A Collaborative Process to Identify the Most Feasible Aquifer Recharge Sites in Oklahoma

Nathan T. Smith, CDM

WaterEnergy 2010
Senate Bill 1410

- Oklahoma Senate Bill 1410 – passed on Earth Day 2008
  - Using artificial recharge (AR) to help increase the State’s available water supplies through collaboration and consensus building

- CDM’s involvement
  - CDM was initiating a revision to the Oklahoma Comprehensive Water Plan (OCWP)
  - OCWP assessed supply and demand statewide
  - CDM contracted to lead collaborative effort to identify AR sites
Western Water Woes

- Western population growth
- Frequent droughts
- Overuse of surface and groundwater
- Of concern primarily in western OK

Photo credit: NOAA; http://www.noaanews.noaa.gov/stories2008/20081007_tools.html
Disadvantages of Normal Water Supplies

- **Rivers/streams**
  - *Water rights limit additional usage of supplies*
  - *Upstream and senior rights get priority*

- **Reservoirs**
  - *Land usage/availability*
  - *Environmental impact*

- **Groundwater**
  - *Demand often exceeds recharge/supply*
  - *Rapidly declining groundwater elevations in many areas*
Perfect Alternative: Artificial Recharge

- Injection of surface water into aquifers
- Uses “unfilled” aquifers
  - Unconfined aquifers – unsaturated matrix
  - Confined aquifers – raise potentiometric surface/ increase pressure
- Recharge water through infiltration or active injection
- Storage for months or years

Photo credit: http://www.cap-az.com/operations/recharge/aguafria/
Perfect Alternative: Artificial Recharge

• Benefits
  • *Utilize excess surface water*
    • Spring runoff
    • Storm events
    • Treated effluent
  • *Potential minimization of area requirement*
  • *Infrastructure often in place*
  • *Limit evaporative losses*
Senate Bill 1410

- CDM to lead collaborative work group in evaluation of AR
- American Water Institute (AWI) to complete preliminary screening
- Collaborative:
  - Meetings
  - Reviews/Feedback
  - Guidance
  - Data sources
  - Site information
Involved Parties

- OWRB
- Ok. Department of Environmental Quality
- Ok. Geologic Survey
- USBR
- USGS
- USEPA
- American Water Institute (AWI)
- Chickasaw Nation
- Ok. Corporation Commission
- University of Oklahoma
- Ok. Climatological Survey
- NOAA, National Severe Storms Laboratory
- Ok. Conservation Commission
- State Senator Susan Paddock
Previous AR Studies

- USBR Draft Planning Framework for Artificial Recharge (USBR 2008)
- National Academy of Sciences Water Science and Technology Board’s Prospects for Managed Underground Storage of Recoverable Water (WTSB 2008)
- American Society of Civil Engineers Managed Aquifer Recharge Standards (ASCE 2001)
- Colorado Senate Bill 06-193 Underground Water Storage Study (CDM 2007)
SB1410 Overall Process and Desired Product

- **Phase 1:** Identification of most suitable area(s)
  - 1: Develop Site Evaluation Methods
  - 2: Preliminary Screening of Potential Sites
  - 3: Detailed Evaluation of Potential Sites
  - 4: Reporting and Coordination

- **Phase 2:** Demonstration project(s) at one or more areas from Phase 1

- Work group identification of key criteria:
  - *Short-term/seasonal for quick success*
  - *Sufficient storage capacity*
  - *Water quality concerns*
  - *Demand*
Conceptual Overview of Screening Process

**Potential Sites**
- All Possibilities
- Candidate Basins

**Criteria**
- Fatal Flaw (3)
- Threshold Criteria (4)

**Detailed Analysis**
- 10–15 Candidate Areas

**Weighted Scoring Matrix**
- All Criteria (11)

**Most Suitable Areas**
Preliminary Screening - AWI

Data Compilation
- Aquifer Delineation
- Groundwater Quality
- Basin-Level Source Water Surplus
- Basin-Level Water Demand Shortage

Fatal Flaw Screen

Candidate Basins

Preliminary Screening

Aquifer Characteristics
- Available Storage Volume
- Permeability
Source Water Quality
- Suitability for Use
Recharged Water Residence Time Potential

10–15 Candidate Areas
Preliminary Screening - AWI

- Preliminary Screening started with 57 sites based on aquifer-surface water basin pairings and known areas of demand
- After Fatal Flaw, 30 sites remained
- After Threshold Screening, 15 sites remained and were passed on to the detailed screening
Detailed Ranking and Scoring - CDM

- Evaluation of each of the criteria identified in the “kick-off” Tech Memo and refined through Workgroup participation
- Several criteria used in fatal flaw and threshold were reviewed in more detail
  - Availability of source water at probable diversion point rather than basin-wide
  - More detailed water quality assessment
  - Depth to water maps generated for available storage capacity evaluation
Detailed Analysis

- Demand Proximity
- Proximity & Quality of Source Water
- Groundwater Quality
- Storage Volume
- Hydrogeologic Analysis
- Existing Infrastructure

Weighted Scoring Matrix

Selected Areas
Detailed Ranking Maps

- Vicinity Map shows well locations, source location, demand density

- Depth to water map used to assess available storage capacity
**Detailed Scoring**

