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# Welcome – Thanks for joining this ITRC Training Class

## Green and Sustainable Remediation

ITRC Technical & Regulatory Guidance Document: *Green and Sustainable Remediation: A Practical Framework* (GSR-2, 2011)

Sponsored by: Interstate Technology and Regulatory Council (www.itrcweb.org)
Hosted by: US EPA Clean Up Information Network (www.cluin.org)

The ultimate goal of remediation systems is to protect human health and the environment from contaminants. Historically, remedies have been implemented without consideration of green or sustainable concepts in order to meet this goal. This includes the potential for transferring impacts to other media. For instance, many remedial decisions do not assess greenhouse gas (GHG) emissions, energy usage, or community engagement factors prior to the investigation or remedy implementation. Considering these factors throughout the investigation and remedy implementation process may lessen negative effects of the overall cleanup impact while the remediation remains protective of human health and the environment. The consideration of these factors is Green and Sustainable Remediation (GSR) - the site-specific employment of products, processes, technologies, and procedures that mitigate contaminant risk to receptors while making decisions that are cognizant of balancing community goals, economic impacts, and net environmental effects.

Many state and federal agencies are just beginning to assess and apply green and sustainable remediation into their regulatory programs. This training provides background on GSR concepts, a scalable and flexible framework and metrics, tools and resources to conduct GSR evaluations on remedial projects. The training is based on the ITRC's Technical & Regulatory Guidance Document: *Green and Sustainable Remediation: A Practical Framework* (GSR-2, 2011) as well as ITRC's Overview Document, *Green and Sustainable Remediation: State of the Science and Practice* (GSR-1, 2011).

Beyond basic GSR principles and definitions, participants will learn the potential benefits of incorporating GSR into their projects; when and how to incorporate GSR within a project's life cycle; and how to perform a GSR evaluation using appropriate tools. In addition, a variety of case studies will demonstrate the application of GSR and the results. The training course provides an important primer for both organizations initiating GSR programs as well as those organizations seeking to incorporate GSR considerations into existing regulatory guidance.

ITRC (Interstate Technology and Regulatory Council) www.itrcweb.org

Training Co-Sponsored by: US EPA Technology Innovation and Field Services Division (TIFSD) (www.clu-in.org)

ITRC Training Program: training@itrcweb.org; Phone: 402-201-2419

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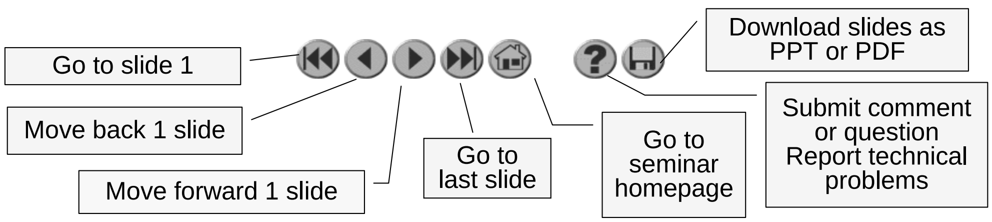
## Housekeeping

- Course time is 2¼ hours
- Question & Answer breaks
  - Phone - unmute *6 to ask question out loud
  - Simulcast - ? icon at top to type in a question
- Turn off any pop-up blockers
- Move through slides
  - Arrow icons at top of screen
  - List of slides on left
- Feedback form available from last slide – **please** complete before leaving
- This event is being recorded






Although I’m sure that some of you are familiar with these rules from previous CLU-IN events, let’s run through them quickly for our new participants.

We have started the seminar with all phone lines muted to prevent background noise. Please keep your phone lines muted during the seminar to minimize disruption and background noise. During the question and answer break, press *6 to unmute your lines to ask a question (note: *6 to mute again). Also, please do NOT put this call on hold as this may bring unwanted background music over the lines and interrupt the seminar.

You should note that throughout the seminar, we will ask for your feedback. You do not need to wait for Q&A breaks to ask questions or provide comments using the ? icon. To submit comments/questions and report technical problems, please use the ? icon at the top of your screen. You can move forward/backward in the slides by using the single arrow buttons (left moves back 1 slide, right moves advances 1 slide). The double arrowed buttons will take you to 1st and last slides respectively. You may also advance to any slide using the numbered links that appear on the left side of your screen. The button with a house icon will take you back to main seminar page which displays our presentation overview, instructor bios, links to the slides and additional resources. Lastly, the button with a computer disc can be used to download and save today’s presentation slides.

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## ITRC (www.itrcweb.org) – Shaping the Future of Regulatory Acceptance

- Host organization
- Network
  - State regulators
    - All 50 states, PR, DC
  - Federal partners

    DOE DOD EPA
  - ITRC Industry Affiliates Program
  - Academia
  - Community stakeholders
- Wide variety of topics
  - Technologies
  - Approaches
  - Contaminants
  - Sites
- Products
  - Technical and regulatory guidance documents
  - Internet-based and classroom training

The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of all 50 states (and Puerto Rico and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we're building the environmental community's ability to expedite quality decision making while protecting human health and the environment. With our network of organizations and individuals throughout the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

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# ITRC Course Topics Planned for 2013 – More information at www.itrcweb.org

**Popular courses from 2012**

- Decision Framework for Applying Attenuation Processes to Metals and Radionuclides
- Development of Performance Specifications for Solidification/Stabilization
- Green and Sustainable Remediation
- Integrated DNAPL Site Strategy
- LNAPL 1: An Improved Understanding of LNAPL Behavior in the Subsurface
- LNAPL 2: LNAPL Characterization and Recoverability - Improved Analysis
- LNAPL 3: Evaluating LNAPL Remedial Technologies for Achieving Project Goals
- Mine Waste Treatment Technology Selection
- Project Risk Management for Site Remediation
- Use and Measurement of Mass Flux and Mass Discharge
- Use of Risk Assessment in Management of Contaminated Sites
- Soil Sampling and Decision Making Using Incremental Sampling Methodology (2 parts)
- Bioavailability Considerations for Contaminated Sediment Sites
- Biofuels: Release Prevention, Environmental Behavior, and Remediation

**New in 2013**

- Environmental Molecular Diagnostics
- Biochemical Reactors for Mining-Influenced Water
- Groundwater Statistics and Monitoring Compliance

**2-Day Classroom Training on Light Nonaqueous-Phase Liquids (LNAPLs)**

- April 9-10 in King of Prussia, PA
- June 4-5 in Springfield, IL
- (tentative) October in Southern CA

More details and schedules are available from www.itrcweb.org.

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# Meet the ITRC Trainers

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**Rebecca Bourdon** is a Hydrogeologist in the Petroleum Remediation Program of the Minnesota Pollution Control Agency (MPCA) in St. Paul. In her roll at the MPCA, she performs technical reviews of petroleum release investigations, corrective actions and brownfields redevelopment projects. She is the Green and Sustainable Remediation and Redevelopment (GSR[2]) Coordinator for the MPCA's Remediation Division. In this roll, she has teamed with internal colleagues to produce division-wide GSR guidance for state and federal funded cleanups, GSR language for state contracts, and brownfields redevelopment GSR integration. She is the Co-Leader of the ITRC GSR Team and a member of the ASTM International Standard Guide for Greener and More Sustainable Cleanup (GAMSC) Task Group and the EPA Region V Greener Cleanups Work Group. She earned a Bachelor's degree in Geology from North Dakota State University in 1998 and spent 9 years in the environmental consulting industry in Colorado and Minnesota until joining the MPCA in 2007. Rebecca is a licensed Professional Geologist in the state of Minnesota.

**Nick Petruzzi** is a Senior Engineer at Cox-Colvin & Associates, Inc. in Plain City, Ohio. Since 2004, Nick has been involved with the evaluation, design, construction, and operation of both established and innovative remedial alternatives for the treatment of contaminated soil and groundwater at industrial facilities under various regulatory programs. In addition, he provides management/technical support for clients with hazardous waste, NPDES, and air permits. Hydrogeological investigation, vadose zone and groundwater modeling, report preparation, and cost estimating are also among his responsibilities. Nick's academic background includes extensive design, testing, and implementation of groundwater field sampling devices; and novel research in the realm of groundwater colloidal/microbial mobilization and characterization. Nick is a member of the ITRC Green and Sustainable Remediation Team. He earned a bachelor's degree in Geology and Environmental Science from Ashland University in Ashland, Ohio in 2002 and a master's degree in Environmental Engineering from the University of Notre Dame in South Bend, Indiana in 2004. Nick is a registered professional engineer in Ohio.

**Karin Holland** is a Senior Sustainability Specialist at Haley & Aldrich, Inc. in San Diego, California. Since 2007, she has been responsible for leading the application of sustainability thinking to Haley & Aldrich's remediation services and has assisted multiple clients with sustainable remediation projects, throughout the remediation lifecycle. This work has included preparing sustainable remediation guidance for clients in the private and public sector. She has also worked on projects involving environmental management systems, greenhouse gas inventories, sustainability appraisals and sustainability training since 2004. Karin is an active member of the ITRC Green and Sustainable Remediation Team and the ASTM Green and Sustainable Site Assessment and Cleanup Committee. She is also on the Sustainable Remediation Forum (SURF) Board of Trustees and chairs SURF's Technical Initiatives Committee. Karin earned a bachelor's degree in Natural Sciences from the University of Cambridge, United Kingdom in 2002 and a master's degree in Law and Environmental Science from the University of Nottingham, United Kingdom in 2003. She is a LEED-Accredited Professional and a Registered Lead ISO14001 Auditor.

**Elisabeth Hawley** is a Senior Environmental Engineer at ARCADIS/Malcolm Pirnie in Emeryville, California. Since 2001, she has worked in consulting on environmental restoration projects involving site characterization, fate and transport, modeling, remediation, sustainability analyses, and cost estimating. Elisabeth has prepared guidance materials and conducted research on technical impracticability assessments and alternative groundwater remedial strategies for the Air Force, Army and ESTCP. Elisabeth is a member of the ITRC Remediation Risk Management Team and the ITRC Green and Sustainable Remediation Team. She earned a bachelor's degree in Environmental Engineering Science from the University of California at Berkeley in 2000 and a master's degree in Civil and Environmental Engineering from the University of California at Berkeley in 2001. Elisabeth is a professional engineer in California.

**Maria D. Watt, PE** is a senior program manager at Camp Dresser & McKee Inc. in Edison, NJ and has worked at Camp Dresser & McKee Inc. since 2004. She has worked in the environmental field since 1985 and has extensive experience in managing multi-tasked, multi-disciplined programs requiring interoffice coordination as well as agency negotiation. Her background contains a unique blend of chemical engineering combined with groundwater and surface water hydrology providing exceptional skills for designing and optimizing remediation systems. Maria has managed major Brownfields, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) contracts and projects for private, state and federal clients within New York and New Jersey These contracts/projects include Brownfield Redevelopment, Hazard Ranking System (HRS) scoring; Remedial Investigation/Feasibility Studies (RI/FSs); RCRA Facility Investigations/Corrective Measures Studies (RFI/CMS), Remedial Designs (RDs); and Remedial Actions (RAs). She is an active member of the Interstate Technology Regulatory Council (ITRC) team developing the ITRC GSR Technical/Regulatory Guidance document and the ASTM International Subcommittee E50.04 developing Green and Sustainable Cleanup Standards. Maria earned her BS degree in Chemical Engineering from Rutgers University in Piscataway, New Jersey in 1985 and is registered as a Professional Engineer in the State of New Jersey.

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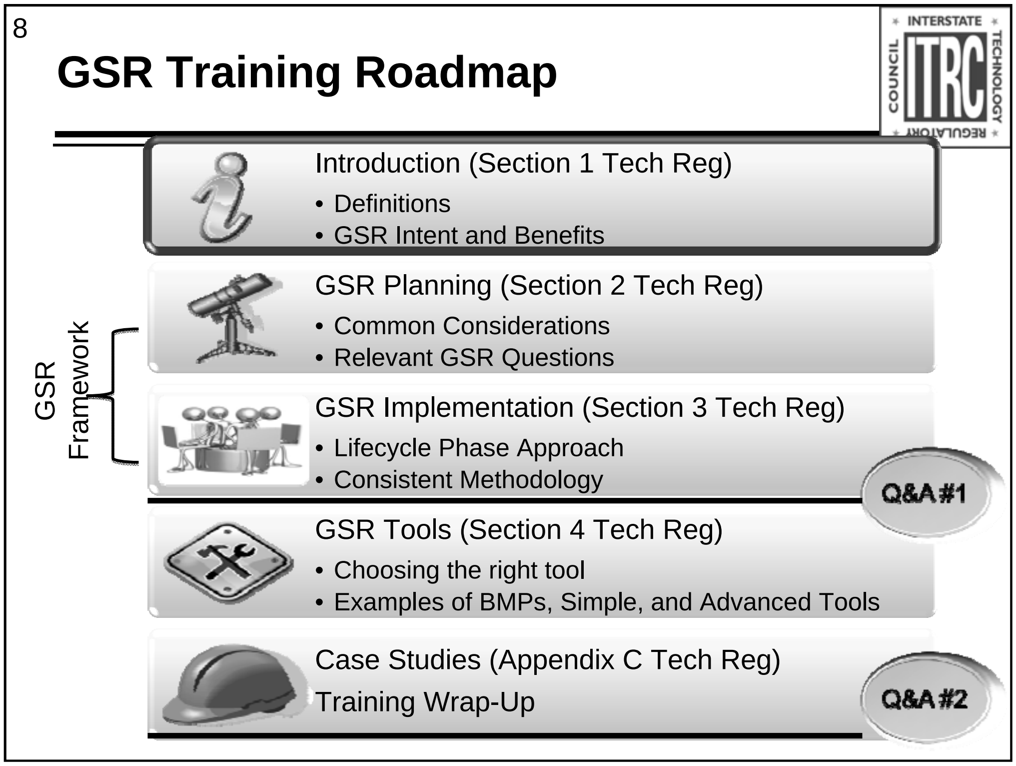
## Why Green and Sustainable Remediation (GSR)?

