Kennedy Space Center
Remediation Program Overview

Streamlined RCRA Remediation via Engineering Evaluation Process

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Objectives

• Typical RCRA Process
• Kennedy Space Center (KSC) Remediation Team
• Overview KSC Engineering Evaluation (EE) Process
  – Preliminary Assessment/Possible Release Locations
  – Step 1 EE – Characterization
  – Step 2 EE – Remedy Alternative Screening
  – Step 3 EE – Remedy Design
  – Step 4 EE – Remedy Implementation
RCRA Corrective Action

- Permit application or discovery of release
  - Interim measure required?
    - Yes: Interim Measure
    - No: RCRA Facility Assessment
  - RCRA Corrective Action required?
    - Yes: Permit Modification of §3008 (h) Order
      - Federal Facility Compliance Agreement
    - No: Cleanup under other authority?
      - Yes: Action under other authority
      - No: No further action

- RCRA §3018 reporting

- NASA KSC Process
  - Preliminary Review (PR)
    - Visual Site Inspections (VSI)
    - Sampling Visit (SV)
      - RCRA Facility Assessment (RFA)
        - Step 1 (Investigation)
        - Step 2 (IM Alternative Screening)
        - Step 3 (IM Design)
        - Step 4 (IM Implementation)
      - Proposed Remedy (MNA)
      - RCRA Facility Investigation (RFI)
      - Corrective Measures Study (CMS)
        - Corrective Measures Implementation (CMI)
      - Corrective Action Completion
KSC Remediation Team (KSCRT)

• Interdisciplinary team:
  – NASA KSC Remediation Project Managers (RPMs)
  – Regulators (FDEP)
  – A/E Contractors:
    • Tetra Tech
    • Jacobs
    • Geosyntec

• Each member reviews and comments on each EE and consensus for these submittals is requested at meeting

• A master KSC schedule for projects and deliverables used to track/coordinate meeting topics and maintain permit compliance

• Meet every 2 months at KSC
Engineering Evaluation Process

• Multi-step process developed to ensure:
  – Adequate site characterization
  – Participate in evaluation of remedial technologies
  – Review preliminary designs
  – Evaluate efficacy of interim measures

• Decouples RFI and CMS Work Plan process
• Remedy conducted through interim measures (IMs)
• IMs conducted such that Long Term Monitoring is final remedy
• Allows prompt action to mitigate and prioritize risks
  – 1 to 3 years versus 5 to 10+ years!
Step 1 EE – Site Characterization

• Goals:
  – Is groundwater contamination fully delineated?
  – Is sufficient data available for site conceptual model and remedial decision making?

• Content:
  – Objectives/Site History
  – Site Conditions (e.g., terrain, hydrogeology, lithology)
  – Assessment summary (results, locations, intervals, mass)
  – Results Visualization (interval/COC plume maps, cross sections, electronic visualization software)
  – Preliminary Remedial Technology Screening
Direct push technology sampling/mobile laboratory based on adaptive grid investigation technique:

- 100’ spacing in Low Concentration Plume (>GCTL, <NADC)
- 50’ spacing in High Concentration Plume (>NADC, <10X NADC)
- 25’ spacing in Hot Spot Plume (>10X NADC)
- 10’ spacing in parent source zone (chemical specific: TCE – 1%)

Membrane interface probe (generally source areas)
Soil coring (lithologic/geotechnical/physical/chemical)
Establish monitoring well network/sampling program
Step 1 EE – Example Excerpts

- Example multi-plume site:

<table>
<thead>
<tr>
<th></th>
<th>Hot Spot 10xNADC (acres)</th>
<th>HCP NADC (acres)</th>
<th>LCP GCTL (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCB</td>
<td>1.4</td>
<td>4.2</td>
<td>11.4</td>
</tr>
<tr>
<td>HS1</td>
<td>0.63</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>HS2</td>
<td>0.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HS3</td>
<td>0.02</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>HS4</td>
<td>0.20</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>HS5</td>
<td>0.20</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>
• DPT data obtained in near real-time
  – Future DPT location/spacing determined based on result
• Final DPT data set compiled and visualized
  – Plan view plume contours (10’ vertical intervals)
  – Combined with lithologic data for cross section view
  – MIPs data evaluated with DPT/lithologic data
  – 3D plume model created via EVS (krigging)
• Contaminant mass calculated
• Engineering data to support preliminary remedial technology screening (biological, chemical, geochemical, physical, etc)
• Data and conclusions compiled into a presentation (Advanced Data Package)
• ADP published to team for review/comment
• Presented at meeting for discussion and consensus
Step 1 EE – Example Excerpts

