Greening Environmental Cleanups with Traditional and Innovative Technologies

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Purpose

- EPA definition of green remediation

  Considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of a cleanup

- Present a case study that illustrates green remediation practices

Case Study Information

- Operating pump and treat (P&T) remedy in eastern United States
- Extracts/treats arsenic with iron co-precipitation
  - Extraction rate = 800 gpm
  - Influent arsenic concentration = 300 ug/L
- Strong history of optimization and significant improvement over past 10 years
- Optimization evaluation conducted in Spring 2010 with green remediation component

Remedy Inventory

Item	Quantity Per Year
Electricity usage (offset by purchased renewable energy)	1,350,000 kWh
Natural gas (building heat)	31,000 therms
Potable Water (polymer blending)	13,000,000 gallons
Treatment chemicals •Hydrogen peroxide (50%) •Ferric chloride (37%) •Sodium hydroxide (25%) •Polymer (flocculation and sludge conditioning	 10,000 gallons 45,000 gallons 100,000 gallons 4,000 gallons
Listed hazardous waste	260 tons
Laboratory analysis (process monitoring only)	$20,000
Operator transportation	25,000 miles

Comments about Electricity and Waste

- Electricity provided by local municipality
  - 100% from combustion of coal
  - Renewable Energy Certificates (RECs) for 100% of electricity
  - Renewable energy from RECs is fed into regional grid (blend of coal, natural gas, and nuclear energy)
- Waste is precipitated metals sludge
  - Dewater with centrifuge (requires polymer addition)
  - 25% solids (75% water)
  - Does not have characteristics of hazardous waste
  - “Listed” as a hazardous waste
  - Hazardous waste facility is 700 miles from site

Estimated Environmental Footprint

Item	Quantity Per Year
Energy footprint	~23,000 MMbtu
Greenhouse gas footprint	~2 million lbs CO2e
"Criteria pollutants" (NOx, SOx, and PM)	~21,000 lbs
Hazardous air pollutants	~1,000 lbs
Potable water	~13,000,000 gallons
Refined materials usage	~600,000 lbs
Non-hazardous waste generation	~ 0 tons
Hazardous waste generation	~260 tons
Land/ecosystem destroyed/disturbed	none

Green Remediation Component of Recommendations

- Many recommendations provided as a result of optimization evaluation
- Optimization evaluation report is currently in draft form and under review by the site team
- Site team is not required to implement recommendations
- Recommendations related to green remediation can be classified into…
  - Traditional technologies/approaches
  - Innovative technologies/approaches

Traditional Technology/Approach Recommendation #1

- Reduce extraction rates to those that are necessary for plume capture (by approximately 50%)

Reason	Potential Result
• Extraction rate is higher than that needed for capture (pulling in clean water) • Limited source area pumping is not significantly reducing cleanup time • Electricity, chemical usage, and waste directly correlated to flow rate	• Decrease electricity usage by 40% • Decrease remedy energy use by ~40% • Decrease chemical usage by 50% • Decrease waste generation by 50%

Traditional Technology/Approach Recommendation #2

- Focus building heat on area requiring heat

Reason	Potential Result
• Previous optimization has resulted in a substantially streamlined treatment system that occupies only a fraction of the original process building	• Decrease natural gas usage by approximately 50% • Decrease total remedy energy use by 5%

Traditional Technology/Approach Recommendation #3

- Consider use of a plate and frame filter press instead of a centrifuge

Reason	Potential Result
• Filter press will achieve lower water content of sludge, reducing waste volume and weight • Filter press will not require the same polymer use • Negative – May require more labor	• 30% decrease in volume and mass of listed hazardous waste • Decrease in use of 1,200 gallons of diesel fuel per year for waste transportation • Decrease in footprint associated with polymer production, including potable water for polymer blending

Traditional Technology/Approach Recommendation #4

- Consider use of hydrated lime in place of sodium hydroxide for pH adjustment

Reason	Potential Result

• Hydrated lime is a cheaper and less refined resource than sodium hydroxide
 	
• Negative – use of lime requires more labor than use of sodium hydroxide
	• Approximately 40% or more reduction in many production-related footprints
	  • Energy
	  • Greenhouse gases
	  • Criteria pollutants
	  • Water
	  • Air toxics

Traditional Technology/Approach Recommendation #5

- Consider "delisting" waste

Reason	Potential Result
• Waste does not have characteristics of hazardous waste. • Transport distance is 10 time further for hazardous waste disposal than for non-hazardous waste disposal • Hazardous waste disposal options are a more limited resource	• Convert 100% of generated waste from hazardous to non-hazardous • Reduce truck transport distances by 25,000 miles • Consume non-hazardous waste landfill space instead of more limited hazardous waste landfill space

Innovative Technology/Approach Recommendation #1

- Consider combined heat and power for electricity, building heat, and enhanced solids dewatering

Reason	Potential Result
• All site electricity is generated by coal. Combined heat and power would use natural gas • Waste heat would be used beneficially, increasing overall energy efficiency • Reduce waste volume and mass	• Eliminate natural gas use for heating • Reduce waste transport and disposal by as much as 50% • Displace electricity from coal with electricity from natural gas • Eliminate reduce transmission losses

Innovative Technology/Approach Recommendation #2

- Consider use of ferric hydroxide solids from acid mine drainage sites for iron addition and pH adjustment

Reason	Potential Result
• Currently add ferric chloride and sodium hydroxide to provide $Fe(OH)_3$ to adsorb arsenic • Iron solids, $Fe(OH)_3$,from acid mine drainage is a waste \that could be used beneficially prior to disposal • Use of iron solids could displace or substantially reduce ferric chloride and sodium hydroxide use	• Beneficially use waste product • Reduce total waste sent to landfills • Potentially reduce remedy energy footprint by 10% just from reduced chemical usage

Innovative Technology/Approach Recommendation #3

- Consider in-situ stabilization of all or part of arsenic plume through oxidant and iron addition to aquifer

Reason	Potential Result
• Arsenic slowly desorbs from aquifer material resulting in long remediation time frame. Stabilization would work with natural geochemistry • Utilize naturally occurring iron for in-situ stabilization (much of iron precipitates in extraction system piping and needs to be replaced by chemical addition for above-ground treatment)	• Substantially reduce remedy time frame and/or scope of P&T system • Eliminate energy to extract/discharge water • Eliminate above-ground waste generation, transport, and disposal

Potential Footprint Reductions

Item	Potential % Reductions Per Year
Energy footprint	~ 50% to 65%
Greenhouse gas footprint	~ 50% to 65%
"Criteria pollutants" (NO_x, SO_x, and PM)	~50% to 60%
Hazardous air pollutants	~50%
Potable water	50% to 75%
Refined materials usage	~50% to 85%
Non-hazardous waste generation	Up to 100% increase
Hazardous waste generation	30% to 100%
Land/ecosystem destroyed/disturbed	None

Observations and Conclusions

- Green remediation integrated well with optimization evaluation
- All of the green remediation considerations are also cost-effective
- Many of the green remediation considerations involve traditional technologies/approaches
- Incorporating green remediation into optimization leads to innovative considerations that may not have been considered otherwise… For example,
  - Application of combined heat and power
  - Use of acid mine drainage waste to displace chemical additive

QUESTIONS????