



Green and Sustainable Remediation Fact Sheet

Introduction to GSR (What, Why, How)

What is Green and Sustainable Remediation?

Sustainable practices are those that consider economic and natural resources, ecology, human health and safety, and quality of life. Although the terms green and sustainable are sometimes used interchangeably, green remediation can be considered as having a focus on environmental factors, whereas green and sustainable remediation (GSR) is of a more holistic view and considers not only environmental factors, but social responsibility (e.g., minimizing risk to surrounding communities) aspects as well.

GSR expands upon current environmental practices and employs strategies for cleanups that use natural resources and energy efficiently, reduce negative impacts on the environment, minimize or eliminate pollution at the source, protect and benefit the community at large, and reduce waste to the greatest extent possible, thereby minimizing the environmental "footprint" and maximizing the overall benefit of cleanup actions. The term environmental footprint refers to the impacts on environmental media and society that are a direct or indirect consequence of performing the remedial action.

Opportunities to increase sustainability can be considered throughout all phases of remediation (i.e., site investigation, remedy selection, remedy design and construction, operation, monitoring, and site closeout) regardless of the selected cleanup remedy. However, it is anticipated that the greatest opportunities to reduce the footprint of the Navy Environmental Restoration Program (NERP) are associated with the remedy selection process. While it must be emphasized that meeting the traditional requirements of remediation (e.g., protection of human health and the environment and compliance with applicable or relevant and appropriate requirements) is still of primary importance, there are significant differences in the environmental footprint among alternatives that meet these requirements, and those remedies with the lesser footprint should be viewed more favorably.

Why now?

Consideration of sustainable practices is becoming increasingly important throughout the remediation community and this emphasis is now being reflected in policy and guidance. Executive orders (EOs) 13514 released on October 8, 2009 and 13423 released on January 26, 2007 mandate inclusion of sustainability and sustainable practices in all the

activities of federal agencies. Furthermore, a memorandum released by the Department of Defense (DoD) in August of 2009 states that the DoD is committed to conduct its environmental program in a sustainable manner, in line with EO 13423. The memorandum requests every DoD component to apprise the office of Under Secretary of Defense by December 2009 about the initiatives undertaken by all the DoD components for implementing green and sustainable options in their environmental restoration programs. In addition, Department of the Navy (DON) Environmental Strategy lays out a vision for "Sustaining our Environment, Protecting our Freedom," which links accomplishing the Navy's war fighting mission with its responsibility to safeguard the natural systems upon which the nation's quality of life depends. Furthermore, regulatory agencies are beginning to request that sustainability be considered during remedy implementation. The Navy remedial project manager (RPM) that applies GSR is able to show compliance with EOs 13423 and 13514, DoD GSR Memorandum, and the DON Environmental Strategy, as well as reduced life-cycle costs and improved community and regulatory acceptance of remedies with lower overall impacts.

How do I apply GSR to my site?

Although the remediation industry is placing an emphasis on GSR and various relevant publications have been produced (a listing of references is provided in the spring 2009 NAVFAC RPM newsletter), no accepted protocols currently exist for implementing GSR. GSR should be considered during (a) evaluation of remedies during the remedy selection process, (b) the remedial design phase, and (c) optimization of remedial actions during the remedial action operation phase. The DON Optimization Workgroup is developing a strategy for applying GSR to the remediation process as part of the optimization program. Until guidance is available, an RPM may consider the following general approach:

- Determine which sustainability metrics should be considered for the site;
- Establish and apply a methodology to quantify or characterize each metric;
- Obtain consensus regarding how metrics are weighed against each other and against traditional criteria in selecting the remedial approach;
- Identify methods to reduce environmental footprint of remedy components; and
- Prioritize, select, and document what footprint reduction methods should be implemented with consideration of the overall net environmental benefit and available funding.

Sustainability Metrics

Sustainability metrics can be used to help determine relative benefits versus negative impacts of remedial actions. The core elements of sustainability that were developed by the U.S. Environmental Protection Agency (EPA) in accordance with EO 13423 and are outlined in the green remediation EPA Technology Primer (hereafter referred to as the Primer) are: (1) air; (2) water; (3) land and ecosystems; (4) materials and waste; (5) energy; and (6) stewardship. These core elements can be developed into quantifiable and qualitative metrics to evaluate the environmental footprint of a remedial action. Upon review of the Primer and other information, the Navy has developed a list of metrics (see below) for consideration as part of sustainable remediation. This list covers the EPA core metrics presented in the Primer as well as additional metrics, such as worker safety and community impacts.