• TCE plume slice at specific depth interval:
Step 1 EE – Example Excerpts

- Example cross section:
Step 1 EE – Example Excerpts

• MIP logs:
### Sample engineering data:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Average</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehalococcoides</td>
<td>1.4E+06</td>
<td>4.0E+08</td>
<td>1.3E+08</td>
<td>gene copy/L</td>
</tr>
<tr>
<td>TCE r-dase</td>
<td>6.6E+04</td>
<td>1.7E+08</td>
<td>3.2E+07</td>
<td>gene copy/L</td>
</tr>
<tr>
<td>BAV1 VC r-dase</td>
<td>0.5 U</td>
<td>5.4E+06</td>
<td>9.1E+05</td>
<td>gene copy/L</td>
</tr>
<tr>
<td>VC r-dase</td>
<td>2.5 U</td>
<td>3.4E+08</td>
<td>8.7E+07</td>
<td>gene copy/L</td>
</tr>
<tr>
<td>Ethane</td>
<td>0.17 U</td>
<td>2.4</td>
<td>1.1</td>
<td>μg/L</td>
</tr>
<tr>
<td>Ethene</td>
<td>2.9</td>
<td>140.0</td>
<td>46</td>
<td>μg/L</td>
</tr>
<tr>
<td>Methane</td>
<td>80</td>
<td>2,700</td>
<td>1,300</td>
<td>μg/L</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0.84</td>
<td>1.30</td>
<td>1.05</td>
<td>nmol</td>
</tr>
<tr>
<td>Total Organic Carbon</td>
<td>3.8</td>
<td>16 V</td>
<td>12.5</td>
<td>mg/L</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>210 V</td>
<td>980</td>
<td>605</td>
<td>mg/L</td>
</tr>
<tr>
<td>Hydrogen Sulfide (HS2)</td>
<td>0 (ND)</td>
<td>0.5</td>
<td>--</td>
<td>mg/L</td>
</tr>
<tr>
<td>Hydrogen Sulfide (S-2)</td>
<td>0 (ND)</td>
<td>0 (ND)</td>
<td>--</td>
<td>mg/L</td>
</tr>
<tr>
<td>Chloride</td>
<td>51</td>
<td>410</td>
<td>258.5</td>
<td>mg/L</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>100 U</td>
<td>100 U</td>
<td>100 U</td>
<td>μg/L</td>
</tr>
<tr>
<td>Nitrite-N</td>
<td>100 U</td>
<td>100 U</td>
<td>100 U</td>
<td>μg/L</td>
</tr>
<tr>
<td>Sulfate</td>
<td>200 U</td>
<td>35</td>
<td>11</td>
<td>mg/L</td>
</tr>
<tr>
<td>Sulfide</td>
<td>1000 U</td>
<td>1000 U</td>
<td>1000 U</td>
<td>μg/L</td>
</tr>
<tr>
<td>Ferrous Iron</td>
<td>0.20</td>
<td>2.20</td>
<td>0.87</td>
<td>mg/L</td>
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<tr>
<td>Iron (total)</td>
<td>0.84</td>
<td>12</td>
<td>3.3</td>
<td>mg/L</td>
</tr>
<tr>
<td>Manganese</td>
<td>0 (ND)</td>
<td>130</td>
<td>36</td>
<td>mg/L</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>50 U</td>
<td>450</td>
<td>375</td>
<td>mg/L</td>
</tr>
<tr>
<td>Conductivity</td>
<td>666</td>
<td>2,014</td>
<td>1,522</td>
<td>mS/cm²</td>
</tr>
<tr>
<td>DO – Field Kit</td>
<td>0.8</td>
<td>1.0</td>
<td>0.9</td>
<td>mg/L</td>
</tr>
<tr>
<td>DO – Meter</td>
<td>0.65</td>
<td>1.69</td>
<td>0.96</td>
<td>mg/L</td>
</tr>
<tr>
<td>ORP</td>
<td>-80.6</td>
<td>-14.7</td>
<td>-46.5</td>
<td>mV</td>
</tr>
<tr>
<td>pH</td>
<td>6.5</td>
<td>7.1</td>
<td>6.9</td>
<td>S.U.</td>
</tr>
<tr>
<td>Temperature</td>
<td>22.7</td>
<td>26.1</td>
<td>24.5</td>
<td>°C</td>
</tr>
<tr>
<td>Turbidity</td>
<td>4.2</td>
<td>8.7</td>
<td>5.8</td>
<td>μg/L</td>
</tr>
</tbody>
</table>
Step 1 EE – Example Excerpts

