United States Environmental Protection Agency

Office of Solid Waste and Emergency Response (5102G)

EPA 542-F-11-008
June 2011

Green Remediation Best Management Practices:
Sites with Leaking Underground Storage Tank Systems

Office of Superfund Remediation and Technology Innovation — Quick Reference Fact Sheet

The U.S. Environmental Protection Agency (EPA) *Principles for Greener Cleanups* outline the Agency's policy for evaluating and minimizing the environmental "footprint" of activities undertaken when cleaning up a contaminated site.[1] Use of the best management practices (BMPs) identified in EPA's series of green remediation fact sheets can help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome.[2]

Overview

Almost 495,000 releases of petroleum from federally regulated underground storage tanks (USTs) have been reported to EPA as of September 2010. Of these, over 93,000 UST site cleanups remain. The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) estimates that cleaning up UST system releases costs the states approximately $700 million each year,[3] in addition to federal expenditures under the Leaking Underground Storage Tank (LUST) Trust fund and costs paid by responsible parties.

State agencies maintain responsibility to implement and oversee corrective actions at UST sites, with the exception of federal authority for UST site cleanup in Indian country. The majority of these actions involve UST systems for petroleum fuel rather than chemicals containing hazardous substances and most involve retail fueling stations. Common contaminants associated with fuel releases include benzene, toluene, ethylbenzene, and xylenes (BTEX) and sometimes other chemicals of concern such as methyl *tert*-butyl ether (MTBE), ethanol, or lead scavengers (ethylene dibromide and 1,2-dichloroethane).

Releases of petroleum, used oil, or chemicals can result from problems such as corrosion of the tank or attached pipes, structural failure, or faulty installation. In addition to the tank, components of an UST system include connected underground piping, underground ancillary equipment, and the containment system, if any.

An UST cleanup that involves ***excavating*** *5,000 cubic feet of soil and* ***operating a soil vapor extraction system*** *over three years for deeper soil could emit* ***190 tons of carbon dioxide equivalent,*** *approximately the same amount emitted through electricity consumption of 21 homes over one year.*

Core Elements of Green Remediation

- *Reducing total energy use and increasing the percentage of energy from renewable resources*
- *Reducing air pollutants and greenhouse gas (GHG) emissions*
- *Reducing water use and negative impacts on water resources*
- *Improving materials management and waste reduction efforts, and*
- *Protecting ecosystem services during cleanup*

Use of green remediation BMPs to remediate these sites can help minimize the environmental footprint of cleanup activities and improve corrective action outcomes. The practices for UST cleanups are intended to complement rather than replace federal requirements for corrective actions (40 CFR Part 280, subpart F). The practices also may enhance state-administered UST programs, which have state-specific corrective action requirements.

"All cleanup approaches, and all elements of the cleanup process, can be optimized to enhance their overall environmental outcome; therefore, ***green remediation involves more than merely adopting a specific technology or technique****."* EPA Principles for Greener Cleanups[1]

Many green remediation BMPs are standard operating procedures that are borrowed from the construction, industrial, and other business sectors working to reduce their environmental footprint. Some involve little or no additional cost while others may involve initial expenditures that can be recovered over the life of a cleanup project. EPA recognizes that project management discretion is involved when comparing the technical feasibility as well as the cost of implementing some BMPs at a given site. Applicability of each BMP may also differ due to variability in site conditions such as the type of stored liquid, UST system size, or anticipated site reuse.

EPA encourages UST cleanup project managers to procure services from contractors, environmental or engineering consultants, and laboratories demonstrating a commitment to the core elements of green remediation. Opportunities to reduce the environmental footprint of cleanup are found during each major phase of activity:

- *Characterizing the site*
- *Removing or replacing a tank system*, and
- *Remediating contaminated environmental media.*

Characterizing the Site

Integrating green remediation ("greener cleanup") BMPs early during the initial response, investigative, and project design phases can help reduce the cumulative footprint of an UST cleanup. *Site investigation BMPs* include:

