

Superfund Green Remediation Strategy

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Superfund & Green Remediation
<http://www.epa.gov/superfund/greenremediation>



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Office of Solid Waste and Emergency Response
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The Workgroup thanks the many stakeholders submitting valuable comments on the earlier August 2009 “public review version” of the Strategy, as received from September through November 2009. This document updates the Agency’s Strategy in response to the comments and describes more recent determinations and activities of EPA’s Office of Solid Waste and Emergency Response.

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Disclaimer

This document is a program management tool describing current EPA plans to maximize the environmental outcome of Superfund projects through reduction of negative environmental effects that might occur during site assessment, site remediation, or non-time critical removal actions. This document presents technical information based on EPA's current understanding of the link between hazardous waste site cleanup activities and potential risks to human health and the environment, and contains information designed to be useful for interested stakeholders including governments, the public, and the regulated community. This document does not impose legally binding requirements nor does it confer legal rights, impose legal obligations, implement any statutory or regulatory provisions, or change or substitute for any statutory or regulatory provisions. Finally, this is a living document that may be revised periodically without public notice. EPA welcomes public comments on this document at any time and will consider those comments in any future revisions of this document.

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Executive Summary

As part of its mission to protect human health and the environment, the U.S. Environmental Protection Agency (EPA, or “the Agency”) and its partners manage and implement the Superfund Remedial Program (“the Program”), which is dedicated to cleaning up releases of hazardous substances, pollutants, and contaminants. Since its inception in 1980, the Program has made considerable progress toward cleaning up contaminated sites and responding to emergencies involving hazardous substances. Site remediation often involves a wide variety of approaches and technologies to address contamination in soil, groundwater, surface water, and sediment. This *Superfund Green Remediation Strategy* (“the Strategy”) is a program management tool designed to describe current plans of the Superfund Remedial Program to reduce greenhouse gas (GHG) emissions and other negative environmental effects that might occur during site assessment and remediation or non-time critical removal actions.

Green remediation is the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions.

Over time, we have recognized that the process of cleaning up a hazardous waste site uses energy, water, and other natural or materials resources and consequently creates an environmental “footprint” of its own. Treatment technologies such as pump-and-treat systems for contaminated groundwater, for example, may use energy from fossil fuel-powered utilities for many years. Another example is the use of heavy-duty construction equipment powered by diesel fuel, which typically emits a complex mixture of air pollutants. We recognize that much can be done to conserve natural resources, minimize waste generation, and reduce energy consumption, consequently improving environmental performance of Superfund activities while fulfilling our mission to protect human health and the environment.

In September 2008, OSRTI formed a workgroup of EPA headquarters and regional staff to develop a green remediation strategy that could reduce the environmental footprint of Superfund response actions taken at private and federal sites, while at the same time protecting human health and the environment. EPA released the initial Strategy in August 2009 for public input. Concurrent to release of the Strategy, the Agency’s Office of Solid Waste and Emergency Response (OSWER) issued the *Principles for Greener Cleanup* with the goal of comprehensively evaluating cleanup actions to ensure protection of human health and the environment and to reduce the environmental footprint of cleanup activities to the maximum extent possible. This updated Strategy reflects the extensive and valuable input received through November 2009 and more recent experience and activities of OSWER, EPA regional offices, and state agencies. The Strategy is not a comprehensive or static document; rather, it may change over time as we learn more about how EPA can improve our cleanup activities.

EPA’s Superfund Remedial Program partners collaborating in this Strategy include the:

- *Office of Superfund Remediation and Technology Innovation (OSRTI)*
- *Office of Emergency Management (OEM)*
- *Federal Facilities Restoration and Reuse Office (FFRRO)*
- *Office of Site Remediation Enforcement (OSRE)*
- *Federal Facilities Enforcement Office (FFEO), and*
- *Superfund offices in Regions 1 through 10.*

The Strategy outlines nine key actions (containing 40 specific actions) and describes related activities to promote green remediation. The actions fall into three overarching categories:

- **Policy and guidance development;**
- **Resource development and program implementation;** and
- **Program evaluation.**

In developing these action items, the workgroup highlighted several needs that are important for their implementation:

- Clarify how green remediation practices fit within the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP);
- Improve our understanding of potential resource and energy demands for many Superfund remedies; and
- Develop metrics that can be used to measure and evaluate green remediation actions.

This Strategy describes actions that OSRTI, OEM, FFRRO, OSRE, FFEO and Superfund regional programs can take when incorporating green remediation practices under existing laws and regulations. The Strategy also includes actions that, consistent with CERCLA and the NCP, help foster greater use of green remediation practices at Fund-lead (i.e., sites where cleanup is funded by the Agency and led by EPA), state-lead, potentially responsible party (PRP)-lead, and federal facility sites.

The Strategy includes a series of Program initiatives to expedite pursuit and use of green remediation practices:

- Maximize use of renewable energy with a goal of using 100% renewable energy to power site operations, and identify methods for increasing energy efficiency;
- Incorporate green remediation factors as part of remedy optimization evaluations starting in fiscal year 2010;
- Pursue ways to reduce the use of natural resources and energy during remedial actions and when developing cleanup alternatives;
- Integrate clean, renewable, and innovative energy sources and advanced diesel technologies (such as diesel particulate filters and alternative fuels) and encourage operational practices (such as engine idle reduction practices) to minimize total emissions;
- Establish tools to track and increase potable water conservation, the reuse of treated water, and recharge of aquifers;
- Identify additional onsite or offsite uses of materials or energy otherwise considered waste;
- Include language in statements of work for removal action, remedial design, and remedial action procurement contracts that specifies use of green remediation practices and requires separate reports for energy/fuel usage and costs; and
- Help communities establish networks and training programs that enable local workers (including minority and low-income populations) to gain proficiency in expertise needed for green cleanups, such as energy efficiency auditing and renewable energy applications.

Finally, the Strategy includes a key action to establish a process for quantifying achievements regarding the Program's commitment to reduce the demands that site cleanups place on the environment. OSRTI will collect and use regional summaries, site-specific data, and trend information to establish a solid baseline on the environmental demands made prior to Strategy implementation. Using this baseline, the Program will establish performance goals, objectives, and measures for the *Superfund Green Remediation Strategy*.

As a "living" document for potential use by a range of interested stakeholders, OSRTI intends to update this Strategy to reflect refined Agency policy, modified activities within the key actions, and other developments as green remediation matures. The Agency also intends to conduct ongoing outreach activities with Superfund "stakeholders" including affected communities, state and local governments, tribal governments, other federal agencies, cleanup contractors, PRPs, and developers. The Agency's outreach will include specific activities to solicit and promote input on further refining this Strategy and focusing this effort. The Strategy's next version may include actions specific to the Agency's Emergency Response/Removal Program.

Summary of Strategic Actions

Policy and Guidance Development	
Key Action #1: Clarify the role of green remediation in remedy selection and implementation	
1.1	Develop OSWER policy on green remediation in remedy selection for remedial and non-time critical removal actions <i>[under development]</i>
1.2	Evaluate potentially applicable or relevant and appropriate requirements (ARARs) <i>[under development]</i>
Resource Development and Program Implementation	
Key Action #2: Develop a compendium of protocols and tools to help project and Program managers integrate green remediation practices	
2.1	Identify green remediation resource needs <i>[under development]</i>
2.2	Identify additional green remediation information resources <i>[under development]</i>
2.3	Develop technology-specific assessment tools and fact sheets <i>[under development]</i>
2.4	Develop green remediation Q&A's <i>[under development]</i>
2.5	Produce green remediation checklists <i>[under development]</i>
2.6	Deliver or host green remediation training through the Technology Innovation and Field Services Division's training infrastructure <i>[already implemented]</i>
2.7	Provide site-specific assistance and assistance mechanisms <i>[already implemented]</i>
Key Action #3: Identify options that enable use of green remediation practices	
3.1	Identify methods to maximize use of renewable energy with a goal of using 100% renewable energy to power site operations <i>[under development]</i>
3.2	Identify methods for increasing energy efficiency <i>[under development]</i>
3.3	Develop a better understanding of the costs or savings associated with use of green remediation strategies and practices <i>[under development]</i>
3.4	Develop a fact sheet on using green power for site cleanup <i>[under development]</i>
3.5	Identify methods to increase use of renewable energy generated onsite for site remediation at remote locations <i>[under development]</i>
3.6	Explore and/or establish funding mechanisms to finance green remediation research, development, and demonstration (RD&D) and initial deployment efforts at Superfund sites <i>[under development]</i>
3.7	Participate in development of a national standards and certification process <i>[under development]</i>

