FINAL STUDY REPORT

EVALUATION OF CONSIDERATION AND INCORPORATION OF GREEN AND SUSTAINABLE REMEDIATION (GSR) PRACTICES IN ARMY ENVIRONMENTAL REMEDIATION

Prepared for:

Office of the Assistant Chief of Staff for Installation Management (OACSIM)
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VOLUME 1 of 2

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PREFACE

The US Army Engineering and Support Center, Huntsville (USAESCH), Environmental and Munitions Center of Expertise (EM CX) contracted Tetra Tech EC, Inc. (Tetra Tech) under Contract W912DQ-08-D-0019, Delivery Order No. ZW02, to help conduct and document a Study that follows the process of considering, incorporating, documenting, and evaluating the benefits of green and sustainable remediation (GSR) practices. The information obtained from this Study is being used to provide recommendations to the Office of the Assistant Chief of Staff for Installation Management (OACSIM) for development of Army-wide GSR guidance and policy.

This document describes the Study implementation and results, and includes a detailed approach for performing GSR evaluations on Army environmental projects (referred to herein as the "GSR Approach"). A preliminary GSR Approach was developed for this Study, and was then applied to 12 Pilot Projects. The GSR Approach was then revised to incorporate lessons learned during the Pilot Projects, and the revised GSR Approach is included in Appendix A of this report. Any questions on the Study or the GSR Approach should be addressed to Carol Dona, Study Project Manager, at DLL-CENWO-PAGEMASTER-HX-E@USACE.ARMY.MIL.

ACRONYMS AND ABBREVIATIONS

AAP	Army Ammunition Plant
ABP	Agent Breakdown Products
AOC	Area of Concern
BIP	Blow in Place
BMP	Best Management Practice
BMPs	Best Management Practices
BMTA	Blue Mountain Training Area
BRAC	Base Realignment and Closure
CA	Chemical Agent
CACM	Chemical Agent Contaminated Medium
CB	Cement Bentonite
ccf	100 cubic feet
CDC	Controlled Detonation Chamber
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFL	Compact Fluorescent Lighting
CO_2	Carbon dioxide
CO2e	Equivalent Global Warming Potential of Carbon Dioxide
CSM	Conceptual Site Model
CTA	Central Test Area
DAR	Detector Aided Reconnaissance
DD	Decision Document
DERP	Defense Environmental Restoration Program
DGM	Digital Geophysical Mapping
DMM	Discarded Military Munitions
DoD	Department of Defense
EAB	Enhanced Anaerobic Bioremediation
EM	Engineer Manual
EM CX	Environmental and Munitions Center of Expertise
EP	Engineer Pamphlet
EPAct 2005	Energy Policy Act of 2005
ER	Engineer Regulation
FFS	Focused Feasibility Study
FSA	Federal Scout Armory
FS	Feasibility Study
FUDS	Formerly Used Defense Site
GAC	Granular Activated Carbon
Gal	Gallon
GHG	Greenhouse Gas
GPS	Global Positioning System
GSR	Green and Sustainable Remediation
HP	Horsepower
HTRW	Hazardous, Toxic, and Radiological Waste
HWMU	Hazardous Waste Management Unit
IAAAP	Iowa Army Ammunition Plant
IDW	Investigation Derived Waste
IGD	Interim Guidance Document
INDA	Incendiary Disposal Area
IRP	Installation Restoration Program
ISCO	In-Situ Chemical Oxidation

ACRONYMS AND ABBREVIATIONS
(continued)

ISM	Incremental Sampling Methodology
ISTT	In-Situ Thermal Treatment
IT	Innovative Technologies
kWh	Kilowatt-hours
lbs	Pounds
LED	Light-Emitting Diode
LL6	Line 6 Ammo Production (Inside Blast Radii)
LTM	Long-Term Monitoring
M	Million
MC	Munitions Constituents
Mcf	1000 cubic feet
MDAS	Material Documented as Safe
MEC	Munitions and Explosives of Concern
MIP	Membrane Interface Probe
MMBtu	Million Metric British Thermal Units
MMRP	Military Munitions Response Program
MNA	Monitored Natural Attenuation
MRA	Munitions Response Area
MRS	Munitions Response Site
N/A	Not Applicable
NAD	Naval Ammunition Depot
NGB	National Guard Bureau
NOx	Nitrogen Oxides
O&M	Operations and Maintenance
OACSIM	Office of the Assistant Chief of Staff for Installation Management
OB/OD	Open Burn/Open Detonation
P&T	Pump and Treat
PDB	Passive Diffusion Bag
PDS	Possible Demolition Site
PDT	Project Delivery Team
POL	Petroleum, Oil, or Lubricants
POTW	Publicly Owned Treatment Works
PM	Particulate Matter
PP	Proposed Plan
PPE	Personal Protective Equipment
PRB	Permeable Reactive Barrier
RA	Remedial Action
RA-C	Remedial Action – Construction
RA-O	Remedial Action – Operation
RAWP	Remedial Action Work Plan
RCWM	Recovered Chemical Warfare Material
RD	Remedial Design
RI	Remedial Investigation
SB	Soil Bentonite
SI	Site Inspection or Site Investigation
SiteWise™	Battelle SiteWise™ Green and Sustainable Remediation Tool
SOx	Sulfur Oxides

ACRONYMS AND ABBREVIATIONS
(continued)

SRT™	Sustainable Remediation Tool developed for the Air Force
SVE	Soil Vapor Extraction
SWMU	Solid Waste Management Unit
UFP	Uniform Federal Policy
US	United States
US EPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers
USAESCH	US Army Engineering and Support Center, Huntsville
UST	Underground Storage Tank
UXO	Unexploded Ordnance
VFD	Variable Frequency Drive
VTA	Vehicle Towed Array
yr	Year

1.0 INTRODUCTION

1.1 PURPOSE OF THIS STUDY

The US Army Corps of Engineers (USACE) Environmental and Munitions Center of Expertise (EM CX) and their contractor (Tetra Tech) have conducted a Study that follows the process of considering, incorporating, documenting, and evaluating the benefits of green and sustainable remediation (GSR) practices (hereafter referred to as "the Study"). The objectives of the Study were to:

(1) Follow the consideration and incorporation of GSR practices on Army environmental remediation projects;

(2) Ascertain the effectiveness of the GSR practices considered and incorporated; and

(3) Provide procedures by which GSR practices shown to be effective can be identified, considered, implemented and documented by Project Teams working on Army sites.

The Interim Guidance Document (IGD) 10-01: *Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects* (USACE, 5 March 2010) was used as a starting document for the Study. Components and ideas from that document, referred to herein as the "*USACE Interim Guidance*", were included in a preliminary "GSR Approach" that was developed in the initial phase of the Study and was then applied by Tetra Tech at 10 Army Pilot Projects in various phases of the remedial process. Two additional Pilot Projects were performed by USACE EM CX as part of the Study. The GSR Approach was then finalized for more general application to Army projects in the future (see Appendix A of this report). The finalized GSR Approach from the Study was formatted in a manner that would allow for use as a stand-alone guidance document with minimal modification.

This report includes a summary of the Study execution and Pilot Projects, including findings and lessons learned. Recommendations for consideration by the Office of the Assistant Chief of Staff for Installation Management (OACSIM) regarding development of Army-wide GSR guidance and policy, and recommendations for USACE regarding USACE GSR guidance, have been provided separately to the Army and are currently under internal review.

1.2 DEFINITION OF GSR

In August 2009, the Department of Defense (DoD) issued "*Memorandum: Consideration of Green and Sustainable Remediation Practices in the Defense Environmental Restoration Program*"(August 2009 DoD Memorandum) (DoD, 2009). In March 2012, the DoD Defense Environmental Restoration Program Manual 4715.20 (DERP Manual) incorporated the August 2009 GSR Memorandum (and at the same time officially cancelled the August 2009 DoD Memorandum). Pursuant to the DERP Manual (March 9, 2012), GSR expands on DoD's current environmental practices and employs strategies for environmental restoration that:

- Use natural resources and energy efficiently;
- Reduce negative impacts on the environment;
- Minimize or eliminate pollution at its source; and
- Reduce waste to the greatest extent possible.

The DERP Manual also explains that GSR uses strategies that consider all environmental effects of remedy implementation and operation and incorporates options to maximize the overall environmental benefit of environmental response actions. The DERP Manual further states that "the DoD component should consider and implement green and sustainable remediation opportunities in current and future remedial activities when feasible" and "…the DoD Component shall, where practicable based on economic and social benefits and costs, ensure green and sustainable remediation practices…".

GSR typically considers environmental factors (e.g., greenhouse gas emissions caused by the remedy), economic factors (e.g., capital and annual costs/savings for implementing GSR recommendations), and societal/community factors (e.g., risks to workers or aesthetic impacts to neighborhoods). GSR is commonly framed as the balancing of the environmental, economic, and societal/community factors associated with implementation of the remedial process. This can be generally translated into the Army concept of "Triple Bottom Line Plus" identified in the *Army Posture Statement* (Feb 2007) illustrated in Figure 1-1. The GSR Approach developed in this Study accounts for mission-related factors by acknowledging that mission-related priorities may place constraints on site-specific remediation decisions that otherwise attempt to balance environmental, economic, and societal/community factors.

Figure 1-1. Pillars of Army Sustainability (Triple Bottom Line Plus), Army Posture Statement, Feb 2007

The USEPA document *Methodology for Understanding and Reducing a Project's Environmental Footprint* (USEPA, February 2012, EPA 542-R-12-002) defines "Green Remediation" as follows: "the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprint of cleanup actions." The term "Green Remediation" used by USEPA focuses on environmental factors associated with the remedy, whereas the term "GSR" used by the Army balances more factors (environmental, economic, community, and mission) as illustrated on Figure 1-1.

A GSR evaluation generally includes site-specific application of GSR Best Management Practice (BMPs) expected to provide beneficial results with respect to one or more GSR considerations, although those considerations are not always quantified. GSR considerations may involve different levels of quantification:

- Some GSR considerations can be quantified in terms of "GSR metrics" (i.e., quantities that are measured, calculated, or estimated), such as energy use or emissions of greenhouse gases

- Some GSR considerations may not be easily quantified, such as unwanted disturbance to cultural resources or negative visual impacts associated with remedy implementation

The GSR BMPs developed for use in this Study are presented in Section 2.1, and specific GSR metrics and other GSR considerations included in this Study are presented in Section 2.2 (with additional details provided in Appendix A). For this Study the calculation of specific metrics only pertains to project-specific decision making, but in the future it is expected that some GSR metrics will be tracked in Army program management databases.

1.3 DOD POLICY REGARDING GSR

DoD policy regarding GSR was updated near the end of this Study, as follows:

- While the Study was being performed (including all of the Pilot Projects) DoD GSR policy was described by the August 2009 DoD Memorandum.

- In March 2012, after the Study activities were largely completed and while the Study report was being prepared, the August 2009 DoD Memorandum was superseded by the March 2012 revision of the DERP Manual.

Both are described below, since they are both relevant to the Study.

August 2009 DoD Memorandum – In Place for Most of the Study

The August 2009 DoD Memorandum referenced *Executive Order 13423: Strengthening Federal Environmental, Energy, and Transportation Management*, and stated that "as part of the Department's ongoing efforts to implement Executive Order 13423 and reduce its energy demand, the Department is considering additional options for minimizing the environmental impact of existing and future remedial systems." The August 2009 DoD Memorandum included the following pursuant to GSR:

- "Opportunities to increase sustainability considerations throughout all phases of remediation (i.e., site investigation, remedy evaluation, design, and construction, operation, monitoring, and site closeout) may exist, regardless of the selected cleanup remedy."

