Green and Sustainable Remediation

Framework and Resources

Introduction

This document describes how to incorporate Green and Sustainable Remediation (GSR) into the general remediation process at sites in the Minnesota Pollution Control Agency's (MPCA's) Remediation Division. GSR is the site-specific employment of products, processes, technologies, procedures, and best management practices (BMPs) that mitigate contaminant risk to receptors while making decisions that are cognizant of balancing community goals, economic impacts, and environmental effects (ITRC, 2011). This document is applicable to all MPCA Remediation programs but does not supersede program-specific policies and guidance. While not a requirement, the MPCA strongly encourages the use of GSR at Remediation sites.

The primary mission of Remediation programs is to protect human health and the environment. While the most obvious results of the remediation process are positive effects from site cleanup, there can also be unintended negative consequences to a site, the environment, and the surrounding community that should be considered and reduced. Examples of negative impacts include air emissions and noise from remediation systems; air pollution—including greenhouse gas emissions—from trucks, drill rigs, and other equipment; potential contaminated groundwater discharge; and physical safety hazards associated with investigation or remedy implementation. GSR is ultimately an approach that considers all the potential effects of the remediation process by combining best practices that reduce the environmental footprint of the remedial process with solutions that increase resiliency, sustainability, and community benefit.

The use of GSR can benefit responsible and voluntary parties, site developers, consulting firms, and others involved in the site remediation process by reducing project costs and helping attain internal corporate sustainability goals. GSR can also be applied to the redevelopment of a site after cleanup to reduce emissions of greenhouse gases and positively contribute to climate resilient communities.

MPCA and Minnesota initiatives related to GSR

Many GSR concepts and goals relate directly to the need to mitigate climate change and its impacts, which is a critical challenge to Minnesota's environment and economy and the health and well-being of all Minnesotans. Use of GSR aligns with Minnesota's Climate Action Framework and the MPCA's strategic plan by incorporating greenhouse gas emission reduction, climate-resilient and adaptive remediation system design, energy efficiency, and climate-resilient and adaptive redevelopment concepts into the remediation process. It also aligns with the MPCA's Environmental Justice Framework Report by incorporating enhanced outreach and engagement efforts to surrounding communities potentially affected by the remediation process (especially in cases of larger site cleanups or in site redevelopment that would impact the community). In addition, a guiding principle of the Remediation Division is that we act on opportunities in our work to help increase the resiliency of communities and to further the effort of mitigating the environmental impacts of climate change. The use of GSR is one of these opportunities.

Given the immediate and long-term impacts of climate change, the most effective and impactful GSR program must include climate change assessments and, if applicable, incorporate climate adaptation and resilience into remedial design and implementation. Climate change impacts identified in Minnesota include the following:

- More extreme precipitation events, resulting in increased flood hazards, erosion, and landslides.
- More severe drought in the summer months, resulting in increased agricultural demand for water and altered stream and lake levels, impacting navigable channels and harbor conditions.
- Increased occurrence and intensity of wildfires, resulting in increased risk to human populations and increased threat to structures and habitat.
- Increased temperatures, resulting in increased risk for human populations and altered ecosystems.

Assessing the risks associated with a changing climate on a site-specific basis is part of the GSR process. A tool for assessing site-specific risk associated with climate change (National Laboratory Environmental Sciences Division Net Environmental Benefit Analysis) is included in **Appendix A**. Once the risks are assessed, adaptation measures across a range of remedial phases can be identified to increase resilience and therefore minimize risk associated with identified climate impacts. Climate action, along with GSR, combine to increase environmental benefits while reducing the environmental impacts from the remedial action.