- EVS View:

- Plumes: TCE (green), cDCE (blue), VC (red)
- Sample Locations:
  - Blue all parameters < 10x NADC
  - Red one or more parameters >10x NADC
Step 1 EE Excerpts

- Remedial technology screening

<table>
<thead>
<tr>
<th>General Action</th>
<th>Technology</th>
<th>Process Option</th>
<th>Retain?</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Situ Treatment</td>
<td>Biological</td>
<td>Anaerobic Enhanced Bioremediation</td>
<td>Retain</td>
<td>Site conditions suggest favorable conditions for anaerobic reductive dechlorination and this technology has been successfully applied widely at KSC. Utilization of compatible co-solvents and/or surfactants may be needed for dissolution and contact of microbes to SZ impacts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aerobic Enhanced Bioremediation</td>
<td>Eliminate</td>
<td>Aerobic technologies are typically most appropriate for less oxidized contaminants such as vinyl chloride. Due to presence of TCE in SZ, aerobic bioremediation is generally not appropriate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bioaugmentation</td>
<td>Retain</td>
<td>Populations of CVOC dechlorinators such as DEIC are present at high levels, but the presence of functional genes for CVOC degradation vary. Addition of commercial dechlorinating cultures may be appropriate in select regions with deficient indigenous dechlorinating potential.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air Sparging (AS)</td>
<td>Retain</td>
<td>Air sparging could be effective in volatilizing high concentrations of dissolved phase mass. In situ treatment of sorbed and residual NAPL mass would be dispersion/dissolution limited and may extend air sparge duration to reach treatment objectives.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Large Diameter Auger (LDA) Mixing</td>
<td>Eliminate</td>
<td>Utility features at the site would limit the footprint that could be excavated via LDA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemical Oxidation (ISCO)</td>
<td>Eliminate</td>
<td>Effective technology to destroy high concentrations of COCs such as that in the SZ. Concern of shallow oxidant injection and interaction with metallic high pressure utilities.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemical Reduction (EZVI)</td>
<td>Retain</td>
<td>Strategic injections within the SZ can be an effective treatment technology to treat high concentrations and residual mass via abiotic and biotic mechanisms.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Permeable Reactive Barrier (PRB)</td>
<td>Eliminate</td>
<td>Inadequate hydrogeological conditions for plume treatment (e.g., low groundwater velocity). Sorbed mass unlikely to flow through PRB.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Co-Solvent Flushing</td>
<td>Eliminate</td>
<td>Due to the limited source zone extent, dissolution via groundwater recirculation is assumed to provide sufficient contact with residual mass for in-situ treatment processes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam Enhanced Extraction</td>
<td>Eliminate</td>
<td>Substantial unit cost for treatment of a small 70 sq ft area. Considerable worker safety risk, energy usage, and logistical intensity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electrical Resistance Heating</td>
<td>Eliminate</td>
<td>Substantial unit cost for treatment of a small 70 sq ft area. ERH could effectively volatilize dissolved-phase COCs and residual NAPL within the SZ.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re-Injection Wells</td>
<td>Retain</td>
<td>Discharge of treated, amended, and/or recirculation water may be needed depending on assembly of alternatives. Discharge quality requirements would be dependent on application.</td>
</tr>
<tr>
<td></td>
<td>On-Site Disposal</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Step 2 EE – Remedial Alternative Evaluation

• Goals:
  – Compile technologies into remedial alternatives
  – Provide unbiased screening and comparison of technologies
  – Select best suited remedial alternative