- Using dynamic, real-time decision-making strategies such as Triad to minimize energy and other resources needed for field mobilization and sampling efforts[4]
- Deploying geophysical tools such as ground penetrating radar or electromagnetic surveys to define boundaries of buried tanks without disturbing land
- Maximizing use of portable meters with photoionization or flame ionization detectors to screen soil cuttings or sample cores for contaminant presence, to efficiently locate materials needing excavation and minimize initial needs for sample analysis by offsite laboratories
- Selecting direct push (DP) tools to collect subsurface samples wherever site conditions allow, rather than conventional drilling systems that typically involve more fuel consumption, land disturbance, and investigation-derived waste
- Equipping DP tools with real-time qualitative tools such as membrane interface probes or laser induced fluorescence, wherever warranted by site complexity, to additionally reduce remobilizations and investigation-derived waste generation
- Using field test kits that minimize needs for offsite analysis of samples and selecting test kits that generate minimal waste
- Integrating remote sampling approaches such as solar-powered telemetry systems to reduce field trips, and
- Deploying mobile laboratories to reduce off-site sample analysis if a high volume of samples is anticipated.

Other techniques resulting in a smaller footprint of field activities include:

- Choosing biodegradable hydraulic fluids on hydraulic equipment such as drill rigs
- Using closed-loop cleaning systems relying on graywater to wash non-sampling related machinery and equipment
- Steam-cleaning or using phosphate-free detergents instead of organic solvents or acids to decontaminate sampling equipment
- Containing decontamination fluids and preventing their entrance into storm drains or the ground surface, and
- Segregating and stockpiling drill cuttings for potential onsite distribution of clean soil.

Additional BMPs are described in EPA's companion fact sheet, *Green Remediation Best Management Practices: Site Investigation*.[5a]

BMPs for *green purchasing* may be introduced to an UST cleanup project during the investigative phase and carried forward to cleanup activities. For example, project managers can:

- Choose products manufactured through processes involving nontoxic chemical alternatives
- Select products with recycled and biobased contents such as agricultural or forestry waste instead of petroleum-based ingredients; EPA offers recycled product listings and procurement guidelines specific to construction, landscaping, and other materials markets[6]
- Use products, packing material, and disposable equipment with reuse or recycling potential
- Use the Electronic Product Environmental Assessment Tool (EPEAT®)[7] to find electronic products with reduced impacts on the environment and Energy Star® ratings on energy efficiency of other products,[8] and
- Select locally made materials whenever possible.

Other BMPs concerning *project administration* include:

- Establishing reduced paperwork systems such as electronic networks for data transfers and deliverables, team decisions, and document preparation
- Reducing travel through increased teleconferencing, and selecting hotel and meeting facilities with green policies when project meetings are needed, and
- Establishing simple record-keeping procedures for green remediation measures such as fuel consumption, groundwater replenishment, and material recycling.

EPA Region 9 investigation of LUST-contaminated soil and groundwater affecting Navajo Nation and Hopi Tribe tribal lands near Tuba City, AZ, involved use of a conceptual site model and mobile laboratory to guide subsurface application of food-grade vegetable oil that accelerated bioremediation of contaminated soil.

BMPs regarding *onsite and offsite transportation* can help reduce the environmental footprint of UST system removals and follow-on site remediation. Opportunities to reduce air pollutant emission from internal combustion engines in vehicles and stationary sources involve identifying local service providers who maximize use of:

- Operation and maintenance plans resulting in lower consumption of petroleum fuel, such as standard operating procedures to reduce engine idle
- Advanced diesel technologies such as diesel oxidation catalysts, diesel particulate matter filters, and partial diesel particulate filters
- Fuel efficient and alternative vehicles such as plug-in electric vehicles for onsite data collection and hybrid

electric vehicles for longer offsite travel; EPA's *Green Vehicle Guide* can help decision-makers evaluate the options when choosing vehicles,[9] and
- Alternative fuels and fuel additives, including biodiesel blends and ultra low-sulfur diesel for all diesel-powered machinery and equipment.

Other methods to reduce liquid fuel consumption and air emissions during UST site cleanup involve increased substitution of petroleum fuel with sources of renewable energy, particularly for powering remediation components or auxiliary equipment with a low energy demand. A small off-grid wind turbine and/or or photovoltaic (PV) system, for example, can be equipped with deep-cycle batteries to provide relatively steady power.

Electricity for various needs can be generated onsite by mobile systems that capture renewable energy.

Recovery of petroleum products from groundwater at the former Adak Naval Complex in Alaska was powered by a mobile wind turbine.

