Green Remediation:
Reducing The Environmental Footprint Of Contaminated Site Cleanups

Green Remediation Conference
Copenhagen, DK. November 2009

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Office of Superfund Remediation and Technology Innovation

What is "Green Remediation"?

Definition: The practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions.

Green Remediation: Common Themes in Site Cleanup Programs

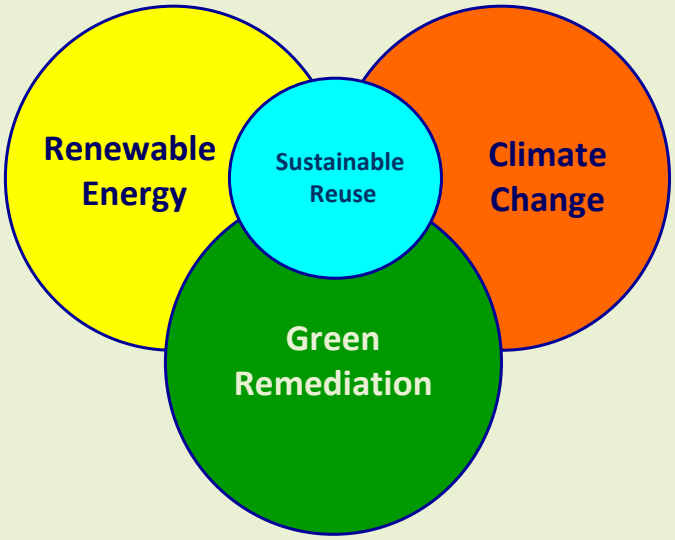
- Fits within existing frameworks
- Opportunities exist throughout site investigation, design, construction, operation, and monitoring
- Addresses core elements (see figure)

U.S. EPA Administrator's Comments on Stewardship & Sustainability

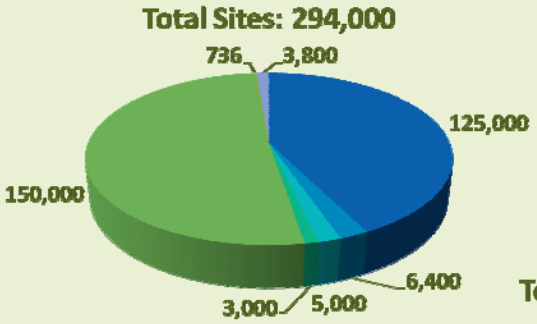
- "Enhancing EPA's ***environmental stewardship*** in the implementation of its core missions"
- "Harnessing non-regulatory agenda to enhance ***sustainability*** given limited resources"
- "How do actions taken on a ***regulatory basis*** help us advance sustainability?"
- "Think of ***simple*** things that have a broad impact"
- "Consider how the Agency impacts ***local communities*** in fulfilling it's mission"

* From notes taken at NACEPT Environmental Stewardship Subcommittee public hearing. Arlington, VA. July 1, 2009.

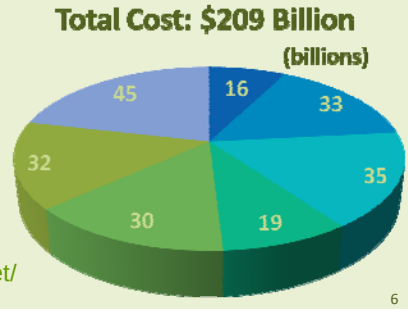
Related But Not Synonymous



There's Still Much Work to Do



- USTs
- U.S. DOD
- U.S. DOE
- Civilian Agencies
- State & Private
- Superfund NPL
- RCRA Corrective Actions



Source: http://cluin.org/market/

Carbon & Energy Footprints of Superfund Cleanup Technologies

Technology	Estimated Energy *Annual Average* (kWh*10^3)	Total Estimated Energy Use *in 2008-2030* (kWh*10^3)
Pump & Treat	489,607	11,260,969
Thermal Desorption	92,919	2,137,126
Multi-Phase Extraction	18,679	429,625
Air Sparging	10,156	233,599
Soil Vapor Extraction	6,734	154,890
Technology Total	*618,095*	*14,216,209*

Annual Carbon Footprint (MT CO2) Sum of 5 Technologies

404,411

Superfund Source Treatment Technologies by Year (Draft data)