Energy Consumption: Consumption of energy from non-renewable versus renewable sources is an important metric because of the need to conserve the U.S. energy supply and reduce dependence on foreign sources of energy. Energy consumption also results in the generation of greenhouse gases (GHGs). Activities resulting in energy consumption include: on-site electrical use, fuel consumed for on-site equipment and transportation, and energy used for the production of consumables associated with the remedy.

GHG Emissions: Quantification of GHG emissions is also an important metric because of growing concern for climate change. The internationally accepted norm is to consider direct GHGs that include carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆) to develop GHG emission inventories. A standard DoD-wide approach for conducting GHG inventories is being developed. On April 17, 2009, the EPA formally declared GHGs as major air pollutants with adverse human health and environmental effects. EPA is considering regulating these gases under the Clean Air Act. Activities that result in GHG emissions include: equipment and electrical use on site; transportation of personnel, material, and equipment; and production of consumables associated with the remedy.

Criteria Pollutant Emissions: Air emission of criteria pollutants, regulated by the Clean Air Act of 1970, can cause smog and adverse health effects such as asthma, bronchitis, lung cancer, and eye irritation. Criteria air pollutants include: sulfur oxides (SO_x), oxides of nitrogen (NO_x), particulate matter (PM), carbon monoxide (CO), ozone, and lead due to various activities such as transportation, electrical usage, and heavy machinery and equipment use during remedy implementation.

Water Impacts: Water consumption can be evaluated both qualitatively and quantitatively. Water can be a lost resource if water from an aquifer is wasted or conversely as a gained resource if contaminated water is treated and re-injected into the aquifer for beneficial use. In addition, water is consumed to produce electricity and manufacture consumables that may be used during remedial activities.

Ecological Impacts: Ecological impacts include adverse effects such as: introduction of invasive species, changes in ecosystem structure or shifts in the geographic distribution and extent of major

ecosystem types, disturbance to soil and surface water bodies, and destruction of habitats. These impacts should be evaluated along with the positive ecological effects of site remediation.

Resource Consumption: The resource consumption metric tracks consumption of resources that are not specifically identified in other metrics such as landfill space occupied by hazardous and non-hazardous waste produced during remedial action or amount of top soil brought to a site for backfill.

Worker Safety: Worker safety/accident risk is the risk of fatality or injury of carrying out a specific task of a remedial activity. The guiding principle of any activity undertaken by DON is to “operate safely”. Therefore, worker safety is crucial and is also a part of NAVFAC’s strategic plan. During remedial action operations, higher risk activities include working around heavy equipment and machinery, and transportation.

Community Impacts: Community impacts are local disturbances and health and safety issues caused by remedial activities, such as: noise; traffic issues, including accidents during transportation; odor; dust; and emissions of VOCs and other contaminants.

Environmental Footprint Assessment Methodology

An environmental footprint can be assessed to determine which potential remedies and which elements of the remedy have the greatest environmental footprint. This allows the RPM to better focus on footprint reduction methods. The evaluation should include effects from on-site and off-site actions, and consider alternate energy sources and more energy efficient alternatives for high-energy demand remedies. A more comprehensive evaluation could also consider impacts from raw materials, supplies, and manufacturing of equipment needed for remedial actions. The remediation industry has not yet developed standard methods of performing these assessments; however, information that can be used to perform an analysis is available from several recognizable sources. Several examples of sources are presented below.

GHG emission footprint calculation: The EPA Climate Leaders Program provides a GHG Inventory Guidance that is used by industry to document emissions of GHGs including CO₂, CH₄, and N₂O. The EPA Climate Leaders GHG Inventory Guidance is a modification of the GHG protocol developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). An example of the results of a GHG footprint analysis is presented in Figure 1, where the GHG footprint was calculated for three remedial alternatives under consideration at Site 228, Naval Air Station (NAS) Meridian.

Energy usage calculation methodology: Electricity used on site can be determined through meter readings for existing systems and/or by performing engineering calculations for each piece of equipment.