Details on benefits, costs, and other factors that can help managers select and implement the most suitable methods to reduce transportation-related footprints are provided in EPA's *Green Remediation Best Management Practices: Clean Fuel & Emission Technologies for Site Cleanup*.[5b]

Decision-makers can also investigate methods for reducing air emissions caused by *long-distance transport* of incoming materials or outgoing waste, such as:

- Procuring services or materials from partners or affiliates in EPA's SmartWay transport partnership[10]
- Considering railroad instead of truck transport, and
- Consolidating deliveries and schedules to avoid deploying partially filled trucks.

Removing or Replacing a Tank System

A major contributor to the environmental footprint of an UST cleanup is the deployment of heavy machinery for excavation, tank system removal, and site restoration. Many related BMPs are described in EPA's *Green Remediation Best Management Practices: Excavation and Surface Restoration*.[5c] Selection of suitable BMPs when removing an UST system during site cleanup may be affected by conditions such as groundwater depth, soil permeability, and subsurface rock types. Greener cleanup BMPs applying to *UST removals* include:

- Segregating and stockpiling excavated soil and material that is clean or minimally contaminated for beneficial reuse
- Covering ground surfaces with re-useable tarp in areas used for fluid extraction and transfer
- Minimizing the volume of water used for rinsing a tank (where allowed by state and local agencies) prior to removal, to generate less waste water
- Flushing system pipes with nitrogen instead of water to reduce waste generation
- Controlling odor and fugitive dust by applying bio-degradable foam on equipment and soil surfaces
- Transferring extracted fuel or chemicals to local recyclers who use environmentally sound procedures, and
- Disposing tanks, piping, and other metal components at a state-approved or -certified tank disposal yard for recycling instead of a landfill.

Surgical excavation and tank removal at the G&L Clothing site in Illinois allowed for minimal site disturbance and maximum recycling or reuse of excavated materials.

Profile: G&L Clothing Cairo, IL

- *Planned investigative and remedial activities that minimized mobilization of staff and equipment for removing two 1,000-gallon gasoline USTs and one 5,000-gallon diesel UST from an abandoned gasoline station*
- *Reduced offsite transportation and associated resources by maximizing deployment of local workers and suppliers*
- *Reduced the number of investigative samples by holistically approaching the target area as a single tank pit rather than three adjacent pits*
- *Conserved fuel by placing engine idle restrictions on construction equipment*
- *Reduced air emissions by using an excavator equipped with emission controls meeting EPA Tier II standards for non-road diesel equipment*
- *Avoided unnecessary double-crushing of excavated materials by loading excess concrete directly from the excavation pit into dump trucks*
- *Reclaimed the excavated tanks for recycling by a local auto salvage business, and*
- *Minimized the amount of imported soil needed as backfill during site redevelopment (for a retail clothing store) by reusing approximately 50 tons of demolition concrete that was crushed onsite*[11]

Cleanup activities that involve removing an UST system are often integrated with site plans to continue using an underground storage facility for industrial or retail purposes. *Tank system replacement* steps that could be taken by owners and operators to minimize potential for petroleum or chemical releases and improve release detection could include:

- Avoid interior lining of tanks or use cathodic protection when lining is in place
- Use secondarily contained tanks and piping
- Use tanks and piping made of steel that are coated and cathodically protected, tanks and piping made of non-corrodible materials, or tanks that are not subject to exterior corrosion (such as clad or jacketed steel tanks)
- Avoid ball floats as a means to prevent tank overfills
- Install upgraded alarm systems
- Increase the frequency of cathodic protection system tests
- Check release detection equipment at least annually according to manufacturer recommendations
- Avoid reliance on groundwater or soil vapor monitoring results as a means of leak detection, and
- Institute non-cumbersome "paper trails" that can facilitate stronger environmental stewardship among short- or long-term UST owners and operators.

Current protocols for release detection systems do not address ethanol blended fuels available in today's market. Information about selecting leak detection technologies for ethanol blends is available in a new quality assurance plan available from EPA's Environmental Technology Verification (ETV) Program.[12] The National Renewable Energy Laboratory offers additional information about biodiesel storage, handling, and use.[13] EPA is developing guidance on the compatibility of UST systems with biofuels, including ethanol-blended fuels containing greater than 10% ethanol; release of the guidance is expected in 2011. Some states also have policies in place regarding ethanol-blended fuel storage.