- "I [Dorothy Robyn, Deputy Under Secretary of Defense (Installations and Environment)] request that each DoD Component take action to evaluate these [GSR] opportunities and consider implementing them in current and future remedial activities."

- "The DoD Components shall consider and implement green and sustainable remediation opportunities when and where they make sense."

According to the August 2009 DoD Memorandum, GSR opportunities were to be evaluated for all DoD projects, in all phases of remediation, with implementation of GSR opportunities "when and where they make sense."

DERP Manual (March 2012) – Current DoD GSR Policy

As discussed above, the August 2009 DoD Memorandum was superseded by the March 2012 revision of the DERP Manual after the Study activities were largely completed and while the Study report was being prepared. Pertinent GSR-related excerpts from the DERP Manual are cited below.

- DERP Manual Section 6.d *(Other Environmental Restoration Management Considerations, Green And Sustainable Remediation, pp. 48-49)* states the following:

  "(1) Green and sustainable remediation expands on DoD's current environmental practices and employs strategies for environmental restoration that use natural resources and energy efficiently, reduce negative impacts on the environment, minimize or eliminate pollution at its source, and reduce waste to the greatest extent possible. Green and sustainable remediation uses strategies that consider all environmental effects of remedy implementation and operation and incorporates options to maximize the overall environmental benefit of environmental response actions.

  (2) Opportunities to increase sustainability considerations throughout all phases of remediation (i.e., site investigation, remedy evaluation, design, construction, operation, monitoring, and site closeout) may exist, regardless of the selected remedy.

  (3) The DoD Component should consider and implement green and sustainable remediation opportunities in current and future remedial activities when feasible. The DoD Component should not under most circumstances re-open DDs and agreements that may be in place or under negotiation with environmental regulators.

  (4) Pursuant to [Executive Order 13514], the DoD Component shall, where practicable based on economic and social benefits and costs, ensure green and sustainable remediation practices by increasing energy efficiency; conserving and protecting water resources through efficiency, reuse, and storm water management; eliminating waste, encouraging recycling, and preventing pollution; leveraging agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services; and strengthening the vitality and livability of the communities in which Federal facilities are located."

- DERP Manual Section 4.b.(5).(b), p. 33, states the following for the Feasibility Study phase:

  "3. In accordance with [Executive Order 13423], the DoD Component shall evaluate remedial alternatives to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems on the environment. During remedy evaluation and selection, consideration of optimization and sustainability concepts will improve performance of the remedial action and reduce the remedy footprint. Optimization concepts include development of a conceptual site model, realistic remedial action objectives, performance objectives, and identifying treatment zones and exit strategies."

- DERP Manual Section 4.b.(10), p.39, states the following for the Remedial Action Work Plan (RAWP):

  "The DoD Component shall document in the RAWP how the remedial action will be staged and implemented during remedial action-construction (RA-C). The DoD Component should consider remediation technologies that are conducted in a sustainable manner; are efficient; and are environmentally, economically, and fiscally sound, in order to reduce the footprint of remediation strategies on the environment."

- DERP Manual, Section 6.d (*Other Environmental Restoration Management Considerations, E. Remedy Optimization, p.49*) states the following for Remedy Optimization:

  "(1) The DoD Component shall maximize DERP effectiveness and minimize the DERP financial liabilities and environmental footprint."

Accordingly, in all phases of remediation and for all DoD projects, the March 2012 DERP Manual instructs DoD Components to consider and implement GSR opportunities when feasible and ensure the use of GSR remediation practices where practicable based on economic and social benefits as well as costs. In addition, the March 2012 DERP Manual also includes direction regarding GSR in specific remedy phases, as follows:

- In the FS phase, evaluate remedial alternatives to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems on the environment.

- In the RAWP in the Remedial Action phase, consider remediation technologies that are conducted in a sustainable manner; are efficient; and are environmentally, economically, and fiscally sound, in order to reduce the footprint of remediation strategies on the environment.

- In the Remedial Operation phase, minimize the environmental footprint as part of optimization performed.

Also, the DERP Manual indicates that, generally, most documents already in place or in negotiation with the regulators should not be re-opened solely for the purpose of considering and/or implementing GSR opportunities.

1.4 STUDY SCOPE AND EXECUTION

The Study began in September 2010 and included the following elements:

- Developing a preliminary GSR Approach for Army projects applicable to sites in the Installation Restoration Program (IRP) and the Military Munitions Response Program (MMRP)

- Performing GSR evaluations for 12 Pilot Projects (10 were performed by Tetra Tech and 2 were performed by USACE EM CX)

- Documenting several GSR case studies that highlight GSR practices for projects that were not included in the Pilot Projects

- Finalizing the GSR Approach for future use on Army projects, based on lessons learned from the Pilot Projects and modified for more general application (see Appendix A)

- Providing recommendations for development of Army-wide policy and guidance on GSR, as well as recommendations for further development of Battelle SiteWise™ Green and Sustainable Remediation Tool (referred to hereafter as SiteWise™) and other footprinting tools, and revisions to the *USACE Interim Guidance*. Note, Army-wide policy and guidance recommendations as developed from the Study results are under internal review by the Army and are not included in this report.

For each Pilot Project, the USACE EM CX concurrently followed and documented the process that the Project Team used in consideration and implementation of the GSR recommendations (summarized in a Memorandum for each Pilot Project, which are included in Appendix C).

1.4.1 Unified GSR Approach for IRP and MMRP Projects

The *USACE Interim Guidance* was used as the starting document for the development of the GSR Approach. Initially there were plans for the Study to include two separate approaches for conducting GSR evaluations, one for Army IRP projects and one for Army MMRP projects. A brief description of IRP and MMRP projects is provided below:

- The DERP Manual (March 2012) indicates that sites in the IRP category require response actions to address releases of: (a) hazardous substances and pollutants or contaminants; (b) Petroleum, Oil, or Lubricants (POLs) with some exclusions; (c) hazardous wastes or hazardous waste constituents; and (d) explosive compounds released to soil, surface water, sediment, or groundwater as a result of ammunition or explosives production or manufacturing at ammunition plants. The IRP category also includes response activities to address unexploded ordnance (UXO), discarded military munitions (DMM), or munitions constituents (MC) posing an explosive, human health, or environmental hazard that are incidental to an existing IRP site. IRP projects are commonly known as hazardous, toxic, and radiological waste (HTRW) projects and response actions may be conducted on a portion of a site identified as an Area of Concern (AOC), Solid Waste Management Unit (SWMU), or Hazardous Waste Management Unit (HWMU).

- The DERP Manual (March 2012) indicates that sites in the MMRP category include Munitions Response Areas (MRAs) and Munitions Response Sites (MRSs) that require a munitions response. Instead of traditional HTRW contaminants, the response action for MMRP projects is to munitions and explosives of concern (MEC) or munitions constituents (MC). MMRP projects address the explosives safety, human health, and environmental risks posed by these contaminants. An area known or suspected to contain MEC or MC (e.g., firing ranges, munitions burial areas) is identified as a MRA, which is composed of one or more discrete MRSs.

Early in the Study, Tetra Tech reviewed 23 Site Investigation (SI) reports for MMRP projects with a diverse range locations, contractors, and site types to draw conclusions on MMRP SI GSR practices. A meeting was held in Huntsville, Alabama on 16 November 2010 and the merits of a unified GSR Approach for IRP and MMRP projects were discussed. There was consensus that there was substantial overlap in the GSR evaluation process for IRP and MMRP projects, and it was decided that that one GSR Approach applicable to both IRP and MMRP projects would be developed during the Study.

1.4.2 Definitions of Teams for Pilot Projects within the Study

The following terminology was used to refer to participants in the Pilot Projects for this Study:

- *Study Team*: The overall team conducting the Study, led by USACE EM CX and their contractor Tetra Tech. Carol Dona (USACE EM CX) was the Project Manager for the Study, and Nick Stolte (USACE EM CX) was MMRP Coordinator for the Study.

- *Project Team*: The site-specific team associated with implementation of the remedial process for each Pilot Project, typically consisting of personnel from the Installation and/or USACE as well as one or more site contractors.

- *GSR Evaluation Team*: The team performing a site-specific GSR evaluation (in this Study the GSR Evaluation Team consisted of members of the Study Team that were independent of the Project Team).

- *Liaison*: A representative of USACE EM CX (for each Pilot Project) who helped coordinate exchange of information between the various teams listed above while the Pilot Projects were being performed.

Note that for the Pilot Projects in this Study, the GSR Evaluation Team consisted of Tetra Tech and/or USACE EM CX personnel who were not part of the Project Team. For future application of the GSR Approach developed in this Study (see Section 1.5 and Appendix A), it is envisioned that most GSR evaluations for Army projects will be performed by a subset of the Project Team (including their contractors).

1.4.3 Use of SiteWise™ Tool for Quantitative Footprinting of GSR Metrics

The term "footprint" is defined in USEPA's *Methodology for Understanding and Reducing a Project's Environmental Footprint (*February 2012) as follows:

> "The term 'footprint' refers to the quantification of a specific metric that has been assigned a particular meaning. For example, the "carbon footprint" is the quantification of carbon dioxide (and other greenhouse gases [GHGs]) emitted into the air by a particular activity, facility, or individual. This common footprint measure has been established in the past because emissions of carbon dioxide and other GHGs have been linked to climate change."

USEPA's *Methodology for Understanding and Reducing a Project's Environmental Footprint (*February 2012) indicates that a "metric" refers to a project parameter for which a quantitative value may be derived mathematically, estimated through engineering details, or extracted from past project records with actual data. The term "environmental footprint" in the above-referenced EPA Methodology includes metrics such as energy use and water use as well as air emissions to represent the effects a cleanup project may have on the environment. The term "environmental footprint" can be more broadly defined as "the direct or indirect impact on environmental media and society from remedial activities" (Navy GSR Fact Sheet 2010). This includes quantification of one or more GSR metrics, plus qualitative considerations, typically assessed for a "baseline case" and one or more alternatives to the baseline. This broad definition of "environmental footprint" (i.e., both quantitative and qualitative considerations) was utilized in this Study.

For some GSR metrics considered in this Study (discussed in detail in Appendix A) quantification is a straightforward accounting of information available from remedial activities (e.g., the amount of refined materials used as part of an in-situ chemical oxidation remedy). For other GSR metrics, intermediate steps are required, such as quantifying the fuel used for a drill rig and the air emissions associated with that fuel use. SiteWise™ is a spreadsheet tool co-developed by Battelle, the Army, the USACE, and the Navy to facilitate many such calculations. Appendix A includes a detailed description of the specific metrics calculated by SiteWise™ and also includes examples for calculating specific GSR metrics included in the Study not directly calculated by SiteWise™.

1.4.4 Listing of Pilot Projects for this Study

The Pilot Projects for which GSR evaluations were performed in this Study are presented in Table 1-1. Additional detail for each Pilot Project is provided in Table 1-2 regarding the timing within the remedial phase when the GSR evaluation was performed, as well as a summary of the alternatives for which GSR metrics were quantitatively evaluated as part of the GSR evaluation.

