



## RCRA Corrective Action Training Program: Getting to YES! *Strategies for Meeting the 2020 Vision*



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## Module 8 Greener Cleanups and Reuse

Part 1 - Basic Concepts  
Part 2 - Implementation

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## What is a Greener Cleanup?



The practice of considering:

- ❖ all environmental effects of a cleanup
- ❖ during each phase of the process, and
- ❖ incorporating strategies to maximize the net environmental benefit of the cleanup.

**Starting Points:**

- Cleaning up contaminated sites is inherently “green”
- Cleanup objectives must be achieved

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## What a Greener Cleanup is NOT?

- ❖ An excuse to:
  - implement only monitored natural attenuation
  - not meet cleanup objectives
  - slow the pace of cleanup activities

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## Greener is a Federal Priority

*"As the largest consumer of energy in the U.S. economy, the Federal government can and should lead by example when it comes to creating innovative ways to reduce greenhouse gas emissions, increase energy efficiency, conserve water, reduce waste, and use environmentally-responsible products and technologies..."*

White House E.O 13514. 2009. Federal Leadership in Environmental, Energy, and Economic Performance, October 5.



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## OSWER Cross-Program Greener Cleanup Principles

- ❖ Cleanups must meet cleanup objectives, comply with regulatory criteria, and consider community input
- ❖ All OSWER cleanup programs, including RCRA Corrective Action, are encouraged to consider the 5 elements when selecting and implementing cleanups.
  - Total Energy Use and Renewable Energy Use
  - Air Pollutants and Greenhouse Gas Emissions
  - Water Use and Impacts to Water Resources
  - Materials Management and Waste Reduction
  - Land Management and Ecosystems Protection
- ❖ As tools are developed, OSWER will work to document reductions in the environmental footprint of cleanup projects
- ❖ Recognize that green cleanup approaches will vary from site to site and from program to program




EPA. 2009. Greener Cleanup Principles. Mathy Stanislaus, AA of OSWER. August 27. [http://www.epa.gov/oswer/greencleanups/pdfs/oswer\\_greencleanup\\_principles.pdf](http://www.epa.gov/oswer/greencleanups/pdfs/oswer_greencleanup_principles.pdf)

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## Current Initiatives


- ❖ EPA
  - OSWER Principles for Greener Cleanups and related OSWER program activities
  - Superfund Green Remediation Strategy
  - Regional Greener Cleanup Policies and Activities
- ❖ Others
  - Executive Order 13514 on Federal Leadership in Environmental, Energy, and Economic Policy (October 5, 2009)
  - ASTM developing Green Cleanup Standard (EPA participating)
  - ASTSWMO Greener Cleanups Task Force
  - States (IL, CA, MN, WI)
  - ITRC Green and Sustainable Team
  - Sustainable Remediation Forum (SURF) industry workgroup
  - Other Federal Agencies (e.g., Air Force, Army)



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## Greener Applies to all Cleanup Phases





- ❖ Interim remedial action
- ❖ Investigation
- ❖ Remedy selection and construction
- ❖ Remedy operation and monitoring
- ❖ Site demolition
- ❖ Site closeout
- ❖ Redevelopment and reuse
- ❖ Remedy Optimization

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 **Examples of Some Green Practices** 


  
Site where 93% of C&D materials were recycled


  
DPT drilling to minimize investigative derived waste (IDW) (continued)


  
Silt fence used during IRM to protect wetland


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 **Examples of Some Green Practices** 


  
Water truck used during construction to control dust

  
Excavated soils characterized during construction for reuse as fill

  
Solar panels used to power pumps for groundwater cleanup

  
Constructed wetland incorporated into site redevelopment

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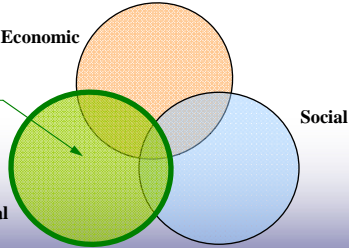


## Sustainability and Green Cleanups


**Sustainability Defined:**

*Meeting the needs of the present without compromising the ability of future generations to meet their needs.*



**Greener Cleanups focus on reducing environmental impacts, which can have environmental, social and economic benefits**




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## Sustainability Hierarchy





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## Core Elements of Greener Cleanups

- ❖ Minimize total energy use and maximize renewable energy use
- ❖ Minimize air pollutants and greenhouse gas emissions
- ❖ Minimize water use and impacts to water resources




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## Core Elements of Greener Cleanups


- ❖ Reduce, reuse, recycle material and waste
- ❖ Optimize future land use and protect ecosystems
- ❖ Optimize sustainable management practices during stewardship




EPA. 2008. Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites. EPA542-R-08-002. April.