GSR Process at a Glance: Planning, Evaluation, and Reporting

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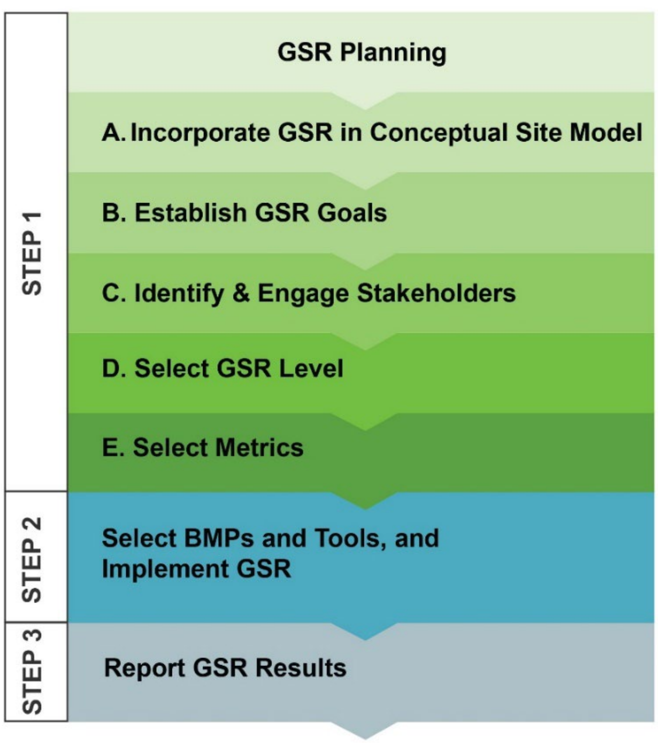
The following three-step process details the planning, evaluation, and reporting of GSR. Applying GSR principles may follow this process; however, it is intended to be flexible and scalable to meet site-specific needs. The graphic below illustrates the series of simple operations associated with the GSR process.

Figure 1. Steps of GSR Framework



GSR steps

Step 1. GSR planning

The GSR planning step begins by either identifying appropriate GSR goals at a new site or using the conceptual site model (CSM) to identify appropriate GSR goals at an existing site. This is followed by engaging the community or stakeholders as appropriate. The level of GSR evaluation is then selected, followed by the tool(s) and metrics appropriate to the site-specific conditions.

A. Incorporate GSR in Conceptual Site Model

The CSM forms a basis for the overall remediation approach at a given site, is established during the pre-investigation stages of a site, and is updated throughout the remediation process as more site data are obtained. The CSM comprehensively summarizes the current knowledge of the geology, hydrology, and contaminant distribution, nature, and behavior with respect to identified exposure pathways. The CSM provides the basis for completing a site investigation, evaluating risks to receptors, and developing a response action if necessary.

A complete and robust CSM is crucial for identifying and implementing the most appropriate and effective GSR for a given site. The selected GSR and its specific goals should be stated in the CSM during its initial development and updated with the CSM throughout the remediation process. If the CSM has already been developed, GSR should be incorporated and the CSM should be updated. GSR may affect the overall CSM in terms of response goals, feasibility of a selected remedy, or justifying a change in the site management decision when the response goals are no longer being efficiently achieved.

Due to variability, site-specific circumstances may help shape appropriate goals and provide opportunities for employing GSR concepts. Consideration of the site circumstances (through the CSM) is essential in making sound professional judgments regarding opportunities for utilizing GSR practices throughout the remediation process.

B. Establish GSR goals

The goals of the GSR for a site may vary; these goals may include, but are not limited to, the following:

- Reducing the impacts of standard investigation tasks.
- Calculating baseline environmental footprints of an activity.
- Characterizing vulnerability to climate change.
- Incorporating climate resilience and adaptation considerations.
- Incorporating social and economic considerations.
- Evaluating and comparing the environmental footprints of several options.
- Reducing the environmental footprint by optimizing an existing remedy.
- Achieve applicable and available incentives.