- Improved stakeholder engagement
  - Community benefited from trails installed on new cap cover to river
  - Educational opportunities
  - Collaboration with local college
- Simplified, reproducible results
  - Quantify desired metrics
- Reduced impacts
  - Emissions/ greenhouse gases (GHGs)
  - Energy/Water/Waste
  - Ecosystems

1. To improve stakeholder relations and engage a targeted audience above and beyond the status quo investigation and cleanup.

2. Create simple, reproducible results based on simple tools developed by and for the remedial industry.

3. You will be able to reduce impacts to the elements below when and where ever possible to the degree your project allows.




Course Roadmap consists of the following 5 sections:

1.INTRO

- Key background information including the team's definition of GSR
- How the team intends the targeted audience (state regulators) to use the GSR concept and team products

2.How to plan GSR integration into your project.

- Section 2 of Tech Reg includes common considerations and questions relevant to adequate planning of a GSR evaluation.

3.Describe the GSR Framework found in Section 3 of the Tech Reg.

- The framework is a generalized and flexible guidance on how to evaluate, select, and implement GSR practices in each phase of site remediation

4.Tools to conduct GSR evaluations.

- These tools and their associated hyperlinks are found in Section 4 of the Tech Reg.
- A discussion of the metrics associated with performing a GSR evaluation will be included in that part of the training.

5.To demonstrate GSR in practice, a variety of case studies.

- The case studies cross the breadth of regulatory programs and will show how the industry is already integrating these concepts.

Tech Reg: ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)

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# ITRC's GSR Definition

The site-specific employment of products, processes, technologies, and procedures that mitigate contaminant risk to receptors while making decisions that are cognizant of balancing community goals, economic impacts, and net environmental effects.

The term GSR is used to reflect the aspects of both green and sustainable remediation.

Recognizing the broad scope of sustainability (which includes green aspects), green remediation is an effective first step towards the more holistic sustainable remediation.

In ITRC’s Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011), ITRC therefore refers to GSR.

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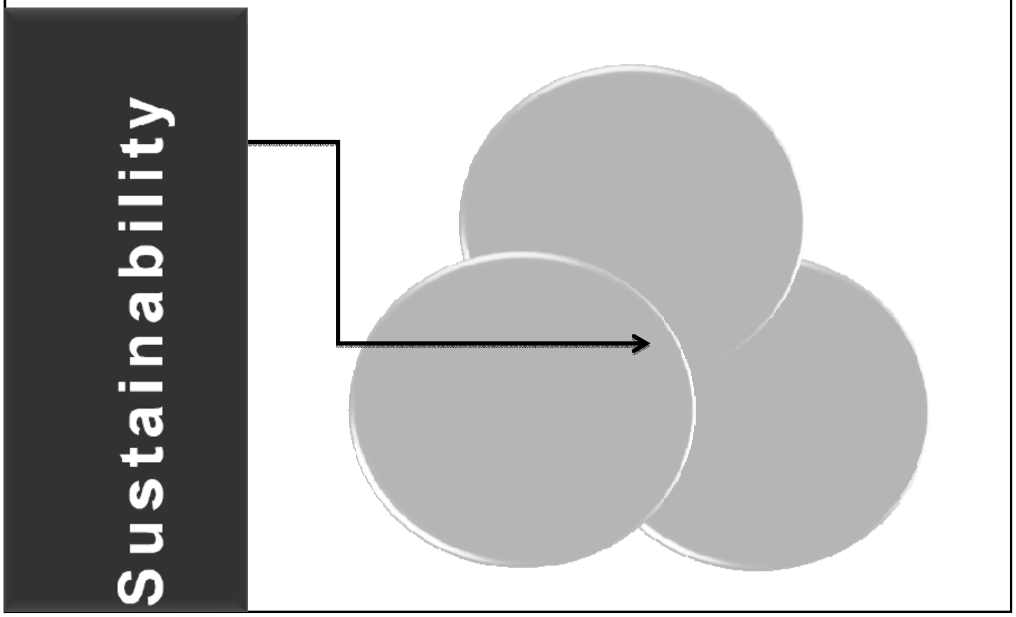
## Green Remediation

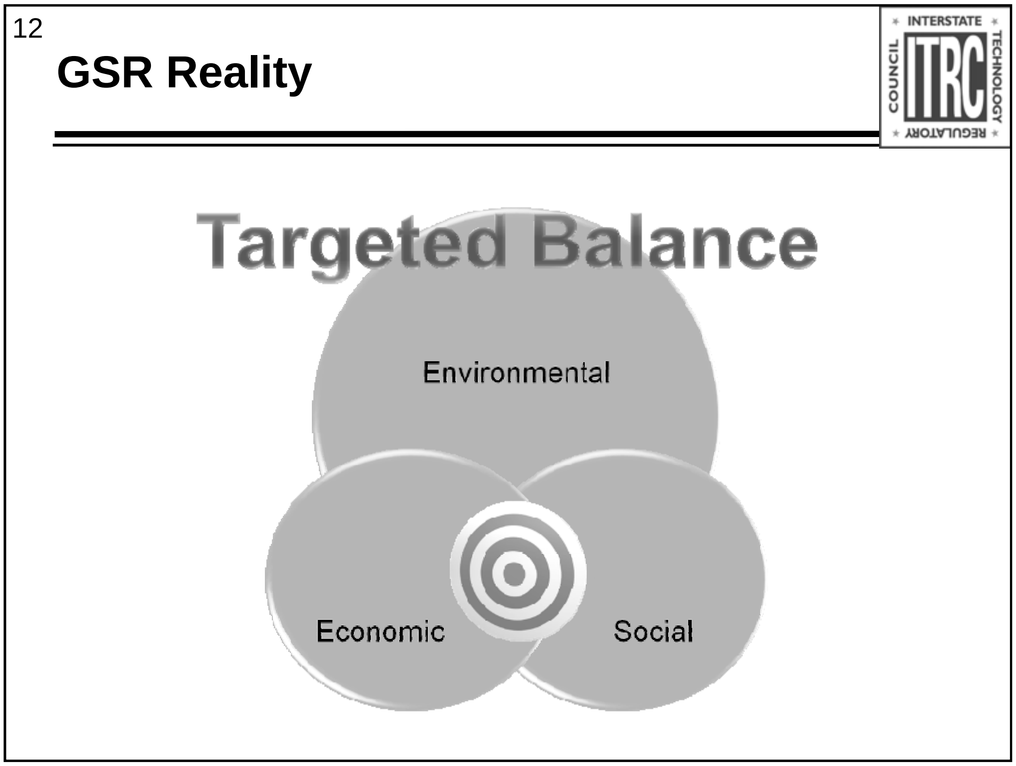
Reducing environmental impacts of common investigation and remediation activities

Green remediation is the concept of reducing the environmental impacts of common investigation and remediation activities. Green, by itself, is solely based on decreasing measurable environmental aspects, in this case, on cleanup activities.

## Green & Sustainable Remediation




Sustainability goes beyond the ‘greening’ of remedial technologies by aiming to balance three common criteria toward the goal of a site cleanup so as not to compromise the use or benefits of the site by future generations.




While aiming at the centroid of the sustainability diagram, where true balance is achieved through consideration of all three aspects of sustainability to equivalent degrees, the GSR team identified a certainty common to all cleanup projects.

This is the “Remediation Reality” that exists at all projects; when one attempts to balance the three over-arching criteria of a sustainable cleanup, they will always have the onus of cleanup as the unwavering base of the cleanup decision.

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# ITRC GSR Products

- Overview Document
  Green and Sustainable Remediation: State of the Science and Practice
  - (GSR-1, 2011)
- Technical & Regulatory Guidance Document:
  Green and Sustainable Remediation: A Practical Framework
  - (GSR-2, 2011)


Our Team has developed 2 companion GSR documents and they are free of charge from ITRC.

The ITRC Mission is to develop resources like these and help break down regulatory barriers for acceptance and use. They may be free but a great deal of resources were spent on their development by many groups like DoD, DoE, industry affiliates, consultants, EPA, and state representatives.

So use the guidance, it's here for us State regulators and the industry as a whole.

Limited printed copies of ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011) are available, so we encourage the audience to download and disseminate an electronic copy at any time from the ITRC website, www.itrcweb.org.

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# User Benefits of GSR Products

| Expected User Group | Intended Use | User Benefits |
|---|---|---|
| Regulators | Integrate GSR into site management decisions | Better site decisions<br>Protective solutions |
| Consultants | Integrate GSR into site recommendations<br>Guide technology selection | Better site decisions<br>Better value for clients<br>Regulatory partnership |
| Site Owners | Integrate GSR into site considerations<br>Guide technology selection | Better site decisions<br>Possible savings |
| Academia | Provide students with latest information | Better equip students |
| Community Stakeholders | Provide trusted resource for decision-makers | Contribute information to achieve the best remediation |

Each sector can use the GSR document at the site level to ultimately achieve the ‘best’ remediation for all involved.

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# Snapshot Simple GSR Evaluation

***Petroleum Surface Soil Excavation Site***

GHG = greenhouse gas

| | **Option 1** 1.5 ft. excavation w/ gravel replacement | **Option 2** 6 in. excavation w/ concrete cap | **Option 3** 6 in. excavation w/ asphalt cap |
|---|---|---|---|
| **Environmental** | 3 tons $CO_2$ 4 tons GHG | 2.4 tons $CO_2$ 11 tons GHG | 2.4 tons $CO_2$ >11 tons GHG |
| **Economic** | $16,723 | $21,538 | $15,623 |
| **Social** | No aesthetic change | Positive aesthetic change | Positive aesthetic change |

No associated notes.

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## GSR in Your Organization

- Framework
- GSR Policy/Guidance integration or adaptation
- How GSR fits into your agency/corporate strategic plan

If your state does not have barriers to implementing GSR, then recognizing that factor may be just as critical as identifying incentives to implementation.

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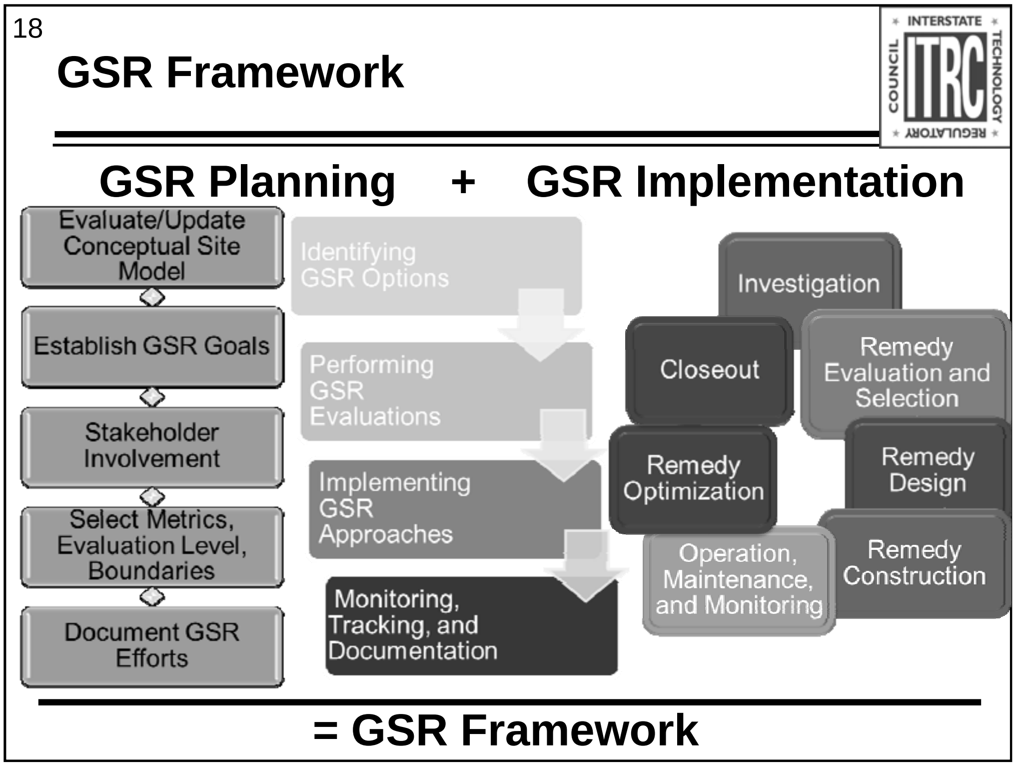
# Learn to Apply GSR Concepts


By the end of today's training class we will answer these questions……

With the primary expectation that you will know how to apply the ITRC GSR guidance document to your projects.




The graphic on this slide appears as Figure 3-1 in ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011) and shows a simple and easy to remember representation of the GSR Framework, which is comprised of both the generalized planning stages and the implementation stages conducted per remedial phase.

The GSR Framework can be incorporated into any regulatory program, existing guidance, or be stand-alone.

