UTILIZING NUMEROUS TECHNOLOGIES IN SYNERGY DURING AN ACCELERATED SITE CLEAN UP

October 14, 2015
The Team

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• Scott Murphy, PE and Rebecca Robbennolt ARCADIS Milwaukee, WI
• Mark Klemmer, PE, ARCADIS, Novi, Michigan
• Brent Winder, Clayton Campbell, McMillan-McGee Corp
• ~12 acre site
• Old CSX Rail Yard
• No documented spills
• Slated for Sale and redevelopment
• Fast track clean up
Assessment Stats (Phase I, II, III)

- Completed ~ 4 years
- 377 soil borings
- 149 monitoring wells
- 1,346 soil samples
- 294 groundwater samples
- ~ 77 samples/acre

Site Contaminants of Concern

- Metals (Sb, Pb, Zn & Hg)
- PCBs
- CVOCs
- Methane associated with petroleum
### Soil Contaminants

<table>
<thead>
<tr>
<th>Metals</th>
<th>Maximum Result</th>
<th>REM Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTIMONY</td>
<td>1,000</td>
<td>300</td>
</tr>
<tr>
<td>LEAD</td>
<td>24,000</td>
<td>3,000</td>
</tr>
<tr>
<td>MERCURY</td>
<td>180</td>
<td>30</td>
</tr>
<tr>
<td>ZINC</td>
<td>14,000</td>
<td>10,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PCBs</th>
<th>Maximum Result</th>
<th>REM Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>AROCLOR 1260</td>
<td>61.2</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CVOCs</th>
<th>Maximum Result</th>
<th>REM Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>cis-1,2-DICHLOROETHENE</td>
<td>87</td>
<td>ND</td>
</tr>
<tr>
<td>TETRACHLOROETHENE</td>
<td>5.6</td>
<td>ND</td>
</tr>
<tr>
<td>TRICHLOROETHENE</td>
<td>120</td>
<td>ND</td>
</tr>
<tr>
<td>VINYL CHLORIDE</td>
<td>8.1</td>
<td>ND</td>
</tr>
</tbody>
</table>

(Units - mg/kg or ppm)

### Groundwater Contaminants

<table>
<thead>
<tr>
<th>Groundwater Contaminants</th>
<th>Maximum Result</th>
<th>REM Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVOCs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cis-1,2-DICHLOROETHENE</td>
<td>8,000</td>
<td>20</td>
</tr>
<tr>
<td>TRICHLOROETHENE</td>
<td>3,100</td>
<td>5</td>
</tr>
<tr>
<td>VINYL CHLORIDE</td>
<td>360</td>
<td>2</td>
</tr>
</tbody>
</table>

(Units - ug/l or ppb)
Remedial Goals

Water
• 5 ug/L trichloroethene (TCE)
• 20 ug/L 1,2-cis-dichloroethene (DCE)
• 2 ug/L vinyl chloride (VC)

Soil (ERH)
• Total concentration of TCE, DCE and VC less than 50 ug/kg
• No sample greater than 100 ug/kg for TCE, DCE or VC
Areas of Impact & Remedial Technologies

- **Soil** - Excavation ~ 33,500 tons requiring remediation
  - Petroleum, PCBs, CVOC, metals
- **GW** ~ 12 acre CVOC plume
  - Extends beneath public road
  - Electric Resistance Heating (ERH)
  - ~ 2 acres
  - Directed Groundwater Recirculation (DGR)
ERH Stats –

331 electrode locations with 576 total installed electrodes
104 Multi-Phase Extraction (MPE) Wells
70 Temperature Monitoring Points (TMPS)
Up to ~4,500 KW energy input into the electrodes
Estimated Power usage ~13 million kWh
Vapor extraction rate ~1500 SCFM
Groundwater Extraction Rate ~50 gpm
Target soil treatment temperature 100°C
From Energy Delivery to Extraction and Treatment

Power Supply

Power Delivery Systems

Water Circulation System

Knockout pot

Blower

Heat exchanger

Pump

Water treatment

Discharge/Recirculation

Treated vapor to atmosphere

Extraction Well

Electrodes

Treatment Bottom (Clay)
ERH System Monitoring

ET-DSP™ Operations
- Power: 4,472 kVA
- Power Density: 80 W/m²
- Input Energy: 18,912 MWh
- Water
- Treatment

Temperature
- 2-7 ft BGS: 99 °C
- 7-12 ft BGS: 98 °C
- 12-17 ft BGS: 101 °C
- 17-22 ft BGS: 97 °C
- 22-27 ft BGS: 94 °C

Graph: DigitAM TH5 Temperature History
Daily Averages are shown for all dates prior to yesterday.
Excavation

- Total Estimated Targeted Tonnage ~ 33,500
- Soil Removed to Date ~ 33,300

Soil Management

<table>
<thead>
<tr>
<th>On-Site Treatment (Tons)</th>
<th>Off-Site Disposal (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,000</td>
<td>27,600</td>
</tr>
<tr>
<td>2,700</td>
<td></td>
</tr>
</tbody>
</table>

Construction & Demolition (Tons)

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Asphalt</th>
<th>Scrap Metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,300</td>
<td>2,800</td>
<td>48</td>
</tr>
</tbody>
</table>

Water Management (Gallons)

<table>
<thead>
<tr>
<th>Dewatering Volume</th>
<th>On-Site Treat Dschg</th>
<th>Off-Site Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>78,600</td>
<td>54,100</td>
<td>23,000</td>
</tr>
<tr>
<td></td>
<td>1,500</td>
<td></td>
</tr>
</tbody>
</table>

