NAVFAC
Naval Facilities Engineering Command

ENVIRONMENTAL RESTORATION

Green and Sustainable Remediation

What is Green and Sustainable Remediation?

Sustainable practices take into account 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 a more holistic view which considers not only environmental factors, but also aspects of social responsibility (such as minimizing risk to surrounding communities).

The idea behind GSR is to improve the Navy's cleanup program by meeting the existing requirements, while minimizing potential negative environmental, societal, and economic impacts that could occur during or as a result of remedial actions. This approach emphasizes 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. It thereby minimizes the remedy "footprint" and maximizes the overall benefit of cleanup actions. The term *remedy 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 exist throughout all phases of remediation (i.e., site investigation, remedy selection, remedial design [RD], construction, operation, long-term monitoring [LTM], and site closeout). As part of the remedy selection process, it is important to meet the traditional requirements of remediation (e.g., protection of human health and the environment and compliance with applicable or relevant and appropriate requirements [ARARs]). However, there can be significant differences in the remedy footprint among remedial alternatives that meet these requirements. The remedies with the lesser footprints are viewed more favorably. During the RD phase, specific footprint reduction methods can be identified and then implemented during construction and remedial action operation (RA-O). As site conditions change over time during extended RA-O and LTM periods, the GSR evaluation can be updated through periodic optimization reviews to identify any additional footprint reduction methods that may further improve sustainability of the remedy.

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Why Now?

The consideration of sustainable practices is becoming increasingly important throughout the remediation community and this emphasis is now being reflected in Department of Defense (DoD) and Department of the Navy (DON) policies and guidance.

The *Defense Environmental Restoration Program (DERP) Management Manual* recommends the evaluation of remedial alternatives to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems on the environment (DoD, 2012).

The DON has approached implementation of GSR as part of its existing optimization program, and has included GSR in the *Policy for Optimizing Remedial and Removal Actions at all DON Environmental Restoration Program Sites* (DON, 2012a). The DON policy mandates the following actions be performed on DON Environmental Restoration (ER) sites:

- Incorporate GSR into the optimization process;
- Perform a remedial alternative analysis (RAA) to ensure sites have been effectively optimized; and
- Ensure use of the SiteWise™ tool in all GSR actions.

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SiteWise™, a tool developed by the Navy, U.S. Army Corps of Engineers (USACE), and Battelle, can assist in calculating GSR metrics during remedial alternatives. The SiteWise™ tool can be applied at the remedy selection, design, or implementation stage. More information can be found in the *NAVFAC SiteWise™ Version 3 User Guide* (NAVFAC, 2013).

The application of GSR within the framework of environmental remediation optimization is further summarized in the *DON Guidance on Green and Sustainable Remediation* (DON, 2012b). This document provides Navy Remedial Project Managers (RPMs) and consultants with a clear approach to incorporating GSR considerations into the current remediation process. It includes a discussion of the sources for GSR metrics, tools for evaluating remedy footprints, specific GSR considerations during each remedial phase, recommended strategies for footprint reduction, and case studies.

GSR Metrics and Remedy Footprint Assessment Methodology

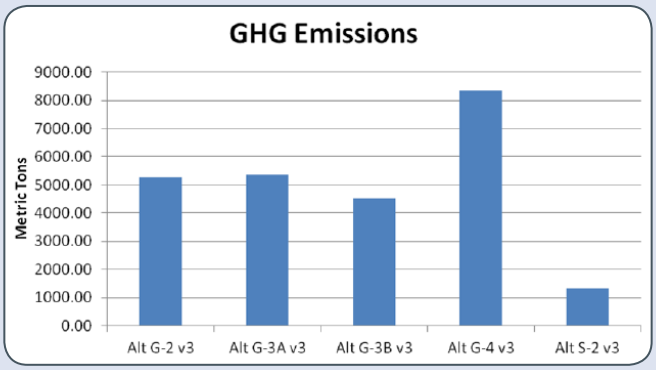
GSR is implemented after determining what specific sustainability metrics are important for the site and project. GSR sustainability metrics can be used to help to determine relative benefits versus negative impacts of remedial actions. The Navy GSR metrics are summarized in Table 1. These metrics can be expanded or reduced based on site, technology, or stakeholder specific information.