Table 1-1. Listing of Pilot Projects for the Study

Pilot Project Site Name	State	Program	Phase	Project Description
GSR Evaluation Performed by Tetra Tech:				
Akiachak Federal Scout Armory	AK	IRP – NGB	RA	Soil Remediation (Petroleum)
Former Black Hills Army Depot	SD	MMRP – FUDS	RI	Chemical Warfare Material Remediation
Former NAD – Hastings	NE	IRP – FUDS	RD	Pump and Treat (P&T) with MNA
Iowa Army Ammunition Plant	IA	MMRP – Active Army	FS	Munitions Remediation
Lake City Army Ammunition Plant	MO	IRP – Active Army	RA-O	Optimization of P&T's and Evaluation of In-situ Bio Substrate
Lockbourne Landfill	OH	IRP – FUDS	RD	Consolidation/Capping of Landfill
Fort Missoula Blue Mountain Training Area	MT	MMRP – NGB	RI	Munitions Remediation
Shepley's Hill Landfill (Draft FFS Phase)	MA	IRP – BRAC	Draft FFS	Alternatives to Current P&T and Alternatives for Plow Shop Pond Barrier Wall
Shepley's Hill Landfill (Constructability Phase)	MA	IRP – BRAC	RD	Hydraulic Barrier Wall (Plow Shop Pond) Constructability Evaluation
Umatilla Chemical Depot	OR	IRP – BRAC	FFS	P&T and Bioremediation
GSR Evaluation Performed by USACE EM CX:				
Schilling Air Force Base Atlas Missile Facility S-1	KS	IRP – FUDS	SI	SI Activities
Former Schilling Atlas Missile Site S-5	KS	IRP – FUDS	Post FS (PP)	MNA w, w/o Source Removal

Table 1-2. Remedial Phase Timing and Summary of Alternatives Evaluated Quantitatively for the Pilot Projects		
Pilot Project	**Remedial Phase (Includes Timing)**	**Summary of Alternatives for which GSR Metrics were Evaluated Quantitatively**
Akiachak FSA	RA (prior to excavation)	• Excavation and off-site disposal (baseline) • On-site biological treatment • Excavation and off-site thermal treatment
Former Black Hills Army Depot (MMRP)	RI (after geophysics but before intrusive investigation)	• Planned RI activities (baseline)
Former NAD - Hastings	RD (after 30% design)	• Planned P&T system (baseline) • Power with wind energy • Use of VFD on air stripper blower motors • Use of VFDs on extraction pumps • Change from air stripping to liquid phase GAC • Build two treatment plants

Iowa AAP (MMRP)	FS (draft FS completed)	• Munitions of Explosive Concern (MEC) alternatives
		  o Land use controls -fencing and signs (4 areas)
		  o Removal from subsurface (4 areas)
		• Munitions Constituents (MC) alternatives
		  o Land use controls – groundwater monitoring (1 area)
		  o Removal with off-site disposal (1 area)

Lake City AAP	RA-O (operating remedy)	• Current P&T remedies (baseline) • Eliminate catalytic oxidizer at Building 163 • Eliminate individual water supply well air strippers • Direct discharge to POTW rather than treatment at Building 163 • Alternate on-site treatment for water treated at Building 163
Lockbourne Landfill	RD (after 30% design)	• Planned remediation activities – consolidation and capping
Fort Missoula BMTA (MMRP)	RI (prior to planned activities)	• Planned RI Activities

Shepley's Hill Landfill (Draft FFS Phase)	FFS (after Draft FFS)	• Alternatives to Current P&T remedy
		  o Current P&T system (baseline)
		  o MNA instead of P&T
		  o P&T with reinjection of treated water
		  o Permeable reactive barrier instead of P&T
		• Plow Shop Pond barrier wall
		  o Permeable reactive barrier
		  o Hydraulic barrier

Shepley's Hill Landfill (Constructability Phase)	RD (Constructability)	• Plow Shop Pond barrier wall (hydraulic barrier)
Umatilla Chemical Depot	FFS (after Draft FFS)	• P&T expansion plus bioremediation (baseline) • Shorter duration for initial remedy phase • Ship samples to closer laboratory

Table 1-2. Remedial Phase Timing and Summary of Alternatives Evaluated Quantitatively for the Pilot Projects		
Pilot Project	**Remedial Phase (Includes Timing)**	**Summary of Alternatives for which GSR Metrics were Evaluated Quantitatively**
Schilling Air Force Base Atlas Missile Facility S-1	SI (based on SI work plan, which was being performed during the GSR evaluation)	• Planned SI field activities (baseline) • Off-site disposal of IDW rather than on-site disposal • Rotosonic drilling rather than mud rotary
Former Schilling Atlas Missile Site S-5	Post-FS (before proposed plan)	• Long-term monitoring/MNA • Enhanced anaerobic bioremediation/MNA • In situ chemical oxidation/MNA

1.4.5 General Approach for Conducting Pilot Project GSR Evaluations in this Study

The general process that was used for the Pilot Project GSR evaluations during the Study is summarized below:

1. **Establish intent to incorporate GSR in project planning** – The EM CX Project Manager and MMRP Coordinator identified Project Teams with projects spanning the remedial phases, Army components, and MMRP and IRP programs that were willing to participate in the Study and consider implementation of GSR recommendations. The EM CX Project Manager established an EM CX liaison for each Pilot Project to serve as an interface between the Project Team and the GSR Evaluation Team, and to assist with GSR identification, consideration, incorporation, and implementation.

2. **Notice to Proceed to Contractor** – This was an informal notice to the GSR Evaluation Team to proceed with the GSR evaluation as part of the Study.

3. **"Step 3 Call"** – This was a short conference call (on the order of 1 hour) with the GSR Evaluation Team, the Project Team manager, and usually one or more Project Team contractors. The call provided the Project Team with an introduction to the GSR evaluation process and the scope of the GSR evaluation, and included a discussion of logistics for the GSR evaluation. A key component of this call was to arrange the transfer of project documents to the GSR Evaluation Team for review. Also, the overall timing of the GSR evaluation within the schedule of the Project Team activities was discussed. In addition, the Project Team and the EM CX liaison were provided with a generic list of GSR BMPs.

4. **Evaluation preparation** – The GSR Evaluation Team reviewed project documents that were provided and evaluated how GSR applied to the project. The GSR Evaluation Team reviewed the BMP checklist based on project-specific information pertinent for footprint quantification. The Project Team and the EM CX liaison reviewed the BMP checklist in preparation for a subsequent GSR conference call or meeting, and in some cases sent a partially completed checklist to the GSR Evaluation Team prior to the GSR conference call.

5. "**Step 5 Call" (or meeting)** – The GSR Evaluation Team and Project Team reconvened for a more substantial GSR conference call (generally required approximately 2 hours). In two cases, a meeting with a site visit occurred in place of a GSR conference call. The BMP

checklist was used as an outline to discuss how GSR applied to the project and the extent to which the GSR BMPs had already been considered or applied. The teams also discussed the merits of including footprint quantification as part of the GSR evaluation. If footprint quantification was appropriate, the GSR Evaluation Team and Project Team discussed the site information and how to address data gaps that remained after the GSR Evaluation Team review of the project documents.

6. **GSR Analysis** – The GSR Evaluation Team analyzed the information obtained from the project documents and the Step 5 Call (or meeting), including further analysis of the BMP checklist. In addition, , the GSR Evaluation Team quantified footprints as selected by the evaluation process using SiteWise^{TM} and other tables/calculations for addressing GSR parameters not directly considered by SiteWise^{TM} (e.g., percent of materials from recycled resources).

7. **GSR Evaluation Report** – Specific GSR findings and recommendations were documented in a GSR Evaluation report, along with the updated BMP checklist forms. The Project Team was provided with a Draft Final GSR Evaluation Report, and their comments (plus any comments from USACE EM CX) were addressed in a Final GSR Evaluation Report.

8. **Consideration and Implementation** – USACE EM CX followed the process of GSR consideration, incorporation, implementation and documentation by each Project Team and documented this process in a memorandum for each Pilot Project (see Appendix C).

1.5 FINALIZED GSR APPROACH FOR ARMY PROJECTS

A finalized GSR Approach for Army Projects is included as Appendix A. This finalized GSR Approach is simpler and more general than the preliminary GSR Approach used for the Pilot Projects during the Study. The finalized GSR Approach assumes a subset of the Project Team (including their contractors) will typically perform GSR evaluations as part of routine project work (whereas the Study used a third-party to perform the GSR evaluations). In addition, the finalized GSR approach incorporates lessons learned from the Pilot Projects conducted during the Study (e.g., the BMP checklist forms were simplified in the finalized GSR Approach). The finalized GSR Approach was formatted in a manner that would allow for use as a stand-alone guidance document with minimal modification.

The finalized GSR Approach (see Appendix A) refers to "teams" that are defined as follows:

- Project Team: Refers to those associated with implementation of the remedial process for the project being evaluated. This may include USACE, Base Realignment and Closure (BRAC), Army Environmental Command (AEC), Army National Guard, and/or contractor Project Delivery Team (PDT) members.

- GSR Evaluation Team: Refers to the personnel that would perform the GSR evaluation. For the purposes of this Approach, this person or persons are hereafter referred to as the GSR Evaluation Team. A subset of the Project Team typically will perform the GSR Evaluation, in some cases augmented by individuals who are otherwise not directly involved in the day-to-day aspects of the remediation. For example, a GSR evaluation at an Active Army Installation project could be performed by a team comprised of the environmental remediation manager (ERM), the project contractor, and the installation environmental manager (EM). In the case of a Remedial System Evaluation (RSE) optimization for an Active Army installation, the GSR evaluation could be performed by a team comprised of the ERM, the installation EM, the installation contractor(s), and the manager for the RSE (e.g., a member of the USACE). It is noted that in some situations where the project contractor is tasked contractually with performance of the GSR evaluation, the "GSR Evaluation Team" could be the contractor. The GSR Evaluation Team is differentiated from the Project Team in this Approach because it is important that the subset of personnel performing the GSR Evaluation, that is, the GSR Evaluation Team, communicate effectively with the overall Project Team in the decision-making process to determine the feasibility and practicality of implementing GSR opportunities identified by the GSR Evaluation Team.

A general process for a GSR evaluation that incorporates consideration of BMPs, and includes footprint quantification where appropriate, is outlined below (more details are provided in Section 2.0 of Appendix A):

1. **Planning** – This step has two main sub-items:

   - *Integrate GSR within Overall Project Planning*. The Project Team should consider the potential incorporation of overall project planning, practices, and methodologies that encourage resource conservation and efficiency (i.e., inherently consistent with GSR). Examples include the following:

     - Optimization - provides the potential for resource conservation through optimization of remedial systems or processes.

     - Third party review - provides the opportunity for experts in remediation to give a fresh look and to draw on their expertise (e.g., suggest alternate technologies or approaches not currently being considered).

     - Systematic planning - allows the project to look forward and coordinate future activities with current activities (e.g., a decision document that allows transition from a resource intensive approach such as P&T to a less intensive approach such as MNA).

     - Stakeholder involvement – allows concerns of stakeholders to be considered during the development and evaluation of GSR opportunities (e.g., preference regarding removal versus re-use of existing site infrastructure).

     If the project phase includes preparation of a decision document or the document for public review preceding the decision document (i.e., a proposed plan), the language in those documents should be flexible enough to allow for consideration of GSR practices during remedy design, construction, and operation.