GSR goals may incorporate local, state, federal, and/or corporate guidance and policies, which may be drivers for GSR considerations on a project. Goals may also reflect applicable and available incentives, such as loans and grants, contractual obligations, project recognition/award, carbon credits, etc. Several websites are available to assist the GSR evaluator in the identification of incentives; examples are included in **Appendix B**. This document does not include a comprehensive list of all incentives associated with GSR implementation. The MPCA encourages parties implementing GSR to do their own research to best leverage available incentives.

C. Identify and engage stakeholders

Site stakeholders are typically identified prior to selecting a remedy and may include federal and state regulators, local units of government, responsible parties, the site owner or occupant, surrounding community members, and others such as neighborhood associations or economic development organizations. Prior to contacting stakeholders, their role in the GSR evaluation should be defined and documented in the planning step, including the extent of their potential impact on the project decisions. The mitigation of risk to receptors must not be undermined by the additional consideration of social or stakeholder concerns.

In communicating GSR to stakeholders, it is important to begin with the objectives of the site investigation and risk evaluation – the overall protection of human health and the environment. It is important to present a balanced message of the response action goals and site-specific considerations that collectively form the decision criteria for the selection of a remedy when a response action is required. In most cases, more than one alternative will meet the response action goals. GSR is not a means of justifying a no action remedy (greenwashing) or justifying less remediation.

D. Select GSR level

The tools and resources used to implement GSR range from BMPs and/or qualitative approaches to complex life cycle assessments (LCAs). The user can start by selecting the appropriate level of detail/effort for the GSR evaluation from the following:

- Level I – GSR BMPs: The objective of this approach is to adopt practices based on common sense and promoting resource conservation and process efficiency, without attempting to quantify their net impact on the environment, community, or economics.
- Level II – GSR BMPs and Simple Evaluation: The objective of this approach is to combine BMPs with a simple evaluation of the three GSR aspects of economic, social, and environmental components. A quantitative evaluation at this level will mean selecting a simple tool to evaluate remedial options. Level II GSR should typically include outreach to surrounding community members, organizations, and city planning office to provide information on the intended investigation and/or response actions planned for the site and engage these stakeholders to participate in an exchange of GSR information/ideas.
- Level III – GSR BMPs and Advanced Evaluation: This approach includes BMPs and an in-depth quantitative evaluation and is intended to be utilized on projects where response actions are anticipated to last longer than five years. Most Level III evaluations determine the best approach using an LCA-type evaluation of different alternatives, combined with weighting criteria to track the effects of production, transportation, use, and disposal of different materials and products associated with the activity. An LCA accounts for energy and resource inputs as well as polluting outputs to land, water, and air. Level III evaluations should typically include and expand on community/stakeholder engagement of Level II, including concepts outlined by the U.S. Environmental Protection Agency (EPA) Office of Community Outreach and Engagement.

Tools and approaches specific to each level are presented in **Appendix A** of this document.

E. Select metrics

If completing a Level II or III evaluation, the user should identify criteria for assessing the GSR goals by evaluating what is realistic to measure (given the intended scope of the GSR evaluation), regulatory requirements, other drivers/incentives, contractual expectations, available funding, schedule, and staff experience. **Appendix C** includes a GSR metrics table to aid in selecting metrics.

Step 2 - Select BMPs and tools, and implement GSR

This section provides users with BMPs and tools for identifying how to evaluate, select, and implement GSR for each GSR Level in each phase of the project.

Level I – BMPs

EPA has identified numerous BMPs, some of which are introduced in **Appendix A**.

Levels II and III – Qualitative and quantitative tools

If either a qualitative or quantitative (simple or advanced) approach is selected, identifying metrics is necessary. Qualitative and quantitative assessment tools have been developed to calculate environmental metrics to help consider all factors in designing and implementing remediation systems. These tools can range from decision tree models and Excel spreadsheets to comprehensive LCAs. Examples of publicly available, free, quantitative GSR tools are included in **Appendix A**. Other GSR tools may be available for a fee (such as Product Sustainability Solutions Software, formerly known as GaBi).