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## Benefits of Considering Core Elements



- ❖ Reduce local environmental impact
- ❖ Reduce GHG and other broader impacts
- ❖ Reduce project impacts on community
- ❖ In some instances, reduce costs

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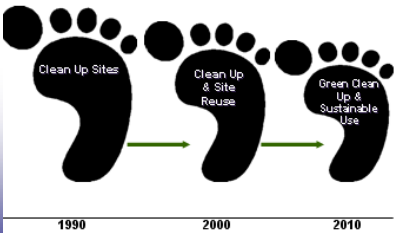


## Analyses and Footprints

- ❖ *An environmental footprint is the environmental impact associated with the activities, products and services of a project.*
- ❖ *“Green cleanup environmental footprint assessments should be conducted in a transparent manner and should include, at a minimum, energy use, air emissions, water impacts, materials use, and land and ecosystem protection.” (OSWER Green Cleanup Principles)*

*Environmental Footprint considers :*

- *amount of depletable raw materials and nonrenewable resources consumed,*
- *Air emissions, generation of wastes, contamination of soils and water*
- *Reducing the impact on the environment.*



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## Case Study

- ❖ Remedy Objectives
  - Recover hydrocarbons from groundwater
  - Use renewable energy systems
- ❖ Implementation
  - 6 wind turbines and 6 photovoltaic panels power submersible pumps and fluid-gathering system
  - Recovered petroleum product recycled at adjacent oil refinery

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## Part 2 - Implementation

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## RCRA Remedy Selection Criteria

**Threshold Criteria**


- ❖ Protect Human Health & the Environment
- ❖ Control Sources
- ❖ Meet Cleanup Objectives

**Balancing Criteria**

- ❖ Long-term reliability
- ❖ Reduction of toxicity, mobility or volume
- ❖ Short-term effectiveness
- ❖ Ease of implementation
- ❖ Cost
- ❖ Community acceptance
- ❖ State acceptance

❖ **Green and Sustainable Practices**

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## Greener Cleanup Decision Process

**Steps:**

Process

**1.**

Exit Strategy

Identify Cleanup Objectives

Develop Conceptual Site Model

**2.**


Pick Remedies that Work!

Evaluate Technologies

**3.**

Apply Green Principles


Identify and Reduce Environmental Impacts




## Greener Cleanup Decision Process

### Balance Inputs and Impacts to Maximize Benefits

- ❖ **Inputs**
  - Raw materials, energy
- ❖ **Environmental Impacts**
  - Air and water quality
  - Solid waste, by-products
- ❖ **Benefits**
  - Reduced environmental impacts
  - Allows land use
  - Community

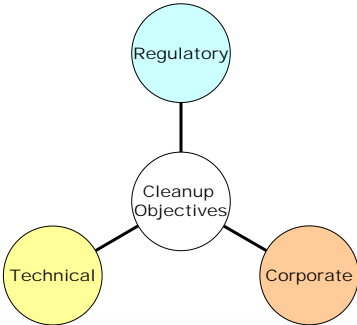


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## Scenario


### Site with Soil and Groundwater Contamination



*Screen Technologies, then Rank Alternatives!*

- ❖ **Technical Issues**
  - Municipal well-field nearby
  - Sandy soil
  - Buildings over soil contamination
  - Soil is leaching into groundwater
- ❖ **Corporate Issues**
  - Long-term operating facility
  - Prefer not to demo buildings
  - Eliminate liability, but control capital costs
  - Protect workers from vapor intrusion


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## Qualitative Analysis for Soil


<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	☺							
SVE	☺							

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## Qualitative Analysis for Soil


<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	☺							
SVE	☺	☺						



Excavation: Electric Trucks, Excavators – Not yet!


SVE: Solar, Wind Powered – YES!

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## Qualitative Analysis for Soil


<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	✔							
SVE	✔	✔	✔					




**Excavation: 270,000 kWh \***

**SVE: 58,000 kWh \***

Source: *Sustainable Remediation Tool*  
Air Force Center for Engineering and the Environment, <http://www.afcee.af.mil>




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## Qualitative Analysis for Soil


<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	✔							
SVE	✔	✔	✔	✔				



**Excavation: Fill material, water for dust control**

**SVE: Construction materials, carbon**

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## Qualitative Analysis for Soil

<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	✔							
SVE	✔	✔	✔	✔				

*Now*


Immediate impacts?

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*Future*

Future Impacts?