Important BMPs for restoring land following tank system removal or replacement include:

- Using native species of plants for revegetation, which typically need little or no maintenance such as irrigation
- Finding beneficial use for woody debris, such as onsite or offsite landscaping or habitat creation
- Using low impact development techniques such as creating bioswales to reduce water runoff, and
- Using pervious construction materials for vehicle or pedestrian traffic areas to increase water infiltration to the subsurface of redeveloped sites.

Remediating Contaminated Environmental Media

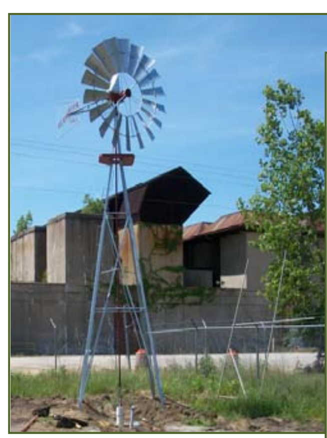
Technologies used for UST cleanups often involve one or a combination of technologies such as groundwater pump-and-treat systems, soil excavation and disposal, soil vapor extraction, air sparging, bioventing, bioremediation, dual-phase extraction, and in situ chemical oxidation.[14] EPA's Office of Superfund Remediation and Technology Innovation (OSRTI) offers companion fact sheets detailing green remediation *BMPs tailored to cleanup technologies*:

- *Pump and Treat Technologies*[5d]
- *Bioremediation*,[5e] and
- *Soil Vapor Extraction & Air Sparging*.[5f]

Decisions on how to implement these and other technologies can be enhanced by assessing their environmental footprint on a site by site basis. The *Green Remediation Focus* Web site sponsored by OSRTI offers a compendium where over 50 free tools such as online calculators and software can be easily accessed to assess one or more elements of a greener cleanup.[15] Other online material includes site-specific results of applying a footprint assessment methodology designed by EPA to include all elements of a greener cleanup, as outlined in the Agency's *Principles for Greener Cleanups*. Organizations conducting or managing multiple UST cleanups with similar site conditions may save resources by also using these tools and examples to select a suite of BMPs that form a technology implementation model.

The environmental outcome of UST site cleanups through use of nearly any technology may be improved through *general BMPs for remediation*:

- Considering tradeoffs associated with energy use and air emissions when evaluating the potential for leaving waste in place at a portion of the site, if site-specific risk criteria can be met with minimal institutional controls
- Assuring proper sizing of remediation equipment that allows minimal rates of energy consumption while sustaining the target cleanup pace
- Periodically reassessing and optimizing existing treatment systems to maintain peak operating performance and identify opportunities for taking any equipment offline as cleanup progresses
- Developing an infrastructure for the remedial system that can be integrated with site reuse
- Switching to a "polishing" remedy once effectiveness of an existing treatment system declines, as evidenced by significant decreases in mass recovery rates, and
- Recovering and recycling separated non-aqueous phase liquid (NAPL) through local fuel or waste recyclers.



Two 21-foot windmills provide mechanical power to extract groundwater for light NAPL recovery at the Hanover brownfield site in South Bend, IN, which was contaminated by two fuel USTs; capture of wind energy avoids the need for two 1-horsepower pumps and reduces consumption of grid electricity by at least 1.5 kW.

Project managers are encouraged to implement an UST remediation *monitoring plan* that reflects BMPs such as:

- Establishing a schedule for environmental sampling that minimizes frequency of sampling events while assuring cleanup progress
- Evaluating environmental monitoring results on a regular basis (possibly quarterly) to identify opportunities for reducing or eliminating unnecessary analyses
- Using remote monitoring techniques to assure effective operation of treatment systems with fewer site trips, and
- Seeking opportunities for integrating remediation monitoring with future use of the site.

An off-grid PV system at Brooks Camp, AK, powered an air sparging pump that operated only during daylight hours, which sufficiently treated contaminated groundwater while avoiding energy loss and freeze potential associated with battery storage.