Key Action #4: Address air pollutant emissions	
4.1	Develop a fact sheet on clean fuel and emission technologies [<i>already implemented</i>]
4.2	Develop cleanup contract requirements for incorporating clean fuel and emission technologies [<i>under development</i>]
4.3	Identify opportunities for recovering and using methane gas emitted from landfills on Superfund sites [<i>under development</i>]
Key Action #5: Develop pilot projects to evaluate and demonstrate green remediation applications	
5.1	Develop a database of innovative green remediation pilot projects [<i>under development</i>]
5.2	Develop and pilot test a green remediation analysis template to help collect information during various phases of the remediation process at any site [<i>under development</i>]
5.3	Incorporate green remediation factors into remedy optimization evaluations [<i>already implemented</i>]
5.4	Support the Re-Powering America's Land Initiative by identifying Superfund sites with outstanding or superb renewable energy potential [<i>under development</i>]
Key Action #6: Establish opportunities in contracts and assistance agreements to identify green remediation practices in selected remedies	
6.1	Modify EPA contract language to include green remediation practices [<i>under development</i>]
6.2	Modify contract language to require reporting of selected activities [<i>under development</i>]
6.3	Develop and periodically update a green remediation contracting tool kit [<i>already implemented</i>]
6.4	Develop model terms and conditions for assistance agreements and IAs concerning site cleanup [<i>under development</i>]
6.5	Explore additional opportunities to use existing federal agreements and establish new agreements [<i>under development</i>]
6.6	Explore and promote opportunities to use local expertise in green cleanups [<i>under development</i>]
Key Action #7: Communicate and share success stories and lessons learned among "implementers" across the Program and the public	
7.1	Develop a communication plan [<i>under development</i>]
7.2	Conduct outreach to contractors and industry [<i>under development</i>]
7.3	Partner with other federal agencies and state organizations to promote national use of green remediation strategies [<i>already implemented</i>]
7.4	Engage local communities in assessing and implementing green remediation options [<i>to be initiated</i>]

Program Evaluation

Key Action #8: Establish a roadmap for evaluating the environmental footprint of a cleanup at a project level

- 8.1 Analyze existing methods and software tools for evaluating the environmental footprint of a cleanup [*already implemented*]
- 8.2 Develop an Agency methodology for evaluating the environmental footprint of a cleanup [*under development*]
- 8.3 Develop evaluation modules for green remediation strategies [*under development*]

Key Action #9: Evaluate the environmental footprints of Superfund cleanups at a programmatic level

- 9.1 Estimate a Program baseline for the environmental footprints of Superfund cleanups [*under development*]
- 9.2 Establish performance goals, objectives, and measures for the Superfund Green Remediation Strategy [*under development*]
- 9.3 Develop options for addressing possible gaps in measures or metrics [*under development*]
- 9.4 Characterize the state of practice and implications of life cycle assessment on Program operations [*under development*]

1.0 Introduction

The EPA Superfund remedial offices managing the long-term cleanup of Superfund sites are dedicated to the broader goal of the Agency’s mission to protect human health and the environment. Consistent with that mission, these offices strive to clean up hazardous waste sites in ways that use natural resources and energy efficiently and reduce negative impacts on human health and the environment in accordance with existing authorities. This *Superfund Green Remediation Strategy* sets out the Program’s current plans for optimizing the environmental performance and outcome of Superfund cleanup activities. OSWER anticipates that implementation of this Strategy will help the Agency assure that efforts to maximize environmental performance and outcomes are conducted in a manner consistent with statutes and regulations governing EPA cleanup programs and without compromising cleanup objectives, community interests, reasonableness of cleanup timeframes, or protectiveness of cleanup actions.

1.1 Background

Cleanup activities use energy, water, and materials resources to achieve cleanup objectives. The process of cleanup therefore creates an environmental “footprint” of its own. For purposes of this Strategy, EPA defines green remediation as the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions.¹ Green remediation also involves taking the steps to minimize the cleanup footprints, when appropriate, while continuing to satisfy threshold requirements for protectiveness and to meet other site-specific cleanup objectives intended to restore contaminated lands.

Green remediation is intended to reduce the demand placed on the environment during cleanup actions and to conserve natural resources. Like all activities, each stage of the remedial process (discovery, assessment, characterization, design and construction, operation of treatment and containment remedies, monitoring and maintenance of remedies, etc.) produces an environmental footprint. Combined, the footprint can be significant in light of the nearly 3,000 sites yet to reach a final assessment decision along with the approximately 1,600 final and deleted sites on the National Priorities List (NPL). Environmental and community effects from cleanup activities, including fossil fuel consumption, emission of GHG and air pollutants, disruption to water cycle balances, and soil erosion, need to be considered.

In context of this Strategy, green remediation focuses on the environmental footprint of Superfund response actions. The broader realm of site sustainability examines environmental issues but also includes social and economic aspects that are typically addressed by site users and local or regional communities.

When green remediation techniques are linked to careful site reuse planning and sustainable development practices, such as applying smart growth principles and green building methods, additional opportunities are often created to reduce the environmental footprint of both remediation and reuse projects. The combined planning and practices provide a basis for a greener approach to land revitalization and help ensure that all socioeconomic groups of affected communities can benefit from the improved environmental outcome of site cleanup.

Green remediation generally is recognized as a major step in maximizing the environmental outcome of contaminated land cleanup.² OSWER has identified **five core elements** of green remediation:

¹ Extensive background information is provided in EPA’s technology primer, *Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites* (USEPA, 2008c).

² Executive Order 13423 defines sustainability as the capacity to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations of Americans.

- **Energy:** Many Superfund cleanups involve energy intensive technologies. Green remediation strategies focus on opportunities to improve energy efficiency and use renewable energy sources.
- **Air and atmosphere:** Many Superfund cleanups involve onsite and offsite emissions of GHGs and air pollutants from activities such as treatment processes, operation of heavy machinery, and transportation of routine vehicles and cargo trucks. These emissions may be reduced by applying the most appropriate advanced technologies and sound field practices.
- **Water:** Superfund cleanups may also involve consumption of significant amounts of water for treatment processes and typically need management of surface water. Green remediation strategies focus on reducing water consumption, reusing treated water, and using efficient techniques to manage and protect surface water and groundwater.
- **Land and ecosystems:** Superfund sites often involve degraded onsite and offsite ecosystems and may have conditions that make the site unsafe for human or other use. Green remediation strategies focus on remedial actions that minimize further harm to the area, protect land resources and ecosystems at or near the site, and foster the return of sites to ecological, economic, social, or other uses.
- **Materials and waste:** Site remediation may use significant amounts of raw materials and sometimes generates its own hazardous and non-hazardous wastes, including materials and debris that often are shipped offsite. Green remediation strategies offer opportunities to reduce materials consumption and waste generation, use recycled and local materials and spent products, and purchase environmentally preferred products.



1.2 Green Remediation and the Waste Programs

Promoting clean energy and mitigating climate change are top priorities for EPA. Superfund’s green remediation efforts intersect a variety of initiatives in other waste programs across EPA, states, and other federal agencies that are addressing sustainability and climate change issues. OSWER also is working to maximize community involvement and benefits of the various waste programs, including site remediation under Superfund.

In August 2009, OSWER issued the Agency’s *Principles for Greener Cleanups* policy, which focuses on evaluating the environmental footprint of cleanup activities (<http://www.epa.gov/oswer/greencleanups/principles.html>) (USEPA, 2009b). The policy emphasizes that all cleanup approaches, and all elements of the cleanup process, can be optimized to enhance their overall environmental outcome; therefore, a “green cleanup involves more than merely adopting a specific technology or technique. Assessment of the five core elements used in green remediation strategies can assist decision makers in evaluating and documenting a greener cleanup. In considering these principles, OSWER cleanup programs will assure that cleanups and subsequent environmental footprint reduction occur in a manner that is consistent with statutes and regulations governing EPA cleanup programs and without compromising cleanup objectives, community interests, the reasonableness of cleanup timeframes, or the protectiveness of the cleanup actions.

OSRTI is working with other OSWER and regional offices that manage cleanup programs to ensure consistency in applying the principles and the Superfund green remediation concepts and implementing this Strategy. These Program partners developed the Strategy with primarily the Superfund Remedial Program in mind, although other Agency cleanup programs may find information in the Strategy to be useful. Other federal, state, tribal, or local government cleanup programs also may adopt some of the implementation steps and evaluation activities to address sustainability and climate change issues. Implementation of the Strategy will involve a dynamic interchange of ideas, data, and practices within and outside of the Superfund Remedial Program. The Agency also expects to exchange “lessons learned” with our partners in cleanup as efforts evolve over time.