Step 3. Report GSR results

The results of the GSR evaluation should be documented or reported in each applicable report submitted to the MPCA. A Level I evaluation might only include an explanation of the GSR BMPs that were used during the project and a description of how they affected the outcome of the project. If conducting a Level II or III evaluation, the user may opt to submit a separate GSR document after discussing the details of the evaluation with the assigned MPCA project team. The level of documentation will vary depending on the approach used to conduct the GSR evaluation. Descriptions of the GSR practices should be concise but, above all, only pertain to site-related activities. This information should document all assumptions, sources of information, and methods used to evaluate the effectiveness of GSR practices. Sufficient information should be provided to determine if the results are verifiable and to document the limits of the evaluation. The GSR evaluation should consider the environmental, social, and economic factors, including energy consumption, resource consumption, climate change adaptation and resilience, greenhouse gas emissions, critical pollutant air emissions, ecological impacts, soil and water impacts, water use, worker safety, and community impacts.

References

Title	Link
MPCA Climate Action Framework	https://climate.state.mn.us/minnesotas-climate-action-framework
MPCA Our long-term goals and our strategic plan	https://www.pca.state.mn.us/sites/default/files/p-gen1-21.pdf
MPCA Environmental Justice Framework	https://www.pca.state.mn.us/sites/default/files/p-gen5-05.pdf
MPCA Office of Communications and Outreach	https://www.pca.state.mn.us/about-mpca/office-of-communications-and-outreach
EPA Environmental Justice	https://www.epa.gov/environmentaljustice

Title	Link
EPA Integrating Green Remediation and Climate Resilience Under the Superfund Remedial Acquisition Framework: A Primer for Service Contractors	https://clu-in.org/greenremediation/docs/Integrating_GR_and_CR_under_the_SF_RAF.pdf
EPA Superfund Green Remediation	https://www.epa.gov/superfund/superfund-green-remediation
EPA Community Outreach and Engagement	https://www.epa.gov/environmentaljustice/community-outreach-and-engagement
EPA Climate Smart Brownfields Manual	https://www.epa.gov/land-revitalization/climate-smart-brownfields-manual
ITRC Home	https://itrcweb.org/home
ITRC Green and Sustainable Remediation	https://itrcweb.org/teams/projects/green-and-sustainable-remediation
Green and Sustainable Remediation: A Practical Framework	Green and Sustainable Remediation: A Practical Framework (higherlogicdownload.s3.amazonaws.com)
Green and Sustainable Remediation: State of the Science and Practice	Green and Sustainable Remediation: State of the Art and Practice (higherlogicdownload.s3.amazonaws.com)
ITRC's Green and Sustainable Remediation GSR seminar:	https://www.clu-in.org/conf/itrc/GSR/
ITRC's Sustainable Resilient Remediation (SRR) seminar:	https://www.clu-in.org/conf/itrc/SRR/
ITRC's Green and Sustainable Remediation (GSR) team	https://itrcweb.org/teams/projects/green-and-sustainable-remediation
	https://itrcweb.org/teams/training/sustainable-and-resilient-remediation
CL:AIRE – Nonprofit leading sustainable land reuse	https://www.claire.co.uk/
SURF Sustainable Remediation Forum	https://www.sustainableremediation.org/
NICOLE – Forum on industrial sustainable land management	https://nicole.org/

