Alternative Air Sparge Test Method Using Sulfur Hexafluoride (SF_6)

Presented by:

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Purpose

Investigation of an Air Sparge (AS) pilot test technique with potential advantages over Dissolved Oxygen (DO) monitoring and other traditional test methods

Purpose (Technique Drivers)

Radius of influence (ROI) is important to AS system design to balance adequate treatment while minimizing the number of injection points

Several methods have traditionally been used to determine ROI including wellhead pressure, groundwater (GW) mounding, and DO

- There is debate regarding which method is most effective
- DO monitoring is often favored for accuracy, however it can be unappealing due to infrastructure, cost, and test duration

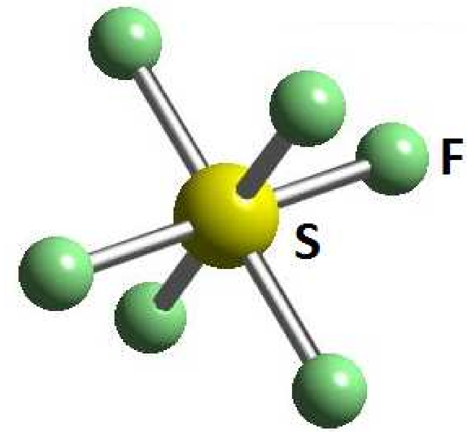
Purpose (Technique Background)

Sulfur hexafluoride (SF_6) was used as a tracer gas in a traditional AS test setting to mimic DO distribution in GW

Although this is not a new idea, very limited information on practical field applications of the technique was readily available

Johnson et al. (2001). *Use of an SF_6-Based Diagnostic Tool for Assessing Air Distributions and Oxygen Transfer Rates during IAS Operation. Bioremediation Journal 5(4), 337-347.*

Application (SF_6 Properties)



- Chemically inert
- Nontoxic
- Volatile
- Inorganic
- Nonflammable gas
- Common applications:
  - Insulator in electrical distribution equipment
  - Tracer in HVAC for leak detection

Application (SF_6 Relevance to Technique)

- Solubility similar to DO in GW
  - Mimics DO distribution
- No natural demand
- Can be detected in low concentrations
  - Minimize injection mass
  - Maximize precision
- Negligible presence in the earth's atmosphere
- Although SF_6 is a greenhouse gas, carbon footprint calculations have shown that SF_6 tests are comparable to DO tests

Application (Test Sites)

The SF_6 technique has been applied at two sites in Michigan:

- Site A – Former petroleum terminal
- Site B – Refined products pipeline release

Both sites have sandy soils and relatively shallow groundwater

Application (Test Setup)