1.3 Green Remediation and Superfund

Green remediation aligns with goals and processes outlined in CERCLA (42 U.S.C. §9601 et seq.) as well as the NCP (40 CFR Part 300). CERCLA provides broad federal response authority to address releases of hazardous substances, pollutants, and contaminants in order to protect human health and the environment from uncontrolled hazardous waste sites. As the basic blueprint for carrying out Superfund response actions, the NCP describes expectations for response actions and includes remedy selection considerations such as “the nine criteria” to evaluate alternatives.³ Green remediation strategies also are useful in non-time critical removal actions, including preparation of engineering evaluation/cost analyses (EE/CAs), but may have less applicability in time critical removals and particularly in emergency response situations.

Green remediation is viewed as a means to enhance remedy protectiveness, not as a disincentive to active remediation processes or an approach that reduces remedy protectiveness.

Opportunities to decrease the environmental footprint of cleanup activities and maximize the environmental outcome of a cleanup exist throughout a project life, extending from site investigation through development of cleanup alternatives and remedy design, construction, operation, and monitoring. All of the Agency’s 10 regional offices have initiated efforts to apply green remediation practices during site cleanups.⁴ These opportunities become more frequent with advances in cleanup technologies and growing awareness of the links between site cleanup and revitalization. Concerns about fluctuations in energy costs and the growing quantity of GHG emissions have highlighted the need to reduce energy consumption and generate a smaller environmental footprint during site cleanup. Given these trends, green remediation strategies offer significant potential for maximizing the environmental outcome of a cleanup, reducing project costs, and returning sites to productive reuse that is consistent with cleanup goals.

Green remediation strategies take precaution to protect areas on and surrounding contaminated sites and provide additional safeguards from activities potentially reducing the environmental outcome of cleanups. For example, treatment technologies used in groundwater pump-and-treat systems often use energy from fossil fuel-powered utilities for many years and in some cases decades. Remediation plans can include value engineering and system optimization techniques to reduce this fuel consumption. Another example is the use of biodiesel to power heavy field equipment, instead of conventional diesel that emits a complex mixture of air pollutants including both solid and gaseous materials with serious human and environmental effects. Diesel emissions pose particular concern in non-attainment areas⁵ and additional problems in environmental justice communities that face disproportionate burdens of potential exposure to environmental hazards.

Comprehensive planning for worker safety protection is part of the Superfund remedy selection and implementation process, in accordance with Occupational Safety & Health Administration regulations covering hazardous waste operations and emergency response (29 CFR 1910.120).

Continued maintenance of robust health and safety planning on a site-specific basis provides the foundation for protecting cleanup workers and local communities during activities such as these. Green remediation strategies provide additional opportunities to reduce these impacts through innovative techniques, treatment system optimization, and use of more practices and technologies such as renewable energy sources, more efficient treatment equipment, and clean diesel technologies.

The Agency’s 2006-2011 *Strategic Plan* includes a number of goals and objectives that can be advanced by green remediation. Goal 5 (“Compliance and Environmental Stewardship”) of the Strategic Plan, for example, specifies that stewards of the environment recycle wastes to the greatest extent possible, minimize or eliminate pollution at its source, conserve natural resources, and use energy efficiently to prevent harm to the environment or human health (USEPA, 2006a). Under sub-objective 3.2.2 (“Clean Up

³ See 40 CFR §300.430, Remedial investigation/feasibility study and selection of remedy.

<http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=15f6d3508190f51e0f3a05a9a3010287&rgn=div8&view=text&node=40:27.0.1.1.1.5.1.7&idno=40>

⁴ See EPA regional policies at: <http://www.clu-in.org/greenremediation/regions/index.cfm>.

⁵ Section 107(d)(1)(A)(i) of the Clean Air Act defines a “nonattainment” area as any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the relevant pollutant.

and Revitalize Contaminated Land”), the Agency commits to ensuring that substantial numbers of NPL sites are ready for site-wide reuse.

Cleanup projects can complement efforts to increase site sustainability by incorporating greener strategies and practices in all phases of a cleanup and redevelopment project. An integrated approach can include activities such as:

- Deconstructing a site’s buildings and infrastructure and reusing the materials on site;
- Designing cleanups that maximize opportunities for mixed use and smart-growth land reuse;
- Using green building design/construction practices for structures such as water treatment plants; and
- Planning long-term remedy operations and reuse activities that are less environmentally intensive and pose minimal adverse effects (such as diesel emissions and fugitive dust) on local communities.

1.4 Federal and State Statutes and Executive Orders Promoting Energy and Water Conservation

Green remediation strategies are derived from CERCLA and NCP frameworks but also involve concepts from executive orders and federal or state statutes and regulations that specifically address reductions in energy and water consumption, increased use of renewable energy, and conservation of other natural resources. The Energy Policy Act of 2005, for example, promotes energy conservation nationwide. The Energy Independence and Security Act of 2007 builds on the Energy Policy Act by setting additional goals for energy consumption and associated GHG emissions, including increased use of alternative fuels for vehicles and accelerated research on alternative energy resources. Executive Order (EO) 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, further states it is the policy of the United States that federal agencies conduct their environmental, transportation, and energy-related activities under the law in support of their respective missions in an environmentally, economically and fiscally sound, integrated, continuously improving, efficient, and sustainable manner (EO, 2007).

EO 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, uses the framework provided by EO 13423 to establish an integrated strategy towards sustainability in the federal government. EO 13514 requires federal agencies to:

- Increase energy efficiency;
- Measure, report, and reduce GHG emissions from direct and indirect sources;
- Conserve and protect water resources through efficiency, reuse, and stormwater management;
- Eliminate waste, recycle, and prevent pollution;
- Leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services;
- Design, construct, maintain, and operate high performance buildings in sustainable locations; and
- Strengthen vitality and livability of communities where federal facilities are located (EO, 2009).

In context of EO 13514, EPA activities include government remediation of Superfund sites. Draft guidance on federal GHG accounting and reporting indicates that emissions associated with this activity are subject to "scope 3" voluntary reporting.⁶ As a related matter, many states are adopting climate legislation and policies, creating climate action plans, and providing incentives to create renewable energy projects.⁷ A majority of states and the District of Columbia have implemented policies for renewable portfolio standards that require electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date.

⁶ EO 13514 defines scope 3 GHG as “emissions from sources not owned or directly controlled by a Federal agency but related to agency activities such as vendor supply chains, delivery services, and employee travel and commuting.”

⁷ See: *Database of State Incentives for Renewables & Efficiency* (North Carolina Solar Center/Interstate Renewable Energy Council, n.d.) and *U.S. States & Regions* (Pew Center on Global Climate Change, n.d.).

2.0 Superfund Remedial Program's Green Remediation Goals and Key Actions

The NCP is designed to serve as a general blueprint for federal cleanups, including those using CERCLA authority. It addresses response actions for oil spills as well as hazardous substances, pollutants, and contaminants. Under CERCLA and the NCP, remedial response actions may involve a number of steps including site assessment, remedial investigation, feasibility study, remedy selection, remedy implementation, and a five-year review for a site where waste is left onsite. Employing green remediation practices fits within the statutory and regulatory framework of the Superfund Remedial Program.

Green remediation comprises a range of best practices that may be applied throughout the Superfund cleanup process, beginning with site assessment and investigation and extending through remedy operations. The best management practices of green remediation provide potential means to improve waste management; conserve or preserve energy, fuel, water, and other natural resources; reduce GHG emissions; promote sustainable long-term stewardship; and reduce adverse impacts on local communities during and after remediation activities. Green remediation can also complement efforts to return brownfields and private or federal Superfund sites to productive use in a sustainable manner, such as utility-scale production of renewable energy.

Utilization of green remediation strategies within the scope of a Superfund response may help ensure a protective remedy. For sites where the remedy has already been selected, it often will be possible to implement the remedy in a way that has lesser long-term negative effects on the environment. At sites with operating remedies, green remediation practices may be used to upgrade or optimize treatment systems.

OSWER is currently developing guidance that addresses how green remediation options can be evaluated in manners consistent with CERCLA requirements and relevant NCP provisions. Since the enactment of CERCLA and promulgation of the final NCP in 1990, EPA has undertaken various initiatives that may provide a platform for consideration and implementation of green remediation measures, such as the Ground Water Optimization Initiative⁸ and the Superfund Redevelopment Initiative (SRI).⁹

In addition, the Environmentally Responsible Redevelopment and Reuse (ER3) Initiative¹⁰ encourages developers and property owners to implement sustainable practices during redevelopment of contaminated sites. The ER3 Initiative complements EPA's efforts to clean up contaminated sites. Through OSRE's partnership with OSRTI, the ER3 Initiative also includes green remediation as part of its efforts to promote sustainable cleanup of contaminated sites.