   - *Other Planning Activities for a Site-Specific GSR Evaluation*. These planning activities include the following:

     - Establish intent to implement GSR when feasible

     - Determine who will perform the GSR evaluation (i.e., the members of the Project Team who will be on the GSR Evaluation Team and any members outside the Project Team if applicable)

     - Perform screening to evaluate applicability of quantitative footprinting

- Establish GSR evaluation objectives and scope
- Determine how GSR will be included and documented in the overall project remedial process
- Evaluate contract strategy for project regarding GSR (consider which phases will be combined into separate contracts, what types of contracts will be used, and what level of GSR consideration will be needed for each contract)
- Establish timing of the GSR evaluation(s) within the current project phase
- Develop and include contract language for GSR inclusion in the project

2. **Identification and Analysis of GSR Opportunities** – This step has several sub-items:

- *Review Information and Fill Data Gaps*. The GSR Evaluation Team reviews project documents and evaluates how GSR applies to the project. The BMP checklist (see Attachment A-1 of Appendix A) is reviewed to identify the extent to which the GSR BMPs have already been considered or applied and additional cases where BMPs could potentially be applied moving forward. It is assumed that the GSR Evaluation Team will typically be a subset of the Project Team, and it is important that the GSR Evaluation Team exchange information and GSR ideas with the overall Project Team. The BMP checklist in Attachment A-1 of Appendix A is recommended as an outline to guide these discussions. If the GSR evaluation will include footprint quantification, pertinent information is obtained from project documents and/or Project Team communications. Pertinent cost information is obtained to determine the cost impacts of any proposed GSR BMPs or remedial options. For MMRP projects, Section 4 of Appendix A (which discusses additional considerations for MMRP projects) should be reviewed.

- *Fill Out GSR BMP Checklist Tables*. The GSR Evaluation Team (ideally with assistance from the overall Project Team) fills out the BMP checklists based on the activities described above.

- *Perform Quantitative Footprinting (When Applicable)*. If footprint quantification has been selected as part of the evaluation process, the GSR Evaluation Team quantifies the footprint using SiteWise™ and other calculations for addressing GSR metrics not directly considered by SiteWise™. [1]

- *Document GSR Evaluation Findings and Recommendations*. Based on the results of the BMP review and footprint quantification, the GSR Evaluation Team documents the information reviewed (including the finalized BMP checklists), and also presents the quantitative footprint assumptions, input values, and results. Qualitative considerations regarding GSR are also presented. Findings and recommendations from the GSR evaluation are documented and provided to the overall Project Team for consensus on the

[1] The Army generally recommends the use of SiteWise™ for GSR quantitative footprinting because of its flexibility and breadth in evaluating remedial options over the remedial cycle. The Sustainable Remediation Tool (SRT) of the Air Force is also publicly available (http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/srt/index.asp), as well as a number of proprietary tools developed by contractors.

final recommendations from the GSR evaluation. It is expected that GSR metrics will be tracked in Army program management databases in the future, and GSR metrics and related information from the GSR recommendations as agreed on by the Project Team should be entered into Army databases as required and/or appropriate. Documentation of a GSR evaluation may be in the form of a full "GSR Evaluation Report" or a less formal document. In some cases a GSR Evaluation Report will become part of the formal record of the project, and in other cases the documentation of findings and recommendations of the GSR evaluation may be an internal report or memorandum. A template GSR Evaluation Report is included as Attachment A-3 of Appendix A, and an example GSR Evaluation Report (i.e., filled in version of the template) is included as Attachment A-4 of Appendix A.

3. **Consideration and Implementation of GSR Opportunities** – The results of the GSR evaluation are reviewed by the Project Team, and site-specific recommendations are considered. The GSR recommendations considered feasible (i.e., practical) are then implemented. In some cases, recommendations may only be partially implemented, or implemented in a modified form.

4. **Documentation of GSR Consideration and Implementation in Project Documents** – The results of the GSR evaluation may be incorporated as a section and/or appendix of a Project report (e.g., as part of a Feasibility Study, Remedial Design, or Remediation System Evaluation report). In some cases, the entire GSR Evaluation Report will be included as a stand-alone report or Appendix, and in other cases the GSR evaluation results may simply be summarized in a formal Project document or provided as a memorandum. One goal of this step is to document that GSR items were considered and GSR recommendations were implemented when feasible. Another goal is to document the assumptions used in the GSR evaluation. The use of tracking tables for each GSR recommendation (a template of which is included in Appendix A), allows the Project Team to document and explain the basis of each GSR recommendation and the implementation status. Such tracking tables for GSR recommendations can be updated throughout the project with reasons provided for implementation or rejection of each recommendation.

As part of the finalized GSR approach, the BMP checklist forms (see Attachment A-1 in Appendix A) were simplified to eliminate items that were potentially burdensome and provided little benefit.

1.6 STRUCTURE OF THIS DOCUMENT

This report is structured as follows:

- Section 1: Introduction
  - Purpose of this Study
  - Definition of GSR
  - DoD Policy Regarding GSR
  - Study Scope and Execution
    - Unified GSR Approach for IRP and MMRP Projects
    - Definitions of Teams for Pilot Projects within the Study
    - Use of SiteWise™ Tool for Quantitative Footprinting of GSR Metrics
    - Listing of Pilot Projects for this Study
    - General Approach for Conducting Pilot Project GSR Evaluations in this Study
  - Finalized GSR Approach for Army Projects

- Section 2: GSR BMPs and GSR Metrics (Footprinting) in this Study
    - GSR BMPs in this Study
    - GSR Metrics and Qualitative Considerations

- Section 3: Results from Pilot Projects and other Case Studies
    - Results from Application of BMPs
    - Results for GSR Metrics
    - Summary of Qualitative Considerations
    - Additional Case Studies

- Section 4: Findings and Lessons Learned from Pilot Project GSR Evaluations
    - Consideration and Implementation of GSR
    - Application of GSR for Different Remedial Phases
    - Application of GSR for Different Remediation Technologies
    - Most Important Drivers for Specific GSR Footprints
    - Work-Arounds for SiteWise™ and Suggestions for Further Tool Development
    - GSR Application for MMRP Projects
    - Cost of Performing a GSR Evaluation
    - Potential Cost and Resource Implications of GSR Recommendations For Pilot Projects

- Section 5: References

Additional information is provided in appendices, as follows:

- A copy of the finalized GSR Approach is included as Appendix A

- Summary sheets for case studies that present GSR information for Army projects that were not part of the 12 Pilot Projects are presented in Appendix B.

- Memorandums prepared by USACE EM CX regarding consideration and implementation of GSR recommendations for Pilot Projects are presented in Appendix C.

Each of the 12 Pilot Project GSR Evaluation reports is included in Volume 2.

2.0 GSR BMPs AND GSR METRICS (FOOTPRINTING) IN THIS STUDY

2.1 GSR BEST MANAGEMENT PRACTICES (BMPs) IN THIS STUDY

A GSR evaluation generally includes site-specific application of BMPs expected to provide beneficial results with respect to one or more GSR considerations, although those considerations are not always quantified. For this Study, a specific list of 66 GSR BMPs was developed. The list is divided into the following categories:

A. Planning
B. Characterization and/or Remedy Approach
C. Energy/Emissions - Transportation
D. Energy/Emissions - Equipment Use
E. Materials & Off-Site Services
F. Water Resource Use
G. Waste Generation, Disposal, and Recycling
H. Land Use, Ecosystems, and Cultural Resources
I. Safety and Community
J. Other Site-Specific BMPs

These were formulated as "BMP checklist forms" (see Attachment A-1 in Appendix A), to serve as an outline for collecting information and developing GSR opportunities during a site-specific GSR evaluation (i.e., by considering project-specific considerations, advantages, or limitations for implementing individual BMPs). The GSR BMPs developed for this Study are listed below (note that BMPs A-11 and I-8 were added after the Pilot Projects were completed). The GSR BMPs were designed to be general so that they are broadly applicable and do not become outdated as related Federal guidance or policy (e.g., regarding procurement of materials with recycled content, low impact design, renewable energy certificates, etc.) is modified in the future. Application of the GSR BMPs should consider specific guidance and policy in place at the time the GSR evaluation is performed.

2.1.1 <u>BMPs for Planning</u>

A-1. Develop a culture of GSR within the Project Team and encourage GSR ideas from project staff, and review similar projects from other sites for possible transfer/adoption of GSR ideas

A-2. Incorporate a section on GSR in project meetings, work plans, and reports

A-3. Identify and periodically update a list of key stakeholders and their concerns with respect to GSR considerations

A-4. Schedule activities for appropriate seasons and/or time of day to reduce delays caused by weather conditions and fuel needed for heating or cooling

Examples:
- Work at night in summer to avoid heat stress
- Perform field activities in summer to take advantage of longer daylight

A-5. Prepare, store, and distribute documents electronically

A-6. Utilize teleconferences rather than meetings when feasible

A-7. Incorporate green and sustainable remediation (GSR) specifications into solicitations and contracts

Examples:

- Follow pertinent green procurement policies
- Select hotel chains with "green" policies
- Select laboratories that utilize renewable energy
- Include GSR in the request for proposal, as well as any incentives for GSR incorporation
- Include GSR as one of the technical evaluation factors for contract award

A-8. Integrate schedules to allow for resource sharing and fewer days of field mobilization

A-9. Tailor the remedy cleanup goals such that they are appropriate for anticipated end-use of the property, rather than assuming a more conservative exposure scenario with more stringent cleanup goals

A-10. Conduct thorough review of project documents and historical records to minimize required scope of investigation

Examples:

- IRP projects: determine if there are previous aquifer tests that can be used for groundwater modeling rather than conducting new aquifer tests
- MMRP projects: perform careful review of historic documents, aerial photographs, and other existing information to reduce the footprint of land that needs to be disturbed for thorough investigation and remediation
- MMRP projects: use IRP sampling data to supplement and enhance the MMRP field program (if available)

A-11. Use language in work plans, proposed plans, and decision documents that maximizes flexibility to allow GSR recommendations to be implemented

Examples:

- designation of a "suitable growth media" for a landfill cap cover material rather than "top soil"
- allow for "treatment technologies that achieve adequate levels of treatment" rather than specifying only one treatment technology

2.1.2 BMPs for Characterization and/or Remedy Approach

B-1. Develop and routinely update a conceptual site model (CSM) to use as a basis for making remedial process decisions

B-2. Perform regular optimization evaluations to improve efficiency of current or planned actions and/or develop alternative remedial approaches that might shorten remedy duration or otherwise improve the net environmental benefit of the remedy, including use of any methodologies, such as TRIAD (www.triadcentral.org), systematic planning (technical project planning), value engineering studies, and remedial system evaluations, expected to optimize the planning and/or execution of the project

B-3. Use appropriate characterization or remedy approach based on site conditions

Examples:

- Consider in-situ and passive remedy options that offer adequate protectiveness
- Consider in-situ bioremediation if conditions are already anaerobic and constituents are conducive to reductive dechlorination
- Compare source removal versus in-situ and ex-situ remedial options
- Consider different technologies for impacted areas with higher and lower concentrations
- Use realistic times to remedy closeout (i.e., estimations through modeling) rather than assumed remedy timeframes (e.g., 30 years, which is often used for evaluation of FS alternatives)
- MMRP projects: evaluate man-portable DGM instruments versus vehicle-towed array (VTA) instruments and inclusion of detector-aided reconnaissance (DAR)
- MMRP projects: evaluate best alternative for destruction of munitions (e.g., blow in place versus consolidated shot versus controlled detonation chamber)

B-4. Establish decision points to trigger a change from one technology to another or from one remedy alternative to another

Examples:

- Change vapor treatment from thermal oxidation to granular activated carbon (GAC) media based on flow rates and concentrations
- Remove a treatment polishing step if influent to that step already meets discharge criteria
- Move to Monitored Natural Attenuation (MNA) if specific concentration thresholds in groundwater are met