Technology	2005	2006	2007	2008	Total	% of Total
IN SITU						
Soil Vapor Extraction	7	5	8	9	**29**	**14%**
Bioremediation	3	7	2	1	**13**	**6%**
Solidification/Stabilization	2	5	2	3	**12**	**6%**
In-Situ Chemical Oxidation (ISCO)	3	3	2	1	**9**	**4%**
Multii-phase Extraction	3	0	3	3	**9**	**4%**
Other*	4	5	2	3	**14**	**7%**
EX SITU						
Physical Separation	9	10	8	10	**37**	**18%**
Solidification/Stabilization	6	9	6	8	**29**	**14%**
Recycling	5	4	2	1	**12**	**6%**
Surface Water Treatment	2	3	2	3	**10**	**5%**
Unspecified Off Site Treatment	2	2	2	4	**10**	**5%**
Other**	7	10	4	0	**21**	**10%**
Total	**53**	**63**	**43**	**46**	**205**	

*Includes Flushing, Fracturing, Phytoremediation, Thermally Enhanced Recovery, and Volatilization

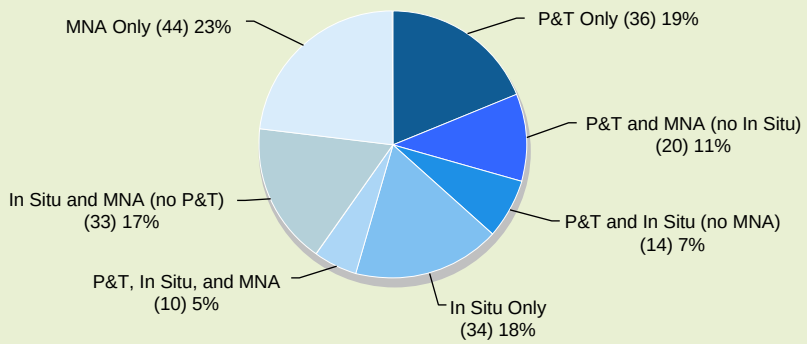
** Includes Biopile, Free Product Recovery, Incineration, Leachate Treatment, Neutralization, Open Burn/Open Detonation, Soil Vapor Extraction, Thermal Desorption, Unspecified On Site Treatment, Unspecified Thermal Treatment

Superfund Groundwater Treatment Technologies by Year (Draft data)

Remedy Type	2005	2006	2007	2008	Total
Groundwater Pump and Treat	20	20	22	18	80
In Situ Treatment of Groundwater	22	27	27	15	91
Bioremediation	12	19	17	11	59
Chemical Treatment	8	10	14	4	36
Other*	10	5	2	1	18
MNA of Groundwater	31	32	28	16	107
Groundwater Containment (VEB)	4	3	5	1	13
Other Groundwater	68	83	76	56	283
Institutional Controls	58	73	67	48	246
Monitoring	61	79	57	39	236
Other**	5	7	6	9	27
Total of Remedy Types	**145**	**165**	**158**	**106**	**574**

*Other includes Air Sparging, Fracturing, Multi-Phase Extraction, Phytoremediation, and PRB
**Other includes Alternate Drinking Water, Install New Water Supply Wells, Sewer/Sump Abandonment, Treat at Use Location, and Well Head Treatment

Combinations of P&T, In Situ Treatment, or MNA Selected as Part of a Groundwater Remedy (Draft 2005-2008 data analysis)



RODs counted only once in this figure as appropriate.

Core Elements: Air Emissions

- Lower air emissions leading to reductions in harmful particulate matter and ground-level ozone precursors
- Use of cleaner fuel and retrofit diesel engines
- Modified operations to reduce operating and idle time

Field Machinery and Vehicles Used for a Typical Multi-Phase Extraction Project over Five Years	Fuel (gallons)	CO_2 (lbs)
Site preparation: One Bobcat with intermittent use of flatbed trailer-truck or dump truck operating for 26 weeks	8,996	199,711
Well construction: Truck-mounted auger system installing ten 75-foot extraction wells over 30 days	612	13,586
Routine field work: Two pickup trucks for site preparation, construction, treatment system monitoring, sampling, and repair over five-year duration	19,760	383,344
Total for Project Life:	**29,368**	**596,641**

Construction could account for 30-40% of fuel consumption and air emissions of a cleanup.