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# GSR Framework

***Flexible and Scalable***

- Flexibility similar to that found in conceptual remedial designs
- Scalable to the size and level-of-detail of the project

**Example: UST site vs. Superfund site**

The GSR Framework is intended to be used with any regulatory program as well as various complexities/sizes of cleanup projects. With this in mind, the GSR Framework was designed to be both flexible and scalable.

# GSR Training Roadmap

Introduction (Section 1 Tech Reg)
- Definitions
- GSR Intent and Benefits

GSR Framework

GSR Planning (Section 2 Tech Reg)
- Common Considerations
- Relevant GSR Questions

GSR Implementation (Section 3 Tech Reg)
- Lifecycle Phase Approach
- Consistent Methodology

Q&A #1

GSR Tools (Section 4 Tech Reg)
- Choosing the right tool
- Examples of BMPs, Simple, and Advanced Tools

Case Studies (Appendix C Tech Reg)

Training Wrap-Up

Q&A #2

Tech Reg: ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)

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## Plan and Incorporate GSR into Your Project


At this point in the training, we will begin to discuss how you can plan and incorporate GSR into your cleanup projects. Common considerations that can help with preparation of proposals, contracts, optimizing projects, or evaluating completed/ongoing projects will also be presented.

As we progress through this training, remember that every site is different, therefore, only certain aspects of environmental, social, and economic components of GSR will be applicable. However, it is necessary to consider all available options to determine which are most appropriate for site-specific circumstances.

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# GSR Planning

***Tech Reg Section 2***


The GSR planning process is presented in Section 2 of ITRC’s Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011) and can be considered the starting point for integrating GSR into your project.

Some or all of the steps in the GSR planning process can be performed to varying degrees during each phase of the project.

The flexibility of the GSR planning process allows the steps to be performed in any order or iteratively depending on site-specific circumstances or stakeholder input.

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# GSR Planning

***Evaluate/Update Conceptual Site Model (CSM)***

- **Evaluate/Update Conceptual Site Model**
- **Establish GSR Goals**
- **Stakeholder Involvement**
- **Select Metrics, GSR Evaluation Level, Boundaries**
- **Document GSR Efforts**

- Evaluate and update as necessary
- Integrate relevant GSR information to reflect potential opportunities were GSR can be considered and implemented
- CSM similar to that discussed in ITRC Performance Based Environmental Management Document (RPO-7)*

*http://www.itrcweb.org/Documents/RPO-7.pdf


The CSM discussed in the GSR planning process is the same CSM many people are familiar with: it is a representation of how contaminants release at a site interact with the environment and potential human and ecological receptors. It terms of GSR planning, the CSM should be evaluate and updated (if necessary) whenever there is a change in site conditions or new valid data becomes available. The act of evaluating/updating the CSM is considered part of GSR because the CSM forms the basis of defining an effective remedial strategy.

The CSM provides a convenient format to incorporate relevant GSR information and potential GSR opportunities. For example, relevant GSR information to incorporate into the CSM may include a nearby recycling and disposal facility as well as the general area having sufficient wind velocities amenable to wind turbines.  Other examples are provided in Section 2 of ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011).

More information on the traditional CSM can be found in ITRC document RPO-7. ITRC Technical and Regulatory Guidance Document: Improving Environmental Site Remediation Through Performance-Based Environmental Management (RPO-7, November 2007) at
http://www.itrcweb.org/guidancedocument.asp?TID=42

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# GSR Planning

***Establish GSR Goals***


- Site setting and circumstances
- GSR components
- EPA's green remediation core elements*
- Drivers: regulatory guidance/policy, corporate directives, incentives
- Goals can relate to remediation and non-remediation activities

*www.clu-in.org/greenremediation

GSR goals should be established early in the planning process to minimize potential bias in their development. Some helpful considerations for establishing GSR goals include:

•Site setting and circumstances – for example, economic impacts of development would be more important at a Brownfield site than a remote site with ecological value.

•Components of GSR – environmental, social, and economic.

•EPA's green remediation core elements of air, energy, water, land/ecosystems, and materials/waste.

•The purpose (i.e., driver) for incorporating GSR into the project – drivers may include regulatory guidance/policy, corporate directives, and incentives. Drivers are discussed in greater detail in Section 2 of ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011).

•Non-remediation activities impacted by the cleanup (e.g., facility operations).

An example of a GSR goal during remedy optimization at a site with a groundwater containment and treatment system that utilizes an air stripper could be the reduction of energy usage by 25% and material and chemical use by 50%.  An added benefit of achieving these GSR goals could be significant cost savings over the long term.

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# GSR Planning

### *Stakeholder Involvement*


- Key consideration of sustainable remediation
- GSR stakeholders are typically a subset of the project stakeholders
- New stakeholders may be identified solely on GSR interest
- Engage at appropriate points during the cleanup project
- For GSR, stakeholder involvement *should* be more frequent or to a greater effort than required by regulatory program
- Includes GSR and non-GSR information

Stakeholder involvement is a very important part of GSR and is a key consideration for sustainable remediation. Stakeholders can be any individual or group that is directly/indirectly affected by project activities. For example, the only stakeholders for a small UST project may be the owner/operator, regulator, and consultant. However, for a Brownfield project, additional stakeholders may include nearby residents, the general public, and a developer.

Stakeholders should be engaged at appropriate points throughout the project (Section 3 provides phase-specific examples). However, for stakeholder involvement to be considered part of GSR, engagement *should* occur more frequently or to a greater level of effort than required by the regulatory program. Increased frequency or effort can promote better decision making in the remedial process, which is an attribute of the environmental component of GSR. For stakeholder involvement to be considered an attribute of the social component of GSR, additional communication and receipt of input on GSR-related efforts is necessary.

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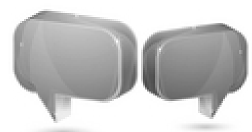
# GSR Planning

***Stakeholder Involvement Examples***

*Stakeholder involvement can be interpreted and fulfilled in many different ways*

- Remedy Construction Example: distribution of information by monthly newsletter

- Remedy Evaluation & Selection Example: interactive dialogue pertaining to limiting excavation



Stakeholder involvement can be interpreted and fulfilled in many different ways. As shown by the following two examples, stakeholder involvement doesn’t have to be time consuming or complex.

Example 1: Monthly progress reports required to be submitted to the regulatory agency during remedy construction can be formatted into an easy-to-read newsletter for additional distribution to nearby residents and the public library.

Example 2: A potential remedial alternative was proposed to address several sources of contamination in soil and underlying bedrock. For soil, it was proposed to excavate soil exceeding risk-based limits and not soil exceeding leach-based limits as it was believed that the overall approach for soil and bedrock could adequately achieve remedial goals. A public meeting was help for concerned citizens to explain the proposed remedial approach and the reason for not excavating soil exceeding leach-based limits. During the meeting, it was further explained that hundreds of additional truck and associated fuel use, air emissions, and traffic would be necessary to remove the leach-based soil.  It was also explained that excavation of the leach based soil may not provide any additional benefits/advantages in achieving the remedial goals for the site.

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# GSR Planning

***Select Metrics, GSR Evaluation Level, Boundaries***

Evaluate/Update Conceptual Site Model

Establish GSR Goals

Stakeholder Involvement

**Select Metrics, GSR Evaluation Level, Boundaries**

Document GSR Efforts

- Establish metric(s) for each GSR goal
- Consider boundary conditions, funding, contracts, schedule, experience
- Quantitative vs. qualitative metrics
- Some metrics identified in Table 4-1 of GSR Overview Document (GSR-1)* and SURF Metrics Toolbox**
- Select GSR Evaluation Level – three levels of detail/complexity

*www.itrcweb.org/Documents/GSR-1.pdf
**www.sustainableremediation.org/library

For each of the previously identified GSR goals, metrics should be selected to assess, track or evaluate those goals. Considerations such as boundary conditions , available funding, contractual mechanisms, project schedule, and staff experience can help select appropriate metrics.

Metrics can be quantitative or qualitative. Quantitative metrics are those that rely on calculations, tools, or life cycle models. Qualitative metrics are somewhat subject. Various quantitative and qualitative metrics that reflect the environmental, social, and/or economic components of GSR are summarized in Table 4-1 of the GSR Overview Document (GSR-1) and in the SURF Metrics Toolbox.

ITRC Green and Sustainable Remediation: State of the Science and Practice (GSR-1, 2011) is available at
http://www.itrcweb.org/guidancedocument.asp?TID=77

The SURF metrics toolbox is available at
http://www.sustainableremediation.org/library/guidance-tools-and-other-resources/metrics-toolbox/

Concurrent with metrics selection, the GSR evaluation level should be determined. ITRC has developed three possible levels of detail/complexity for a GSR evaluation.

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# GSR Planning

***Metric Examples from Part of Table 4-1 in GSR-1***

| Metric | Land | Water | Waste | Community | Economic | Metric Units | Metric Description |
|---|---|---|---|---|---|---|---|
| Fresh Water Consumption | | | | | | gallons | volume of fresh water used |
| Biodiversity | | | | | | species count | assessment of impacts on biodiversity |
| Renewable Energy Use | | | | | | gallons; BTU; kWh | measure of use of renewable energy |
| Greenhouse Gas Emissions | | | | | | $CO_2$ equivalents emitted | tons of GHGs emitted |
| Material Use | | | | | | Kg | kg of total material use, or mass by category of material |
| Employment | | | | | | jobs created | number of jobs created as a result of implementing remedy |
| Capital Costs | | | | | | $ | capital costs of project |
| Community Impacts | | | | | | subjective | impacts of project on the community |
| Cultural Resources | | | | | | subjective | impacts of project on cultural resources |

A portion of Table 4-1 in ITRC's Overview Document, Green and Sustainable Remediation: State of the Science and Practice (GSR-1, 2011) is included in this slide to provide examples of various quantitative and qualitative metrics. As show in the table, some metrics can have multiple units or represent various aspects of project activities. It is important to not only identify appropriate metrics but also understand how they will be measured and what they will represent.

There is currently no single resource with an all-inclusive list of metrics.

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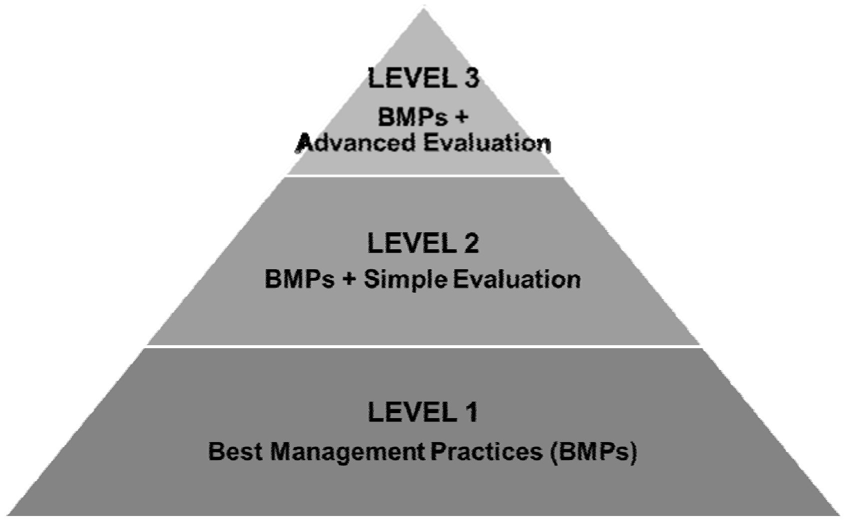
# GSR Planning

***GSR Evaluation Levels***




Level 1 - BMPs: The objective of Level 1 approaches is to adopt practices based on common sense, promoting resource conservation and process efficiency, without attempting to quantify their net impact on the environment, community, or economic impacts. It is anticipated the greatest number of sites will perform a Level 1.

Level 2 – BMPs + Simple Evaluation: Includes BMPs and a qualitative or semi-quantitative evaluation, such as those that utilize value judgments, ranking/scoring or basic calculators/spreadsheets.

Level 3 – BMPs + Advanced Evaluation: Includes BMPs and complex quantitative evaluation, such as methods that rely on life cycle assessment or footprint analysis.