Air emission inventories development: Mobile 6 and Non-road are two computer programs developed by the EPA’s Office of Transportation and Air Quality that calculate NO_x, SO_x, CO, VOCs,

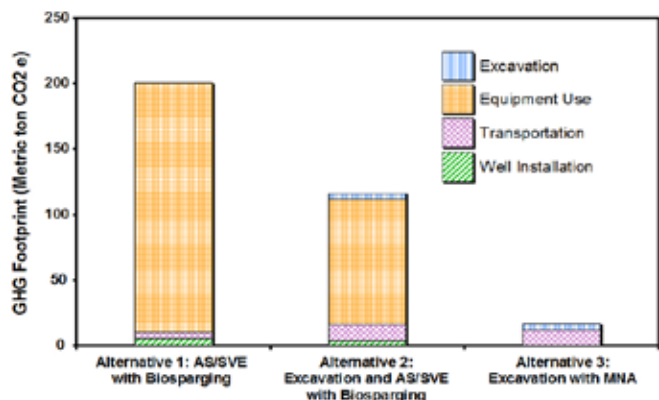


Figure 1. GHG footprint of remedial alternatives at Site 228 NAS Meridian

and PM10 emission factors for mobile and non-road equipment, respectively. Other inventories, such as AP-42, are available for obtaining emission factors for various activities.

Accident risk calculation methodology: Several organizations (including Automobile Transport Statistics, Airplane Transport Statistics, Railroad Transport Statistics, and Labor Statistics) provide statistics of both fatalities and injuries that occur during various activities including transportation by automobile, airplane, rail and labor.

A number of tools are available for conducting these baseline assessments that allow the RPM and other interested parties to make better decisions regarding their sustainability choices. Some tools are in the public domain and some are proprietary. The most important attribute of a good tool is the degree of comprehensiveness it brings to the accounting of air (including GHG emissions), water, and land impacts of the various materials and energy sources used in a remedial action. This would include at the very least one step backwards (origins of the materials and energy sources) and one step forward (fate of end products), not just the current step (the use of a material or energy source during remediation). For example, one step back includes manufacturing of treatment chemicals but not mining of raw materials that are sent to the manufacturer. The DON Optimization Workgroup is currently evaluating several tools that can be used for environmental footprint assessment. SiteWise™ is one such tool, developed by the Navy, Army, and Battelle for assessing remedial alternatives/technologies in terms of GHG emissions/footprint, energy use, air emissions of criteria pollutants, water impacts, and worker safety. An RPM can contact a representative of the workgroup for additional information.

Incorporating GSR into the Environmental Restoration Process

Although sustainability should be considered throughout the ER process, key points include remedy selection, remedial design and system operation. During remedy selection, the environmental footprint of each remedy should be analyzed and presented along with other evaluation criteria. Although each remediation program (e.g., CERCLA, RCRA) has a different set of evaluation criteria, sustainability fits into the existing framework for those programs and usually can be included under short-term effectiveness. Sustainability considerations

should not be presented as an additional criterion. Existing guidance is available for addressing some of the sustainability metrics. For example, the EPA Risk Assessment Guidance for Superfund (RAGS) Part C provides a framework for considering risk to the community and remediation workers during implementation of the remedy. Also, the Net Environmental Benefits Analysis (NEBA) provides a framework for considering the ecological impacts of remediation activities.

During remedy selection and remedial system design, it is important to develop well-defined performance objectives and exit strategies. This is an important GSR consideration because as remedial systems continue to operate over time, the effectiveness tends to decline, and thus the benefit of continued operation declines, causing an increase in the footprint to benefit ratio. For example, GHG emissions per mass of contaminant removed may increase significantly over time (Figure 2), indicating that the treatment system has reached the end of useful operation. This typical life-cycle characteristic should be considered when developing performance objectives and exit strategies so a plan is in place, where GSR metrics are tracked over time and the remedial system is shut down or transitioned to a less active system at the appropriate time. For systems already in operation, the monitoring and reporting plan can be modified to include this type of analysis and prevent systems from operating beyond the point of diminishing returns.

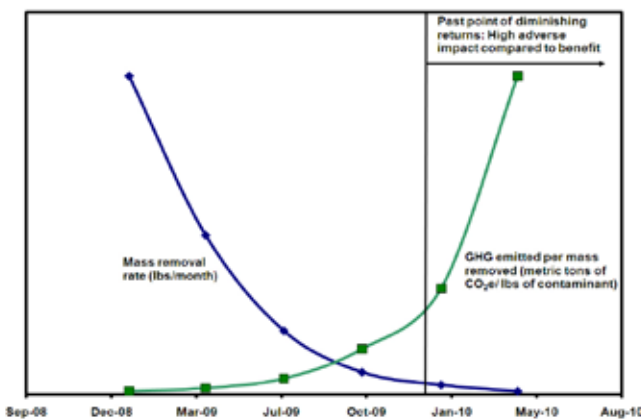


Figure 2. Applying sustainability metrics to determine point of diminishing returns during the remedial action operation phase