- ~ 18 CSX rail cars – Hazardous soil
- ~ 900 Trucks – Other off-site disposal

- Recycle Rate (Solids) – 92%
- Unknowns - 9 USTs & structures; new haz-waste streams, increased disposal volumes, clay surface variability.
Directed Groundwater Recirculation (DGR)

- 58 injection wells
- 29 extraction wells
- Metals treatment
- O2 stripping (to prevent iron fouling)
- VOC treatment (Air-stripper and LGAC)
Groundwater Treatment System

- Heat Exchangers to cool water
- Pre-Treatment – Sand filtration & iron removal
- VOC Treatment - Air Stripping, vapor and liquid GAC,
- O₂ Removal for reinjection - Nitrogen sparging
DGR System Monitoring

- On-site operators
- Real time remote monitoring and adjustment capabilities
- Increased operational efficiency and troubleshooting
## Overall Construction Stats

<table>
<thead>
<tr>
<th>Excavation</th>
<th>DGR System</th>
<th>ERH System</th>
</tr>
</thead>
<tbody>
<tr>
<td>~33,500 tons targeted</td>
<td>~10 Acre Area</td>
<td>~2 acre area</td>
</tr>
<tr>
<td>~3,000 tons treated on-site</td>
<td>~1.6 miles of Trenching</td>
<td>~25,926 feet (5 miles) well drilling</td>
</tr>
<tr>
<td>34,600 tons of backfill</td>
<td>~5.4 miles of piping</td>
<td>331 electrode wells</td>
</tr>
<tr>
<td>Temp GW Treatment System</td>
<td>~3,900 ft. directional drill</td>
<td>104 GW extraction wells</td>
</tr>
<tr>
<td>~78,000 gal of water treated</td>
<td>~12.3 miles of wiring</td>
<td>70 sensor wells</td>
</tr>
<tr>
<td>~25,000 VSF sheeting</td>
<td>58 injection wells</td>
<td>576 electrodes</td>
</tr>
<tr>
<td></td>
<td>29 extraction wells</td>
<td>~5,000 ft of steel extraction piping installed</td>
</tr>
<tr>
<td></td>
<td>135 gpm design flow rate</td>
<td>~6,000 yard³ of cellular concrete</td>
</tr>
<tr>
<td>Mobile GW treatment system</td>
<td>Mobile GW treatment system</td>
<td>~17 miles of high pressure water hose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>~15 miles of 1/0 electrode lead wire</td>
</tr>
<tr>
<td></td>
<td></td>
<td>~6 miles of Teck cable</td>
</tr>
</tbody>
</table>

- All work done in parallel; Completed ~7 months
- Daily on-site management & coordination
  - ~70 people/day; 4 union trades, Union stewards/reps & city inspectors
- Air/dust monitoring programs – work areas and perimeter
- Over 60,000 hours worked – No reportable incidents
- Key factors of success
  - Communication, planning and more communication (all levels)
Design Construction and Operational Challenges

- Construction Coordination
- Varying Clay Depths
- Unknown USTs
- Iron Fouling
- Temperature and cooling issues
- Contract terminology
- Snow
CSX Romar

Groundwater Analytical Plumes

Plume Boundaries

- VOC Plume Prior to November 2014 Baseline
- Flushing Zones Boundaries
- ERH Footprint

Groundwater Analytical Data

- Groundwater monitoring well

GW2 Exceedances

- >10xGW2
- GW2 – 10xGW2
- <GW2
- Non-detect

Groundwater Plumes

Comparison to GW2 for Cis-1,2-DCE, TCE, VC

- >10xGW2
- GW2 – 10xGW2

Note:
Groundwater analytical plumes represent the most recent data for sampling locations; however, only samples collected on designated dates are shown. Constituent concentrations were normalized to GW2 exceedances; groundwater analytical plumes and sample data represent the maximum GW2 exceedance at each location for a given sampling event.
November 2014 Baseline Groundwater Data

GW2 Exceedances

Figure 1
July 30–August 3, 2015 Groundwater Data; July-August Yield Up

GW2 Exceedances

Figure 2
DGR and ERH Reduction

- TCE
  - DGR: 97%; ERH: 5%

- Cis-1,2-DCE
  - DGR: 96%; ERH: 60%

- VC
  - DGR: 87%; ERH: 72%

September 14–September 18, 2015
Groundwater Data; September Yield Up

GW2 Exceedances

Figure 3
GW2 Exceedances

<table>
<thead>
<tr>
<th></th>
<th>TCE</th>
<th>Cis-1,2-DCE</th>
<th>VC</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 2015 Baseline</td>
<td>DGR: 98%; ERH: 19%</td>
<td>DGR: 95%; ERH: 68%</td>
<td>DGR: 76%; ERH: 82%</td>
</tr>
<tr>
<td>July-August 2015 Yield Up</td>
<td>DGR: 97%; ERH: 5%</td>
<td>DGR: 96%; ERH: 60%</td>
<td>DGR: 87%; ERH: 72%</td>
</tr>
</tbody>
</table>

Extraction well data is from the August 27 – September 1, 2015 groundwater sampling event.
Where we are Today

Final Groundwater sampling event slated for Week of October 19th
Soil sampling event expected to occur first week in November
Shutdown end of November!
Conclusion

- Integration of numerous systems lead to a successful project.
- Communication amongst the remedial remedies was vital.
- Flexibility to adapt operational changes was key to ensure both systems remained operational and meet the remedial goals.
Questions?