In addition to general green remediation steps that parties can take throughout the cleanup life cycle, such as minimizing travel to and from sites, decision makers can integrate practices of green remediation into all phases of the remedial process; for example:

⁸ OSWER initiated optimization of Superfund-financed groundwater remedies as part of the *FY2000-FY2001 Superfund Reforms Strategy* (OSWER 9200.0-33; July 7, 2000). Remedy optimization is designed to facilitate systematic review and modification of remedies to promote continuous improvement in overall remedy and cost effectiveness (USEPA, n.d.2). In the Superfund Program, optimization evaluations generally use the remediation system evaluation (RSE) process, a tool developed by the U.S. Army Corps of Engineers. RSEs can be conducted for Superfund remedies involving one or more technologies used for groundwater, soil, and/or sediment treatment (USEPA, n.d.10).

⁹ Consistent with the SRI Initiative, communities return some of the nation's worst hazardous waste sites to safe and productive uses. In addition to cleaning up Superfund sites and making them protective of human health and the environment, EPA is working with communities and other partners by considering reasonably anticipated future land use in the cleanup process. The Agency also is working with PRPs, communities, and other stakeholders at sites that have already been cleaned up to ensure that reuse and long-term stewardship are consistent with maintaining the integrity of cleanups (USEPA, n.d.9).

¹⁰ EPA's ER3 Initiative uses enforcement incentives to encourage developers, property owners, and other parties to implement sustainable practices during cleanup, redevelopment, and reuse of contaminated sites (USEPA, n.d.3).

- **Preliminary Assessment and Site Investigation (PA/SI):** Project managers can use more efficient, streamlined approaches that minimize field mobilizations, materials and natural resource consumption, and waste generation.
- **Remedial Investigation and Feasibility Study (RI/FS):** Managers can reduce the environmental effects of more intensive site characterization activities such as field sampling by employing the same practices used for a PA/SI. When developing options for remedial actions that are consistent with remedial action objectives, project managers should consider alternatives that include opportunities for reducing the environmental footprint of remedial design and construction activities. Thorough site characterization, including full delineation of contaminant source areas and plumes, will help avoid unnecessary consumption of materials and natural resources during a remedial action.
- **Remedial Design (RD):** Opportunities to integrate green remediation strategies into a remedy can be taken when:
 - Designing a new remedy,
 - Conducting a pilot test, or
 - Updating an existing remedy to ensure remedy protectiveness, based on new information or changes in science and technology.
- **Remedial Action (RA):** The construction phase as well as the operational phase of a remedial action provides significant opportunities to reduce onsite and offsite footprints of a cleanup. Best management practices introduced during construction can continue during remedy operation. The practices include using clean fuels and renewable energy sources for vehicles and equipment, retrofitting diesel machinery and vehicles for improved emission controls, reusing construction and routine operational materials, reclaiming demolition or processing waste, and installing maximum controls for stormwater runoff.
- **Short- and Long-Term Remedy Operations and Five-Year Reviews:** Periodic reviews are required at sites where contaminants remaining on site after a cleanup action do not allow for unrestricted use or unlimited exposure. The five-year review serves to ensure that the remedy remains protective and offers opportunities for project managers to evaluate whether green remediation practices can be integrated into remedy operation and maintenance (O&M).

EPA considers reasonably anticipated future land use throughout the remedy selection and implementation process to help ensure that response actions will remain protective in light of the anticipated reuse of remediated sites. Green remediation strategies can complement anticipated site reuse involving sustainable activities or property development in accordance with community-level smart growth principles and green building practices. Integrated planning of cleanup and reuse projects also facilitates sharing of site infrastructure components such as stormwater controls, waste recycling networks, or small-scale renewable energy systems.

To provide ready access to updated information about the *Superfund Green Remediation Strategy* and its implementation, OSRTI has added a “Superfund & Green Remediation” page to the EPA’s website (<http://www.epa.gov/superfund/greenremediation>) (USEPA, n.d.8). The Agency has also identified a Superfund Green Remediation Coordinator in each EPA region to foster consideration of green remediation within his/her region, serve as a liaison in green remediation issues, coordinate with other regional programs, and update stakeholders on potential or actual changes in environmental and community effects as a result of using green remediation strategies; a listing of the coordinators is available online (<http://www.epa.gov/superfund/greenremediation/coordinators.html>).

The Strategy consists of nine key actions involving 40 specific actions associated with: **(1) policy and guidance development, (2) resource development and program implementation, and (3) Program evaluation.** OSRTI intends to track the progress of each strategic action; many are currently under development or already implemented (and in some cases ongoing), while others will be initiated shortly.

2.1 Policy and Guidance Development

Goal:

Provide policy and guidance to achieve greater pursuit and use of green remediation practices throughout the Superfund cleanup process (consistent with CERCLA and NCP requirements) that will provide a clear, legally defensible foundation for facilitating green remediation.

Introduction:

Policy and guidance development will focus on a single key action intended to integrate green remediation within the Program and provide an overall context for using green remediation strategies to the maximum extent practicable. OSRTI recognizes the need to develop a policy statement that clarifies the scope of green remediation within the sphere of Superfund activities and how it fits within various phases of the Program. Superfund response actions to be covered in the policy and related guidance include non time-critical removal actions, site investigations, feasibility studies, remedial design, remedy construction, remedy O&M, and long-term remedial actions. The policy would encourage collaboration among EPA regions and stakeholders when evaluating the environmental effects of remedy implementation and incorporating options to minimize environmental footprints of cleanups.

The Agency's anticipated actions regarding policy and guidance are designed to integrate green remediation concepts into Superfund response actions in ways that are consistent with the Statute and its regulations. EPA regions may wish to adapt or tailor the actions and concepts for incorporation into region-specific policies. As the national framework for green remediation evolves, this key action may need revision.

Key Action #1: Clarify the role of green remediation in remedy selection and implementation

The goals of green remediation are designed to be consistent with objectives and processes specified in CERCLA and the NCP, which provides detailed expectations and criteria to follow in selecting and implementing cleanup remedies. This action area describes efforts EPA will undertake to ensure green remediation efforts can be effectively pursued and integrated into Superfund response actions while adhering to NCP requirements and related statutes. Experiences gained from recent EPA negotiations with PRPs for consent orders that successfully incorporate green remediation provisions will inform the policy development process. The Agency will take the following actions:

- 1.1 Develop OSWER policy on green remediation in remedy selection for remedial and non-time critical removal actions:** OSRTI will continue working with FFRRO and other OSWER offices (the Office of Brownfields and Land Revitalization, Office of Underground Storage Tanks, Office of Resource Conservation and Recovery, and Center for Policy Analysis) and other Agency offices to develop an approach for considering green remediation strategies within the existing NCP remedy selection process and documenting the strategies in CERCLA remedial decision documents. OSWER anticipates this policy will clarify how green remediation can factor into the NCP's nine evaluation criteria for remedy selection and the Superfund evaluation criteria for non-time critical removal actions involving the EE/CA process. The policy also would describe considerations in potential amendment of decision documents for an existing remedy, such as remedy protectiveness, integrity, and cost. Policy recommendations would address the importance of key statutory requirements and NCP provisions. [*under development*]
- 1.2 Evaluate potentially applicable or relevant and appropriate requirements (ARARs):** OSRTI will analyze and summarize existing state and federal regulations such as state renewable energy portfolio standards to determine whether they may be potential ARARs under CERCLA. This analysis could assist regions in developing and implementing remedies that address new ARARs related to green remediation goals. OSRTI will distribute the summary information to EPA regional

offices and post the material online at the “Green Remediation Focus” area of the Agency’s “CLU-IN” Web platform (<http://www.cluin.org/greenremediation>).¹¹ [*under development*]

2.2 Resource Development and Program Implementation

Goal:

Formulate and develop green remediation practices and resources to help on-scene coordinators (OSCs) and remedial project managers (RPMs) ensure that green remediation is considered throughout the response process and in meeting remedial goals.

Introduction:

Throughout the Superfund cleanup process (including site assessment and characterization, removal, design, construction, O&M, monitoring, closeout, and revitalization), there are opportunities to improve the environmental outcome of a cleanup and contribute to site sustainability. As cleanup technologies continue to advance and related options evolve, green remediation strategies may offer significant potential for reducing project costs while meeting the selected remedy’s remedial action objectives. Key actions involve researching and evaluating existing or evolving green remediation resources such as technical data, information on new technologies, internal and external knowledge, funding, contracts, and grants, and developing new tools and resources as needed.