• Content:
  – Conceptual designs (layouts, design criteria, cost estimates, etc.)
  – Comparative analysis of alternatives (similar to RCRA selection criteria)
  – Supplemental attachments: cost estimates, design calculations, models, alternative narratives
<table>
<thead>
<tr>
<th>No.</th>
<th>Alternative</th>
<th>General Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-1</td>
<td>Air Sparging</td>
<td>AS wells (6 shallow, 18 shallow-intermediate, and 40 intermediate), AS system (rotary claw compressed air pump, heat exchanger, and instrumentation), and conveyance trenching and piping.</td>
</tr>
<tr>
<td>G-2</td>
<td>Anaerobic Bioremediation with Recirculation</td>
<td>Injection and extraction wells for application of substrate through recirculation (30 injection wells and 8 extraction wells). Extraction pumps, substrate mixing, and conveyance piping/tubing.</td>
</tr>
<tr>
<td>G-3</td>
<td>Anaerobic Bioremediation with Recirculation and EZVI Injection in HS1 SZ</td>
<td>Injection and extraction wells for application of ethyl lactate through recirculation (30 injection wells and 8 extraction wells). Extraction pumps, substrate mixing, and conveyance piping/tubing. Injection of EZVI at 2 locations at HS1.</td>
</tr>
<tr>
<td>G-4</td>
<td>Anaerobic Bioremediation with Recirculation and Selective Treatment</td>
<td>Injection and extraction wells for application of ethyl lactate through recirculation (30 injection wells and 8 extraction wells). Extraction pumps, infiltration gallery, air stripper, substrate mixing, and conveyance piping/tubing.</td>
</tr>
<tr>
<td>G-5</td>
<td>Anaerobic Bioremediation with Recirculation, Selective Treatment, and EZVI Injection in HS1 SZ</td>
<td>Injection and extraction wells for application of ethyl lactate through recirculation (30 injection wells and 8 extraction wells). Extraction pumps, infiltration gallery, air stripper, substrate mixing, and conveyance piping/tubing. Injection of EZVI at 2 locations at HS1.</td>
</tr>
</tbody>
</table>
Step 2 EE – Example Excerpts

- Enhanced reductive dechlorination alternative example:

  Alternative G-2 Summary
  - Biological and geochemical conditions favorable for enhanced anaerobic bioremediation
  - Soluble electron donor substrate (e.g., LactOil) distributed by cycled groundwater recirculation
  - Target substrate concentration of 550 mg/L
  - Six recirculation zones, consisting of:
    - 8 extraction wells within 3 extraction transects
    - 30 injection wells within 4 injection transects
  - Treatment zones would be operated in phases, under the below groupings:
    - Sequence 1: Zone 1, 4, and 6
    - Sequence 2: Zones 2 and 5
    - Sequence 3: Zone 3
  - 30 day sequence duration; 2 pore volumes for each sequence; 90 days per sequence cycle
Step 2 EE – Example Excerpts

• Enhanced reductive dechlorination alternative example:

Alternative G-2 Summary

• Extracted fluids would be directed to one of two manifolds – a high concentration manifold and a low concentration manifold
• Flexible manifold design allows all injection/extraction well laterals to be easily interchangeable between low and high concentration manifolds
• Substrate mixing, injection equipment, tanks, and pumps would be housed in a trailer
• 5,300 gallons (~100 drums) 60% soybean water-in-oil emulsion injected through the recirculation zones.
• Estimated time to reach treatment goals: ~3 years
• Estimated Cost: $879K (~$7.3K per pound of total TCE, cDCE, and VC mass)
Step 2 EE – Example Excerpts

• Enhanced reductive dechlorination example:
• Cost evaluation:

Cumulative Costs

- Alt G-1
- Alt G-2
- Alt G-3
- Alt G-4
- Alt G-5

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$600,000</td>
<td>$650,000</td>
<td>$700,000</td>
</tr>
<tr>
<td>$700,000</td>
<td>$750,000</td>
<td>$800,000</td>
</tr>
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<td>$900,000</td>
</tr>
<tr>
<td>$900,000</td>
<td>$950,000</td>
<td>$1,000,000</td>
</tr>
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</table>
## Step 2 EE – Example Excerpts