Table 1. Navy GSR Metrics

Metric	Description
Energy Consumption	British Thermal Units (BTUs) including renewables and non-renewables
Greenhouse Gas (GHG) Emissions	Metric tons CO_2e (includes CO_2, CH_4, and N_2O)
Criteria Pollutant Emissions	NOx, SOx, particulate matter in metric tons On-site and total emissions
Water Impacts	Expressed as gallons
Resource Consumption	Landfill space, top soil
Worker Safety and Accident Risk	Accidental injury, death and lost hours
Ecological Impacts	Qualitative (e.g., land, surface water, and aquifer impacts)
Community Impacts	Qualitative (e.g., noise, traffic, odor)

SiteWise™ GSR Evaluation Tool

SiteWise™ is a tool developed by the Navy, USACE, and Battelle to assist in calculating GSR metrics for comparing remedial alternatives. The use of SiteWise™ is required by DON policy (DON, 2012a) during the feasibility study. The remedy footprint in the SiteWise™ tool is calculated by multiplying the impact factors (e.g., emissions per usage rate) with the usage rate (e.g., consumption) of a material, electricity, or fuels during a remedial action. SiteWise™ performs calculations based on emission factors that have been obtained from credible governmental or non-governmental research sources. Ecological and community impacts can be evaluated qualitatively by the user. Example output from SiteWise™ is shown below.



SiteWise™ Output Screen

Footprint Reduction Methods

A wide variety of footprint reduction technologies can be applied to a given project. The challenge to an RPM is to determine which technologies are appropriate for a given site. Three basic methods of reducing the footprint of a site cleanup include:

1) Select technologies and approaches that have a low footprint relative to the other alternatives;
2) Apply general best management practices (BMPs) that should be implemented on a routine basis; and/or
3) Implement footprint reduction methods to enhance the sustainability of selected or existing remedies.

Before considering any footprint reduction method, it is important to perform a baseline GSR assessment to determine which elements or activities of the remedy have the most significant footprint. A baseline GSR assessment helps to quantify the level of sustainability as it applies to the selected remedy. Understanding the baseline remedy footprint allows the RPM to better focus resources to address those activities for which footprint reduction will have the greatest benefit.

Examples of footprint reduction methods from the DON GSR Guidance (DON, 2012b) are highlighted below for alternative fuels, renewable energy, alternative transportation, after-treatment technologies, energy conservation, resource conservation and green materials, injection methods, procurement, and project

management. In addition, practices that can help reduce the remedy footprint of a site cleanup are described in EPA's publication series on *Green Remediation: Best Management Practices* (EPA, 2013). EPA has developed BMPs related to site investigation, bioremediation, pump-and-treat, soil vapor extraction (SVE), air sparging, excavation, alternative fuels, renewable energy, and more.

Alternative Fuels. The use of alternative fuels for transportation and construction activities can result in reductions of GHG emissions. Several alternative fuel options such as biodiesel and natural gas (compressed or liquefied) exist. More information on various fuel options can be found in the *DON GSR Guidance* (DON, 2012b) and on the EPA Renewable and Alternate Fuel Web site. It is recommended that information from the manufacturer be checked to ensure compatibility and that warranties will not be voided by the use of a biofuel blend or other alternative fuel.

Soil Excavation using Biodiesel-Powered Equipment (EPA, 2008)

Renewable Energy. The use of renewable energy systems to power remediation equipment can significantly reduce the remedy footprint, particularly for remedies that require moderate to long-term equipment operation. Renewable energy options include on-site use of photovoltaics (PV), wind power, landfill gas recovery, microturbines, and peak shaving and/or shifting. In addition, it may be an option to purchase green power from an off-site energy provider. Although the capital cost of a renewable energy system is sometimes high in comparison to the energy savings, 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 prohibitive. Several tools are available to evaluate the feasibility of renewable energy use at a given site. For example, SiteWise™ includes cost calculations related to footprint reduction via renewable energy (e.g., wind, solar, and microturbines). Incentives for the use of renewable energy change frequently so RPMs should continue to track how this impacts the economic evaluation.

Solar-Powered Skimmers (Navy, 2012)

Alternative Transportation. Selection of the optimum mode of transportation is a low-cost method for reducing the footprint. The best example is the use of rail to transport materials or personnel rather than road vehicles. SiteWise™ can be used to quantify and compare the benefits of using rail services rather than road vehicles. The project can also be managed to minimize the number of trips or mobilization events needed for project management, site characterization, operations, and/or LTM.

After-Treatment Technologies for Diesel Engines. Diesel engines retrofitted with after-treatment technologies can reduce emissions of particulate matter, hydrocarbons, NOx, and carbon monoxide. The type of devices that can be added onto existing diesel engines include diesel oxidation catalysts (DOCs), diesel particulate filters (DPFs), selective catalytic reductions (SCRs), and diesel multistage filters (DMFs). The manufacturer of the equipment should be consulted to determine if a retrofit would impact the warranty.