B-5. Focus sampling efforts to meet objectives of the specific remedial phase (e.g., sampling during O&M should be focused on evaluating remedy performance and not on thorough plume characterization)

Examples:

- Eliminate sampling parameters as appropriate
- Reduce sampling frequency as appropriate
- Reduce sample locations as appropriate
- Enhance monitoring program as appropriate
- MMRP projects: consider Incremental Sampling Methodology (ISM) versus discrete sampling for MC characterization

B-6. Consider real-time measurements and dynamic work plans to reduce mobilizations and improve effectiveness of investigation efforts

Examples:

- Field test kits (e.g., test kits for sulfate)
- Field screening instruments (e.g., x-ray fluorescence for lead or photoionization detectors for volatile organics)
- Drive point sensor technologies (e.g., membrane interface probe or "MIP")

- Visual staining or odor
- Establish excavation extent based on real-time data collected as excavation proceeds and use GPS to accurately delineate excavation areas
- MMRP projects: use GPS and/or the same equipment that was used for detection to confirm anomaly signatures prior to excavating
- MMRP projects: consider incorporating field screening methods (e.g., X-ray fluorescence, EXPRAY and explosives test kits, as appropriate or applicable) into the field program to refine sampling locations and reduce the quantities of samples submitted for off-site laboratory analysis
- MMRP projects: consider use of advanced electromagnetic sensors (e.g., MetalMapper) for better subsurface item identification to reduce digging requirements

B-7. Consider use of existing site structures/infrastructure or mobilization of temporary structures versus new construction

Examples:

- Buildings (e.g., for treatment building or field office)
- Concrete slabs or foundations
- Wells
- Existing excavations for storm water control

B-8. Establish project-specific decision points to limit extent of remediation

Examples:

- Project-specific cleanup levels based on a site-specific risk assessment (coordinated with risk assessment experts) rather than generic cleanup levels, if it results in lower footprints for key metrics and is acceptable to all stakeholders
- MMRP projects: dig stopping rules and anomaly prioritization/detection criteria to minimize false positives

B-9. Consider leaving in place structures whose removal is not necessary (i.e., foundations, underground pillars, etc.)

2.1.3 BMPs for Energy/Emissions – Transportation

C-1. Reduce the number of trips for personnel

Examples:

- Encourage carpooling
- Use telemetry systems and webcams to remotely transmit data directly to project offices to avoid trips

C-2. Reduce the number of trips and/or volume for transported materials, equipment, or waste

Examples:

- Transfer full loads by consolidating shipments from vendors and/or shipments to disposal sites (also share shipments with neighbors if feasible)
- Purchase more concentrated chemicals to reduce transportation weight and/or volume

C-3. Reduce trip lengths

Examples:

- Dispose of waste at closest appropriate facility
- Purchase materials, equipment, and services from local vendors
- Use locally produced supplies
- Select most efficient transportation route

C-4. Use alternate fuels or other options for transportation when possible

Examples:

- Compressed natural gas
- Biodiesel blends
- Ethanol blends
- Hybrid and/or electric
- Rail lines versus trucks
- Use a fuel efficient passenger car rather than a pickup truck if task allows

2.1.4 BMPs for Energy/Emissions – Equipment Use

D-1. Consider and implement approaches to minimize engine idle times

D-2. Ensure peak operating efficiency of equipment to reduce energy use and emissions

Examples:

- Perform preventative maintenance and operate equipment per manufacturer instructions
- Perform retrofits involving low-maintenance multi-stage filters for cleaner engine exhaust
- Use synthetic oil to extend operating life (and reduce waste oil)
- Purchase newer equipment with reduced emissions

D-3. Use alternate fuel options for equipment when possible

Examples:

- Compressed natural gas
- Biodiesel
- Ethanol blends
- Ultra-low sulfur diesel, wherever available (and as required by engines with PM traps)
- Recycled oil (ensure compliance with operating requirements/warranties)

D-4. Select appropriate equipment and/or power source for the job

Examples:

- Avoid using large excavators for small earthmoving projects
- Use direct push methods when possible to reduce drilling duration
- Compare potential use of electricity versus battery versus generator

D-5. Use variable frequency drives on motors (e.g., pumps, blowers), or replace oversized motors with properly sized motors

D-6. Identify options for generating renewable energy for direct use in the remedial activities and/or for alternate use at or near the project site

Examples:

- Solar, wind, landfill gas (microturbines), combined heat and power, geothermal heat exchange
- Applications for remote areas such as solar pumps or solar flares (if demand is not continuous, the need for a battery backup may be avoided)
- Generate power or heat exchange from water to be discharged

D-7. Consider purchase of renewable energy certificates (RECs) to offset emissions from the remedial activities (note that a Memorandum titled Department of the Army Policy for Renewable Energy Credits, dated 24 May 2012, states that "the Army shall not purchase RECs solely to meet Federal renewable energy goals," but it is possible that Project Teams might in some cases consider the purchase of RECs to address concerns of one or more stakeholders at a specific site)

D-8. Design/modify housing required for above-ground treatment components for energy-efficiency

Examples:

- Passive lighting
- Compact fluorescent lighting (CFL) or light-emitting diode (LED) lighting
- Timers and/or motion control sensors for lighting
- Shading
- Minimize heating and cooling needs (building size, insulation, etc.)

D-9. For remedies that involve groundwater or air extraction, optimize extraction to reduce flow rates (potentially beneficial with respect to energy use, materials usage, water resources, waste disposal, etc.)

D-10. Consider pulsing for extraction and/or injection of water or air for extraction of water or air to maximize mass removal per unit of time or energy, by extracting higher concentrations

D-11. Run electrical equipment during times of lower electric demand if possible (this does not reduce energy use but could lower cost and also can lower stress on the energy grid during periods of peak demand)

2.1.5 BMPs for Materials and Off-Site Services

E-1. Use materials that are made from recycled materials

Examples:

- Steel
- Asphalt
- Plastics
- Concrete

E-2. Optimize the amount of materials used

Examples:

- Experiment with different material amounts/doses
- Consider alternate materials

- Use timers or feedback loops and process controls for dosing
- MMRP projects: minimize quantities of donor explosives for MEC destruction

E-3. Utilize less refined materials when feasible

Examples:

- Limestone instead of sodium hydroxide for pH adjustment
- Native fill instead of select fill

E-4. Identify opportunities for using by-products or "waste" materials from local sources in place of refined chemicals or materials

Examples:

- Cheese whey, molasses, compost, or off-spec food products for inducing anaerobic conditions
- Crushed concrete for use as fill
- Concrete from coal combustion byproducts

E-5. Reduce demand on Publicly Owned Treatment Works (POTWs)

Examples:

- Discharge treated water to groundwater or to surface water rather than POTW
- Minimize amount of water requiring treatment

2.1.6 BMPs for Water Resource Use

F-1. Minimize water consumption

Examples:

- Sensors to turn off water when not needed
- Low flow fittings
- Minimize water needs for irrigation (landscape choices, use of mats and mulch)

F-2. Preferentially use less refined water resources when feasible

Examples:

- Use extracted groundwater instead of potable water for chemical blending
- Capture and store rain/storm water for future use
- Employ rumble grates with a closed-loop gray-water washing system

F-3. Use extracted and treated water for beneficial purposes

Examples:

- Irrigation
- Potable water
- Industrial process water

F-4. Promote groundwater recharge

Examples:

- Recharge extracted and treated water when beneficial uses of the water are not identified and reinjection is practical
- Minimize site area covered by impervious surfaces to reduce runoff and maximize infiltration (unless such capping is a specific component of the remedial action)

F-5. Maintain water quality by preventing nutrient loading to surface water or groundwater

Examples:

- Use phosphate-free detergents instead of organic solvents or acids to decontaminate sampling equipment (if not required for some contaminants)

2.1.7 BMPs for Waste Generation, Disposal, and Recycling

G-1. Minimize drill cuttings and all other investigation derived waste (including personal protection equipment)

Examples:

- Direct push or sonic drilling to reduce drill cuttings
- Low-flow sampling or passive diffusion bags (if applicable) to reduce purge water
- When possible place drill cuttings on-site rather than off-site disposal

G-2. Segregate excavated soil in pre-planned staging areas so that "clean" material can be deposited on-site and/or reused rather than transported for off-site disposal

G-3. Consider on-site treatment and re-use of soil instead of off-site disposal

Examples:

- Land farming
- Above ground soil vapor extraction (SVE)

G-4. Minimize need to transport and dispose hazardous waste

Examples:

- Consider delisting listed hazardous waste if waste is not characteristically hazardous waste
- Segregate hazardous waste and non-hazardous waste

G-5. When possible avoid/minimize use of hazardous/toxic materials that may require special handling or disposal

Examples:

- Cleaning solutions
- Pesticides
- Disposable batteries (use rechargeable batteries)
- MMRP projects: minimize Chemical Agent Contaminated Media (CACM) at RCWM sites.

G-6. Recycle or reuse materials rather than disposing of them

Examples:

- Cardboard
- Plastics
- Concrete
- Asphalt
- Steel and other metals
- Recovered oil/product
- Mulch/compost

- MMRP projects - recycle recovered Material Documented as Safe (MDAS) after inspection and certification that the remnants are free of explosive hazards

2.1.8 BMPs for Land Use, Ecosystems, and Cultural Resources

H-1. Minimize erosion and soil transport to surface water bodies

Examples:

- Quickly restore any vegetated areas disrupted by equipment or vehicles
- Institute appropriate erosion controls during excavation such as silt fencing

H-2. Minimize disturbances to land

Examples:

- Establish well-defined traffic patterns for onsite activities to minimize disturbed areas
- Consider non-intrusive investigation techniques (e.g., geophysical methods) to identify items like USTs and buried drums

H-3. Preserve/restore ecosystems to the extent possible

Examples:

- Limit the removal of trees and vegetation
- Attempt to transplant disturbed shrubs and small trees to other locations
- Use native species for re-vegetation
- Retrieve dead trees during excavation and later reposition them as habitat snags
- Select and place suitably sized and typed stones into water beds and banks
- Undercut surface water banks in ways that mirror natural conditions
- Cut back rather than remove trees, bushes, vegetation

H-4. Minimize drawdown of the water table in sensitive areas such as wetlands or areas subject to subsidence

H-5. Construct wells and other remedial process infrastructure (piping, buildings, etc.) to minimize restrictions to anticipated future use of the site

H-6. Preserve/restore cultural resources to the extent possible

Examples:

- Protected lands such as wildlife refuges, national parks, and wilderness areas
- Culturally sensitive sites such as cemeteries, native burials, and archaeological finds
- Buildings or land parcels with historical significance

H-7. Document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources

Examples:

- photodocument conditions prior to clearing brush
- MMRP projects: photodocument conditions prior to BIP

2.1.9 BMPs for Safety and Community

I-1. Minimize and mitigate noise, light and odor disturbance during all phases of the remedial process, to the extent practicable

I-2. Minimize dust during construction activities by spraying water or techniques such as laying biodegradable mats, tarps, or materials (already in EM385-1-1)

I-3. Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts

I-4. Minimize drawdown of the water table in areas that could impact production rates at supply wells and/or irrigation wells

I-5. Minimize amount of time that heavy machinery is needed to enhance safety

I-6. Minimize handling of dangerous chemicals by selecting alternate chemicals and/or engineering to minimize contact with chemicals (for MMRP projects, there is enhanced risk related to explosion potential and exposure to chemical agents (CA) and agent breakdown products (ABP) associated with RCWM responses)

I-7. Contribute to local economy when possible

Examples:

- Consider leasing local office space
- Purchase or lease equipment from local vendors
- Hire workers from local community

I-8. Utilize on-site construction practices and PPE requirements for anticipated exposure scenarios rather than an overly conservative level of protectiveness that is more resource intensive

Example:

- Utilize general construction PPE protectiveness, which is less personnel and equipment resource intensive, rather than HTRW PPE protectiveness, when applying a non-hazardous soil cover for a HTRW landfill

2.1.10 Other Site-Specific BMPs

This would include any project-specific BMPs appropriate for this project not identified in the BMP list presented above. These may include any BMPs that would be associated with the Army mission factor, such as security or readiness.