Appendix A – Best management practices and tools

<table>
<tr><th>Type</th><th colspan="2">Documentation title/Description</th><th>Long-form link</th></tr>
<tr><td rowspan="4">BMPs</td><td colspan="2">EPA Introduction to Green Remediation</td><td>EPA Introduction to Green Remediation - https://www.cluin.org/greenremediation/docs/GR_Quick_Ref_FS_Intro.pdf</td></tr>
<tr><td colspan="2">EPA Green Remediation Best Management Practices: Site Investigation and Environmental Monitoring</td><td>Green Remediation Best Management Practices: Site Investigation and Environmental Monitoring (epa.gov)</td></tr>
<tr><td colspan="2">EPA Green Remediation Best Management Practices: Integrating Renewable Energy</td><td>Integrated Renewable Energy - https://www.clu-in.org/greenremediation/docs/GR_fact_sheet_renewable_energy.pdf</td></tr>
<tr><td colspan="2">CLU-IN Green Remediation Focus: Best Management Practices</td><td>CLU-IN | Strategies & Initiatives > Green Remediation Focus</td></tr>
<tr><td rowspan="4">GSR Evaluation Tools</td><td rowspan="2">ITRC GSR Overview Document</td><td>Green and Sustainable Remediation: State of the Science and Practice</td><td>Green and Sustainable Remediation: State of the Science and Practice - https://www.cluin.org/greenremediation/docs/GR_Quick_Ref_FS_Intro.pdf</td></tr>
<tr><td>ITRC Green and Sustainable Remediation: A Practical Framework</td><td>Green and Sustainable Remediation: A Practical Framework (higherlogicdownload.s3.amazonaws.com)</td></tr>
<tr><td>CLU-IN</td><td>Green Remediation Focus: Spreadsheets for Environmental Footprint Analysis (SEFA)</td><td>Footprint Assessment - https://clu-in.org/greenremediation/footprintassessment</td></tr>
<tr><td>National Laboratory Environmental Sciences Division Net Environmental Benefit Analysis (NEBA)</td><td>According to the Oak Ridge National Laboratory, Environmental Sciences Division, a net environmental benefit analysis (NEBA) is a methodology for comparing and ranking the net environmental benefit associated with multiple management alternatives. NEBAs can be conducted for a variety of stressors and management options, including chemical contaminant mitigation, hydropower mitigation, global climate change mitigation (e.g., carbon sequestration), etc. NEBA for chemically contaminated sites typically involves the comparison of the following management alternatives: 1) leaving contamination in place; 2) physically, chemically, or biologically remediating the site through traditional means; 3) improving ecological value through on-site and off-site restoration alternatives that do not directly focus on removal of chemical contamination; or 4) a combination of those alternatives.</td><td>Net Environmental Benefit Analysis - https://www.esd.ornl.gov/programs/ecorisk/net_environmental.html</td></tr>
<tr><td rowspan="2">Life Cycle Assessment Tools</td><td colspan="2">Guidance for Performing Footprint Analyses and Life-Cycle Assessments for the Remediation Industry, SURF, Remediation Journal Summer 2011</td><td>Life-Cycle Assessments - https://www.cresp.org/wordpress/wp-content/uploads/2012/02/Footprint-LCA-20289_ftp.pdf</td></tr>
<tr><td colspan="2">SimaPro LCA software http://www.pre.nl/content/simapro-lca-software (requires license)</td><td>LCA software - https://www.cresp.org/wordpress/wp-content/uploads/2012/02/Footprint-LCA-20289_ftp.pdf</td></tr>
</table>

Appendix B – Incentives examples for green and sustainable remediation
http://www.epa.gov/renewableenergyland/incentives.htm
http://www.dsireusa.org/
https://greenstep.pca.state.mn.us/

