightarrow \)  \( \text{HS}^{-} \)

\( \rightarrow \)  \( \text{H}_2\text{S} \)

\( \rightarrow \)  \( \text{OH} \)

\( \rightarrow \)  \( \text{OH} \)

\( \rightarrow \)  \( \text{OH} \)

\( \rightarrow \)  \( \text{OH} \)

\( \rightarrow \)  \( \text{O} \)

\( \rightarrow \)  \( \text{Fe}^{+3} \)

\( \rightarrow \)  \( \text{Fe}^{+3} \)

\( \rightarrow \)  \( \text{H}_2\text{S} \rightarrow \text{H}_2\text{SO}_4 \)
Treat the Source Water to Mitigate Issues

• Removal of total suspended solids (TSS) or dissolved metals
• Removal of parameters which will degrade the water quality of the injection zone
• Remove minerals which will react with native groundwater or minerals in the injection zone
  – Release arsenic, release sulfuric acid, clay instability
Comparison of Turbidity in Recovered Water from Several Recharge Water Types at UWTR Well 46
Permitting Produced Water ASR Wells

- Class I
  (>10,000 TDS)
- Class V
  (<10,000 TDS)
Class I and Class V Injection Wells

Class I
- Higher well cost
- Lower yield
- Moderate permitting difficulty

USDW (10,000 mg/L TDS)

Class V
- Lower cost
- Higher yield
- Significant permitting difficulty

Into or above lowest USDW

Confining Unit

Below lowest USDW
Options for Recharge into USDW (Class V)

• **Aquifer Exemption**
  - Enables Some Disposal and Storage Activities that Would be Prohibited by Federal and State Regulations:
    - Prohibition of movement of fluid into USDW (40 CFR, Part 144.12)
    - Protect USDW (40 CFR, Part 144.7)

• **Control Access to Stored Water**
  - EPA clarified in 2013 that current rules allow permitting storage of water that does not meet drinking water standards
  - Requires permit conditions to prevent “any pathway to human consumption”
  - Texas passed HB 655 in 2015 that limits groundwater changes from ASR that would cause harm or require additional treatment for use
  - Texas rules to be adopted by April 27, 2016
San Antonio Water System ASR Program

- 2001 - first permanent pumping permits issued
- Permit 289,024 ac-ft (2014)
- Critical period triggers based on 10-day average J17 level and/or flow in Comal or San Marcos Springs
- Stage IV (620 ft NAGD) - 40% cut
- 2014 actual availability 187,866 ac-ft (35%)
- Total 2014 Demand 237,411 ac-ft
The Wellfield

- 3,200 Acres
- 64 MGD
- 8 miles of 12”-54” Pipeline
- 29 Wells
- 1400 to 3500 gpm
- Total Volume over 750 M BBL
Aurora Aquifer Recharge and Recovery (ARR)

• Flow from riverbank filtration wells is distributed to a series of infiltration basins within the ARR site.

• Flow is Recovered from the ARR via recovery wells and pumped to the conveyance system.
ARR Project Goals

• Provide natural pretreatment of river water for drinking water source.

• Average travel time of 20 days from infiltration basin to recovery well.

• Treatment of phosphorous, micropollutants, nitrogen.
ARR Site Components

- 3 infiltration basins, 3 cells each (55 acres area).
- 27, 16-inch recovery wells
- ~15,000 LF of pipeline 8 to 36 inch.
- Isolated from native groundwater by slurry wall.
Thank You