2.2 GSR METRICS AND QUALITATIVE CONSIDERATIONS

A list of specific GSR metrics recommended for consideration of quantification (i.e., in the finalized GSR Approach developed for this Study) is presented in Table 2-1, along with qualitative considerations that are more difficult to quantify but may be equally important to consider as part of a GSR evaluation.

Table 2-1
Specific GSR Metrics and Qualitative Considerations Included in the Finalized GSR Approach Developed in this Study

Note that any project-specific metrics or other qualitative considerations not listed can be added by inserting a row in the Table

GSR Considerations**	Unit
Quantitative Environmental Metrics:	
Energy Use	MMBtus
Global Warming Potential	Metric Tons CO2e
Criteria Air Pollutants (NOx + SOx + PM)	Metric Tons
Hazardous or Toxic Air Pollutants	Pounds
Potable Water Use	Thousands of Gallons
Other Water Use	Thousands of Gallons
Refined Materials	Pounds
Percent of Refined Materials from Recycled or Reused Sources	%
Unrefined Materials	Tons
Percent of Unrefined Materials from Recycled or Reused Sources	%
Non-Hazardous Waste Disposal	Tons
Hazardous Waste Disposal	Tons
Percent of Total Potential Waste Recycled or Reused	%
Quantitative Economic Metrics:	
Life-Cycle Cost, Discounted	$ (net present value)
Life-Cycle Cost, Undiscounted	$
Up-Front Cost	$
Quantitative Societal Metrics:	
Risk for Injuries/Fatalities	Number of Injuries + Fatalities
One-Way Heavy Vehicle Trips through Residential Areas	Number of Trips
Qualitative Considerations:	
Land Transferred or Made Available for Potential Beneficial Use	N/A*
Existing Ecosystem Destruction	N/A*
Time Frame for Land Reuse	N/A*
Flexibility and Breadth of Options for Site Reuse	N/A*
Aesthetics	N/A*
Use of Renewable Energy	N/A*

**N/A = "Not Applicable" – these items are difficult to fully quantify although some quantification may be possible and can be described as part of a GSR evaluation in those cases*
***This table includes refinement of the preliminary metrics used during the Pilot Projects*

A detailed description of each metric is provided in Section 1.4 of Appendix A, and examples for calculating metrics not estimated by the SiteWise™ tool are provided in Section 2.2.3.3 of Appendix A.

Footprint results for the 12 Pilot Projects (for selected metrics) are summarized in Section 3.2. Generally, the data required for input to the quantitative footprinting were obtained from existing site reports, which in several cases were draft reports. In some instances, these data were augmented with specific information provided by the Project Team via email or during the "Step 5" call. Cost information was generally provided by the Project Team based on existing project-specific information. If such cost estimates were not available, the GSR Evaluation Team suggested cost estimates based on previous experience, and the Project Team could comment on the estimates when reviewing the Draft Final GSR Evaluation Report for each Pilot Project.

It is important to note that the SiteWise™ tool was updated during the course of the Study. As a result, some of the GSR evaluations for the Pilot Projects were conducted with Version 1.0 of SiteWise™ and some were conducted with Version 2.0. The version of SiteWise™ used for each Pilot Project is summarized in Table 2-2.

Table 2-2. Version of SiteWise™ Used for Pilot Projects in the Study

Pilot Project Site Name	Version of SiteWise™ Applied
Akiachak Federal Scout Armory	Version 1.0
Former Black Hills Army Depot	Version 2.0
Former NAD – Hastings	Version 1.0
Iowa Army Ammunition Plant	Version 2.0
Lake City Army Ammunition Plant	Version 2.0
Lockbourne Landfill	Version 1.0
Fort Missoula Blue Mountain Training Area	Version 1.0
Shepley's Hill Landfill (Draft FFS Phase)	Version 1.0
Shepley's Hill Landfill (Constructability Phase)	Version 2.0
Umatilla Chemical Depot	Version 2.0
Schilling Air Force Base Atlas Missile Facility S-1	Version 2.0
Former Schilling Atlas Missile Site S-5	Version 1.0

There was an attempt to keep the calculations of these metrics consistent, and as a result there are a few features in SiteWise Version 2.0 that were not fully utilized in the Pilot Projects. The items included the following: applying the number of non-machine-operated labor hours on-site for the safety calculations; footprint of laboratory analysis based on analytical costs; footprint of POTW discharge; footprint of potable water production; and footprint of waste disposal operations beyond transport to the landfill. An informal sensitivity analysis was performed, and including these items in the calculated footprints for the Pilot Projects evaluated with SiteWise™ would have had an insignificant impact on the calculated footprints (and would not have changed any recommendations or conclusions for those Pilot Projects). These features in SiteWise Version 2.0 should be used in future GSR evaluations, and those features are highlighted in the "Example GSR Evaluation Report" included as Attachment A-4 in Appendix A.

In addition to the quantitative metrics described in Table 2-1, there are other important considerations appropriate to evaluate as part of a GSR evaluation even if they are not fully quantified. Examples include the following:

- **Land Transferred or Made Available for Potential Beneficial Use** – Remedial activities typically involve restoring the site and making it available for reuse. The potential to make land available for reuse should be addressed as part of a GSR evaluation when pertinent. Restrictions associated with land use should also be noted.

- **Existing Ecosystem Destruction** – Remedial activities typically involve heavy equipment traffic on unpaved surfaces, and/or require surfaces to be re-graded or re-paved. These activities can result in destruction of existing ecosystems and reduction in existing ecosystem services such as erosion control, flood control, and nutrient absorption. The potential for ecosystem destruction should be addressed as part of a GSR evaluation when pertinent, even if the land is eventually reused or reestablished.

- **Time Frame for Land Reuse** – Remedial alternatives may differ in the amount of time required to reuse the land. A shorter remedy time frame is generally preferred to allow productive reuse of the land to occur more quickly. Considerations regarding the time frame for land reuse should be addressed as part of a GSR evaluation, when pertinent.

- **Flexibility and Breadth of Options for Site Reuse** – Remedial activities, site closeout activities, and the potential range of site reuse (i.e., flexibility in institutional controls) can be controlled and tailored to allow multiple uses of the site during and after remediation. Multiple site reuse options can lead to considerable resource savings if a site reuse with more restricted land use, but lower resource consumption during the remedy, meets mission and protection of human health and environment goals. Potential tradeoffs between land use restrictions versus intensity of the remediation (i.e., resource consumption) should be addressed as part of a GSR evaluation, when pertinent.

- **Aesthetic Considerations** - Items such as odor, noise, dust, and visual impacts associated with the remedial process should be addressed. These issues may be difficult to quantify, but can be extremely important for project stakeholders.

- **Renewable Energy Use Associated with the Remedy** - Renewable energy is favored because it typically has a lower environmental footprint (especially with respect to air emissions) than conventional energy resources. The extent of renewable energy used in the remedy may be quantified (e.g., as a percentage of total energy used) or may be qualitatively described. For the purpose of this document, the following are defined as renewable energy resources:

    - Biodiesel
    - Crop-based ethanol
    - Landfill gas
    - Electricity generated directly from
        - Wind
        - Geothermal reservoirs
        - Hydroelectric
        - Solar
        - Biomass, including landfill gas
    - Useful heat generated from
        - Geothermal reservoirs
        - Biomass, including landfill gas
        - Solar

Note that renewable energy generated on-site may be used directly as part of the remedy (e.g., solar panels used to power a trailer), but also may be associated with the off-site generation of electricity used on-site for the remedy. Both potential aspects of renewable energy use associated with a remedy should be addressed qualitatively as part of a GSR evaluation, when pertinent. On-site renewable energy production can also be accounted for quantitatively in the calculation of emissions from energy use (i.e., will result in lower emissions). Also note that the Energy Policy Act of 2005 (EPAct 2005) defines "renewable energy" as electric energy generated from solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project. The definition of renewable energy used for this Study (provided above) differs slightly because the focus for the Study was to understand how the sources of energy impact the remedy footprint (e.g., how much of the electricity comes from hydrothermal versus coal results in different emissions) rather than quantifying how much new renewable electricity is "owned" by the Army which is the focus of the EPAct05.

These and potentially other qualitative considerations are addressed in the BMPs described earlier. It is appropriate to highlight key project-specific qualitative considerations when evaluating GSR opportunities.

3.0 RESULTS FROM PILOT PROJECTS AND OTHER CASE STUDIES

3.1 RESULTS FROM APPLICATION OF BMPS FOR PILOT PROJECTS

The GSR BMPs listed in Section 2.1 and included in Attachment A-1 of Appendix A were considered for 11 of the 12 Pilot Projects in the Study[2]. During the Pilot Project GSR evaluations, the list of GSR BMPs was used as an outline for a general discussion regarding GSR opportunities already implemented for the project and additional GSR opportunities that could be considered and potentially implemented. In general, going through this list of GSR BMPs required a discussion of approximately two hours. The BMPs are divided into the following categories:

A. Planning
B. Characterization and/or Remedy Approach
C. Energy/Emissions - Transportation
D. Energy/Emissions - Equipment Use
E. Materials & Off-Site Services
F. Water Resource Use
G. Waste Generation, Disposal, and Recycling
H. Land Use, Ecosystems, and Cultural Resources
I. Safety and Community
J. Other Site-Specific BMPs

In the Pilot Project GSR evaluation reports, consideration of the GSR BMPs was summarized as follows:

- Examples of GSR BMPs already considered or incorporated by the Project Team prior to the GSR evaluation being performed.
- Suggestions during the GSR evaluation for GSR BMPs that could be considered for further analysis and/or implementation (i.e., BMPs that appeared to be "practical" for potential implementation). Here "practical" is defined as being feasible from a technical standpoint and providing net GSR benefits as shown from the economic, social, and environmental metrics and other GSR considerations evaluated in this Study for the individual Project Pilot. Other Project Team limitations such as schedule, regulatory constraints, and site-specific logistics also impact the potential implementability of the GSR opportunities. Examples of these limitations are discussed in Section 4.8.
- Examples of GSR BMPs that the Project Team previously determined were not "practical" to implement.

Table 3-1 illustrates the manner in which the items listed above can be presented in a project-specific GSR evaluation report. An overall summary of the application of the specific GSR BMPs during the Pilot Projects is presented on the following tables:

- Table 3-2: Number of Times Each BMP was Determined to be "Applicable"
- Table 3-3: Number of Times Each BMP was Determined to be "Practical"
- Table 3-4: Number of Times Each BMP was Determined to be "Fully or Partially Implemented"

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[2] One of the 12 Pilot Projects (Schilling S-5) was performed before the BMP list for the Study was developed, so in general the BMPs were considered for 11 of the 12 Pilot Projects. BMP H-7 was added during the Study and was only applied at 9 of the Pilot Projects. Also, two BMPs (A-11 and I-8) were added after the Study and therefore were not considered during the Pilot Projects.