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. Electricity consumption can cause significant remedy footprint impacts due to energy use and GHG generation. General techniques for energy conservation include: selecting energy efficient equipment, proper sizing of equipment, the use of variable frequency drives, and intermittent or pulsed operations. It is particularly important to ensure that remediation proceeds effectively and efficiently and that active systems are shut down at the appropriate time.

Resource Conservation and Green Materials. 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. The use of "green" products and materials such as eco-friendly concrete or the use of native plants for site restoration also advances the sustainability objectives of the project.

Injection Methods. It has been found that for in situ remediation technologies, a large component of the remedy footprint is related to the manufacturing of the material consumed during injection. Therefore, it is important to optimize the injection strategy to efficiently distribute the chemicals. This will result in less time in the field and less consumption of injected materials. Direct-push technology (where appropriate) rather than rotary drilling rigs can reduce drilling duration, avoid drilling fluids, and eliminate drill cuttings. It is also recommended to consider re-using wells and subsurface boreholes.

Procurement. Early integration of green objectives and criteria into contracts and administrative documents increases the likelihood that BMPs of green remediation will be used throughout a project's life. Bid documents such as scope of work in the contractor procurement process can include GSR requirements. They can also include incentives for contractors to be sustainable. Contracts designed to require GSR elements within the scope of work can use tracking mechanisms for verification of targets.

Project Management. Effective project management practices can help reduce the footprint of remediation activities. These include planning multiple tasks for singular events, hosting virtual meetings to eliminate unnecessary travel, and electronic submittal of documents.

Summary

Interest in GSR is rapidly growing and the need for including GSR practices into DoD remedial programs has become a reality. GSR supports DoD's goal to decrease energy demand and consider options for reducing the environmental impact of systems as discussed in the DERP manual (DoD, 2012). DON has included GSR requirements in the *Policy for Optimizing Remedial and Removal Actions at All DON Environmental Restoration Program Sites* (DON, 2012a).

NAVFAC RPMs should become familiar with the key GSR concepts reviewed in this factsheet, along with consulting the relevant literature for more detailed information. This factsheet also serves as a resource for regulatory agencies and other stakeholders, who can be engaged throughout the remedial process to assist with reviewing GSR evaluations and footprint reduction methods. GSR-related resources are listed here, and links are provided for further reference.

Navy Resources

Department of Defense (DoD). 2012. *Department of Defense Manual, Defense Environmental Restoration Program (DERP) Management,* Publication Number 4715.20, March 9.

http://www.dtic.mil/whs/directives/corres/pdf/471520m.pdf

Department of Defense (DoD). 2009. *Consideration of GSR Practices in the Defense Environmental Restoration Program.* August.

http://www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary%20Warfare%20Center/Environmental/Restoration/er_pdfs/gpr/dod-ev-memo gsr-20090810.pdf

Department of Navy (DON). 2012a. *Policy for Optimizing Remedial and Removal Actions at All DON Environmental Restoration Program Sites.* April.

http://www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary%20Warfare%20Center/Environmental/Restoration/er_pdfs/gpr/don-ev-pol-opt-actions-20120402.pdf

Department of Navy (DON). 2012b. *Guidance on Green and Sustainable Remediation.* April.

http://www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary%20Warfare%20Center/Environmental/Restoration/er_pdfs/gpr/navfacesc-ev-ug-2093-env-gsr-20120405r1.pdf

NAVFAC. 2012. *Integrating Green and Sustainable Remediation Metrics within the CERCLA Process during the Feasibility Study.* July

http://www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary%20Warfare%20Center/Environmental/Restoration/er_pdfs/g/navfacesc-ev-rpt-gsr-cercla-integrate-201207.pdf

NAVFAC. 2013. *SiteWise™ Version 3 User's Guide.*

http://www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary%20Warfare%20Center/Environmental/Restoration/er_pdfs/s/navfacexwc-ev-ug-1302-sitewise3-20130807.pdf

SiteWise™
(File Available Upon Request)

Other Technical Resources

Environmental Protection Agency (EPA). 2013. *Green Remediation Best Management Practices.*

http://www.clu-in.org/greenremediation/docs/GR_factsheet_topics.pdf

Environmental Protection Agency (EPA). 2008. *Smart Energy Resources Guide (SERG)*. March.

http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1000Z9K.txt

Environmental Protection Agency (EPA) Renewable and Alternative Fuels Web Site

http://www.epa.gov/otaq/fuels/alternative-renewablefuels/index.htm

Environmental Protection Agency (EPA) Spreadsheets for Environmental Footprint Analysis (SEFA)

http://www.clu-in.org/conf/tio/sefa/