Key Action #2: Develop a compendium of practices and tools to help project and Program managers integrate green remediation practices

The Agency will design a compendium of practices and tools to facilitate understanding and implementation of green remediation efforts by consolidating available tools and resources in a central location organized by cleanup phase (extending from site discovery through post-construction). OSRTI will establish quality assurance/quality control procedures to minimize duplicative or excessive information, assure efficiencies, and maximize user friendliness of the compendium, and will update the compendium as needed to reflect evolving cleanup or auxiliary technologies and new practices or tools. Actions to develop the compendium include:

- 2.1 Identify green remediation resource needs:** OSRTI will work with Program partners in researching and evaluating existing green remediation tools and frameworks available on CLU-IN as well as materials such as checklists, fact sheets, and outlines issued by regional or other program offices. [*under development*]
- 2.2 Identify additional green remediation information resources:** Program partners will reach out to communities, contractors, technology vendors, states, other EPA workgroups, and non-governmental organizations for green remediation evaluations, case studies, fact sheets, and other resources. The Agency will engage other federal agencies to document and share the tools and best management practices. [*under development*]
- 2.3 Develop technology-specific assessment tools and fact sheets:** OSRTI will continue developing fact sheets that demonstrate best management practices of green remediation.¹² Fact sheets will address specific technologies and methods for assessing and improving technology efficiencies as well as particular remedies or crosscutting topics. Environmental footprint evaluation topics may include life cycle assessment of remedial actions, use of liquid fuels during site operations, energy and water consumption, and GHG emissions. One example is a fact sheet illustrating site-specific application, unique considerations, and operating procedures associated with green remediation practices for pump-and-treat remedies. [*under development*]

¹¹ Cross-program technical materials, federal and state policies, and background information are available on the *Green Remediation Focus* website at: <http://www.cluin.org/greenremediation> (USEPA, n.d.4).

¹² Such as *Green Remediation: Best Management Practices for Excavation and Surface Restoration* (USEPA, 2008b).

- 2.4 Develop green remediation “Q&A’s”:** The Program will continue collaboration with state regulatory partners to develop “Questions & Answers” and “Myths vs. Facts” summaries to foster better understanding of green remediation.¹³ [*under development*]
- 2.5 Produce green remediation checklists:** OSRTI will develop national checklists for existing Superfund processes (PA/SI, RI/FS, and RD/RA) and long-term response actions. Checklists also would apply to RSEs and five-year reviews, which foster strategic actions involving advances in science and technology. This action will integrate information from existing checklists developed through regional or cross-program initiatives to the extent possible, such as Region 2’s “Green Site Assessments and Remediation Checklist for the Superfund RI/FS,” Region 3’s efforts to develop a voluntary green cleanup standard and certification system (USEPA, n.d.5), and the Engineering Forum’s checklist for energy conservation and production (USEPA, 2004). [*under development*]
- 2.6 Deliver or host green remediation training through the Technology Innovation and Field Services Division’s training infrastructure:** Training generally will be co-located with other venues such as annual National Association of Remedial Project Managers (NARPM) conferences, OSC Readiness training, and North American Commission for Environmental Cooperation meetings. Program partners also will sponsor periodic Internet seminars on CLU-IN. [*already implemented*]
- 2.7 Provide site-specific assistance and assistance mechanisms:** OSRTI will assist regional staff in reviewing green remediation options during the site investigation and remedy selection processes and in optimizing and retrofitting existing remedial systems. This assistance includes direct technical support from experts in Agency program offices and groups such as the Technical Support Project’s Green Remediation Committee. OSWER also could collaborate with the Office of Research and Development’s National Risk Management Research Laboratory (NRMRL) through: (a) NRMRL’s Materials Management and Remediation Center operating under the Environmental Technology Verification Program, and (b) workings of the Superfund technical liaisons. Site-specific assistance mechanisms would include OSWER interagency agreements (IAs) with missions to support green remediation. [*already implemented*]

Key Action #3: Identify options that enable use of green remediation practices

The Superfund Remedial Program needs to examine additional options for incorporating green remediation consistent with the NCP and CERCLA. The design of such options can complement activities developed independently by EPA regions and other federal, state, tribal or local organizations. Potential actions include:

- 3.1 Identify methods to maximize use of renewable energy with a goal of using 100% renewable energy to power site operations:** OSWER encourages the use of renewable energy as one way to reduce GHG emissions in site operations. Options for securing energy from renewable resources include onsite production, green power purchases from electric service providers, or purchases of renewable energy certificates (RECs). The Program’s ultimate goal is to power 100% of site operations through renewable energy resources; however, this goal will not take priority over meeting cleanup goals. [*under development*]
- 3.2 Identify methods for increasing energy efficiency:** OSWER also encourages reduced energy consumption and GHG emissions in site operations at all Superfund sites through energy conservation practices such as using EnergyStar[®] equipment. OSRTI will include energy conservation measures in all future site-specific RSEs and include energy conservation recommendations in the follow-up evaluation reports. The Agency also will work with other organizations such as DOE’s Office of Energy Efficiency and Renewable Energy, trade organizations, and cleanup contractors to identify advanced technologies and conduct outreach through mechanisms such as CLU-IN seminars or training courses. [*under development*]

¹³Such as *Green Remediation Myth Busters* developed by the Association of State and Territorial Solid Waste Management Officials (http://www.astswmo.org/resources_sustainability_greenercleanups.html).

3.3 Develop a better understanding of the costs or savings associated with use of green remediation strategies and practices: OSRTI will evaluate the costs and savings of various green remediation strategies, including those for achieving greater energy efficiency and using renewable energy sources, by analyzing the data available at a sampling of green remediation projects implemented to date. The Agency will evaluate and build upon successful internal and external efforts to facilitate green remediation and plans to work with other federal agencies, states, and private industry to find independent financing mechanisms or incentives. Potential mechanisms include loans or grants, expedited permitting processes used by state or local government agencies, cleanup contractor bonuses, a green cleanup certification system, and/or REC purchases. OSRTI will summarize the information and make it available to the public through online CLU-IN seminars and documents posted on OSRTI's green remediation Web pages. [*under development*]

Green remediation strategies can significantly benefit from value engineering, which involves systematic and creative methods to reduce nonessential procurement and program costs without sacrificing reliability, efficiency, or original objectives of a cleanup, whether in the design or implementation phase. (USEPA, 2006b)

3.4 Develop a fact sheet on using green power for site cleanup: OSRTI will lead development of a fact sheet on best management practices for generating or procuring electricity from renewable sources such as solar, wind, geothermal, biomass, and landfill methane-gas resources. Fact sheet topics will include small-scale onsite production for direct use or utility sale/credit, purchases of RECs to power site operations, development of power purchase agreements for onsite production, and commercial-scale production from onsite resources. This action complements action 5.4, which supports the RE-Powering America's Land Initiative, and action 4.3, which identifies opportunities to recover methane gas from Superfund landfill. [*under development*]

3.5 Identify methods to increase use of renewable energy resources for site remediation at remote locations: EPA will work with NREL, PRPs, and vendors to identify opportunities for integrating renewable energy systems that can power treatment systems at sites without existing access to the electricity grid. [*under development*]

3.6 Explore and/or establish mechanisms to finance green remediation research, development, and demonstration (RD&D) and initial deployment at Superfund sites: OSRTI and FFRRO will identify existing federal resources (such as U.S. Department of Defense, U.S. Department of Energy (DOE), and Small Business Innovation Research programs) to fund green remediation research and application. One sample approach for this action is the Materials Management and Remediation pilot project sponsored by the public-private Environmental Technology Verification Program. Finance mechanisms may involve assistance agreements, IAs, and contracts as appropriate (see Key Action #6). EPA also will explore options for establishing headquarters and/or regional green remediation funds for financing green remediation activities at Fund-lead sites. The Agency would need to establish the amount of available funding, criteria for accessing the fund, and methods for returning any savings to the fund and/or the region. Lessons and strategies gained at Fund-lead sites may then be applied to similar efforts at federal facility, state-lead, and PRP-lead sites. [*under development*]

3.7 Participate in development of a national standards and certification process: Program partners will build on a project initiated by Region 3 that involves EPA participation in an ASTM International work item to develop a national, voluntary standard for green cleanups.¹⁴ The Agency is working with state partners to develop a draft framework that outlines desired outcomes for a green cleanup standard and serves as a starting point for the consensus-based process used to develop the standard. The Agency's Green Cleanup Standards Workgroup will continue developing various options for associated certification of voluntary green cleanups. [*under development*]

¹⁴ See periodic updates on EPA's Green Cleanup Standard Initiative (USEPA, n.d.5) and related updates from ASTM International (ASTM International, n.d.).

Key Action #4: Address air pollutant emissions

This key action targets various methods for reducing air pollutants caused by Superfund response activities (particularly vehicle and equipment deployment) and converting waste gas to sources of renewable energy. OSRTI will explore the use of clean fuel and emission technologies for all types of Superfund contracts.

4.1 Develop a fact sheet on clean fuel and emission technologies:

OSRTI will coordinate with EPA's Office of Transportation and Air Quality and regional offices in compiling an OSRTI fact sheet that discusses methods for reducing consumption of fossil fuel and associated emission of air pollutants. The fact sheet would target best management practices involved in operations and maintenance (such as engine idle reduction planning), use of advanced diesel technologies (such as retrofitting vehicles with engine exhaust filters), and selection of fuel efficient and alternative vehicles. The fact sheet also will address alternative fuels and fuel additives and provide a better understanding of the environmental effects of using various liquid fuels such as biodiesel. Information resources would include technical material such as listings of diesel retrofit technologies verified by EPA and background information supporting EPA rulemakings. [*already implemented*]

Minimizing diesel emissions reduces the risk to people – residents and workers alike – in the vicinity of a cleanup project.