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# GSR Planning

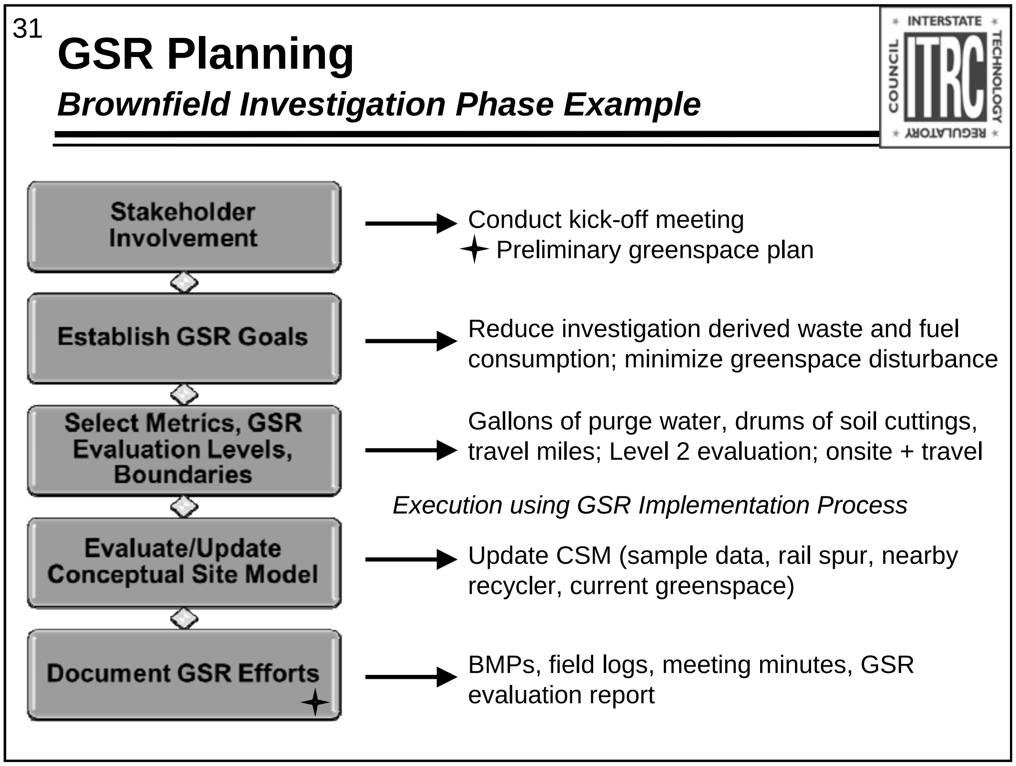
### *Document GSR Efforts*


- Critical to GSR goals and stakeholder communication
- Planning and field work records, GSR evaluation reports, progress updates, etc.
- Document assumptions, resources, tools, goals, metrics, constraints/barriers, etc.
- Phase-specific examples in Tech Reg Section 3

Although documentation of GSR efforts is shown as the last step in the GSR planning process, it should be performed at all applicable times during planning and implementation. Documentation is critical to determine if GSR goals have been achieve and communicating to stakeholders the benefits/accomplishments of achieving those goals.

Documentation examples include planning and field work records, GSR evaluation reports, progress updates, etc. Phase-specific examples for GSR documentation are provided in Section 3 of ITRC’s Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)

Tech Reg: ITRC’s Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)




A hypothetical example of utilizing the GSR planning process during the investigation phase of a Brownfield project is presented. As shown on the slide, the flexibility of the planning process allows the steps to be performed in an order that is most appropriate for site-specific circumstances.

Stakeholder involvement began with a kickoff meeting with the owner, regulator, public official, and consultant. Expectations, project objectives, and GSR were discussed. Stakeholder involvement was also performed as part of documenting GSR efforts. Preservation and possible expansion of greenspace was an important stakeholder consideration/need in this example.

Also indicated within the hypothetical example is when the GSR implementation process (Section 3 of ITRC's GSR-2) was utilized during the investigation phase. Specifically, the implementation process was used to select BMPs, perform the Level 2 evaluation, implement results of the evaluation, and document GSR efforts.

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# GSR Training Roadmap

GSR Framework

Introduction (Section 1 Tech Reg)
- Definitions
- GSR Intent and Benefits

GSR Planning (Section 2 Tech Reg)
- Common Considerations
- Relevant GSR Questions

GSR Implementation (Section 3 Tech Reg)
- Lifecycle Phase Approach
- Consistent Methodology

Q&A #1

GSR Tools (Section 4 Tech Reg)
- Choosing the right tool
- Examples of BMPs, Simple, and Advanced Tools

Case Studies (Appendix C Tech Reg)

Training Wrap-Up

Q&A #2

Tech Reg: ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)

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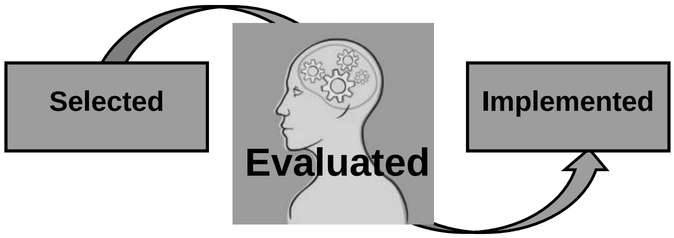
## GSR Implementation

*Tech/Reg Section 3*

- Identifies how GSR approaches may be




- Covers each remediation phase
- Provides a flexible approach

GSR implementation provides a flexible approach:

Site-specific

Can be integrated into existing regulatory programs

Users may not need to complete every step

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# Remediation Phases

- Investigation (Section 3.1)
- Remedy Evaluation and Selection (Section 3.2)
- Remedy Design (Section 3.3)
- Remedy Construction (Section 3.4)
- Operation, Maintenance, and Monitoring (Section 3.5)
- Remedy Optimization (Section 3.6)
- Closeout (Section 3.7)

No additional notes

## How Does GSR Fit In?

| | |
|---|---|
| Investigation | • GSR application during planning |
| Remedy Evaluation and Selection | • Ideal point for incorporating GSR |
| Remedy Design | • Integration of GSR into selected remedy |
| Remedy Construction | • GSR integral part of remedy |
| Operation, Maintenance and Monitoring | • Cumulative benefits resulting from GSR |
| Remedy Optimization | • Sustainability performance improvement for existing remedies |
| Closeout | • Support for site reuse |

Investigation: GSR approaches may provide the greatest benefit when employed early in the process. Therefore, investigation preparations should include GSR approaches to the degree possible to optimize the results.

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# Relationships with Existing Programs

ITRC GSR-2: Table 3.1 (excerpt)

- Can be applied to any federal or state program

| Remedial Phase | RCRA | CERCLA | State Programs | LUST |
|---|---|---|---|---|
| **Investigation** | RCRA Facility Investigation | Remedial Investigation | Site Assessment | Remedial Investigation; Secondary Investigation |
| **Remedy Evaluation and Selection** | Corrective Measures Study and Statement of Basis | Feasibility Study, Proposed Plan, and Record of Decision | Remedial Alternative Evaluation | Conceptual Corrective Action Design; Corrective Action Plan |
| **Remedy Design** | Corrective Measures Design/Corrective Measures Implementation Work Plan; Interim Measure | Remedial Design | Remedial Action Plan; Interim Source Removal Plan | Focused Investigation, Detailed Corrective Action Design |

Can be applied to any federal or state program, e.g.:

RCRA

CERCLA

LUST

State-specific programs

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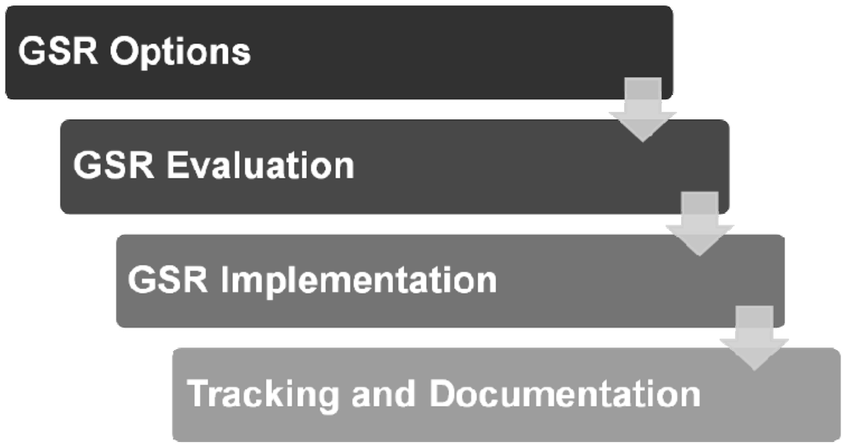
## Approach

- Consistent for each phase
- Provides a methodology for




The different framework components will be described in detail on the following slides.

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# GSR Options

## Sustainable BMP Examples

- *Minimize impacts to natural resources*
- *Engage stakeholders*
- *Identify recycling/ reuse options*
- *Maximize renewable energy use*
- *Use local labor and resources*
- *Reuse unimpacted soil*

The application of GSR options involves identifying BMPs that are applicable to the project and the phase of the project, as well as evaluating more sustainable alternatives. There is a multitude of environmental, social and economic BMPs that can be applied to the different phases of remediation. Some examples of key BMPs are provided on this slide.

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# GSR Options

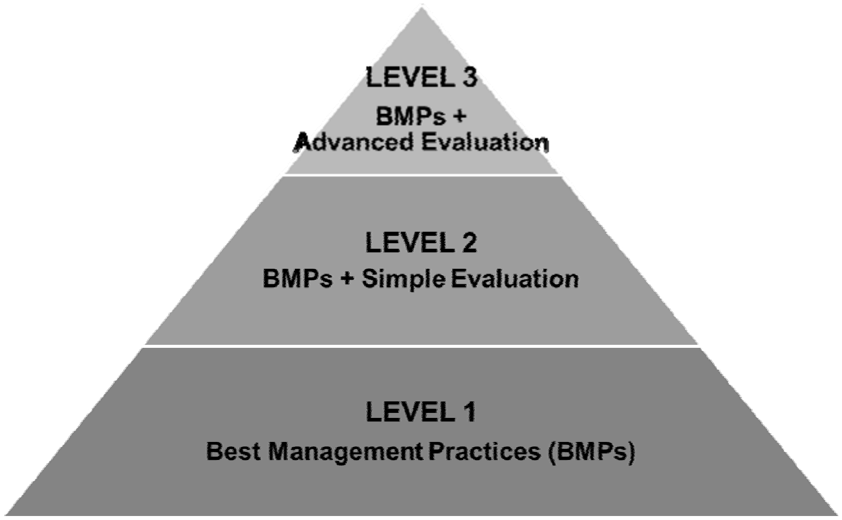
***Remedy Construction Example***

| Environmental | Social | Economic |
|---|---|---|
| - Minimize idling<br>- Control/mitigate dust and odors<br>- Conduct air monitoring<br>- Set up an on-site recycling program<br>- Minimize fuel/energy use | - Implement community notifications<br>- Conduct community meetings<br>- Post information on project progress<br>- Maximize use of local businesses<br>- Sequence construction activities | - Consider economic benefits to community |

ITRC GSR-2: Table 3.7

No additional notes

## GSR Evaluation Levels




The GSR evaluation is integral to other evaluations being performed: e.g. at the remedy selection phase, GSR should tie in to work already being completed to evaluate remedial technologies and alternatives. The approach is site-specific and depends on many considerations, for example site complexity, budget and project objectives.

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# GSR Evaluation
## *Level 1 Example*

**Operation, maintenance, and monitoring example BMPs**

- Select local contractors
- Minimize mobilizations
- Engage the local community
- Use renewable energy
- Reduce noise, especially beyond site boundary
- Implement land revitalization opportunities

No additional notes

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# GSR Evaluation

## *Level 2 Example*

### Hypothetical Remedy Evaluation and Selection

Performing GR evaluations

| Metric | In Situ Thermal | Bioremediation | In Situ Chemical Oxidation |
|---|---|---|---|
| Greenhouse gases | ☹ | ☺ | 😐 |
| Solid waste | ☺ | ☺ | ☺ |
| Sensitive species | 😐 | ☺ | 😐 |
| Community disturbance | ☺ | ☺ | ☺ |
| Community acceptance | ☺ | 😐 | 😐 |
| Cost | ☹ | ☺ | 😐 |

This is a hypothetical example.

Cost include operation, maintenance and monitoring costs, permitting fees, labor costs…

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# GSR Evaluation

## Level 3 Example

### Hypothetical Investigation

| Metric | Approach 1 | Approach 2 |
|---|---|---|
| **Carbon dioxide** | 2 metric tons | 1.5 metric tons |
| **Investigation Derived Waste** | 1,750 pounds | 1,230 pounds |
| **Waste Water** | 500 gallons | 390 gallons |
| **Local Economy Benefit** | $62,000 | $35,000 |
| **Cost** | $120,000 | $85,000 |

Approach 1 does not incorporate any BMPs

Approach 2 incorporates BMPs, e.g. strategic planning to minimize mobilizations and data collection, and using a mobile lab

The evaluation results are estimated for the lifecycle of the investigation phase.

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## GSR Implementation

- Phase-specific
- Incorporate GSR options and evaluation results
- Ensure team understands GSR elements
- Estimate benefits
- Involve stakeholders

No additional notes

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## GSR Implementation
### *Closeout Example*

- Implement GSR evaluation recommendations
- Incorporate GSR aspects into
  - Procurement documents
  - Field work plans
- Ensure contractors understand GSR practices

No additional notes

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# GSR Implementation Benefits

***Remedy Optimization Example***

- VOC concentrations to an air stripper dropped significantly
- Unit downsized from 20 to 10 HP motor

**1.7M KWh saved!**

**GHG emissions reduced by 1,080 metric tons!**

**$168K cost savings!**

Influent VOC concentrations to an air stripper significantly dropped from 200 ppb to 50 ppb after the first five years of operation. A 20 HP blower is no longer needed to supply air to the air stripper and the unit is downsized to a 10 HP motor.

This equates to removing 212 passenger vehicles off the road. Or powering 94 homes for one year.