Diesel oxidation catalysts, diesel particulate filters, selective catalytic reduction, and ultra-low sulfur diesel are options for reducing emissions from onsite equipment

Core Elements: Water Requirements & Resources

- Minimum fresh water use and maximum reuse
- Prevention of water quality impacts, e.g. nutrient-loading or disruption of natural hydraulics
- Reclaimed treated or stormwater for beneficial use or storage
- Alignment with proposed EPA rule on construction effluent:
  - Specific BMPs at all construction sites
  - Sediment basins at sites > 10 acres
  - Numeric limits of turbidity at sites > 30 acres with high rainfall and clay content

Portable closed-loop wheel washing systems for reducing onsite and offsite trackout during construction

Rock-filled stormwater channels and erosion control blankets used for excavation and backfilling at former U.S. Navy landfill

http://cicacenter.org/cs.cfm

Core Elements: Land & Ecosystems

- Minimal habitat disturbance such as noise and lighting
- Soil and sediment protection from compaction, decon, or uncontrolled traffic
- Use of local byproducts such as fly ash or ag waste
- Ecosystem restoration and protection practices such as selecting native plant species and relocating affected animals

Metal salt crust along Upper Arkansas River in Colorado prior to Superfund removal

Ten years after applying municipal biosolids and assorted nutrients along the Arkansas River

"I promise I'll walk and feed him"

… alligator rescues during removal actions at contaminated swampland in Georgia

Core Elements: Material Consumption & Waste Generation

- Site cleanups often require demolition work, use raw materials and generate waste
- Reuse and recycling of materials, including C&D debris and clean metal
- Reduction of secondary wastes such as soil corings, wastewater, expended chemicals, routine supplies, and single-use materials
- Passive sampling devices producing minimal waste
- Minimized extraction and disposal of natural resources

10,000³-yd soil removal in Georgia yielding 280 tons of scrap steel and 58 tons of tin left by past wood treating

Concrete salvaging during cleanup at Barksdale AFB in Louisiana to help meet federal "greening the government" goals

Triad planning for 10-day mobilization to investigate plus conduct removal at Paducah GDP in Kentucky, and only 23 lab samples

Core Elements: Energy Requirements

- Renewable energy systems in remote locations or to offset grid electricity
- Optimized and effective treatment systems
- Energy efficient equipment operating at peak performance

PV array to pump 2-3 gpm of water through a low-energy mulch bioreactor at Altus AFB in Texas

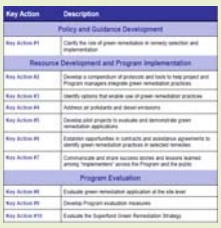
10-kW turbine for ground water circulation, reducing grid electricity consumption by 26% at former Nebraska ordnance plant

Portable PV system for 5-month SVE after oil pipeline break at Rocky Mountain House air base in Alberta, Canada

OSWER Green Remediation "Strategy"

Major efforts in U.S. EPA/OSWER to advance green remediation best practices across cleanup programs:

- **Principles for Greener Cleanups**: Common policy position for all U.S. EPA cleanup programs
- **Superfund Green Remediation Strategy**: "Operationalizing" the Principles in the Superfund Cleanup Program
- **Voluntary Green Cleanup Standards & Certification System**: A robust tool for fostering greener cleanups in the various cleanup programs
- **RE-Powering America's Land**: Renewable energy on contaminated lands



More Information from U.S. EPA

CLU-IN Green Remediation Focus

www.clu-in.org/greenremediation

Aerojet-General Corporation	CA		☀	☁			
Altus Air Force Base	OK		☀	☁	💧		♻
Apache Powder	AZ		☀	☁	💧		
Barksdale AF Base	LA				💧	🌲	♻
BP Casper	WY					🌲	♻
BP Paulsboro	NJ		☀	☁			
California Gulch	CO			☁			♻
Crozet Orchard	VA		☀	☁	💧		
De Sale Restoration Area	PA		☀	☁	💧	🌲	♻
Delfasco Forge	TX		☀	☁			♻
Former Carswell Air Force Base	TX		☀	☁			♻
Former Ferdula Landfill	NY		☀	☁			
Former Nebraska Ordnance Plant	NE		☀	☁			
Former St. Croix Alumina Plant	VI		☀	☁			♻
Fort Carson	CO		☀	☁	💧		♻
Frontier Fertilizer Superfund Site	CA		☀	☁			