4.2 Develop cleanup contract requirements for incorporating clean fuel and emission technologies:

As a complement to Key Action #6, this action involves detailed investigation and development of sample contract language related to air emission reductions and tracking for Superfund sites. [*under development*]

4.3 Identify opportunities for recovering and using methane gas emitted from landfills on Superfund sites:

EPA will work with PRPs and owners or operators of landfills on Superfund sites to implement voluntary cost-effective methane recovery projects for supplementing the energy demands of onsite operations (such as groundwater pump-and-treat systems) instead of exclusively treating methane gas as waste. For both Fund-lead and PRP-lead projects, the regions can apply the landfill methane-to-energy screening tool under development by OSRTI and FFRRO to evaluate the technical feasibility of landfill methane recovery, associated cost and practicality, and anticipated reduction in GHG emission from the landfills. [*under development*]

Key Action #5: Develop pilot projects to evaluate and demonstrate green remediation applications

Pilot projects will help build a collection of data on actual costs and results of green remediation practices, operational and administrative lessons learned, and materials for planned training and information sessions. EPA headquarters could provide regional offices with funding to support scoping, planning, or design activities related to green remediation pilot projects.

5.1 Develop a database of innovative green remediation pilot projects:

Pilot projects can provide valuable information on practical field experience with green remediation practices. OSRTI's Technology Innovation and Field Services Division and the regions will collect data generated from innovative green remediation pilot projects undertaken by EPA and others and develop a comprehensive database that supports future cleanup actions. OSRTI will reach out to other government agencies, cleanup contractors, and other stakeholders to collect information on experience with green remediation contracting language. [*under development*]

5.2 Develop and pilot test a green remediation analysis template to help collect information during various phases of the remediation process at any site:

The anticipated template may consist of a series of checklists for compiling baseline information and comparing potential green remediation strategies. Template topics will include opportunities for greater energy efficiency and site suitability for long-term wind farming, solar or thermal energy generation, and gas production. [*under development*]

- 5.3 Incorporate green remediation factors into remedy optimization evaluations:** Following a successful pilot effort in FY 2010, the Program will continue to incorporate green remediation into future optimization reviews. The effort will include pursuit of energy efficiency and alternative energy sources, reduction of air emissions, water conservation, efficiencies in materials use, reduction of waste generated by the remedy, use of recycled materials, minimized habitat destruction, and other key green remediation considerations relevant to the operating remedies. *[already implemented]*
- 5.4 Support the RE-Powering America's Land Initiative by identifying Superfund sites with outstanding or superb renewable energy potential:**¹⁵ OSWER will encourage EPA regions to work with renewable energy developers and other stakeholders to assess feasibility of locating renewable energy generation projects on contaminated lands and mining sites. Technical assistance to the regions is available through an OSWER IA with NREL. *[under development]*

Key Action #6: Establish opportunities in contracts and assistance agreements to identify green remediation practices in selected remedies

OSWER will examine opportunities to enter into or modify EPA contracts, cooperative agreements, grants, and IAs as a means to assure use of green remediation best management practices consistent with the remedy selected. Consistent with Federal Acquisition Regulations and Executive Order 13423 (EO, 2007), OSWER will work with the Office of Acquisitions Management to:

- 6.1 Modify EPA contract language to include green remediation practices:** The Agency will identify upcoming solicitations and develop language for the statements of work (SOWs) and requests for proposals. The Agency also will modify SOW language in existing remedial and removal contracts (both region-wide and site-specific) and work assignments or task orders whenever possible. Pertinent language in new or existing contracts will remain consistent with remedy selection under the NCP and other requirements. The Agency expects to use results-based language directing contractors to explore green remediation strategies (such as incorporating renewable energy sources, reducing water consumption, increasing material reuse, and reducing energy/fuel consumption during O&M) in all cases with the exception of time critical removals. Efforts to modify contract language may begin with referencing the best management practices (as posted on OSRTI's website at www.cluin.org/greenremediation). The Agency also plans to develop national model contract language that contains SOWs referencing EO 13514, federal mandates, and adaptations of EPA regional specifications in Remedial Action Contract (RAC) and Emergency and Rapid Response Services (ERRS) SOWs (as compiled in OSRTI's *Green Response Action Contracting and Administrative Toolkit* (see action 6.3)). Model language also may reflect specifications in Federal Acquisition Regulations. OSRTI will share model contract language through Web posting for potential use by other government agencies or other Superfund stakeholders. *[under development]*
- 6.2 Modify contract language to require reporting of selected activities:** The Agency plans to modify SOW language in remedial and removal contracts (and/or associated work assignments or task orders) to require contractors to annually and/or monthly report on concerns such as energy and fuel usage, separate from other direct costs. *[under development]*
- 6.3 Develop and periodically update a green remediation contracting tool kit:** OSRTI will disseminate the *Green Response Action Contracting and Administrative Toolkit* to regional project managers and Superfund contractors (USEPA, 2009a). Program partners will continue compiling new language adopted by regions or other agencies and information on innovative contracting or administrative mechanisms coming into use, and make toolkit updates publically available through posting on OSRTI's green remediation Web pages (www.cluin.org/greenremediation). The Program also will explore opportunities to provide incentives that encourage cleanup contractors to use green remediation practices consistent with remedy selection under the NCP; incentives may include Agency recognition, education, training, and partnerships. *[already implemented]*

¹⁵ RE-Powering America's Land products include maps and incentive sheets on potential for community wind energy, utility-scale wind energy, concentrating solar power, photovoltaic solar energy, and biomass energy (USEPA, n.d.7).

- 6.4 Develop model terms and conditions for assistance agreements and IAs concerning site cleanup:** Using regional examples such as Region 2's IA with the U.S. Army Corps of Engineers, OSWER will draft and institutionalize requirements for green remediation considerations consistent with the selected remedy in assistance agreements, IAs, and other vehicles. This effort will include development of model outputs/outcomes for regions to use in state agreements. [*under development*]
- 6.5 Explore additional opportunities to use existing federal agreements and establish new agreements:** OSWER will use its memoranda of understanding and/or IAs with NREL and Argonne National Laboratory to provide regions with site-specific technical assistance. EPA will pursue additional IAs with other agencies to additionally enable green remediation strategies consistent with NCP response actions. [*under development*]
- 6.6 Explore and promote opportunities to use local expertise in green cleanups:** Through venues such as the Superfund Job Training Initiative, the Program will seek to engage stakeholders in worker training and hiring opportunities applicable to green cleanups. For example, regional and local utility businesses will be encouraged to develop strategies that develop and retain local workers with expertise in energy optimization and renewable energy integration. In addition, local government agencies and businesses directly or indirectly involved in cleanups will be encouraged to institute service contracts and agreements with clauses that give preference to local workers and firms using environmentally preferable practices. [*under development*]

Key Action #7: Communicate and share success stories and lessons learned among “implementers” across the Program and the public

Development of green remediation program-wide and site-level initiatives will depend on shared activities and information that involve multiple interested parties, disciplines, and federal and state cleanup programs. A dedicated, well organized communications effort is needed to: (a) ensure that all stakeholders have an opportunity to be involved, (b) ensure consistency of green remediation messages across and within programs, (c) share technical and programmatic information, and (d) provide options that incorporate green remediation practices. OSRTI plans to undertake the following actions to address these needs:

- 7.1 Develop a communication plan:** The communication plan will complement OSWER efforts to ensure consistency of green remediation messages across the various cleanup programs. The plan will include sharing of success stories and lessons learned gained by communities, EPA regions, other federal agencies, states, tribes, local organizations, and contractors. Tools for information sharing will include websites, periodic teleconferences among Program offices, regional staff and managers, Internet seminars, and EPA's biannual Community Involvement Training Conference. Regular communications at events such as OSC Readiness and the annual NARPM training conference are an integral aspect of the plan. Program partners also will maintain communications at non-Superfund events such as the National Brownfields Conference, the RCRA Corrective Action Conference, and the National UST Conference. [*under development*]
- 7.2 Conduct outreach to contractors and industry:** This action will facilitate information sharing among EPA regions and help define or refine the best management practices of green remediation. Target information includes success stories, complications and technical roadblocks, and costs incurred or saved. [*under development*]
- 7.3 Partner with other federal agencies and state organizations to promote national use of green remediation strategies:** Program partners will share EPA success stories and lessons learned with other agencies and state organizations. Government organizations with work teams dedicated to green cleanup issues include the Federal Remediation Technologies Roundtable, Interstate Technology and Regulatory Council (ITRC), and Association of State and Territorial Solid Waste Management Officials (ASTSWMO). OSRTI and FFRRO will partner with other federal agencies and states to compile federal and state publications and information resources on green remediation strategies and distribute them to EPA, state, and other federal agency program and project managers. [*already implemented*]

- 7.4 Engage local communities in assessing and implementing green remediation options:** OSRTI will work with EPA regional offices to strengthen participation of local stakeholders, including minority and low-income populations affected by site cleanup. Mechanisms may include the Technical Assistance Services for Communities Program to help communities understand technical issues and opportunities posed by green remediation strategies; the Technical Assistance Grant Program to establish information networks; and the Superfund Job Training Initiative to help educate local workers in specialty fields such as energy efficiency and renewable energy applications. [*to be initiated*]

2.3 Program Evaluation

Goal:

Identify and make available measures and metrics for evaluating green remediation implementation at a site level and a Program level as part of a coordinated effort among OSWER program offices. OSWER may use the resulting measures and metrics to integrate green remediation goals into EPA's Strategic Plan and align green remediation activities with Agency budgets.