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# Tracking and Documentation

- Ensures transparency
- Documents GSR practices
- Identifies sustainability benefits
- Tracks successes and lessons learned
- Incorporated in regulatory reports

No additional notes

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## Documentation

- BMPs selected
- Evaluation level performed
- GSR implementation
- Stakeholder collaboration efforts
- Monitoring and tracking results
- Data collected

Data collected could include:

Electricity use

Fuel use

Miles traveled

Water use

Quantities of materials recycled

Quantities of materials reused

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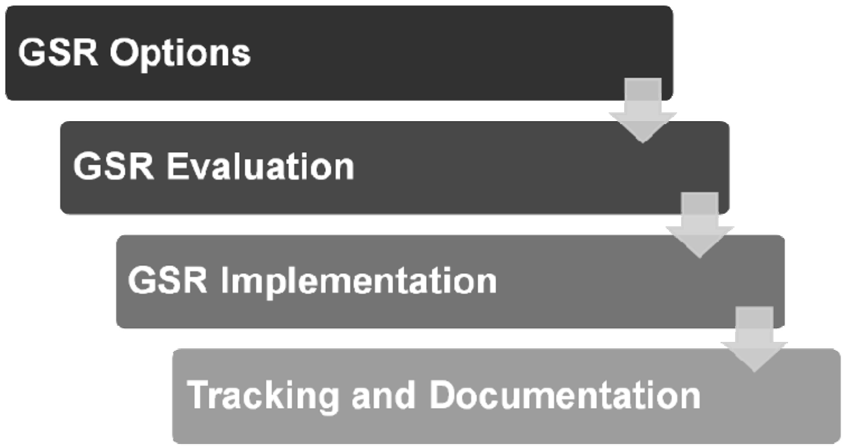
## GSR Implementation Summary

- Consistent methodology for

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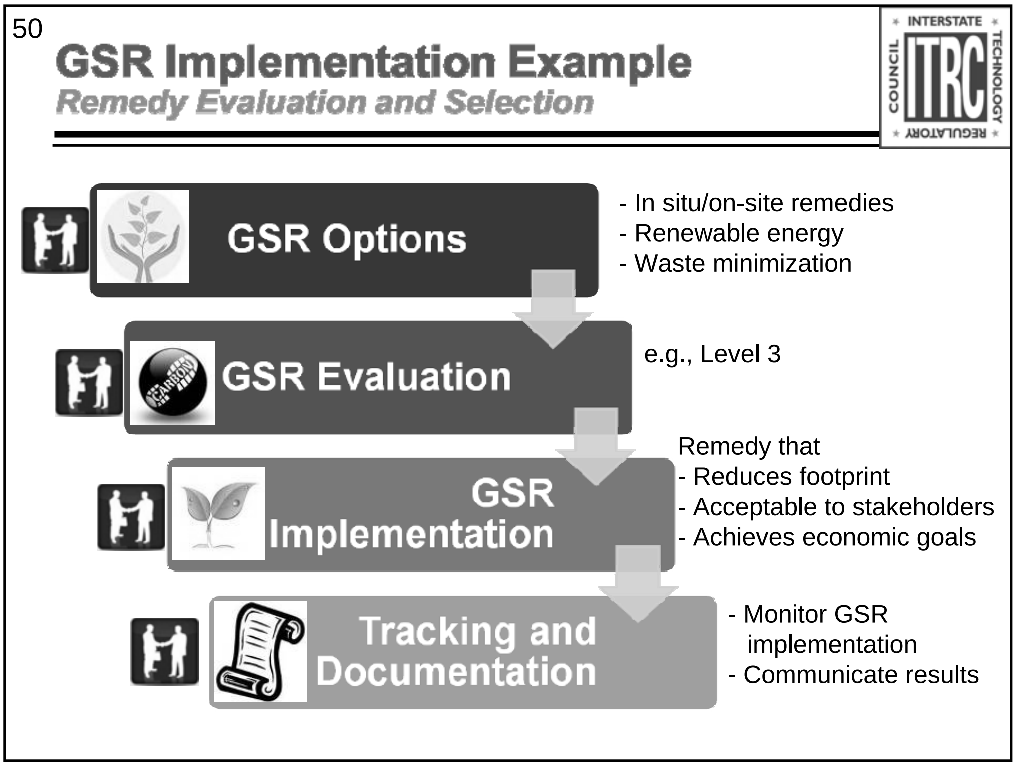


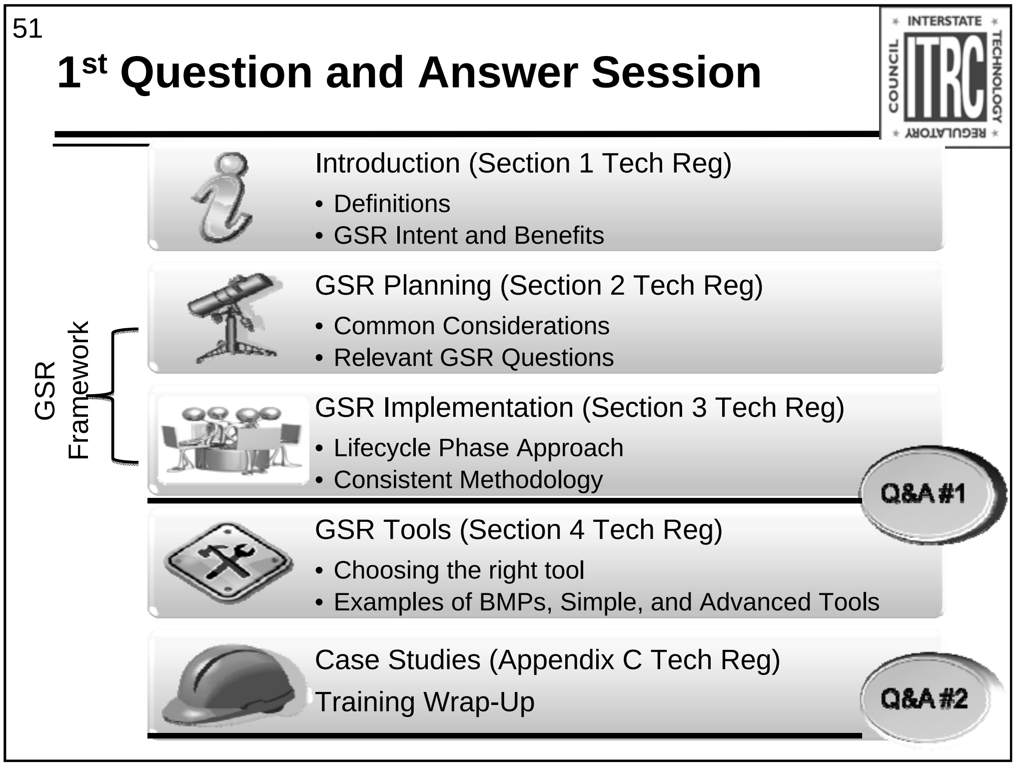

**Stakeholders:** Extensive stakeholder collaboration event was held at the beginning of the phase. Stakeholders discussed and agreed upon the sustainability metrics that would be evaluated and considered during and following the stakeholder event.

**GSR options:** Remedies considered: air stripping, ZVI, in-situ chemical oxidation, electrical resistive heating, hydraulic barrier.

**GSR evaluation:** Simple life cycle assessment performed. Metrics included greenhouse gas emissions, criteria pollutants (for example particulate matter) emissions, non-hazardous and hazardous waste disposal, natural resource (for example raw material and water…) consumption, community disturbance and cost.

**GSR implementation:** it is hoped that the selected remedy will take into account the results of GSR options and GSR evaluation.

**Tracking and documentation:** a sustainability section and appendix has been included in the remedy evaluation and selection report submitted to the regulatory agency.




Tech Reg: ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)

# GSR Training Roadmap

GSR Framework

- Introduction (Section 1 Tech Reg)
  - Definitions
  - GSR Intent and Benefits
- GSR Planning (Section 2 Tech Reg)
  - Common Considerations
  - Relevant GSR Questions
- GSR Implementation (Section 3 Tech Reg)
  - Lifecycle Phase Approach
  - Consistent Methodology

Q&A #1

- GSR Tools (Section 4 Tech Reg)
  - Choosing the right tool
  - Examples of BMPs, Simple, and Advanced Tools
- Case Studies (Appendix C Tech Reg)
- Training Wrap-Up

Q&A #2

Tech Reg: ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)

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# Before Selecting GSR Tools

## *Set GSR Goals and Select Metrics*

Goals → Metrics → Tools

| Example Goals | Example Metrics |
|---|---|
| Reduce emissions | Greenhouse gases<br>Air quality emissions |
| Conserve natural resources | Energy and water use<br>Resource consumption |
| Create habitat | Ecological service value |
| Improve community | Traffic volume<br>Jobs for local workers |

Because these tools will help us measure greenness or sustainability, we need to first define what exactly we are measuring, the GSR metrics.

These follow from the GSR goals.

Several examples of GSR goals and associated metrics are shown in this table.

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# Before Selecting GSR Tools

***Evaluate Project Scope***

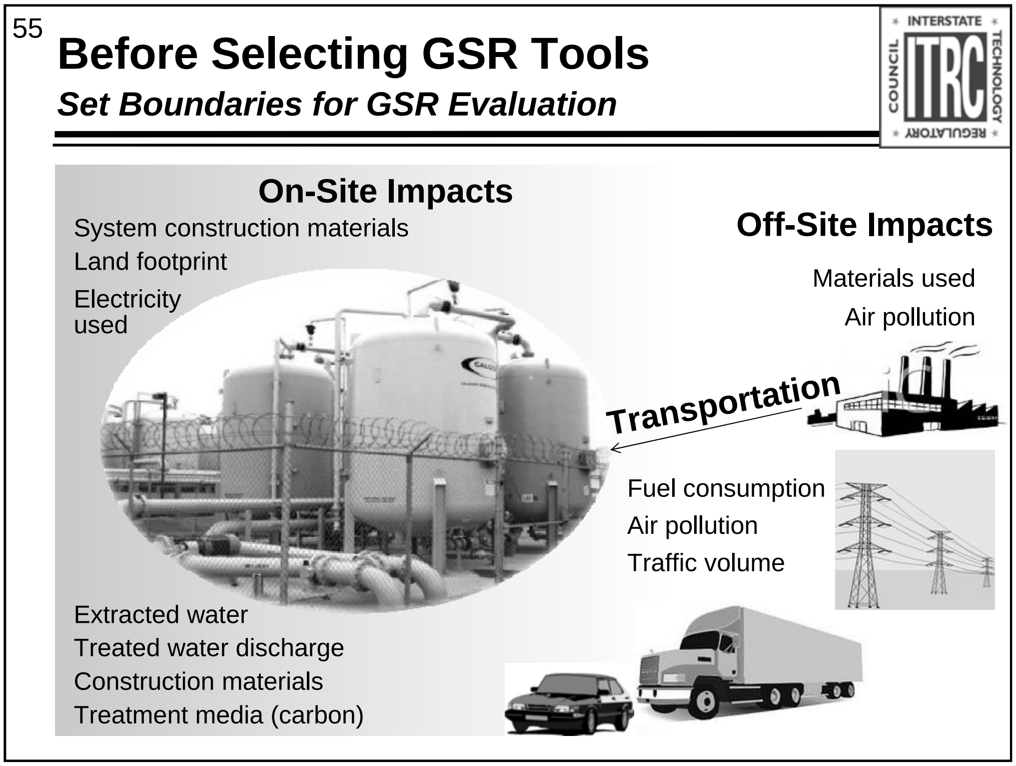
| Stakeholders | Values | GSR Metrics |
|---|---|---|
| Project leader | Project efficiency | Energy & cost savings |
| Property owner | Property value | Land use |
| Community group | Safety and quality of life | Traffic volume |
| Site regulator | Health and environment | Air pollutant emissions |
| | | Ecological habitat |

It is important to include stakeholders in the process of setting GSR goals and metrics

Different stakeholders can have different values, as shown in the table.

GSR metrics that reflect these stakeholder values would all be included in the GSR evaluation

Otherwise, the GSR evaluation might not be acceptable to all parties.




For each metric, you will need to define boundaries in space and time for measuring emissions, materials used, etc.

On-site impacts are typically included. Some GSR evaluations also include impacts of transportation to/from the site, and off-site impacts.

This can make a big difference in the result so all assumptions need to be clearly documented.

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# Tool Selection

***Considerations***

- Consider
  - Site-specific GSR goals and metrics
  - Scope, budget, and purpose of GSR evaluation
  - Available site data
  - Type of remediation technologies
  - Regulatory cleanup program
- No certification or standard evaluation method
- ITRC team does not endorse any specific GSR tool

Some considerations for selecting a GSR tool are listed.

There is really no certification or industry standard for GSR tools.

ITRC does not endorse any particular tool. ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011) is intended to provide an overview of tools that are available and orient you to the use of these tools for GSR evaluation.

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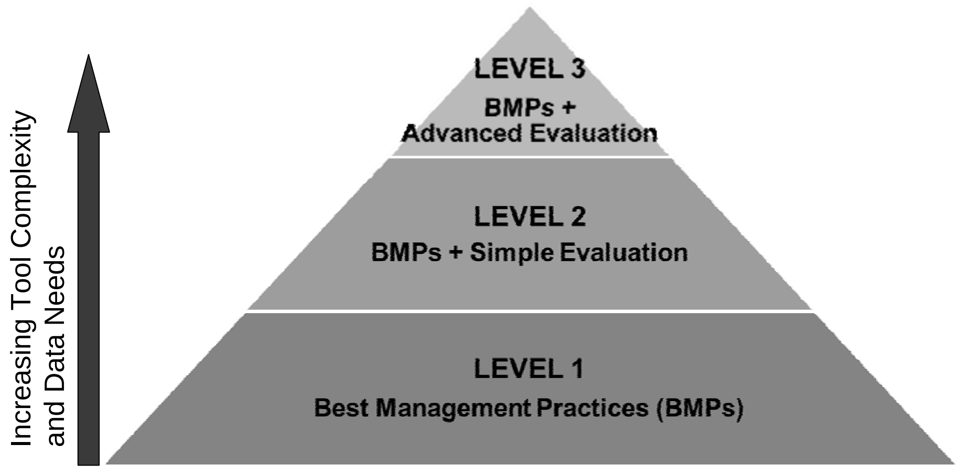
# Tool Selection

***Wide Range of Available Tools***

- Choose simplest tool that gets the job done
- BMPs (Level 1) are most often used




ITRC is looking at GSR as a scalable effort. The pyramid shape illustrates how often each of the different levels of GSR evaluation are performed.