### Comparative Analysis of IM Alternatives

<table>
<thead>
<tr>
<th>ALTERNATIVE</th>
<th>LIMITATIONS</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
<th>SUSTAINABILITY</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative G-1 Air Sparging</td>
<td>- Treatment of potential NAPL ganglia dissolution limited - Air distribution in heterogeneous lithologies</td>
<td>- Effective technology widely applied and understood at KSC - Large mass reduction in short timeframe - Operations are easily adjustable and flexible</td>
<td>- Capture of volatilized VOCs not feasible - Potential HS plume expansion into HCP - Fairly energy intensive - Preferential pathways may result in pockets of untreated zones</td>
<td>CO2e: 263 tonnes NOx: 0.45 tonnes SOx: 0.59 tonnes PM10: 0.0125 tonnes Energy: 4,519 MMBTU Water: 181,000 gal</td>
<td>Capital: $799K Year 1 Costs: $55K Total Costs: $889K Cost/lb VOC Mass: $7.4K</td>
</tr>
<tr>
<td>Alternative G-2 Anaerobic Bioremediation with Recirculation</td>
<td>- Distribution uniformity of substrate predicated by lithology - Treatment timeframe generally unpredictable - Treatment of potential NAPL ganglia limited to dissolution interface</td>
<td>- Proven technology at nearby VAB area - Flexible, substrate selection and dosage can be modified according to results - Injection/extraction flow rates can be optimized - Easily expandable into HCP</td>
<td>- Closed loop recirculation does not fully contain plume footprint - Competing microbes and electron acceptors result in higher substrate loading</td>
<td>CO2e: 134 tonnes NOx: 0.31 tonnes SOx: 0.28 tonnes PM10: 0.0124 tonnes Energy: 3,252 MMBTU Water: 78,000 gal</td>
<td>Capital: $650K Year 1 Costs: $109K Total Costs: $879K Cost/lb VOC Mass: $7.3K</td>
</tr>
<tr>
<td>Alternative G-3 Anaerobic Bioremediation with Recirculation and EZVI Injection</td>
<td>- Alt. G-2 limitations - Contact of potential NAPL with EZVI requires NAPL to transport into EZVI droplets. - Distribution is variable and general injection technologies are complex</td>
<td>- Inclusive of Alt. G-2 advantages - Aggressive treatment of high TCE concentrations - Biotic and abiotic mechanisms accelerated</td>
<td>- Distribution of EZVI can be preferential and viscous properties can limit distribution - Potential secondary groundwater quality impacts by mobilization of metals and sulfide production</td>
<td>CO2e: 142 tonnes NOx: 0.31 tonnes SOx: 0.28 tonnes PM10: 0.0125 tonnes Energy: 3,469 MMBTU Water: 82,000 gal</td>
<td>Capital: $689K Year 1 Costs: $108K Total Costs: $918K Cost/lb VOC Mass: $7.7K</td>
</tr>
<tr>
<td>Alternative G-4 Anaerobic Bioremediation with Recirculation and Selective Treatment</td>
<td>- Alt. G-2 limitations - Fluctuations in initial influent concentrations may require adaptive flow diversion to maintain emission compliance.</td>
<td>- Inclusive of Alt. G-2 advantages - Continuous operation of recirculation zones - Most conservative recirculation scenario - Hydraulic containment of plume footprint - Mass removal - No treatment residuals generated</td>
<td>- Additional component of discharge compliance monitoring - Additional equipment operation and maintenance</td>
<td>CO2e: 157 tonnes NOx: 0.34 tonnes SOx: 0.33 tonnes PM10: 0.0131 tonnes Energy: 3,610 MMBTU Water: 93,000 gal</td>
<td>Capital: $675K Year 1 Costs: $114K Total Costs: $914K Cost/lb VOC Mass: $7.6K</td>
</tr>
</tbody>
</table>
Step 3 EE – Remedial Design

• Goals:
  – Present remedial design to KSCRT
  – Opportunity to review and comment on focused design

• Content:
  – Interim Measure Objectives
  – Design and Process Calculations and Drawings
  – Design description
  – Performance specifications
  – Detailed costing and duration modelling
  – Performance monitoring/ exist strategy
Step 3 EE – Example Excerpts
Step 3 EE – Example Excerpts
Step 3 EE – Example Excerpts
Step 3 EE – Example Excerpts
Step 4 EE - Remedy Implementation

• Goals:
  – Present remedy construction/implementation
  – Optimize ongoing remedy
  – Refine exit strategy on updated data sets