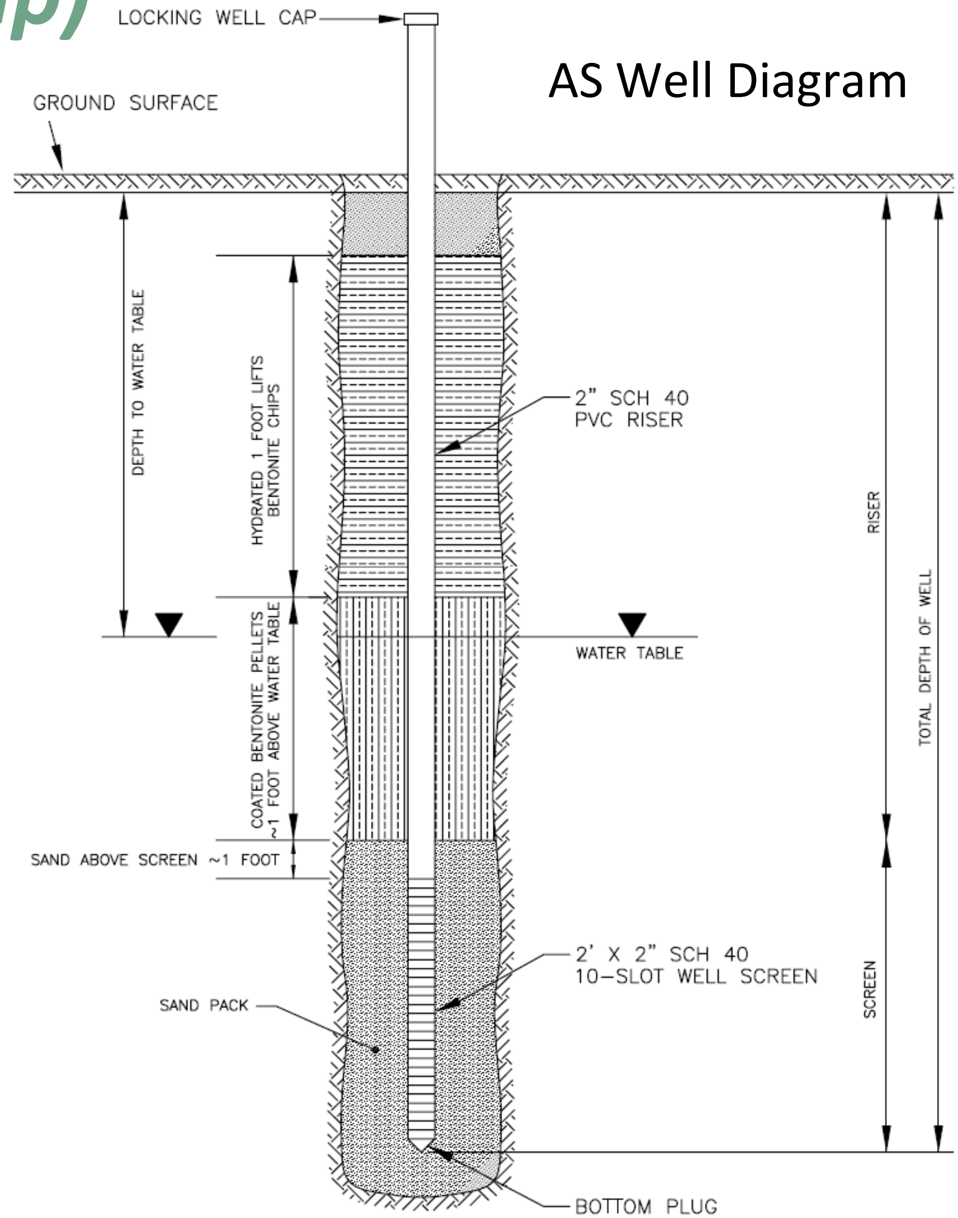
AS Injection Points

- 2-foot submerged screen set ~25-feet below GW

Monitoring Wells

- 1-foot submerged screens
- Ranging 5 to 40-feet from AS point
- Depths varied from ~2 to 15-feet below GW
- Zone of interest at both sites was the shallow zone (~2-feet below GW)

AS Well Diagram



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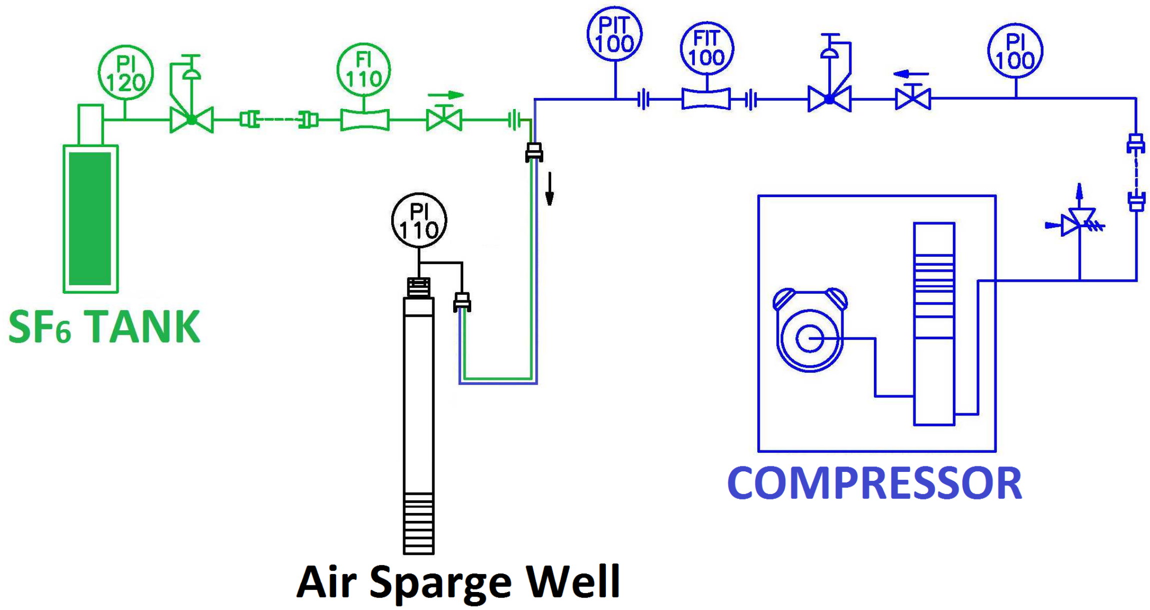
Application (Control Test)

