Travis Air Force Base: Greener, Faster, and More Cost Effective Remediation

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Presentation Outline

• How we approach green and sustainable remediation (GSR)
• Overview of results
• How we did it
• Questions
How We Approach GSR

• When properly implemented, green and sustainable remediation (GSR) goes hand-in-hand with accelerating cleanup timeframes and reducing costs

• Passive or solar-powered systems, such as our subgrade biogeochemical reactors (SBGRs) can meet these objectives
Green and Sustainable Remediation Results
Green and Sustainable Results

• Annual electricity reduction of ~790,000 kWh/yr
  – Equivalent to annual consumption of ~120 CA homes
  – Saved over $50,000/year in electrical costs

• Greenhouse gas reduction of ~930 tons per year
  – Equivalent to annual emissions of ~200 cars

• Use of non-refined, recycled, or waste materials
  – Avoid impacts from manufacturing new materials
  – Used fast food fryer oil, recycled drywall, bark mulch, straw, repurposed pump and treat system components
ASTM Greener Cleanups Documentation

• Travis AFB was the first DoD installation to complete the ASTM Greener Cleanups self-declaration process
  – Develop best management practices (BMPs)
  – Implement greener cleanups project(s)
  – Document results and post to administrative record
Faster Remediation
Performance Results

• 26 sites on track for closure by 2021
  – ~16-19 sites to achieve closure by end of 2017

• Predicted cleanup timeframe for ten (10) sites reduced by range of ~10 to 120 years

• Source area treatment example:
  – Site SS016 subgrade biogeochemical reactor (SBGR) reduced TCE source area from 182,000 µg/L in 2010 to 0.29 J µg/L in 2016
More Cost Effective Remediation
Cost Savings

• Central Groundwater Treatment Plant
  – 12-month rolling average reduced from $250,000 to $35,000 (6.5-times return on investment)

• North Groundwater Treatment Plant
  – 12-month rolling average reduced from $66,000 to $15,000 (3-times return on investment)

• Site SS016 Optimization
  – Approximately $4.6 million saved over projected 30 year period of operations and maintenance
Project Examples
Solar Pump and Treat Systems

- LF007C solar system reduction
  ~158,000 kWh/year
  ~59 tons CO$_2$/year

- Site ST018 solar system reduction
  ~35,000 kWh/year
  ~13 tons CO$_2$/year
Site DP039 Phytoremediation System

• Phytoremediation of TCE included in Groundwater ROD

• Trees must be maintained, even during periods of drought

• Solar-powered groundwater recirculation system supports heath of trees and increases residence time of treatment
What is a Subgrade Biogeochemical Reactor (SBGR)?

SBGR is filled with gravel and amendments (site-specific and based on contaminant).

Source Area Excavation/Backfill

Infiltration Pipe Installation

2013 Environmental Business Journal Technology Merit Award

2015 NICOLE Technology Innovation Award
Sites DP039 and SS016
Subgrade Biogeochemical Reactors (SBGRs)

Starting TCE = 8,000 µg/L  
SBGRs replaced dual-phase extraction systems  
SS016 connected to horizontal well for treatment under flight line

Starting TCE = 182,000 µg/L
SITES DP039 AND SS016 SBGR PERFORMANCE

**Site DP039**

- **Starting TCE = 8,000 µg/L**

**Site SS016**

- **Starting TCE = 182,000 µg/L**

Performance from wells located within aquifer, between SBGR and extraction well.

<table>
<thead>
<tr>
<th>Site</th>
<th>Treatment Inside SBGR</th>
<th>Treatment ~25 feet from SBGR</th>
<th>Treatment ~100 feet from SBGR</th>
<th>Treatment ~200 feet from SBGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP039 (left)</td>
<td>96-98%</td>
<td>99%</td>
<td>99%</td>
<td>85%</td>
</tr>
<tr>
<td>SS016 (right)</td>
<td>99%</td>
<td>99%</td>
<td>47-97%</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Sustainability Life Cycle Assessment

Normalized comparison assuming equivalent target treatment area and treatment time

SBGR is more sustainable than emulsified vegetable oil (EVO) injection

EVO Injection

SBGR
Site SD031 Infiltration Chimney SBGRs

• Innovative design was needed for 1,1-DCE plume
  – Active industrial complex, extensive utilities, and aircraft-rated covers

• 12- to 18-inch boreholes filled with coarse gravel and iron pyrite sand/gravel, coated with emulsified vegetable oil (EVO)
Site SD031 Recirculation Layout

- Infiltration Chimneys
- Injection Wells
- Extraction Wells
Site SD031 Results

• ~50% total molar concentration reduction within first year across entire 1.2 acre plume

• 1,1-DCE hot spot reduced from 390 µg/L to 5 µg/L within first year
Site FT004 Recirculation System

SBGR trench is filled with gravel, bark mulch, iron pyrite sand, and used fast food fryer oil to support biotic and abiotic degradation of chlorinated solvents.
Site FT004 Results

• ~50% total molar concentration reduction within first year across entire 5.7 acre plume

• Max TCE concentration reduced from 560 µg/L to 140 µg/L within first year
Site SS014 Technology Demonstration

• Subgrade biogeochemical reactor (SBGR) for remediation of fuel contamination
  - Design based on internally-funded CH2M bench-scale research
  - Drywall as a safe and sustainable source of sulfate
SBGR is filled with gravel, scraps of drywall, wheat straw, and iron pyrite gravel to support enhanced biodegradation of fuel contamination.
Site SS014 SBGR Completed Layout
Site SS014 Initial Results

• Source area groundwater concentrations after post-construction sampling
  – TPH-D: 5,500 µg/L to non-detect
  – TPH-G: 1,900 µg/L to non-detect

• Electricity and GHG reduction
  – ~9,000 kWh/year
  – ~3 tons CO₂/year
Site SD034 Aerobic SBGR Demonstration

- Extensive Utilities
- SBGR Trench
- EX Well

Groundwater Flow

TPH-D = 1,000 µg/L
TPH-D = 100 µg/L

Travis Air Force Base: Greener, Faster, and More Cost Effective Remediation
Backfill with Gravel, Calcium Peroxide, Vitamin Package, and Infiltration/Sparge Lines

• Electricity and GHG reduction
  – ~38,000 kWh/year
  – ~14 tons CO$_2$/year
Literature Related to Travis AFB Work

• SERDP/ESTCP Environmental Restoration Wiki
  – http://www.environmentalrestoration.wiki (and then click on SBGR)
  Or Google “SBGR ER Wiki”

• “Design and Performance of Subgrade Biogeochemical Reactors” in Journal of Environmental Management

• “Utilization of waste materials, non-refined materials, and renewable energy in in situ remediation and their sustainability benefits” in Journal of Environmental Management

• “Travis Air Force Base: A Greener Cleanups Case Study” to be published soon in Remediation Journal
Ongoing Research

• Development of subgrade biogeochemical reactors (SBGRs) for other contaminant classes
  – PFASs, explosives, pesticides, etc.
Thank You

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