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## Qualitative Analysis for Soil

<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	✔							
SVE	✔	✔	✔	✔	✔			

*Now*

Excavation: GHG emissions, volatilization

SVE: Can treat off-gas

1.3 lbs CO<sub>2</sub> per kWh

20 lbs CO<sub>2</sub> per gal gasoline

US DOE, 2000


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*Future*

Excavation: No air impacts

SVE: Vapor intrusion

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## Qualitative Analysis for Soil

<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	✔					✔		
SVE	✔	✔	✔	✔	✔			

*Now*

**Excavation:** Dewatering waste stream  
**SVE:** None




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*Future*

**Excavation:** No groundwater or surface water impacts  
**SVE:** Condensate

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## Qualitative Analysis for Soil

<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	✔					✔		
SVE	✔	✔	✔	✔	✔		✔	

*Now*

**Excavation:** Contaminated soil  
**SVE:** Construction debris




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*Future*

**Excavation:** None  
**SVE:** Carbon, scrap metal

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## Qualitative Analysis for Soil

<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	✔					✔		
SVE	✔	✔	✔	✔	✔		✔	✔

**Now**

**Excavation:** Site can be redeveloped quickly; landfill space need for excavated soil

**SVE:** More flexible to implement since existing structures will remain


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**Future**

**Excavation:** Site reuse/redevelopment

**SVE:** Risk of vapor intrusion

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## Qualitative Analysis for Soil

<u>SOIL</u>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
Excavation	✔					✔		
SVE	✔	✔	✔	✔	✔		✔	✔

**Now**

**Excavation:** More energy, higher emissions  
Can be implemented during site redevelopment

**SVE:** Better if existing facility, less energy & materials

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**Future**

**Excavation:** Good source Rx, No ICs, allows redevelopment

**SVE:** Less energy & materials, greater flexibility to implement

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## Qualitative Analysis for GW

<b>GROUNDWATER</b>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
MNA, NFA w/ICs	☺							
Bio	☺							
Thermal Treatment (ERH)	☺							
Pump & Treat	☺							

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## Qualitative Analysis for GW

<b>GROUNDWATER</b>		Inputs			Environmental Impacts			
Remedial Technology	Meets Cleanup Objectives	Renewable Energy Sources	Non-Renewable Energy Use	Natural Resources	Air Quality	Water Quality	Solid Waste	Land Use
MNA, NFA w/ICs	☺	☺	☺	☺	?		☺	
Bio	☺	☺	☺	☺	☺	☺	☺	☺
Thermal Treatment (ERH)	☺				☺	☺		☺
Pump & Treat	☺	☺				?		

- ❖ Bio may be right choice, but many other factors go into decision
- ❖ When multiple technologies can meet cleanup goals, decision becomes more quantitative

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## Example of Quantitative Analysis

Alternatives

	Hybrid	Bio	P&T
<b>Materials</b>			
PVC Pipe (lbs)	11,000	9,000	20,000
Cement (ft3)	70	70	70
Molasses (gallons)	140,000	220,000	0
Water (gallons)	4,500,000	6,800,000	0
<b>Energy</b>			
Diesel Fuel (gallons)	20,000	11,000	40,000
Gasoline (gallons)	8,000	8,000	4,000
Electricity (kWh)	10,000,000	20,000	42,000,000
<b>Waste Generation</b>			
Spent Carbon (lbs)	1,200,000	0	3,900,000
Wastewater (gallons)	1,600,000,000	0	5,300,000,000
<b>Air Emissions</b>			
CO <sub>2</sub> (tons)	5,000	200	19,000
<b>Other</b>			
Road Distance (miles)	300,000	200,000	300,000
Remediation Time (years)	16	11	21


Inputs

Relatively high impact

Relatively low impacts

Similar impacts

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## Greener Cleanup Tools and Resources

**Greener Cleanups is a new and evolving field. EPA will post new tools and resources as they are developed. Resources include:**

- EPA’s Green Remediation Toolbox
- Best Management Practices and Fact Sheets
  - Excavation and Surface Restoration
  - Pump and Treat (coming soon)
  - Site Investigation (coming soon)
- Environmental and Energy Footprints and Case Studies

**EPA’s Key Green Cleanup Websites**  
[www.epa.gov/oswer/greencleanups](http://www.epa.gov/oswer/greencleanups)  
[www.clu-in.org/greenremediation](http://www.clu-in.org/greenremediation)



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## Remedial System Operation

- ❖ Have cleanup objectives changed?
- ❖ Periodic review of performance indicators and treatment costs
- ❖ Use Data Quality Objectives to optimize sampling activities
- ❖ Can we downsize equipment?

*Consider New & Emerging Technologies or Regulatory Approaches*




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## Ongoing EPA Activities

- **Superfund Green Remediation Strategy (Draft)**
- **Participating in ASTM Green Cleanup Standard Development Process**
- **Regional Green Cleanup Policies, Trainings, and Activities**
- **Developing Technical documents, BMPs, case studies (OSRTI and other OSWER offices)**
- **Internet sessions**
- **ORCR including Green Remediation Module in RCRA CA training**


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## On the Horizon

### Watch for:


- ❖ New tools for estimating environmental footprint
- ❖ ASTM cleanup standards initiative
- ❖ Information on emerging technologies
- ❖ More pilots and case studies
- ❖ Product research guides (LID/LEED)



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## Remember...



- ❖ Cleaning up a site is inherently green
- ❖ Look holistically at each project
- ❖ Identify environmental impacts early
- ❖ Look for opportunities to reduce environmental impacts in each phase of cleanup and reuse

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