Appendix C – Green and sustainable remediation metrics table

Sustainable Remediation practices and objectives	Land	Water	Waste	Community	Economic	Metric units	Metric description
Fresh water consumption		X	X			Gallons	Volume of fresh water used
Water reuse		x	x			Gallons, percentage	Volume of water used; percentage of water reused
Groundwater protection		x		x		Gallons, acre-feet	Volume of surface water protected
Surface water protection		x		x		Gallons, acre-feet	Volume of surface water protected
Bioavailability of Contaminants	x	x	x	x		kg	Mass of bio-available contaminants
Biodiversity	x	x		x		Species count	Assessment of impacts on biodiversity
Habitat disturbance	x			x		Ecosystem services; area of land impacted	Measure of impact on area impacted or change in ecosystem services
Ecosystem protection	x	x	x	x	x	Ecosystem services; area of land impacted	Measure of impact on area impacted or change in ecosystem services
Natural resource protection	x	x	x	x	x	Acres; acre-feet; ecosystem services; human use value	Measure of impact on natural resources or natural resources quality
Non-renewable Energy Use					x	Gallons; BTU; kWH	Measure of use of non-renewable energy resources
Renewable energy use					x	Gallons; BTU; kWH	Measure of use of renewable energy
Net energy reduction						%	Percent change from baseline
Greenhouse			x	x		CO_2 equivalents	Tons of GHGs emitted
Gas emission			x	x		Emitted	
Air Pollution (non-ghs)			x	x		Pounds emitted	Pounds of air pollutants emitted
Contaminant migration		x		x	x	Mass migration over distance; flux	Measure of amount of mass migrated over distance and time; flux is a measure of mass migration through an area cross-sectional and perpendicular to flow
Material use					x	kg	Mass of total material use, or mass by category of material
Material extraction			x		x	Mass per mass	Mass of material extracted per mass recovered
Waste reduction	x	x	x		x	Volume or mass diverted	Measure of water diverted from landfill or wastewater treatment operations
Re-use of Materials	x		x		x	Volume or mass reused	Measure of water diverted from landfill could also use $ for savings aspect or reuse, volume of water reused
Life cycle cost	x		x		x	$	Costs associated with complete life cycle
Use of Recycled Materials	x		x		x	Mass or percentage of materials reused	Mass or volume of material reused in proportion to virgin materials
Net environmental benefit	x	x	x	x	x	Discounted service acre years; human use value	Measure of impact (negative or positive) to ecosystems and human use
Consider Cost of the "Sustainability Delta," if any					x	$ per improvement from implemented sustainability	Normalize impacts of sustainability to a common unit and factor in cost
Property value				x	x	$ or subjective	Improvement in property value as a result of implementing remedy
Tax base				x	x	$	Improvement in taxable value of property
Employment				x	x	Jobs created	Number of jobs created as a result of implementing remedy
Capital cost					x	$	Capital costs of projects
O&M cost					x	Present value O&M costs ($)	PV of O&M for project life cycle
Worker risks					x	Fatality and injury	Potential for fatality or injury based on worker hours and miles driven
Community risks				x	x	Fatality and injury	Potential for fatality or injury based on miles associated with off-site transportation

Appendix C – Green and sustainable remediation metrics table

Sustainable Remediation practices and objectives	Land	Water	Waste	Community	Economic	Metric units	Metric description
Land reuse	x			x	x	Acres	Acres of land reused for beneficial reuse
Local material use				x	x	% of material for local sources	Percentage of materials procured for project from local sources
Noise				x		dB	Noise level of project
Odor				x		Subjective	Olfactory impacts of project
Lighting				x		Lumens	Increase of lighting intensity to nearby impacted people
Environmental justice				x	x	Subjective	Potential for project to disproportionately disadvantage communities
Community impacts				x	x	Subjective	Impacts of project on the community
Cultural resources				x		Subjective	Involvement of interested stakeholders in project decisions
Stakeholder involvement				x	x	Subjective	Involvement of interested stakeholders in project decisions
Access to	x			x	x	Subjective	Impacts of project on public access
Open spaces	x			x	x		
Maximize future land use potential	x			x	x	Acres	Maximize future land use of property for uses that are beneficial to the local community

Notes:

Additional guidance on metrics selection is provided on the SURF organization's website: https://www.sustainableremediation.org/library/

% = percent

$ = dollars

BTU = British Thermal Unit

CO_2 = carbon dioxide

dB = decibel

GHG = greenhouse gas

kg = kilogram

kWH = kilowatt hour

O&M = operations and maintenance

PV = present value