Introduction:

Superfund stakeholders need evaluation objectives for green remediation at both the site and Program levels to: (1) identify elements leading to improved environmental outcomes, (2) evaluate progress resulting from green remediation practices over time, and (3) report accomplishments at specific sites and across the Program. OSWER will begin this effort by establishing a conceptual framework that includes criteria for selecting green remediation measures. Criteria may include the degree of resolution acceptable for different evaluation parameters; limits to the level of effort required to employ the measures; the need to align with updated EPA goals; and the needs of various users such as site managers, regional offices, and national program managers. The criteria should also address acceptable approaches for addressing indirect or intangible effects of green remediation, managing disparate data, and weighing disparate measures.

Clear definition of green remediation measures and metrics will expedite subsequent data collection and contribute to the use of qualitative measures for tracking progress toward green remediation goals. EPA will work with states through ASTSWMO and the ITRC to identify measures and metrics suitable for use in assistance agreements and IAs concerning green remediation.

Key actions for green remediation evaluation will begin by examining existing tools developed by EPA, other federal agencies, states, and private industry for potential application to the Program. Common needs in site and Program evaluations include:

- **Estimate of a baseline** based on specific parameters such as energy use, fuel consumption, air emissions, and water use. Other baseline parameters may include the extent to which decision makers consider green remediation options at individual sites, deploy the best management practices at individual sites, or institute certain approaches as an integral part of the Superfund process.
- **Performance measure benchmarks**, which will build upon Agency and other standards such as ASTM International's environmental management series or a forthcoming voluntary green cleanup standard, as well as policies and methodologies issued under initiatives such as the United Nations Framework on Climate Change (United Nations, 2003). Baselines and methodologies pertaining to GHG and associated consumption of fossil fuel energy will be derived in part from EPA information such as the Office of Air and Radiation's October 30, 2009, final rule on mandatory reporting of GHG and related rule amendments (USEPA, n.d.1) and EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2008* (USEPA, 2010).

Internal baselines will provide the Agency with a starting point from which to measure related changes and quantify related project improvements in accordance with one or more core elements of green remediation.

- **Evaluation measures**, which should be meaningful and transferable across site and Program use levels. Anticipated measures include fuel and energy consumption, contributions from renewable energy sources, GHG and air contaminant emissions, water consumption and reuse, and material recycling or reuse.
- **A core set of metrics** that is practical to apply and poses minimal reporting burdens on RPMs and OSCs. Consistent, intuitive metrics will help balance project decision making and supply quantitative or qualitative data for measuring changes from relevant baselines. Examples include gallons of fuel, kilowatts of electricity, pounds of carbon dioxide equivalents, gallons of water, and cubic yards of waste.

Key Action #8: Establish a roadmap for evaluating the environmental footprint of a cleanup at a project level

In order to make informed decisions on green remediation strategies at a site level, the Agency and Superfund cleanup stakeholders need a consistent approach to quantify cleanup footprints associated with each of the core elements of green remediation. Many tools exist for evaluating the effects of site activity on one or more core elements, but none meets the Agency's need to evaluate the environmental footprint of a cleanup in accordance with OSWER's *Principles for Greener Cleanups*. Information gathered from the Program's pilot projects will generate valuable data and lessons for use in developing a consistent "roadmap" for site-specific evaluation of green remediation strategies. The green remediation roadmap will maintain consistency with NCP criteria for remedy evaluation.

RPMs and OSCs can use the roadmap to collect and evaluate information at a site-specific level, enabling them to focus efforts on reducing potential footprints through innovation, optimization, and best practices. The roadmap could be applied during remedy selection, design, construction, operation, and monitoring phases. In all cases, evaluation of the environmental footprint of remedy alternatives assumes that each adequately addresses a site's remedial objectives. Collective information gathered under this key action can also contribute to Program evaluation efforts by Agency management (Key Action #9).

OSRTI will take the following actions to establish a roadmap for green remediation at a project level:

- 8.1 Analyze existing methods and software tools for evaluating the environmental footprint of a cleanup:** OSRTI will identify and analyze applicable methods and software compiled by government organizations or private industry for use within an environmental footprint evaluation approach that aligns with OSWER's *Principles for Greener Cleanups*. OSRTI will make the resulting summary of existing decision-making tools available to RPMs, OSCs, and other stakeholders and periodically update the summary to reflect new or expanded decision-making tools (USEPA, n.d.6). [*already implemented*]
- 8.2 Develop an Agency methodology for evaluating the environmental footprint of a cleanup:** OSRTI will work with EPA regions to develop a consistent approach to quantify the environmental footprint of a cleanup project. The approach will use: (a) strategies outlined in EPA's technology primer (USEPA, 2008c), (b) results of the Agency's green remediation pilot projects, and (c) selected components of existing methods and software tools (identified in Action 8.1). In addition to specific criteria, the methodology will address intangible, unique, and composite measures of value to decision makers when choosing suitable measures and metrics for a particular site. [*under development*]
- 8.3 Develop evaluation modules for green remediation strategies:** OSRTI will work with EPA regions to subsequently document the environmental footprint evaluation methodology (produced through Action 8.2) in distinct modules for evaluating the footprint associated with each core element. Each module will describe potential metrics for site-by-site evaluation, provide pertinent formulas, and present samples of logistical tools such as checklists, worksheets, and summary reports. OSRTI anticipates that use of the integrated modules will help decision makers: identify contributors to a potential or existing remedial project's environmental footprint; quantify the footprint under various scenarios; identify best management practices for reducing the footprint; and modify or prioritize activities and practices as needed for each site-specific remedial project.

Upon completion, the evaluation modules and supporting materials will be publically available (at <http://www.cluin.org/greenremediation>). [*under development*]

Key Action #9: Evaluate the Environmental Footprints of Superfund Cleanups at a Programmatic Level

Effective implementation of the Strategy as part of EPA's Superfund Remedial Program relies on consistent quantitative and qualitative tools to:

- Inform decision making on future directions of the Program;
- Compile information supporting OSWER's *Principles for Greener Cleanups*; and
- Provide new data for EPA reports responding to EO 13514.

Evaluation of the environmental footprints of cleanup activities across the Program, whether at a regional or national level, involves establishing a comprehensive baseline and measuring performance of the Strategy. Evaluation processes and goals may emulate federal agency requirements of EO 13514 in a manner consistent with selecting and implementing responses under the NCP. Actions for Program evaluation include:

9.1 Estimate a Program baseline for the environmental footprints of Superfund cleanups:

OSWER will use a defined baseline to evaluate progress in reducing demands that site cleanups place on the environment and communities. Baseline estimation will involve use of an empirical model reflecting:

- (1) preliminary studies of historic information, such as OSRTI's estimates of energy consumption and carbon dioxide emissions from frequently used treatment technologies at NPL sites (USEPA, 2008a); and
- (2) aggregation of new information gained from: (a) green remediation pilot studies that apply the Agency's site-specific methodology (as developed in action 8.3); (b) new information gained from integrated RSE and green remediation evaluations for existing groundwater, soil, or sediment treatment systems; and (c) site-specific reports gathered by EPA regions through cleanup contracts. The baseline will address parameters corresponding to OSWER's *Principles for Greener Cleanups* and may include additional parameters outlined in the Agency's methodology for evaluating the individual footprint of a cleanup project (Action 8.2). [*under development*]

9.2 Establish performance goals, objectives, and measures for the Superfund Green Remediation Strategy:

This action involves formative evaluation of the Agency's Strategy through use of a logic model to: identify specific goals and objectives potentially incorporated into EPA's Strategic Plan; identify performance measures related to the Strategy; and measure environmental outcomes derived from implementation of the Strategy over time. The logic model will consist of five components:

- Strategic inputs such as funding, personnel, and information resources;
- Actions outlined in this Strategy;
- Strategic outputs provided to the Superfund cleanup community over the near term;
- Intermediate outcomes relating to the core elements of green remediation; and
- Long-term environmental outcomes resulting from sustained use of the Strategy's outputs [*under development*]

Region 2 intends to measure the cost differentials and environmental benefits of implementing its *Clean and Green* policy. Examples include tracking quantities of materials reduced, reused or recycled; carbon or GHG reductions; and quantities of water conserved or replenished. The Region plans to use existing progress reporting requirements in enforcement instruments, grants, and contracts to collect this data.