- Optical DO sensors sealed in monitoring wells
- Solar powered telemetry provided real-time access to data

Application (SF_6 Injection)



Test Parameters	Site A	Site B
Duration (hours)	20	40
Total Air Flow (SCFM)	25	15
SF_6 Flow (SCFM)	0.00375	0.0125
SF_6 Concentration (ppmv)	1	5
SF_6 mass injected (g)	0.64	14.58

Application (SF_6 Sampling)

- GW samples collected using a peristaltic pump
- Sample volume (40 mL VOAs)
- Collected in 4-hour intervals
- Analyzed onsite according to US EPA method 8260B

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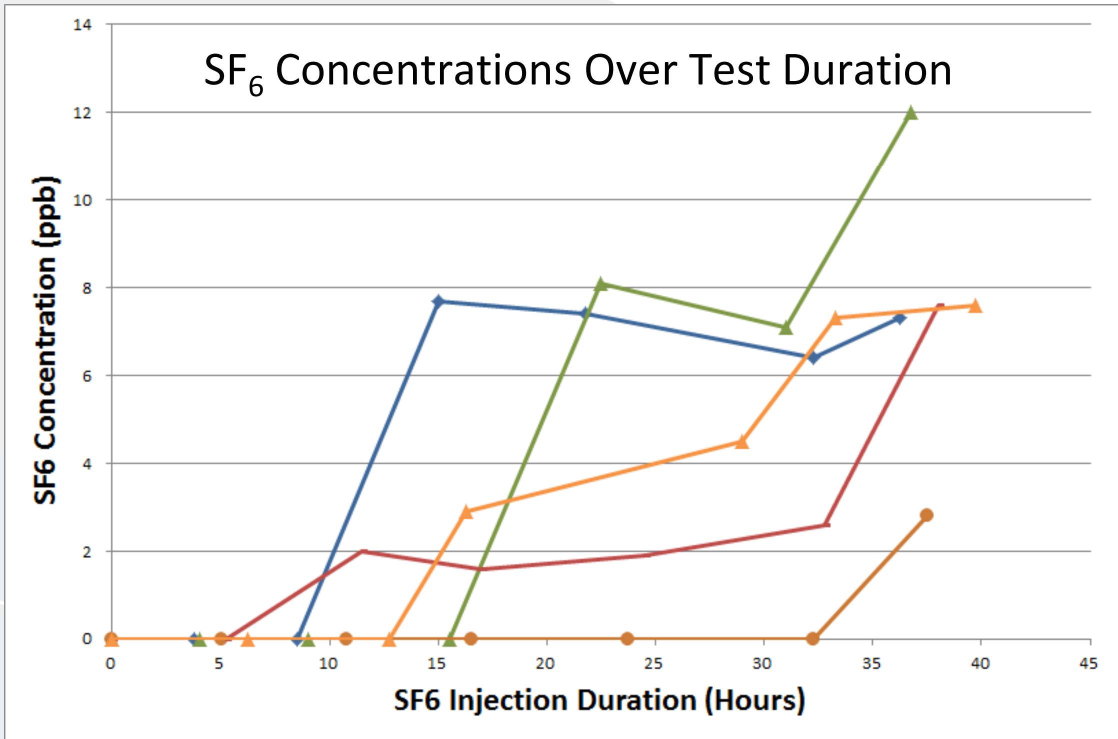
Results (SF_6 Concentrations)

- Baseline samples < MDL of 1 ppb SF_6
- SF_6 concentrations were measured in a majority of shallow monitoring wells and increased over time