Most people will use Level 1, best management practices.

More advanced tools will likely require more site-specific data.

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# Tool Selection

***Select the Right Level of Evaluation***

| | Level 1<br>BMPs | Level 2<br>BMPs + Simple | Level 3<br>BMPs + Advanced |
|---|---|---|---|
| Description | • Best practices (e.g., no idling of truck engines at job site) | • Qualitative ranking process | • Quantitative analysis (e.g., footprint analysis, Net Environmental Benefits Analysis) |
| Pros | • Simple<br>• Cost-effective<br>• Easy to implement | • Evaluates multiple metrics<br>• Simple calculations only (lb $CO_2$/lb contaminant treated) | • Quantifies multiple metrics<br>• Track impacts from cradle to cradle |
| Cons | • Does not evaluate trade-offs | • Requires scoring method | • Requires scoring method<br>• More costly, time-consuming<br>• More data required |

Pros and cons of using the different GSR levels 1 through 3 are illustrated in the table.

If you are interested in evaluating several different alternatives and deciding which is more green or sustainable, you would need to use a Level 2 or Level 3 GSR evaluation.

Note: “Cradle to cradle” refers to life-cycle impacts of a product or activity. In contrast to “cradle to grave”, products are not discarded at the end of their useful lifetime but are recycled to serve another purpose.

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# GSR Tools

***BMPs (Level 1)***

- ASTM, EPA, SURF, USACE
- EPA fact sheets
  - Introduction to BMPs
  - Site investigation
  - Excavation
  - Pump-and-treat
  - Bioremediation
  - SVE/air sparging
  - Clean fuel and emission technologies
  - Renewable energy


http://www.clu-in.org/greenremediation/

The next set of slides provides examples of tools that can be used for each level.

Level 1 tools are described in several references published by ASTM, SURF and USACE, including BMPs for social and economic considerations.

Several states have developed tools to encourage the use of BMPs, including the state of Illinois Greener Cleanups Matrix and the Minnesota Toolkit for Greener Practices.

EPA has published a series of fact sheets on BMPs for different remedial technologies. These are posted on the clu-in website under green remediation.

These BMPs are useful for reducing a technology’s environmental footprint, not for deciding which remedy is greener or more sustainable. The ITRC team discussed and generally came to a consensus that there are no green or sustainable technologies, as this is site-specific conclusion.

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# GSR Tools

***Simple Tools (Level 2)***

- California Department of Toxic Substances Control Green Remediation Evaluation Matrix (GREM)

| **Metrics** | **Option 1 - SVE** | | **Option 2 - MNA** | | Relative Importance |
|---|---|---|---|---|---|
| | Yes/No | Score* | Yes/No | Score* | |
| Air emissions | Yes | 2 | Yes | 1 | 1 |
| Solid waste | Yes | 2 | Yes | 1 | 1 |
| Wastewater | Yes | 1 | Yes | 1 | 1 |
| Noise/odor/vibration | Yes | 3 | Yes | 1 | 1 |
| Land stagnation | Yes | 1 | Yes | 3 | 2 |
| TOTAL | | 9 | | 7 | |
| WEIGHTED TOTAL | | 10 | | 10 | |

*Scale of 1 to 3 where 1 is favorable (more green or sustainable) in this example

http://www.dtsc.ca.gov/omf/grn_remediation.cfm

An example of a simple tool that can be used for a Level 2 GSR evaluation is the Green Remediation Evaluation Matrix, developed by the California Department of Toxic Substances Control (DTSC).

This tool is basically a spreadsheet. The stakeholders list all of the different metrics in the spreadsheet. (The DTSC spreadsheet calls these “Stressors”). For each metric, you evaluate whether or not it is relevant (yes or no), and provide a score such as 1 through 3, 1 through 10, High Med or Low, to differentiate the impacts of remedial options 1 and 2.

In this example, low score = better from GSR perspective. So with these scores, option 2 would be favored.

By adding another column to this spreadsheet and assigning weights to designate the relative  importance of each metric, total weighted scores could be calculated.

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# GSR Tools

***Advanced Tools (Level 3)***

- Carbon footprint calculators
- Remedy footprint tools
  - Air Force Sustainable Remediation Tool (SRT™)
  - Navy and Army Corps of Engineers SiteWise™
  - Other tools
- Net environmental benefits analysis tools
- Life-cycle assessment (LCA) tools

Different types of tools are described in section 4.4 of ITRC’s Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011).

The next few slides focus on two publically and freely available environmental footprint tools (SRT™ and SiteWise™) and LCA tools.

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# GSR Tools

***Sustainable Remediation Tool (SRT)™***

- Use for remedy selection and optimization
- Two choices for level of detail
- Eight technologies
- Measures air emissions, greenhouse gas emissions, energy, cost, accident risk, change in resource use
- Stakeholder scoring matrix

http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/srt/index.asp

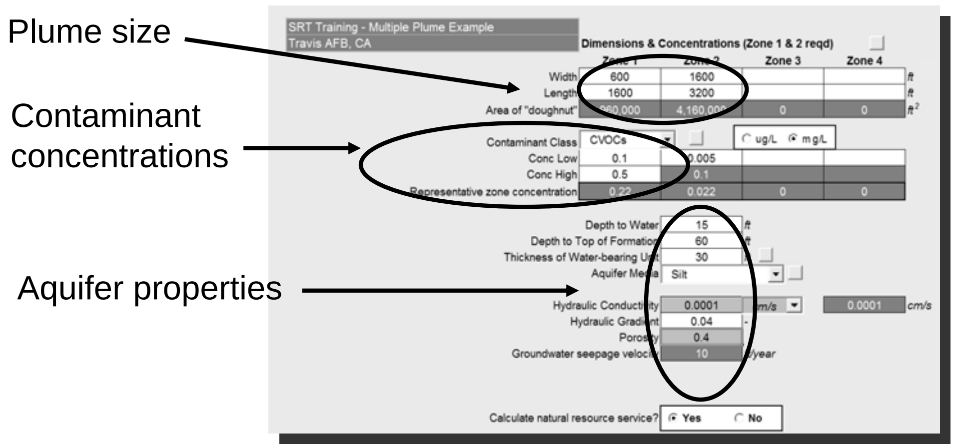
Sustainable Remediation Tool™ or SRT™ was developed by GSI Environmental on behalf of the Air Force Center for Engineering and Environment.

SRT™ is a spreadsheet-based model that can be used for remedy selection or for optimizing an existing remedy.

SRT™ also includes a stakeholder scoring matrix that can be used to take each stakeholders' weightings for importance of different metrics and come up with the group's collective answer.

# GSR Tools

***SRT™ General Inputs***




http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/srt/index.asp

This screen-shot shows the type of user interface and prompts for site-specific data

# GSR Tools

## *SRT™ Results*

Technologies

Metrics

| | Carbon Dioxide Emissions to Atmosphere | | Total Energy Consumed | | $PM_{10}$ |
|---|---|---|---|---|---|
| | *tons $CO_2$* | *lb $CO_2$ per lb dissolved mass* | *Megajoules* | *kWh* | *tons $PM_{10}$* |
| **Pump & Treat** | 980. | 17,000. | 5,000,000. | 1,400,000. | 0.36 |
| **Enhanced Bio.** | 5,300. | 94,000. | 4,600,000. | 1,300,000. | 0.14 |
| **ISCO** | - | - | - | - | - |
| **PRB** | - | - | - | - | - |
| **LTM / MNA** | - | - | - | - | - |

*: See SRT v.2 Known Issues

*Normalize?* Yes ● No

http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/srt/index.asp

Typical presentation of results from SRT™ – a table that compares GSR metrics for each remedial alternative/technology

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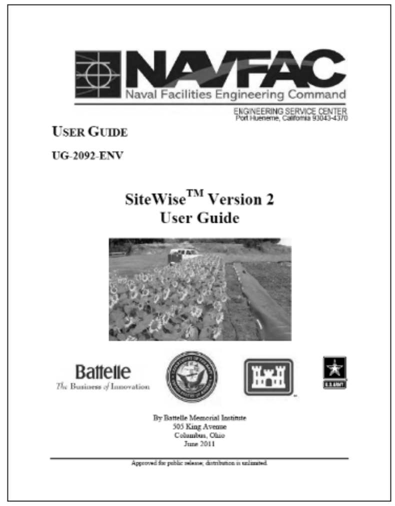
# GSR Tools

***SiteWise$^{TM}$***

- Spreadsheet for each stage of remedial action
  - Remedial investigation
  - Remedy construction
  - Remedy operation
  - Long-term monitoring
- Activities in each stage
  - Material production
  - Transportation
  - Equipment used
  - Waste handling




http://www.ert2.org/t2gsrportal/SiteWise.aspx

SiteWise$^{TM}$ was developed by Battelle on behalf of the Navy and Army Corps of Engineers.

SiteWise$^{TM}$ is set up as a series of Excel spreadsheets that can be used for each stage of remedial action.

To calculate life-cycle impacts, sum up the results from multiple spreadsheets.

Within each spreadsheet are a variety of activities that go on during that phase including materials, transportation, equipment and waste handling.

SiteWise$^{TM}$ v. 2 was recently released. There is also an online training webinar on the website as well as the user’s manual.

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# GSR Tools

***SiteWise$^{TM}$ General Inputs***

Example: Materials Production

Item 1, Item 2

Well materials

Treatment chemicals

Granular activated carbon

Construction materials

| WELL MATERIALS | Well Type 1 | Well Type 2 |
|---|---|---|
| Input number of wells | | |
| Input depth of wells (ft) | | |
| Choose well diameter (in) from drop down menu | 1/2 | 1/2 |
| Choose material type from drop down menu | Steel | Steel |
| Choose specific material schedule from drop down menu | Schedule 40 Steel | Schedule 40 Steel |
| **TREATMENT CHEMICALS** | **Treatment 1** | **Treatment 2** |
| Input number of injection points | | |
| Choose material type from drop down menu | ISCO Chemical | Sodium Hypochlorite |
| Input amount of material injected at each point (lbs) | | |
| Input number of injections per injection point | | |
| **GAC** | **Treatment 1** | **Treatment 2** |
| Input weight of GAC used (lbs) | | |
| Choose material type from drop down menu | GAC | GAC |
| **CONSTRUCTION MATERIALS** | **Material 1** | **Material 2** |
| Choose material type from drop down menu | HDPE | HDPE |
| Input area of material (ft$^2$) | | |

http://www.ert2.org/t2gsrportal/SiteWise.aspx

Typical user interface for entering site-specific data into SiteWise$^{TM}$. This is the spreadsheet where the user inputs all the materials used for site remediation.

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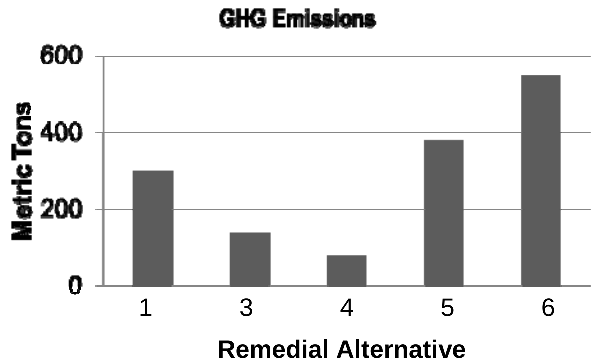
# GSR Tools

***SiteWise™ Results***

| Remedial Alternative | Energy (MMBTU) | Emissions (Metric Tons) | | | Accident Risk Injury |
|---|---|---|---|---|---|
| | | GHGs | $NO_x$ | $SO_x$ | |
| Alternative 1 | 3.05 | 300 | 0 | 0 | 0 |
| Alternative 3 | 3.05 | 140 | 0 | 0 | 0 |
| Alternative 4 | 3.05 | 80 | 0 | 0 | 0 |
| Alternative 5 | 0.22 | 380 | 6.0E-05 | 1.0E-06 | 3.14E-06 |
| Alternative 6 | 0.22 | 550 | 6.0E-05 | 1.0E-06 | 3.14E-06 |

Comparative graph generated for each metric

http://www.ert2.org/t2gsrportal/SiteWise.aspx




Results from Sitewise™ are automatically populated in a table along with graphical summary of each of the metrics

The bottom graph shows metric tons of greenhouse gas emissions associated with each remedial alternative.

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# GSR Tools

***Other Remedy Footprint Tools***

- Other footprint tools and methodologies
  - Private industry/consulting firms
  - Universities
  - States
  - EPA tools
  - DOE
  - Other organizations
- Potential benefits
  - Technology modules
  - Simplified tracking for a portfolio of sites
  - Biofuels, renewable energy options

ITRC GSR-1: Appendix A

Other footprint tools have been developed by private industry, universities, EPA, states, DOE and others. ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011) does not go into detail. However, Appendix A in ITRC's Overview Document, Green and Sustainable Remediation: State of the Science and Practice (GSR-1, 2011) provides a list.

Some of these tools provide more technology modules compared with SiteWise™ or SRT™. Others make it easier to track GSR impacts associated with a portfolio of different sites. Others have built-in information about biofuels and other green options.