Tables 3-2 to 3-4 can be compared to determine how many of the “applicable” BMPs were considered to be “practical”, and how many of the “practical” BMPs had already been “implemented” by the Project Teams prior to the GSR evaluation.

Table 3-1
Examples of How Consideration of GSR BMPs can be Summarized in GSR Evaluation Reports

- Examples of GSR BMPs already considered or incorporated prior to the GSR evaluation include (but are not limited to) the following:
    - BMP G-2 (Segregate excavated soil in pre-planned staging areas so that “clean” material can be deposited on-site and/or reused rather than transported for off-site disposal): *Project Team is using field screening methods to determine the extent of contamination and using staging areas to separate contaminated and potentially clean soil. Soil that does not appear contaminated is sampled and, if clean, used for backfill.*
    - BMP I-3 (Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts): *The Project Team has identified an entry point to the site for heavy equipment with less potential to disturb residences.*
- The GSR evaluation suggests several potentially practical BMPs the Project Team could consider moving forward. Some examples include the following:
    - BMP D-8 (Design/modify housing required for above-ground treatment components for energy efficiency): *Have the architect look into passive lighting, sensors for lighting, and other design elements for the treatment building that might reduce energy consumption.*
    - BMP G-1 (Minimize drill cuttings and all other investigation derived waste including personal protection equipment): *Consider use of whole-water or no-purge samplers such as HydraSleeves™ rather than low flow sampling to reduce or eliminate purge water from sampling, since purge water must be disposed of as investigation derived waste.*
- The Project Team identified that some BMPs are not practical to implement because of other project-specific constraints. Examples include the following:
    - BMP D-6 (Identify options for generating renewable energy for direct use in the remedy and/or for alternate use at or near the project site): *Re-using the capped area for wind energy would likely compromise the cap (would require structures that pierce the cap, which the Project Team indicated was not desirable) and is likely not feasible given the proximity to an active airport runway. Using the capped area for crops (e.g., biodiesel) would likely cause negative impacts related to sediment and fertilizer runoff at the storm water drainage ditch.*
    - BMP C-3 (Reduce trip lengths): *Due to the specialized nature of MMRP work, the labor for the intrusive operations and geophysics must be brought to the site and performed by trained and qualified specialists (i.e., the ability to use local labor is limited).*

Table 3-2
Number of Times Each BMP was Determined to be "Applicable" (11 Pilots*)

BMP # in the Category**		A. Planning	B. Characterization and/or Remedy Approach	C. Energy/Emissions – Transportation	D. Energy/Emissions - Equipment Use	E. Materials & Off-Site Services	F. Water Resource Use	G. Waste Generation, Disposal, and Recycling	H. Land Use, Ecosystems, and Cultural Resources	I. Safety and Community
1		11 (100%)	11 (100%)	11 (100%)	6 (55%)	7 (64%)	6 (55%)	8 (73%)	8 (73%)	6 (55%)
2		11 (100%)	6 (55%)	11 (100%)	8 (73%)	9 (82%)	4 (36%)	4 (36%)	8 (73%)	4 (36%)
3		10 (91%)	10 (91%)	10 (91%)	5 (45%)	11 (100%)	4 (36%)	5 (45%)	6 (55%)	6 (55%)
4		9 (82%)	7 (64%)	5 (45%)	8 (73%)	7 (64%)	4 (36%)	2 (18%)	3 (27%)	3 (27%)
5		11 (100%)	10 (91%)		4 (36%)	2 (18%)	7 (64%)	6 (55%)	3 (27%)	8 (73%)
6		11 (100%)	9 (82%)		5 (45%)			9 (82%)	6 (55%)	6 (55%)
7		11 (100%)	11 (100%)		7 (64%)				4 (36%)	11 (100%)
8		9 (82%)	9 (82%)		4 (36%)					
9		4 (36%)	4 (36%)		4 (36%)					
10		11 (100%)			1 (9%)					
11					0 (0%)					

** One of the 12 Pilot Projects (Former Schilling Atlas Missile Site S-5) was performed before the BMP list for the Study was developed, so in general the BMPs were considered for 11 of the 12 Pilot Projects. BMP H-7 was added during the Study and was only applied at 9 of the Pilot Projects. Also, two BMPs (A-11 and I-8) were added after the Study and therefore were not considered during the Pilot Projects.*

***The list of BMPs is provided in Section 2.1. The shaded boxes indicate that there are less than 11 BMPs for that category that were considered in the Pilot Projects. For instance, the last BMP in Category C is "C-4" and the last BMP in category F is "F-5".*

Table 3-3 Number of Times Each BMP was Determined to be "Practical" (11 Pilots)										
BMP # in the Category**		A. Planning	B. Characterization and/or Remedy Approach	C. Energy/Emissions - Transportation	D. Energy/Emissions - Equipment Use	E. Materials & Off-Site Services	F. Water Resource Use	G. Waste Generation, Disposal, and Recycling	H. Land Use, Ecosystems, and Cultural Resources	I. Safety and Community
1		11 (100%)	11 (100%)	10 (91%)	3 (27%)	3 (27%)	3 (27%)	6 (55%)	5 (45%)	5 (45%)
2		11 (100%)	6 (55%)	9 (82%)	3 (27%)	6 (55%)	1 (9%)	2 (18%)	8 (73%)	2 (18%)
3		9 (82%)	10 (91%)	5 (45%)	0 (0%)	7 (64%)	2 (18%)	2 (18%)	5 (45%)	5 (45%)
4		7 (64%)	6 (55%)	2 (18%)	7 (64%)	3 (27%)	2 (18%)	2 (18%)	1 (9%)	2 (18%)
5		11 (100%)	8 (73%)		2 (18%)	0 (0%)	4 (36%)	4 (36%)	3 (27%)	5 (45%)
6		11 (100%)	9 (82%)		0 (0%)			7 (64%)	4 (36%)	5 (45%)
7		3 (27%)	9 (82%)		0 (0%)				4 (36%)	10 (91%)
8		8 (73%)	7 (64%)		1 (9%)					
9		3 (27%)	3 (27%)		2 (18%)					
10		11 (100%)			0 (0%)					
11					0 (0%)					

** One of the 12 Pilot Projects (Former Schilling Atlas Missile Site S-5) was performed before the BMP list for the Study was developed, so in general the BMPs were considered for 11 of the 12 Pilot Projects. BMP H-7 was added during the Study and was only applied at 9 of the Pilot Projects. Also, two BMPs (A-11 and I-8) were added after the Study and therefore were not considered during the Pilot Projects.*

***The list of BMPs is provided in Section 2.1. The shaded boxes indicate that there are less than 11 BMPs for that category that were considered in the Pilot Projects. For instance, the last BMP in Category C is "C-4" and the last BMP in category F is "F-5".*

Table 3-4
Number of Times Each BMP was Determined to be
"Fully or Partially Implemented*" (11 Pilots)**

BMP # in the Category**	A. Planning	B. Characterization and/or Remedy Approach	C. Energy/Emissions - Transportation	D. Energy/Emissions - Equipment Use	E. Materials & Off-Site Services	F. Water Resource Use	G. Waste Generation, Disposal, and Recycling	H. Land Use, Ecosystems, and Cultural Resources	I. Safety and Community
1	9 (82%)	11 (100%)	8 (73%)	3 (27%)	3 (27%)	2 (18%)	5 (45%)	5 (45%)	5 (45%)
2	3 (27%)	4 (36%)	9 (82%)	2 (18%)	6 (55%)	1 (9%)	2 (18%)	7 (64%)	1 (9%)
3	8 (73%)	9 (82%)	5 (45%)	0 (0%)	7 (64%)	2 (18%)	1 (9%)	4 (36%)	5 (45%)
4	7 (64%)	5 (45%)	2 (18%)	6 (55%)	2 (18%)	1 (9%)	2 (18%)	1 (9%)	2 (18%)
5	10 (91%)	6 (55%)		2 (18%)	0 (0%)	4 (36%)	4 (36%)	3 (27%)	4 (36%)
6	11 (100%)	9 (82%)		0 (0%)			6 (55%)	4 (36%)	5 (45%)
7	2 (18%)	7 (64%)		0 (0%)				4 (36%)	9 (82%)
8	7 (64%)	6 (55%)		0 (0%)					
9	3 (27%)	3 (27%)		2 (18%)					
10	10 (91%)			0 (0%)					
11				0 (0%)					

** One of the 12 Pilot Projects (Former Schilling Atlas Missile Site S-5) was performed before the BMP list for the Study was developed, so in general the BMPs were considered for 11 of the 12 Pilot Projects. BMP H-7 was added during the Study and was only applied at 9 of the Pilot Projects. Also, two BMPs (A-11 and I-8) were added after the Study and therefore were not considered during the Pilot Projects.*

***The list of BMPs is provided in Section 2.1. The shaded boxes indicate that there are less than 11 BMPs for that category that were considered in the Pilot Projects. For instance, the last BMP in Category C is "C-4" and the last BMP in category F is "F-5".*

**** These are BMPs already implemented prior to the GSR evaluation recommendations.*

Observations from Tables 3-2 to 3-4 include the following:

- All of the BMP categories were widely applicable to the Pilot Projects. For BMP categories A (planning), B (characterization and/or remedy approach) and C (energy/emissions - transportation) there were multiple BMPs applicable to all 11 Pilot Projects where the BMPs were applied, and at least one additional BMP in those categories was applicable to 10 of the 11 Pilot Projects. It was expected that many BMPs in categories A (planning) and B (characterization and/or remedy approach) would be widely applicable, since the GSR BMPs in those categories are general and are typically addressed in overall project planning and execution.

- Only one BMP was not applicable to any of the Pilot Projects (BMP D-11: Run electrical equipment during times of lower electric demand if possible, which does not reduce energy use but could lower cost and also can lower stress on the energy grid during periods of peak demand). This is a highly specific BMP and it is not surprising that it is not widely applicable.

- The applicability of some of the BMPs is limited because the BMP will only apply to specific remedial technologies. For example, BMP F-3 (use extracted and treated water for beneficial purposes) will only be applicable for projects where water is extracted and treated, and this BMP was only applicable to 4 of the 11 Pilot Projects. This differs from other BMPs that apply regardless of remedial technology, such as BMP C-1 (reduce the number of trips for personnel) which was applicable to 10 of the 11 Pilot Projects.

- A comparison of Table 3-2 to Table 3-3 indicates that many of the “applicable” BMPs were considered “practical”. Examples where a BMP was “practical” every time the BMP was “applicable” are BMPs A-5, B-2, H-2 (and others). Other BMPs were only “practical” for some of the projects where the BMP was “applicable”. For example, BMP C-3 (reduce trip lengths) was “applicable” to 10 of the Pilot Projects, but was only considered to be “practical” for 5 of those 10 projects.

- The following BMPs were not considered practical for any of the 11 Pilot Projects where the BMPs were applied (though they could be practical for other projects):

    - D-3: Use alternate fuel options for equipment when possible

    - D-6: Identify options for generating renewable energy for direct use in the remedial activities and/or for alternate use at or near the project site

    - D-10: Consider pulsing for extraction of water or air to maximize mass removal per unit of time or energy, by extracting higher concentrations

    - D-11: Run electrical equipment during times of lower electric demand if possible (this does not reduce energy use but could lower cost and also can lower stress on the energy grid during periods of peak demand)

    - E-5: Reduce demand on Publicly Owned Treatment Works (POTWs)

- A comparison of Tables 3-3 and 3-4 indicates that a high percentage of BMPs considered as “practical” have already been implemented by the Project Team. Examples where there was a 100% correspondence between “practical” and “implemented” include D-1, E-2, and H-6 (and many others).