Region 2 "Clean and Green" Policy

9.3 Develop options for addressing possible gaps in measures or metrics: OSRTI will examine the adequacy of data collected through regional summaries of site-specific data. Gaps may relate to environmental outcomes that are difficult to quantify in terms of cleanup baselines, such as changes in sulfur dioxide and nitrogen oxide emissions, while other gaps may relate to complex issues such as carbon sequestration. Options for resolving measures and metrics gaps may involve application of methods such as present value analysis. [*under development*]

9.4 Characterize the state of practice and implications of life cycle assessment on Program operations: OSRTI will identify and develop tools and guidance to explore: (a) upstream and downstream effects on the environmental footprints of remedial actions, (b) methods to aggregate data involving disparate metrics, and (c) approaches to compare options extending over different time periods, such as waste excavation and disposal versus multi-year onsite treatment. Upstream impacts may include offsite activities such as material manufacturing that consumes energy and water. Potential downstream contributors include activities such as discharge of wastewater to publicly owned treatment works. Impact characterization would help direct environmental implications of the Program's actions over time. [*under development*]

Incremental measurements of strategic outputs and intermediate outcomes will help the Agency identify potential improvements to the strategic inputs and actions, consequently improving the long-term environmental outcomes achieved by implementation of the Strategy. OSWER will coordinate the Program evaluation measures with the Strategy's actions concerning resource development and program implementation (Actions 2.1 through 7.4). OSWER also may use the Program evaluation results to inform other EPA programs or address the Agency's cross-program priorities.

3.0 Strategy Implementation

EPA's Superfund Remedial Program partners will continue working on these strategic actions over coming months. Some actions are already complete, while others involve ongoing efforts. EPA anticipates revisiting the Strategy's overall status, accomplishments, and challenges in 2011. Future updates to the Strategy, as well as completed materials pertaining to the strategic actions, will be available online at:

- **Superfund & Green Remediation** (www.epa.gov/superfund/greenremediation), and
- **Green Remediation Focus** of the CLU-IN Web host (www.cluin.org/greenremediation).

Examples of initial products generated through completed strategic actions include:

Action 2.6 Deliver or host green remediation training through the Technology Innovation and Field Services Division's training infrastructure

- **CLU-IN Seminar Archives**
http://www.cluin.org/greenremediation/subtab_b6.cfm

Action 4.1 Develop a fact sheet on clean fuel and emission technologies

- **Green Remediation Best Management Practices: Clean Fuel & Emission Technologies for Site Cleanup**
<http://www.cluin.org/greenremediation/index.cfm>

Action 5.3 Incorporate green remediation factors into remedy optimization evaluations

- **Shepley's Hill Landfill RSE & GR Evaluation**
http://www.cluin.org/greenremediation/subtab_b3.cfm

Action 6.3 Develop and periodically update a green remediation contracting tool kit

- **Green Response and Remedial Action Contracting and Administrative Toolkit**
http://www.clu-in.org/greenremediation/docs/Green_RR_Action_Contract_Admn_Toolkit_July2009.pdf

Action 8.1 Analyze existing methods and software tools for evaluating the environmental footprint of a cleanup

- **Evaluation Tools**
http://www.cluin.org/greenremediation/subtab_b3.cfm

More information, or answers to questions concerning implementation of the Strategy at specific Superfund sites, is available from EPA's **Superfund Green Remediation Regional Coordinators** (listed at: <http://www.epa.gov/superfund/greenremediation/coordinators.html>).

Appendix A: Abbreviations and Acronyms

ARAR	applicable or relevant and appropriate requirement
ASTSWMO	Association of State and Territorial Solid Waste Management Officials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
DOE	U.S. Department of Energy
EE/CA	engineering evaluation/cost analysis
EO	executive order
EPA	U.S. Environmental Protection Agency
ER3	Environmentally Responsible Redevelopment and Reuse Initiative
ERRS	Emergency and Rapid Response Services
FFEO	Federal Facilities Enforcement Office
FFRRO	Federal Facilities Restoration and Reuse Office
GHG	greenhouse gas
IA	interagency agreement
ITRC	Interstate Technology and Regulatory Council
NARPM	National Association of Remedial Project Managers
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NREL	National Renewable Energy Laboratory
NRMRL	National Risk Management Research Laboratory
O&M	operation and maintenance
OEM	Office of Emergency Management
OSC	on-scene coordinator
OSRE	Office of Site Remediation Enforcement
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
PA/SI	preliminary assessment/site investigation
PRP	potentially responsible party
RA	remedial action
RAC	remedial action contract
RD	remedial design
REC	renewable energy certificate
RI/FS	remedial investigation/feasibility study
RPM	remedial project manager
RSE	remediation system evaluation
SOW	statement of work
SRI	Superfund Redevelopment Initiative

Appendix B: Glossary

This glossary provides definitions of key terms pertaining to EPA's *Superfund Green Remediation Strategy*.

Best management practice: Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources; also referenced as "practice" or "best practice." [EPA Terms of Environment; <http://www.epa.gov/OCEPAterms/gterms.html>]

Climate change: Any significant change in measures of climate (e.g. temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun; natural processes within the climate system (e.g. changes in ocean circulation); human activities that change the atmosphere's composition (e.g. through burning fossil fuels) and the land surface (e.g. deforestation, reforestation, urbanization, and desertification). [EPA; Climate Change; <http://www.epa.gov/climatechange/glossary.html>]

Global warming: An average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities. [EPA; Climate Change; <http://www.epa.gov/climatechange/glossary.html>]

Global warming potential (GWP): The cumulative radiative forcing effects of a gas over a specified time horizon resulting from the emission of a unit mass of gas relative to a reference gas. The GWP-weighted emissions of direct greenhouse gases in the U.S. Inventory are presented in terms of equivalent emissions of carbon dioxide (CO₂), using units of teragrams of carbon dioxide equivalents (Tg CO₂ Eq.) [EPA; Climate Change; <http://www.epa.gov/climatechange/glossary.html>]

Green cleanup: A remediation project that considers all environmental effects of remedy implementation and incorporates options to minimize the environmental footprints of a cleanup by evaluating core elements: (1) total energy use and renewable energy use, (2) air pollutants and greenhouse gas emissions, (3) water use and impacts to water resources, (4) materials management and waste reduction, and (5) land management and ecosystems protection.

Green power: Electricity produced from solar, wind, geothermal, biogas, biomass, and low-impact small hydroelectric sources as renewable energy resources and technologies that provide the highest environmental benefit relating to greenhouse gas reduction. [<http://www.epa.gov/grnpower/gpmarket/index.htm>]

Greenhouse gas: Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), ozone (O₃), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆). [EPA; Climate Change; <http://www.epa.gov/climatechange/glossary.html>]

Formative assessment: Evaluation used in the earliest stages of a program, during the design phase or early in the implementation phase. A formative assessment examines the intent of a program and helps assess features of program design and operating environment (including external factors) that influence the chances of successful achievement of program objectives. [EPA; *Planning and Implementing Program Evaluations within the Office of Solid Waste*; <http://www.epa.gov/evaluate/pdf/pumphrey.pdf>]

Power purchase agreement: A financing structure that enables property owners or tenants to realize the benefits of renewable energy generation without having to own the equipment and pay upfront capital costs, which are instead paid by private investors. In this structure, a property owner or tenant enters into a long-term (typically 10-20 years) contract agreeing to pay a predetermined rate (typically fixed or linked to a floating index on par with current utility rates) for kilowatt hours delivered from a renewable energy asset. [<http://www1.eere.energy.gov/wip/solutioncenter/financialproducts/ppa.html>]

Renewable energy: Energy produced by solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project. [Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance; October 8, 2009]

Renewable energy certificate (credit): Representation of property rights to the environmental, social, and other nonpower qualities of renewable electricity generation. A REC and its associated attributes and benefits can be sold separately from the underlying physical electricity associated with a renewable-based generation source. [<http://www.epa.gov/grnpower/gpmarket/rec.htm>]

Sustainability (sustainable): To create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations. [Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance; October 8, 2009]

Appendix C: References

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