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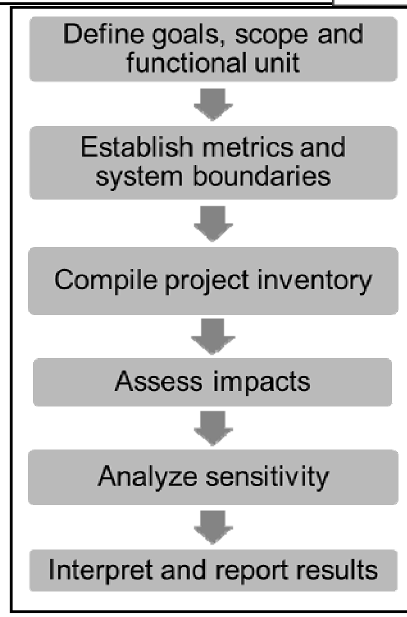
## GSR Tools

***Life Cycle Assessment (LCA) Process***

- LCA Process
- Example tools
  - SimaPro®
  - GaBi
- Can be used to evaluate wide range of metrics
- Draw from variety of emissions inventory databases
- Provide different methods for impact assessment




ITRC GSR-2 Section 4 and SURF, 2011

Steps in the LCA process are listed here. More details on LCA are provided in ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011) and in a Sustainable Remediation Forum (SURF) report was published in the Summer 2011 issue of Remediation Journal.

Examples of LCA tools include SimaPro®, developed by Product Ecology Consultants, and GaBi, developed by PE International in Germany.

Both tools can be used to evaluate a wide range of metrics, draw information from a number of different emissions inventory databases, and provide options for dozens of different impact assessment methods.

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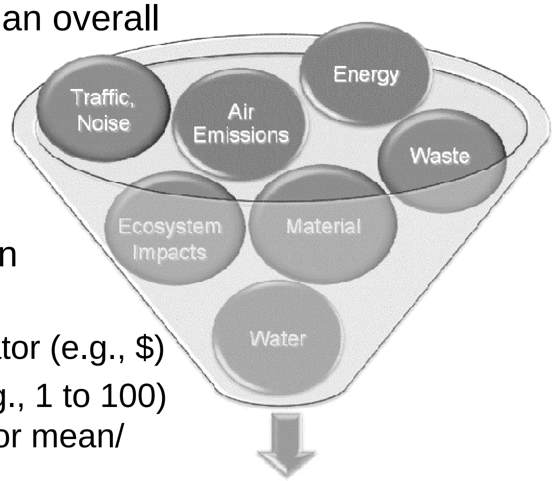
# GSR Tools

***Weighting and Scoring Methods***

- Some tools give you an overall GSR score
- Decide relative importance of each GSR metric
- Normalize to common units and range
  - Common denominator (e.g., $)
  - Common range (e.g., 1 to 100) based on min/max or mean/ standard deviation
- No “perfect” approach




**Tool Output**

Some tools have a built-in method to help you combine results from a variety of different GSR metrics, each with their own units, and come up with a single score or some other output

This is useful if you are considering several remedial options, as you can score each remedial option and then compare the resulting scores.

To do this, you will first need to determine the relative importance of each metric.

Some metrics might be more important than others. This is site-specific and may depend on the site setting or stakeholder group’s values.

Next, tools must normalize various units and quantities in different ranges (different orders of magnitude).

Some tools convert everything to a common denominator, such as $

Another approach normalizes all results to a common unitless range (such as 0 to 1 or 1 to 100) using the maximum and minimum values. This can increase the impact of small variations.

Normalizing to a common unitless range using mean and standard deviation values is another approach that does not maintain the original “shape” of the data.

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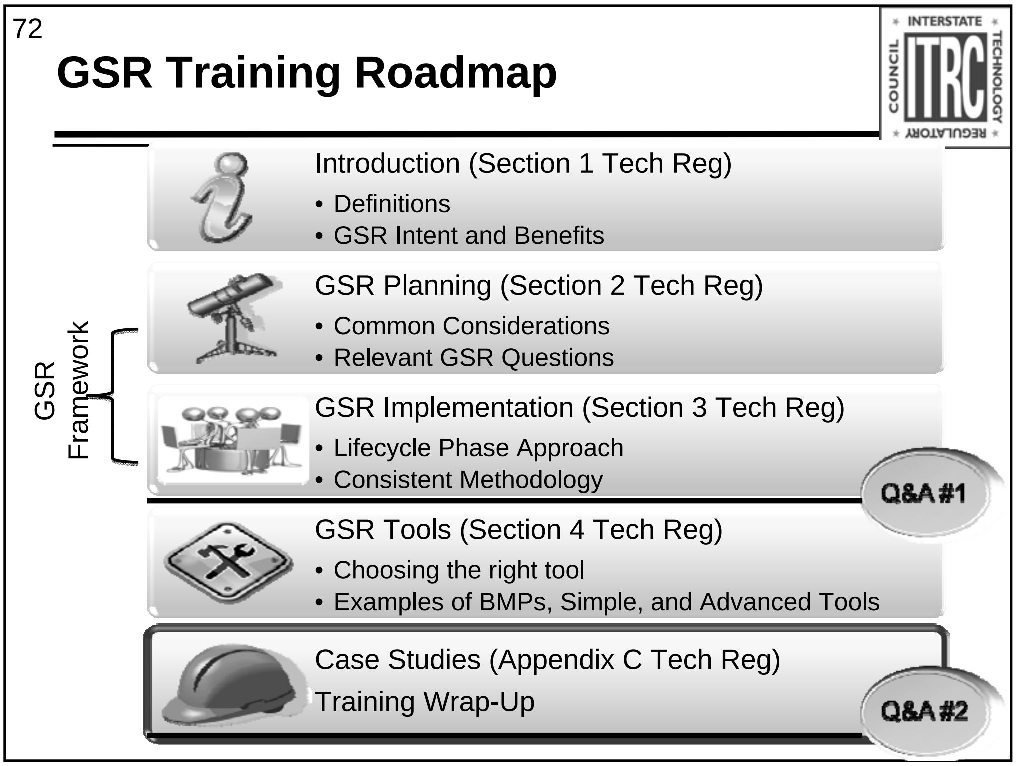
# GSR Tools

***Best Practices***

- Use BMPs
- Select the simplest evaluation needed for the job
- Involve stakeholders in process
- Evaluate the uncertainty/sensitivity of results
- Document GSR evaluation process

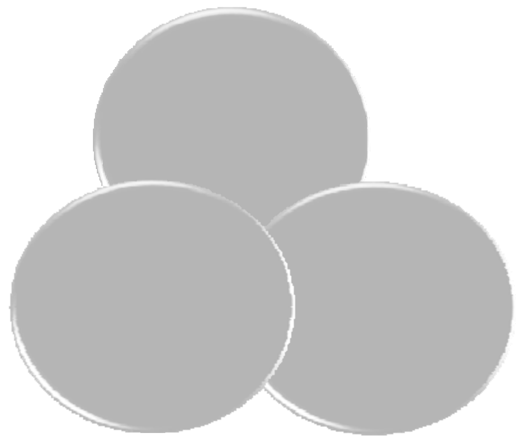
Key take-home points about conducting a GSR evaluation




Tech Reg: ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)

# Case Studies

- Application of Green & Sustainable Remediation to sites
- Examples with different
  - GSR levels
  - Remediation phases
  - Metrics
  - Regulatory programs



The Case Studies being presented are intended to show how GSR can be applied to a variety of sites, with different remediation scenarios, in different phases of remediation, and in different regulatory programs.

# Former Refinery Site (Level 1)
***Overview***

- Pre-GSR: no formal evaluation for selection of optimization measures
- GSR scope: applied during Remedy Optimization
- GSR metrics
  - Energy consumption
  - Ecological diversity
  - Community benefits

ITRC GSR-2: Appendix C

"before GSR"

Decisions made with stakeholder input and professional judgment

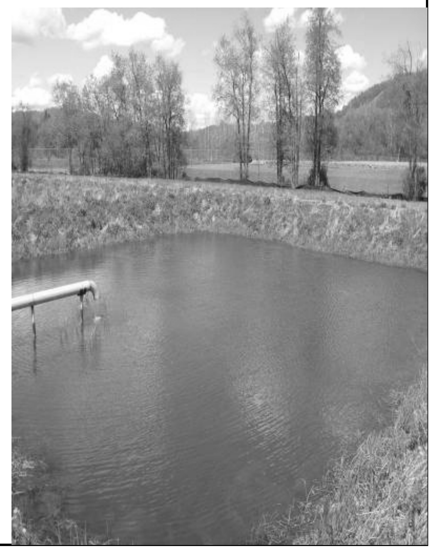
Photo is of downgradient river

# Former Refinery Site (Level 1)
***Site Remediation***

**Setting**

- Superfund, US EPA Region 2 and NYS DEC
- Site type: Former Refinery
- Hydrocarbon impacted groundwater
- Remediation driver
  - River downgradient
- Existing remedy
  - Chemical treatment of extracted groundwater
- Optimized remedy
  - Constructed wetland for treatment of extracted groundwater

**Vertical Flow Wetland**



Other remedy considered was the ‘unoptimized’ or existing remedy; used GAC

Additional GSR ‘upgrades’ were re-do of a landfill cap.

The photo is of part of the constructed treatment wetland. The vertical flow component is one of the last stages.

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# Former Refinery Site (Level 1)



Another key aspect of the optimization was the replacement of conventional turf grass with native grasses, removal of fence, and placement of hiking trails and bird watching stations

Top photo shows fence around landfill and turf grass, bottom photo shows fence removed, native grass, hiking trails, birdhouses and interpretative signs.

Work is in progress; existing is as site has been. Planned is once all upgrades are in place. It doesn’t look like this yet. It will after the grass grows, etc.

# Former Refinery Site (Level 1)

***Significant GSR Elements***

- Environmental
  - In situ treatment via constructed wetland
  - Biodiversity
  - Reduced chemical use and energy consumption
- Social
  - Community access
    - Bird watching stations and hiking trail
  - Education
    - Environmental center with state college
- Economic
  - Cost savings

Biodiversity from both Constructed Treatment Wetland and use of native grasses instead of turf for landfill cap

Trail connects community through landfill to river hiking trail

Direct cost savings; details on next slide's notes

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# Former Refinery Site (Level 1)

***Summary***

- Benefits of GSR approach
  - Wetland reduced treatment chemical use and energy consumption and increased biodiversity
  - Communication between site owner and community improved through meetings, website, and newsletters
  - Better connection to natural environment
  - Improved educational opportunities
- Challenge to incorporating GSR
  - Regulatory – changing a record of decision (ROD) remedy through an explanation of significant difference (ESD) rather than a ROD amendment
- Lessons learned
  - Communication with stakeholders is key to successful outcome

In first year of conversion to constructed treatment wetland, 6,000 kwh were saved, 100,000 lbs of water treatment chemicals and 4500 lbs of granular activated carbon were eliminated, 1000 loaded trucks were removed from road, and 3350 metric tons of CO2 equivalents were saved. This amounted to $40,000 reduced annually in treatment chemicals and $60,000 reduced annually in cap maintenance.

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# RCRA Site (Level 2)

***Overview***

- Evaluation method
  - Qualitative and quantitative during remedy selection
  - Professional judgment and BMPs during all phases
- GSR scope
  - Applied from Site Assessment through Remedy Selection, Design and Construction
- GSR metrics
  - Carbon dioxide ($CO_2$) emissions
  - Waste minimization and reuse
  - Consumption of resources
  - Community benefits
  - Corporate sustainability goals

No associated notes.

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# RCRA Site (Level 2)

***Site Remediation***

**Setting**

- State RCRA program, confidential location
- Permeable sand and glacial outwash with glacial till near surface
- 39 volatile and semivolatile organic compounds (VOCs) + (SVOCs) in subsurface soil and perched groundwater
- Remediation driver
  - Sole source aquifer
- Remedy selected
  - Source excavation of 70,000 tons
- Other remedies considered
  - Ex situ thermal
  - In situ electrical resistive heating (ERH) and hot spot excavation

Excavation may not seem like a green alternative, but based on the GSR evaluation results, it was ranked best compared to the other alternatives (this helps people see that everything needs to be put into context and properly evaluated – don't just assume something is not green or sustainable because it may in fact be your best choice when considering site-specific circumstances)

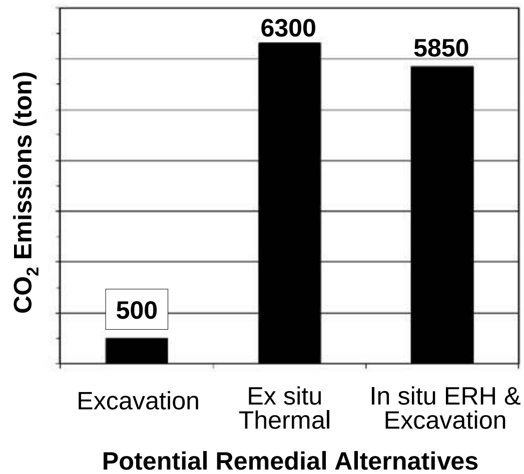
More evidence shown on next slide

# RCRA Site (Level 2)

***Significant GSR Elements***

## Significant GSR Elements Utilized

- Environmental
  - Triad for assessment
  - Efficient trip routing
  - No idling
  - Reduced $CO_2$ emissions
- Social
  - Communication
  - Reduced nuisance
- Economic
  - Time to completion




Recall one metric was $CO_2$. This graph shows that the selected remedy had much lower $CO_2$ emissions.

Estimation of $CO_2$ emissions included accounting for fuel use by equipment on remediation site, trucking, and equipment at landfill, as well as electricity use.