• Step 4 EE (Construction Completion):
  – Overview of remedy design and construction
  – Lessons learned and health and safety
  – Baseline data

• Step 4 EE (Operation, Maintenance, and Monitoring):
  – Evaluation of performance metrics (GW data, run-time, ...)
  – Cost evaluation and mass removal
  – IM optimization
  – Exit strategy update/refinement
  – Planned activities
Step 4 EE - Construction Photos
Step 4 EE - Construction Photos
Step 4 EE - LDA/Steam/ZVI Photos

Photographs courtesy of Jacobs Engineering
Step 4 - Remedy Progress/Optimization

Mann Kendall Analysis (sitewide)
Step 4 - Remedy Progress/Optimization

- cVOC Mass recovery: 32,042 lb (03/11/2013); 24 lb/d average (Yr 3)
- Cost per pound of cVOC mass recovered: $94/lb (Previous Yr: $119/lb)
  - Capital cost driven, figure continues to decrease as operation continues
- Groundwater recovery: 44,601,839 gallons (03/11/2013)
Step 4 - Remedy Progress/Optimization
Step 4 - Remedy Progress/Optimization

- Influent Data, Actual
- Forecasted Influent, Average Trend Fit
- Flushing Rate Calculation, Residual Concentration

ΣTCE, cDCE, VC Concentration (ug/l)

- Pumping Rate Modification
- CatOx Cost Efficient
- Carbon Cost Efficient

Year

IM Progress
Step 4 - Remedy Progress/Optimization

Each curve represents a scenario where GAC replaces CatOx within a specific year. GAC/CatOx lifecycle operation shown for baseline comparison.
Step 4 - Remedy Progress/Optimization

Pre-IM Site Lithologic Model

Layer 1: Sand (Upper sand unit; S zone; 30 LTM wells; 10 foot screen interval 1’-17’ range; 3 System Performance Wells 13’-23’)
Layer 2: Fine silty sand (Middle fine-grained unit; I zone; 39 LTM wells; 5 foot screen interval 20’-35’ range; 3 SPW 20’-28’)
Layer 3: Coarse to silty sand (Lower sand unit; D zone; 11 LTM wells; 5 foot screen interval 35’-45’ range; 3 SPW 28’-43’)
Layer 4: Silt and clay (Lower clay unit, ~ 5 feet thick; no wells in this layer)
Layer 5: Fine to coarse silty sand with shell fragments (3 SPW 45’-55’/47’-57’/52’-57’)
Layer 6: “Salt and pepper” sand (D1 zone; 10 LTM wells; 10 foot screen interval 50’-75’ range; 6 SPW 60’-70’/70’-80’)
Layer 7: Silty to clayey sand (IW42D2 screened 87’-92’)
Layer 8: Fine to coarse sand (D2 Zone; 5 LTM well; 10 foot screen interval 105’-115’ range)
Layer 9: Clay to sandy clay (Hawthorn confining unit; no wells in this layer)
Step 4 - Remedy Progress/Optimization

RW2A (15-45’ bls screen)
- Primary mass transport at 33-45’ bls
- Isolate well pumping screen from 33-45’ bls

RW2B (50-80’ bls screen)
- Mass storage at 47-50’bls
- Mass transport at 53-73’ bls
- Move pump intake to 73’ bls

*Layer 4 and 7 mass storage
Step 4 - Remedy Progress/Optimization
Notable Current Activities at KSC

- Large diameter auger/steam/ZVI TCE source zone IM
- EZVI/bioremediation PCE source zone IM
- Enhanced anaerobic reductive dechlorination at several sites
- Air sparging successfully applied at many sites and continuing to be applied at new sites
- Centralized multi-site air sparging integration (now at 365 wells)
- Highly successful source zone containment/mass removal via pump and treat
- Planned electrical resistance heating project
Overview of KSC Interim Measure Process

• Engineering evaluations significantly streamline and enhance documentation and design process
  – Multi-disciplinary team of stake-holders vested in a common goal of project success
  – Investigation to remedy timeframe drastically shortened
  – Adaptive and progressive investigation and design methods
  – Savings from reduced reporting and enhanced designs applied to effective investigations and interim measures
Kennedy Space Center Remediation Program Overview

Questions/Comments

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