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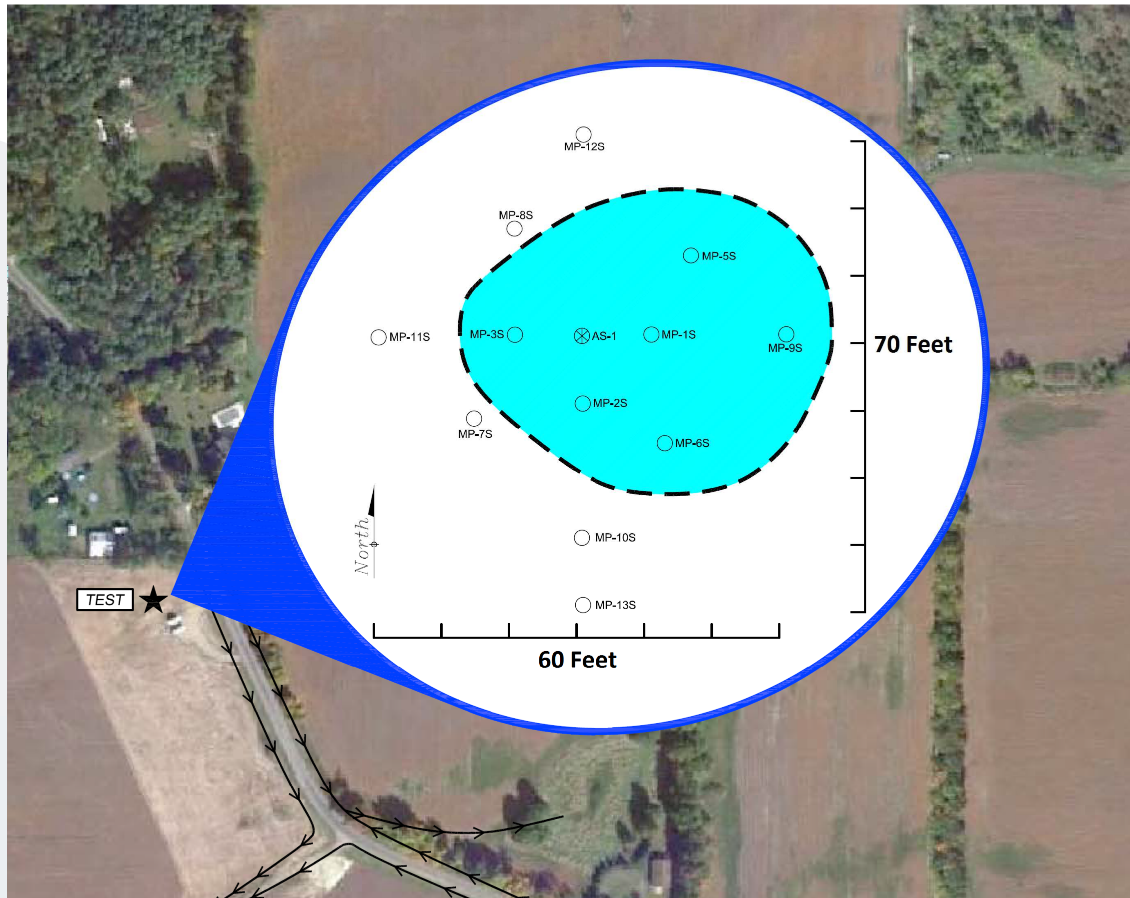
Results (SF_6 Distribution)

Distribution of SF_6 matched the control test (DO), therefore validating the SF_6 technique!



Implications (SF_6 Technique)

- Scalable to accommodate a wide variety of site conditions
- Field application is straightforward
- Resulting ROI is more definitive than DO testing
- GHG emissions of SF_6 technique are comparable to traditional AS pilot tests

Implications (Project Efficiencies)

- Potential to decrease pilot test time and costs
- Accurately measuring ROI reduces construction and lifecycle costs
- Example: Site A treatment area of ~5 acres
  - Well spacing based on *AS Design Paradigm:* ROI of 9-ft = ~850 AS wells
  - Well spacing based on SF_6 testing: ROI of 25-ft = ~110 AS wells

Lessons Learned

Technique continues to be refined:

- Smaller sample volume
- Sample hold time
- SF_6 saturation testing for mass transfer rates

Questions

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