- Water Quality data from USGS and EPA online databases at nearby locations, summarized for each site

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- Langelier Index used to compare chemistry
- Glover Equation used for residence time calculations
- Transmissivity and storativity data from several sources including AWI 2010
- Little difference in ranges between alluvial and bedrock T values
Detailed Ranking Maps

- Water quality sampling locations mapped to help WQ assessment

- GW contours, aquifer footprint used for residence time analysis
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<th>Source Availability</th>
<th>Demand Proximity</th>
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<th>Source Water Quality</th>
<th>Native GW Quality</th>
<th>Geochemical Interactions</th>
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Recommended Sites for Pilot Project

Potential Recharge Sites
that passed the "Threshold" criteria
Recommended Pilot Project Sites

• Common Criteria
  • Good groundwater and source water quality, compatible water chemistry
  • Public water supply wells in vicinity
  • Potential diversion points within 1 mile
  • Favorable hydrogeology (transmissivity, storage)
  • Pre-treatment likely not required

• Pilot Project
Site 12 - Ada

- Blue River provides source – minimal MCL exceedences, and low TDS
- Nearby PWS wells
- Karst aquifer
- Similar Langelier indices for source and groundwater
- Would require pipeline to convey water to project site
Site 42 - Eakly

- Lake Creek provides source – limited WQ data, but minimal MCL exceedences and low TDS in nearby creek
- Nearby PWS wells
- Project could meet entire town’s demand
- Would require pipeline to convey water to project site
Site 19 - Woodward

- North Canadian River provides source – minimal MCL exceedences, but higher TDS (pre-treatment?)
- Nearby PWS wells
- Alluvial aquifer – spreading basin use
- Would require pipeline to convey water to project site
Thanks to:

- Matt Bliss, Mike Smith, John Rehring, Rebecca Farmer, Dan Reisinger, Mike Lamar (CDM); Wayne Kellogg (AWI)
- OWRB
- Susan Paddock
- Work group members

Questions?
Email: smithnt@cdm.com
# Detailed Ranking Methods

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<th>Factors for High Score</th>
<th>Factors for Moderate Score</th>
<th>Factors for Low Score</th>
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<tr>
<td>Demand Proximity (distance from recharge area)</td>
<td>Within 1 mile</td>
<td>Approximately 1.5 miles</td>
<td>Greater than 2 miles</td>
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<tr>
<td>Source Availability</td>
<td>Sufficient available water year-round for project with recent data</td>
<td>Sufficient available water for project during part of year. Older or more distant gage dagt</td>
<td>Sufficient water not available at proposed point of diversion.</td>
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<tr>
<td>Source Proximity (distance from recharge area)</td>
<td>Within 1 mile</td>
<td>Approximately 1.5 miles</td>
<td>Greater than 2 miles</td>
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<td>Available Freeboard and Ability to Meet Demand</td>
<td>Plentiful volume for meeting the associated demand; no areas will raise water level to less than 15 feet bgs</td>
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<td>Not enough volume to meet the associated demand; may raise the water level to less than 15 feet</td>
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<td>Demand Density (number of wells)</td>
<td>Greater than 10 PWS wells within 1 mile</td>
<td>5 to 10 PWS wells within 1 mile</td>
<td>Less than 5 PWS wells within 1 mile</td>
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# Detailed Ranking Methods

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<td>Source Quality for Non-degradation</td>
<td>Similar concentrations as groundwater or lower concentrations that will improve groundwater; no MCL exceedences; low TDS</td>
<td>Borderline TDS; few exceedences of MCLs</td>
<td>Quality will degrade groundwater; high TDS; many MCL exceedences</td>
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<td>Native Groundwater Quality</td>
<td>Low TDS (&lt;500 mg/L); no exceedences of MCLs</td>
<td>Borderline TDS; few exceedences of MCLs</td>
<td>High TDS (&gt;500 mg/L); many exceedences of MCLs</td>
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<td>Geochemical Interactions of Source and Groundwater</td>
<td>Similar Langelier Indices (source and groundwater within 0.5 units); similar pH values</td>
<td>Langelier index unable to be computed, but similar pH and hardness values</td>
<td>Langelier indices that are greater than 0.5 units different; largely different pH or hardness values</td>
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<td>Transmissivity</td>
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<td>Residence Time</td>
<td>Less than 10% loss in 180 days, &gt;480 days to 25% loss</td>
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## Detailed Ranking Methods

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<tr>
<td>Cost (O&amp;M)</td>
<td>No pretreatment required; gravity flow delivery; spreading basin use</td>
<td>Pretreatment required; ASR wells utilized; force mains required</td>
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<td>Cost (capital)</td>
<td>Gravity flow delivery; ASR well retrofit</td>
<td>Spreading basin in rural area</td>
<td>Spreading basin near municipality; ASR well construction; pipeline construction</td>
</tr>
<tr>
<td>Qualitative Considerations</td>
<td>Project size meets 100% of demand</td>
<td>Project size meets 25% of demand</td>
<td>Project size meets &lt;10% of demand</td>
</tr>
</tbody>
</table>