Site assessment employed a dynamic work strategy, with expedited electronic lab results, field screening, pre-established decision logic, samples collected with direct push.

Soil was not recycled. Excavation was backfilled with clean material from off-site.

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# RCRA Site (Level 2)

***Summary***

- Benefits of GSR approach
  - Reduced energy consumption and $CO_2$ emissions
  - Positive relations with stakeholders
- Challenges to implementation of GSR
  - Selection of an appropriate GSR evaluation approach
  - Weighting of metrics
  - Lack of incentives and recognition for facility
- Lessons learned
  - Clear communication and documentation key
  - Construction worker/contractor understanding of GSR benefits may take time

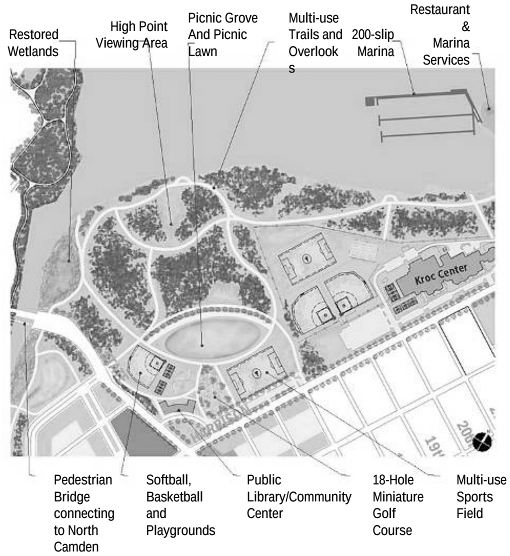
Communication critical for agency understanding and approval and stakeholder acceptance

Workers have set routines, an understanding and appreciation of GSR benefits may take time – for example, equipment anti-idling is easier said than done – minimized this issue by efficient scheduling of trucks

# Brownfield Site (Level 3)

***Overview***

- Evaluation method: SiteWise™ and Sustainable Remediation Tools™ (SRT™)
- GSR scope: applied during Site Assessment and Remedy Selection
- GSR metrics: energy consumption, air emissions (including GHG), water consumption, accident risk, cost savings
- GSR boundaries: both tools account for material manufacturing and site impacts




Source: Cooper's Ferry Development Corp

Refer to Section 4 training

These are publicly available tools

Similar to second case study

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# Brownfield Site (Level 3)

***Site Remediation***

## Setting

- NJDEP Brownfield Site
- Former Landfill - chlorinated benzenes impacting soil and groundwater
- Remediation Driver: Redevelopment
- Interim Remedy Selected: Excavation
- Other Remedies Considered: in situ chemical oxidation (ISCO), in situ thermal remediation (ISTR)


85 acre municipal landfill on 200 acre Brownfield site

Unlined landfill operated from 1952 to 1971

Note Cl-benzenes can be DNAPLs

Landfill underlain by clay and sand

Impacts from 18 - 55 ft bgs; gw at 25 ft bgs

Redevelopment can accelerate remediation time line

Note excavation as selected remedy

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# Brownfield Site (Level 3)

***Significant GSR Elements***

- Environmental
  - Triad - Membrane Interface Probe
  - Biofuels
  - Footprint/Tool Comparison
- Social
  - Revitalize blighted neighborhood
  - Reduce accident risk
- Economic
  - Leverage public/private investment for future redevelopment

Picture of Triad Investigation identifying extent of clay layer contamination acting as residual source area. Red-Yellow areas are the highest levels of residual contamination in the clay while blue-purple areas are the lowest level of contamination in the residual clay. The expedited delineation of this residual source area helped to identify a previously unknown extent of impacts and remediate this site in an effective manner. Redevelopment could utilize time-sensitive grant funding available.

# Brownfield Site (Level 3)

***SiteWise™ Output***

| Activities | GHG Emissions | Total energy Used | Water Consumption | NOx Emissions | SOx Emissions | PM10 Emissions | Accident Risk Fatality | Accident Risk Injury |
|---|---|---|---|---|---|---|---|---|
| | metric tons | MMBTU | gallons | metric tons | metric tons | metric tons | | |
| Consumables | 108.18 | 1.00E+03 | NA | NA | NA | NA | NA | NA |
| Transportation-Personnel | 19.35 | 2.20E+02 | NA | 3.30E+01 | 6.90E+00 | 1.60E+00 | 1.20E-04 | 8.30E-03 |
| Transportation-Equipment | 0 | 0.00E+00 | NA | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Equipment Use and Misc | 2,856.43 | 5.70E+04 | 2.80E+06 | 4.10E+00 | 1.90E+01 | 9.90E-04 | 1.60E-05 | 7.00E-03 |
| Residual Handling | 0.71 | 1.70E+01 | NA | 7.60E-04 | 1.80E-04 | 1.10E-04 | 1.90E-06 | 3.90E-04 |
| Total | 2,984.67 | 5.81E+04 | 2.80E+06 | 3.69E+01 | 2.63E+01 | 1.57E+00 | 1.38E-04 | 1.56E-02 |

Sustainable Remediation 2011, UMASS Amherst

These are the results for the thermal option
SiteWise™ allows you to break down the results by activity so you can see what the main contributor is and potentially change your design to address it
A separate table in SiteWise™ also gives percent total for each metric.
Analysis showed that the thermal options used an excessive amount of energy, 58,000 MMBTU (recall metrics from overview slide), and produced almost 3,000 metric tons of GHGs. Results are similar to the analysis from Case Study #2, leading to selection of the excavation alternative.

**Output sheet for each Alternative breaks down metrics:**

- **Consumables**
- **Transportation-personnel**
- **Transportation-equipment**
- **Equipment use and miscellaneous**
- **Residual Handling**

**Summary sheet compares metrics totals for each remedial alternative**

# Brownfield Site (Level 3)
***Summary***

- Benefits of GSR approach
  - Triad process expedited investigation and redevelopment, improved remediation
  - Community institutions were strengthened
  - Air emissions (including GHG) were reduced
  - Project catalyzed neighborhood revitalization and job creation will reduce poverty
- Challenge to implementing GSR
  - Weighting social, economic and environmental metrics was difficult
- Lessons learned
  - Tool selection depends on amount of information available and technologies being evaluated

Triad approach also improved remediation by identifying hot spot area.

Energy consumption also reduced by GSR approach.

Similar challenges noted by second case study.

Refer back to Section 4 of training to see level of site knowledge needed for different tools

# Key Lessons from Case Studies

- **Flexibility**:  GSR process can be applied to a variety of sites, remediation phases and regulatory programs
- **Communication**: Communication with stakeholders is critical to successful application of GSR
- **Assumptions**: Because evaluation methods are new, users must understand the assumptions of the tools being used
- **Holistic**: This holistic approach will minimize a project's life cycle impacts

No associated notes.

# GSR Training Wrap-Up

GSR Framework (Sections 2–3)

Introduction (Section 1 Tech Reg)
- Definitions
- GSR Intent and Benefits

GSR Planning (Section 2 Tech Reg)
- Common Considerations
- Relevant GSR Questions

GSR Implementation (Section 3 Tech Reg)
- Lifecycle Phase Approach
- Consistent Methodology

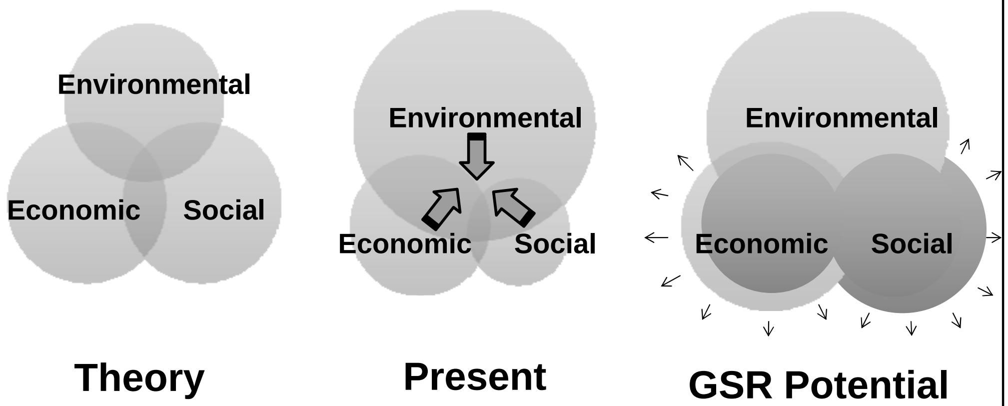
GSR Tools (Section 4 Tech Reg)
- Choosing the right tool
- Examples of BMPs, Simple, and Advanced Tools

Case Studies (Appendix C Tech Reg)

Training Wrap-Up

Tech Reg: ITRC's Technical & Regulatory Guidance Document: Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)

## GSR Maturation




ITRC GSR-2: Figure 1-2

Adapted from International Union for Conservation of Nature, 2006

To borrow a visualization of sustainability from the International Union for Conservation of Nature's report titled, "The Future of Sustainability: Re-Thinking Environment and Development in the 21st Century" (2006), this diagram demonstrates an evolution of GSR. First, GSR in theory on the left, then presently beginning to bring together social and economic factors to a greater degree, and finally, where the environmental industry has room to grow in terms of integrating economic and social aspects to a greater degree.

At no point of integrating the GSR framework into your cleanup process, will the overarching onus of environmental cleanup be surpassed by the economic and social aspects.

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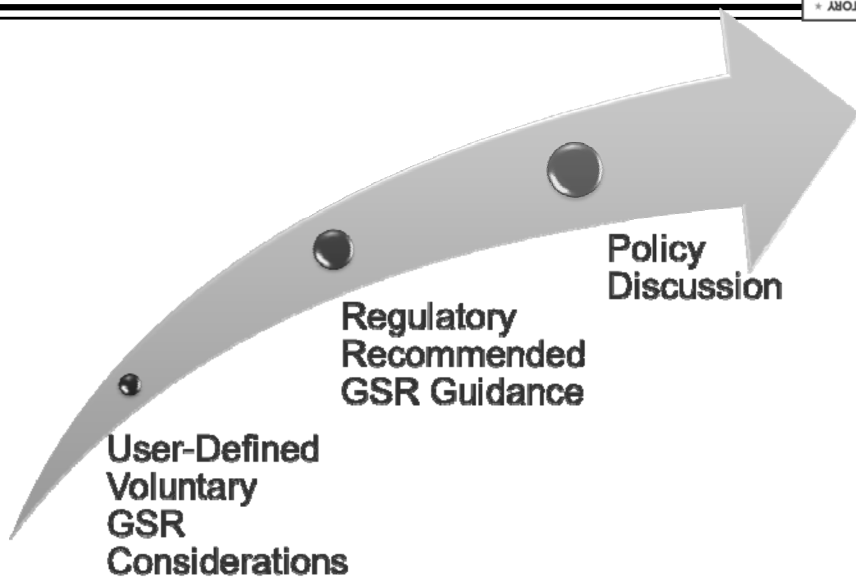
# Remedial Industry GSR Growth




Remedial decision making evolution is a step-by-step progression toward ever-more holistic, thoughtful consideration of concepts only now identified as 'externalities'.

Federal government = top down
Industry = immense resources

GSR has brought forth the next generation of remedial decision making.

# Relationship to Other GSR Efforts

Information clearinghouse, Core Elements, fact sheets, best management practices, standard guide

Detailed information specific to metrics, framework, and life-cycle assessment

White papers, BMPs, and incentives

Sustainable Remediation Tool™, SiteWise™ Tool, Fact Sheets, Case Studies

Practical guidance with a framework, metrics and tools for remedial practitioners

We have been following these entities from the beginning of ITRC GSR team and closely working with them to compliment our efforts to theirs, avoiding duplication as much as possible.

Our mandate and what we are charged with is different from these other entities.

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# Concluding Statements

- Make the ITRC GSR Framework your own
- GSR potential is limitless
- Top-down or bottom-up, integration is possible
- Share your successes!

No associated notes.

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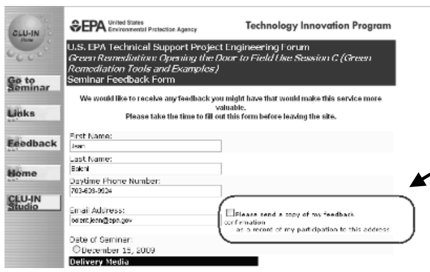
## Thank You for Participating

- 2nd question and answer break
- Links to additional resources
  - http://www.clu-in.org/conf/itrc/gsr/resource.cfm
- Feedback form – *please* complete
  - http://www.clu-in.org/conf/itrc/gsr/feedback.cfm




Need confirmation of your participation today?

Fill out the feedback form and check box for confirmation email.

Links to additional resources:
http://www.clu-in.org/conf/itrc/gsr/resource.cfm

Your feedback is important – please fill out the form at:
http://www.clu-in.org/conf/itrc/gsr/feedback.cfm

**The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:**

✓Helping regulators build their knowledge base and raise their confidence about new environmental technologies

✓Helping regulators save time and money when evaluating environmental technologies

✓Guiding technology developers in the collection of performance data to satisfy the requirements of multiple states

✓Helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations

✓Providing a reliable network among members of the environmental community to focus on innovative environmental technologies

**How you can get involved with ITRC:**

✓Join an ITRC Team – with just 10% of your time you can have a positive impact on the regulatory process and acceptance of innovative technologies and approaches

✓Sponsor ITRC's technical team and other activities

✓Use ITRC products and attend training courses

✓Submit proposals for new technical teams and projects