Footprint Reduction Methods

Each activity during remedy implementation results in an environmental footprint. Certain activities, such as those listed in Table 1, tend to have the most significant footprint and should be the focus of footprint reduction. Several footprint reduction methods are discussed below. This is not a complete listing and it is up to the project personnel to find appropriate solutions to minimize the overall footprint. Methods of reducing the environmental footprint are also presented in EPA publications, such as *Incorporating Sustainable Practices into Site Remediation* (April 2008) and *Green Remediation: Best Management Practices for Excavation and Surface Restoration* (Dec. 2008) and may also include provisions related to landscape alteration where the concepts and resources are similar in scope to the "Sustainable Sites" section of the "Leadership in Energy and Environment Design (LEED) for Core and Shell" development framework found in LEED.

Table 1. Examples of Activities with High Environmental Footprint

Activity	Metrics Most Impacted
Transportation (for materials and waste as well as personnel during RA-O & LTMgt)	Emissions of GHGs and criteria pollutants, consumption of energy, accidental death and injury
Operation of mechanical equipment (e.g., pumps, blowers, compressors)	Emissions of GHGs and criteria pollutants, consumption of energy
Drilling/Well installation	Emissions of GHGs and criteria pollutants, consumption of energy, accidental injury
Consumption of chemicals or other materials (e.g. oxidants, reductants, biostimulants, activated carbon)	Emissions of GHGs and criteria pollutants, consumption of energy
Site clearing and excavation in sensitive habitats	Ecological, emissions of GHGs and criteria pollutants

Energy conservation: Energy conservation is of particular importance if electric motors are part of an active remediation system and operate continuously as part of routine operations. General techniques for energy conservation include: selecting energy efficient equipment (e.g., high efficiency motors), proper sizing of equipment, and the use of variable frequency drives. It is particularly important to ensure that remediation proceeds effectively and efficiently and that active systems are shut down at the appropriate time.

Renewable energy: The use of renewable energy systems to power remediation equipment can significantly reduce the environmental footprint, particularly for remedies that require moderate to long-term equipment operation. Renewable energy options include photovoltaics (PV), wind power and landfill gas recovery. The EPA's *Smart Energy Resources Guide* provides information regarding renewable energy options, including practical considerations such as: determining the location-specific solar radiation and wind potential, estimating the capital cost and energy output of the renewable energy systems, finding system installers, warranties, permits and other environmental issues.

It should be acknowledged that the capital cost of a renewable energy system is sometimes high in comparison to the savings in energy consumption but the economics can be improved if it is integrated with the installation's energy strategy or for remote sites where the cost of bringing in electric power lines is expensive. An example of this is where a portable wind turbine was used to power remediation equipment at a remote Navy site in Adak, Alaska (Figure 3).



Figure 3. Portable wind turbine used at a remote Navy site in Adak, Alaska

Resource conservation through recovery, recycle and re-use: Examples of resource conservation include: recycling of construction and demolition debris, treated water re-injection, and re-use of treated soil on site. Such practices also reduce the consumption of landfill space and reduce various other impacts associated with the transportation of waste off site and new materials on site.

Transportation and heavy equipment: Many choices are available regarding the type of fuel to power engines used for transportation and construction. Several of these, including ultra low sulfur fuel, are discussed in the EPA Cleaner Diesels publication. It should be noted that research is ongoing evaluating the life-cycle impacts of producing alternative fuels and there is currently uncertainty regarding the benefits compared to the use of fossil fuels. Other methods to reduce the impact of transportation include use of rail or river for material transport.

Direct-push technology (where appropriate) instead of rotary drilling rigs can reduce drilling duration by as much as 50 to 60%, avoid drilling fluids, and eliminate drill cuttings. It is also recommended to consider re-using wells and subsurface bore holes.

Summary

Interest in GSR is rapidly growing and the need for including GSR practices into remedial programs has become a reality. Although regulatory agencies generally concur with the concepts of GSR, there are many details about how this should be implemented that will need to be resolved as this area matures. At the current time, RPMs can become familiar with the GSR concepts and related literature discussed in this fact sheet, as well as those presented on the GSR web portal and tool developed by the Navy and available on the ERT2 Web site (www.ert2.org). They can also look for ways to reduce the environmental footprint of remedial actions. All future GSR guidance documents will be made available on the GSR portal.