Demonstration of Two Long-Term Monitoring Optimization Methods

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Project Overview

- EPA, AFCEE, and USACE project to showcase 2 methods for optimizing ground water monitoring

- Goals:
  - Improve understanding of statistical and geostatistical methods for LTMO
  - Provide case study examples
  - Understand differences between methods
Project Team

- Kathy Yager, US EPA OSRTI
- Dave Becker, US ACE HTRW CX
- Javier Santillan, AFCEE
- John Anthony, Mitretek Systems
- Carolyn Nobel, Parsons
- Julia Aziz, GSI
LTMO Methods

- Monitoring and Remediation Optimization Software (MAROS)
  - Free software developed by AFCEE and GSI
  - Employs spatial and temporal data analysis techniques
  - Objectives are to minimize monitoring locations and reduce sampling frequency without significant loss of information
  - Spatial analysis based on 2-D sampling reduction method (Delaunay method)
  - Temporal analysis based on a modified Cost Effective Sampling (CES) method – developed by LLNL
  - Can be used by individual with basic statistical knowledge
LTMO Methods

- Parsons’ 3-Tiered Monitoring Network Optimization (3-Tiered LTMO)
  - Employs a 3-tiered approach
    - Qualitative evaluation (hydrostatigraphy, locations of potential receptors, direction and rate of contaminant migration)
    - Mann-Kendall statistical analysis to determine trends in each well (combined with decision tree to retain/remove/reduce)
    - Spatial analysis using geostatistical kriging error predictions
  - 3 tiers are combined for recommended sampling network
  - Requires trained hydrogeologist and geostatistician
  - Has been applied at multiple AF sites across country
LTMO Methods

- Primary differences between MAROS and MNO
  - MNO incorporates a qualitative review as a preliminary step in screening data
  - Geostatistics in MNO could be considered more robust
  - MNO considered to be more flexible because a trained geostatistician and hydro make final recommendations
  - MAROS designed to be simple and easy to use – MNO must hire geostatistician/hydrogeologist
  - MAROS also evaluates data sufficiency, plume trend, size, shape, and movement
Project Design

- Two long-term ground water monitoring optimization methods showcased

- Two methods attempt to answer the following questions
  - how many wells are required (spatial)?
  - how frequently should wells be sampled (temporal)?
  - e.g., define plume boundary or otherwise meet data quality objectives
Project Design

- 3 sites with existing GW monitoring networks evaluated
- Fort Lewis Army Depot in Washington
  - GW sampling since 1995, CVOCs
  - 72 monitoring wells
- McClellan Air Force Base OUD in California
  - GW sampling since 1984, CVOCs
  - 51 monitoring wells
- Long Prairie Superfund Site in Minnesota
  - GW monitoring since 1996, CVOCs
  - 44 monitoring wells
Project Design

- Evaluation of site data and consolidation of ground water monitoring data
- Meetings with site managers and regulators to discuss objectives and ground rules for optimization of well network early in process
- Each optimization team worked independently to evaluate GW monitoring network
- Teams evaluated both redundancy and data deficiency
## Results, Spatial Analysis (number of wells per site)

<table>
<thead>
<tr>
<th>Site</th>
<th>Original Number of Wells</th>
<th>Parson’s Result (percent reduction)</th>
<th>MAROS Result (percent reduction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fort Lewis</td>
<td>72</td>
<td>69 (4 %)</td>
<td>57 (21 %)</td>
</tr>
<tr>
<td>McClellan</td>
<td>51</td>
<td>21 (59 %)</td>
<td>41 (20 %)</td>
</tr>
<tr>
<td>Long Prairie</td>
<td>44</td>
<td>26 (41 %)</td>
<td>32 (27%)</td>
</tr>
</tbody>
</table>
## Results – Reduction in Total Sampling Events Per Year

<table>
<thead>
<tr>
<th>Site</th>
<th>Original Sample Frequency (events/yr)</th>
<th>Parsons Results (percent &amp; cost reduction/yr)</th>
<th>MAROS Results (percent &amp; cost reduction/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fort Lewis</td>
<td>180</td>
<td>110 (39% &amp; $36,500)</td>
<td>113 (37% &amp; $34,600)</td>
</tr>
<tr>
<td>McClellan</td>
<td>34</td>
<td>17 (50% &amp; ?)</td>
<td>31.5 (7% and ?)</td>
</tr>
<tr>
<td>Long Prairie</td>
<td>51</td>
<td>36 (30% &amp; $4,000)</td>
<td>24 (53% &amp; $6,700)</td>
</tr>
</tbody>
</table>
Summary and Observations

- Two methods identified potential for significant reduction in monitoring well networks – average of 36% reduction

- Cost savings lower on a percentage basis (because many monitoring costs are fixed)

- Based on initial feedback from regulators & facilities, results appear reasonable and have potential for being implemented

- Some reluctance to implement due to other perceived concerns (co-located plumes, negotiation with regulators, implementation costs)
Summary and Observations

- Costs for performing LTMO relatively low ~ $10K per site with 30 wells (both methods)

- Methods have potential for increasing certainty that monitoring network is adequate (by evaluating both over sampling and undersampling)

- No consistent differences between methods identified: qualitative review may be most significant difference

- Some problems identified with MAROS plume trend analysis (consistent at all sites, but minor problem)
Lessons Learned

- Larger sites with more wells more likely to benefit
  - Minimum of 20-30 wells in each aquifer layer required
  - Minimum of 4 sampling events required

- Methods show promise, have not been widely used

- Methods need broader regulatory acceptance

- Data consolidation time consuming

- Future LTMO simplified once initial data consolidation complete. Provides consistent storage of future data
Next Steps

- Final report expected this summer
- Internet seminar on project results this fall
- Potential LTMO workshops
- Follow-on project – LTMO Roadmap
  - Overview of all LTMO methods
  - Explanation of method applicability (which method should I use at my site?)
  - Information on common red flags with the methods
  - USACE, USEPA, Parsons, Mitretek
  - Draft roadmap this summer

All reports available at cluin.org and frtr.gov/optimization
Discussion