Profile: Brooks Camp, Katmai National Park and Preserve, AK

- *Minimized land disturbance during remedial construction in this archeologically and biologically sensitive property of the National Park Service (NPS) by surgically removing vegetation in the treatment area and using compact designs*
- *Began operating an in situ remediation system in 1998 involving bioremediation (via injection of oxygen releasing compounds), air sparging, and bioventing to treat soil and groundwater contaminated by two former petroleum LUSTs*
- *Optimized energy use through treatment design allowing use of a single 1.5-horsepower blower to alternately operate the air sparging and bioventing equipment in four-hour increments*
- *Housed the aboveground mechanical equipment in a prefabricated treatment shed with south-facing windows that provide interior daylighting*
- *Eliminated unnecessary energy consumption by taking the bioventing system offline after two years of operation, when sampling indicated a source reduction in diesel-range organics to below cleanup levels set by the Alaska Department of Environmental Conservation*
- *Installed an onsite, 770-watt PV system in 2000 for powering the air sparging pump, to avoid continued use of the site's diesel-powered generator and assure ongoing treatment operations at this remote location, and*
- *Began re-purposing the PV system in 2006 (when cleanup goals were met and the system was no longer needed for remediation) to meet other critical energy needs evolving at Brooks Camp*[16]

Similar or additional green practices established by other federal or state programs and sectors also can be explored. For example, EPA recommends incorporation of green practices into construction projects funded through the American Recovery and Reinvestment Act (ARRA) of 2009, many of which involve UST site cleanup. In addition to incorporating EPA's recommendations, some states maintain supplemental criteria applying to UST cleanups. The Minnesota Pollution Control Agency, for example, requests contractors and vendors at ARRA-funded LUST sites to report on use of greener cleanup practices for purchasing, transportation, field and laboratory work, and materials and waste management.[17]

Another example is the Smart Growth Network, which identifies principles that can minimize air and water pollution and preserve natural lands during property development.[18] Implementation of the principles at UST sites can help integrate a greener cleanup into site reuse. As a member of the network, EPA offers technical assistance and funding to organizations and communities working toward smart growth and sustainability.

Sustainable redevelopment of a remediated brownfield site formerly used as a gasoline station in Eugene, OR, focused on building a biofuel station with solar power along with low impact development elements such as bioswales; the biofuel is made of discarded cooking oil collected across the state.

Lane County-Sequential Biofuels, 2007 Phoenix Award

A Sampling of Success Measures for UST Site Cleanup

- *Reduced land disturbance during site investigation due to substitution of exploratory excavation or drilling with advanced geophysical techniques*
- *Lower emission of GHG, particulate matter, and other air toxics due to fewer field mobilizations and associated fuel consumption*
- *Beneficial use of local industrial or agricultural waste as reactive media for onsite soil treatment*
- *Higher percentages of demolition material transferred to recycling facilities instead of municipal landfills*
- *Beneficial use of treated groundwater for onsite purposes such as irrigation rather than treatment-water discharge to a public sewer system*
- *Increased offsets of air emissions and lower monthly utility costs due to capture of onsite renewable energy*

UST Site Cleanup: Recommended Checklist

Characterizing the Site

- ✓ Use investigative techniques involving minimal land disturbance, field mobilization, and waste generation
- ✓ Employ green purchasing techniques for products and services
- ✓ Institute greener methods for project administration and accounting
- ✓ Establish mechanisms to assure use of EPA's BMPs for using clean fuel and emission technologies throughout the project

Removing or Replacing a Tank System

- ✓ Use surgical excavation techniques that minimize land disturbance
- ✓ Prevent spillage and control odors and fugitive dust when emptying a tank and recycle all reusable fluids
- ✓ Use advanced equipment for release prevention and detection when replacing an UST system as part of integrated site remediation and redevelopment
- ✓ Restore excavated areas quickly with native plants or pervious ground covers, depending on site reuse

Remediating Contaminated Environmental Media

- ✓ Employ EPA's BMPs for commonly used remediation technologies such as pump-and-treat systems, bioremediation, and soil vapor extraction
- ✓ Optimize remedial operations through proper equipment sizing and frequent reassessment
- ✓ Establish operating or performance criteria that could trigger use of less intensive polishing technologies as cleanup progresses
- ✓ Substitute electricity drawn from the utility grid with power generated by onsite renewable energy resources
- ✓ Deploy long-term monitoring techniques that rely on remote sensing/control technology, with potential integration into site reuse

EPA and state organizations offer ***additional resources*** to help project managers reduce the environmental footprint of UST corrective and remedial actions:

- EPA's *Greener Cleanups Contracting and Administrative Toolkit*, which contains samples of specifications used by EPA regions and other government agencies in cleanup service contracts, records of decision, and other administrative documents[19]
- Information on green remediation and other UST initiatives of the ASTSWMO LUST Task Force and Greener Cleanup Task Force,[20] and
- Updated methods, resources, and guidance from EPA's Office of Underground Storage Tanks.[21]

References [Web accessed: May 2011]

1 U.S. EPA; *Principles for Greener Cleanups;* August 27, 2009; http://www.epa.gov/oswer/greencleanups/principles.html

2 U.S. EPA; *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites*; EPA 542-R-08-002, April 2008; http://www.cluin.org/greenremediation

3 ASTSWMO; State Funds Survey Results 2010; http://www.astswmo.org/Pages/Policies_and_Publications/Tanks.htm

4 Triad Resource Center; http://www.triadcentral.org

5 U.S. EPA OSWER; http://www.cluin.org/greenremediation; *Green Remediation Best Management Practices*:
[a] *Site Investigation*; EPA 542-F-09-004, December 2009
[b] *Clean Fuel & Emission Technologies for Site Cleanup*; EPA 542-F-10-008, August 2010
[c] *Excavation and Surface Restoration*; EPA 542-F-08-012, December 2008
[d] *Pump and Treat Technologies;* EPA 542-F-09-005, December 2009
[e] *Bioremediation;* EPA 542-F-10-006, March 2010
[f] *Soil Vapor Extraction & Air Sparging*; EPA 542-F-10-007, March 2010

6 U.S. EPA; Resource Conservation – Comprehensive Procurement Guidelines; http://www.epa.gov/epawaste/conserve/tools/cpg/products/index.htm

7 Green Electronics Council; EPEAT; http://www.epeat.net/

8 U.S. EPA; Find Energy Star Products; http://www.energystar.gov/index.cfm?c=products.pr_find_es_products

9 U.S. EPA; Green Vehicle Guide; http://www.epa.gov/greenvehicles/Index.do

10 U.S. EPA; SmartWay Transport Partnership; http://www.epa.gov/smartway/transport/partner-list/index.htm

11 Pers. comm., Joyce Munie, IL EPA (joyce.munie@illinois.gov)

12 U.S. EPA ETV Program; Advanced Monitoring Systems Center; http://www.epa.gov/etv/etvoice0910.html

13 National Renewable Energy Laboratory; *Biodiesel Handling and Use Guide*; Fourth Edition, NREL/TP-540-43672; January 2009; http://www.nrel.gov/vehiclesandfuels/npbf/feature_guidelines.html

14 U.S. EPA; How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers; http://www.epa.gov/OUST/pubs/tums.htm

15 U.S. EPA; CLU-IN Green Remediation Focus; Footprint Assessment; http://www.cluin.org/greenremediation/subtab_b3.cfm

16 Pers. comm., Linda Stromquist, NPS (linda_stromquist@nps.gov)

17 Minnesota Pollution Control Agency; ARRA of 2009 LUST (PRP) Guidance; http://www.pca.state.mn.us/index.php/about-mpca/assistance/financial-assistance/american-recovery-and-reinvestment-act-arra-of-2009-lust-prp-guidance.html

18 U.S. EPA; Smart Growth; http://www.epa.gov/smartgrowth/index.htm

19 U.S. EPA; Office of Superfund Remediation and Technology Innovation; http://www.cluin.org/greenremediation/docs/Greener_Cleanups_Contracting_and_Administrative_Toolkit.pdf

20 ASTSWMO; http://www.astswmo.org/Pages/Policies_and_Publications/Tanks.htm; http://www.astswmo.org/Pages/Policies_and_Publications/Sustainability/Greener_Cleanups.html

21 U.S. EPA Office of Underground Storage Tanks; Cleaning up Underground Storage Tank System Releases; http://www.epa.gov/OUST/cat/index.htm

EPA appreciates the many document contributions from representatives of EPA regional offices or LUST Teams and ASTSWMO members.

Visit ***Green Remediation Focus*** online:
http://cluin.org/greenremediation

For more information, contact:
Carlos Pachon, OSWER/OSRTI (pachon.carlos@epa.gov)
U.S. Environmental Protection Agency