In some cases, the high percentage of "practical" GSR BMPs already "implemented" by the Project Team is most likely due to previous consideration of GSR principles during the planning of those projects. For instance, the Project Team for the *Fort Missoula Blue Mountain Training Area* Pilot Project had extensively considered GSR principles in developing the RI/FS Work Plan, and has already included a page entitled "Sustainability Commitment" on their project website available to the public. In other cases, the Project Team may not have specifically considered GSR principles as part of project planning, but nevertheless implemented GSR BMPs as a result of general project planning, value engineering, and/or cost minimization.

Outside the project-specific GSR Evaluation Report for each Pilot Project, USACE EM CX subsequently followed the Project Team's consideration of the BMPs that were identified as "practical" in the GSR evaluation but had not been previously implemented. Additional considerations of the Project Team regarding "practicality" of implementing BMPs (e.g., schedule, funding, regulatory constraints), and the process of GSR consideration followed by the Project Team, was documented in a memorandum prepared by USACE EM CX for each Pilot Project (Appendix C).). Several examples of these additional project-specific considerations are described in Section 4.8.

3.2 RESULTS FOR GSR METRICS FROM PILOT PROJECTS

3.2.1 Categorization of Pilot Project Alternatives Based on Duration of Active Remedy

For comparison of footprint results between Pilot Projects, the alternatives for the 12 Pilot Projects were grouped into two categories:

- Long-term active remedies; and
- Short-term active remedies and/or MNA (in some cases MNA follows a short-term active remedy).

The grouping of alternatives from the Pilot Projects (where quantitative footprints were calculated) into these categories is summarized in Table 3-5.

Table 3-5
Pilot Project Alternatives Categorized as "Long Term Active Remedies" or "Short Term Active Remedies and/or MNA"

Pilot Project & Alternative	Active Remedy Duration* (Years)
Long-Term Active Remedies ("Long Duration")	
Lake City - P&T Systems	30
Lake City - Eliminate Catox at Building 163	30
Lake City - Eliminate Individual Water Supply Well Strippers	30
Lake City - Direct Discharge to POTW	30
Lake City - On-Site Treatment of All Extracted Water	30
Hastings - Baseline P&T Remedy	30
Hastings - Power Remedy with Wind Energy	30

Table 3-5 **Pilot Project Alternatives Categorized as "Long Term Active Remedies" or "Short Term Active Remedies and/or MNA"**	
Pilot Project & Alternative	**Active Remedy Duration* (Years)**
Hastings - Use VFDs on Air Stripper Blower Motors	30
Hastings - Use VFDs on Extraction Pumps	30
Hastings - Change from Air Stripping to Virgin GAC	30
Hastings - Change from Air Stripping to Regenerated GAC	30
Hastings - Change from One to Two Treatment Systems	30
Umatilla - Expanded P&T; Full-Scale Bio (Alternative 4)	15
Umatilla - Initial P&T only 3 yrs (Variation 1)	15
Shepley's Hill (Draft FFS) - Current P&T Remedy	100
Shepley's Hill (Draft FFS) - P&T with Reinjection	100
Short-Term Active Remedies and/or MNA ("Short Duration")*	
Shepley's Hill (Draft FFS) – PRB	Short-Term
Lockbourne - Consolidation & Capping	Short-Term
Schilling S-5 - LTM /MNA (208 years)	Short-Term
Schilling S-5 - EAB/MNA/LTM (78 years)	Short-Term
Schilling S-5 - ISCO/LTM (78 years)	Short-Term
Shepley's Hill (Draft FFS) - Monitored Natural Attenuation	Short-Term
Shepley's Hill (Draft FFS) - Containment Wall/PRB	Short-Term
Shepley's Hill (Draft FFS) - Containment Wall	Short-Term
Shepley's Hill (Constructability) - SB Slurry Wall	Short-Term
Shepley's Hill (Constructability) - CB Slurry Wall	Short-Term
Shepley's Hill (Constructability) - Sheet Pile Wall	Short-Term
Akiachak - Excavation & Off-Site Disposal	Short-Term
Akiachak - On-Site Biological Treatment	Short-Term
Akiachak - Ex-Situ Thermal Treatment	Short-Term
Missoula - Remedial Investigation Activities	Short-Term
Black Hills - Planned RI Field Activities	Short-Term
IAAAP - MEC Alternative 2 at CTA	Short-Term
IAAAP - MEC Alternative 2 at LL6	Short-Term
IAAAP - MEC Alternative 2 at PDS	Short-Term
IAAAP - MEC Alternative 2 at INDA	Short-Term
IAAAP - MC Alternative 2 at PDS	Short-Term
IAAAP - MEC Alternative 3 at CTA	Short-Term
IAAAP - MEC Alternative 3 at LL6	Short-Term
IAAAP - MEC Alternative 3 at PDS	Short-Term

Table 3-5 Pilot Project Alternatives Categorized as "Long Term Active Remedies" or "Short Term Active Remedies and/or MNA"	
Pilot Project & Alternative	**Active Remedy Duration* (Years)**
IAAAP - MEC Alternative 3 at INDA	Short-Term
IAAAP - MC Alternative 3 at PDS	Short-Term
Schilling S-1 - SI Activities	Short-Term
Schilling S-1 - Off-site Disposal of IDW	Short-Term
Schilling S-1 - Drilling with a Roto-Sonic Drill Rig	Short-Term

**Duration refers to timeframe with significant active remedy component other than monitoring*
***May include long-term monitoring but does not include a significant long-term active remedy*

3.2.2 Comparison of Selected Metrics between Alternatives (Linear Scale and Log Scale)

The following figures illustrate selected metrics according to these groupings, plotted on a linear scale:

- Figure 3-1: Total Energy Use (MMBtus) – Linear Scale
- Figure 3-2: Greenhouse Gas Emissions (metric tons CO2e) – Linear Scale
- Figure 3-3: Water Consumption (millions of gallons) – Linear Scale
- Figure 3-4: Hazardous and Non-Hazardous Waste Disposal (tons) – Linear Scale

Observations from Figures 3-1 to 3-4 (linear scale) include the following:

- For total energy use and greenhouse gas emissions, it is evident that the short-term active remedies and/or MNA have negligible footprints relative to the long-term active remedies. In the Pilot Projects, these long-term active remedies included pump-and-treat and in-situ bio with multiple substrate injections over time. This strongly suggests that if the Army wants to make the greatest reductions in these metrics, the highest priority should be to evaluate GSR opportunities for projects with long-term active remedies.

- For water consumption and waste disposal, there are also small or negligible footprints for the short-term active remedies and/or MNA, whereas some (but not all) of the long-term active remedies have relatively large footprints.

The following figures illustrate these same metrics plotted on a logarithmic scale:

- Figure 3-5: Total Energy Use (MMBtus) – Logarithmic Scale
- Figure 3-6: Greenhouse Gas Emissions (metric tons CO2e) – Logarithmic Scale
- Figure 3-7: Water Consumption (millions of gallons) – Logarithmic Scale
- Figure 3-8: Hazardous and Non-Hazardous Waste Disposal (tons) – Logarithmic Scale

The logarithmic scale allows the footprints for the short-term active remedies to be more clearly seen on the same graph as the footprints of long-term active remedies. However, the logarithm scale also makes it easy for the reader to potentially miss how much greater the footprints are for the long-term active remedies compared to the short-term active remedies and/or MNA (i.e., greater risk of misinterpretation).

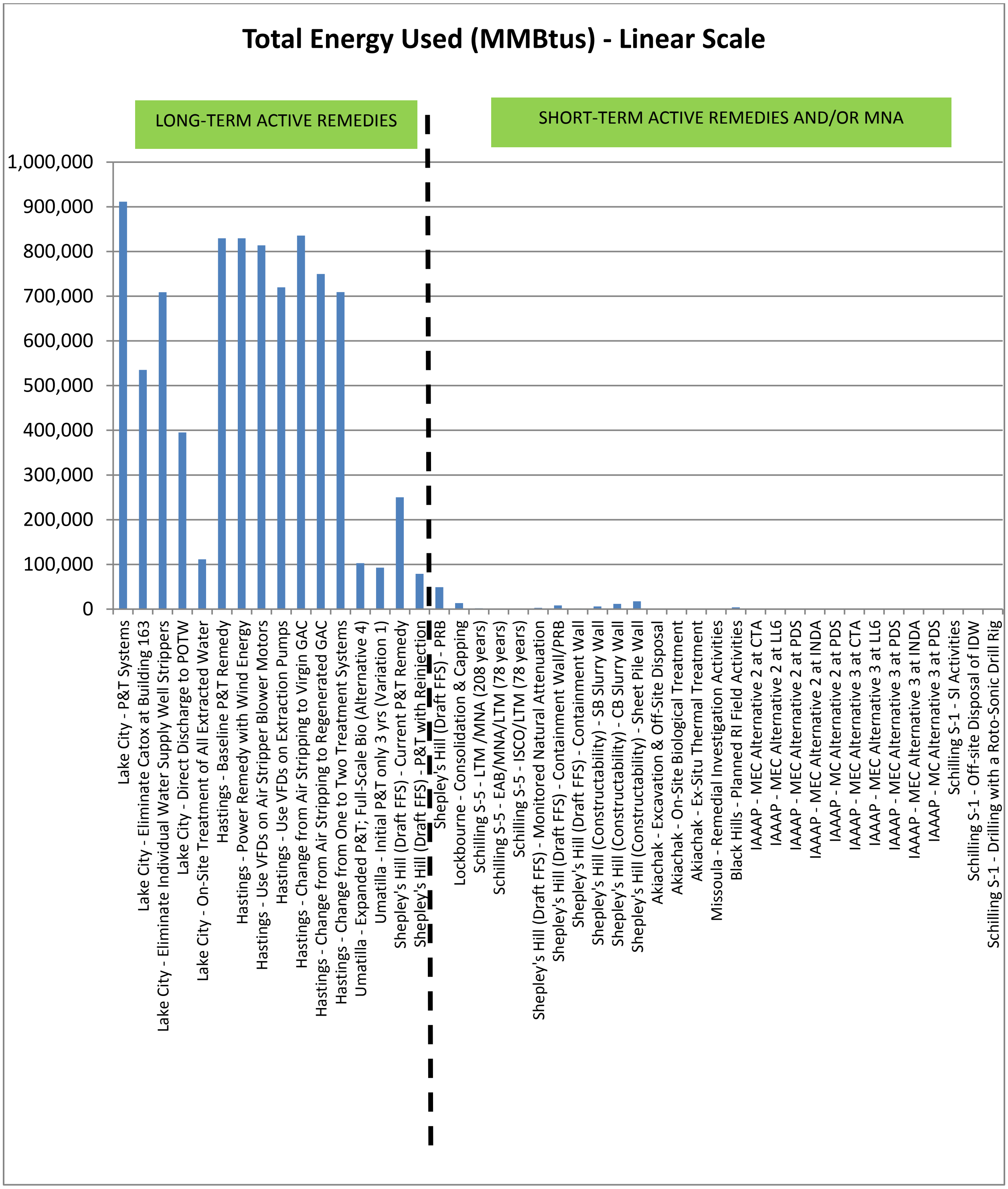

Figure 3-1. Total Energy Use for Pilot Project Alternatives (Linear Scale)

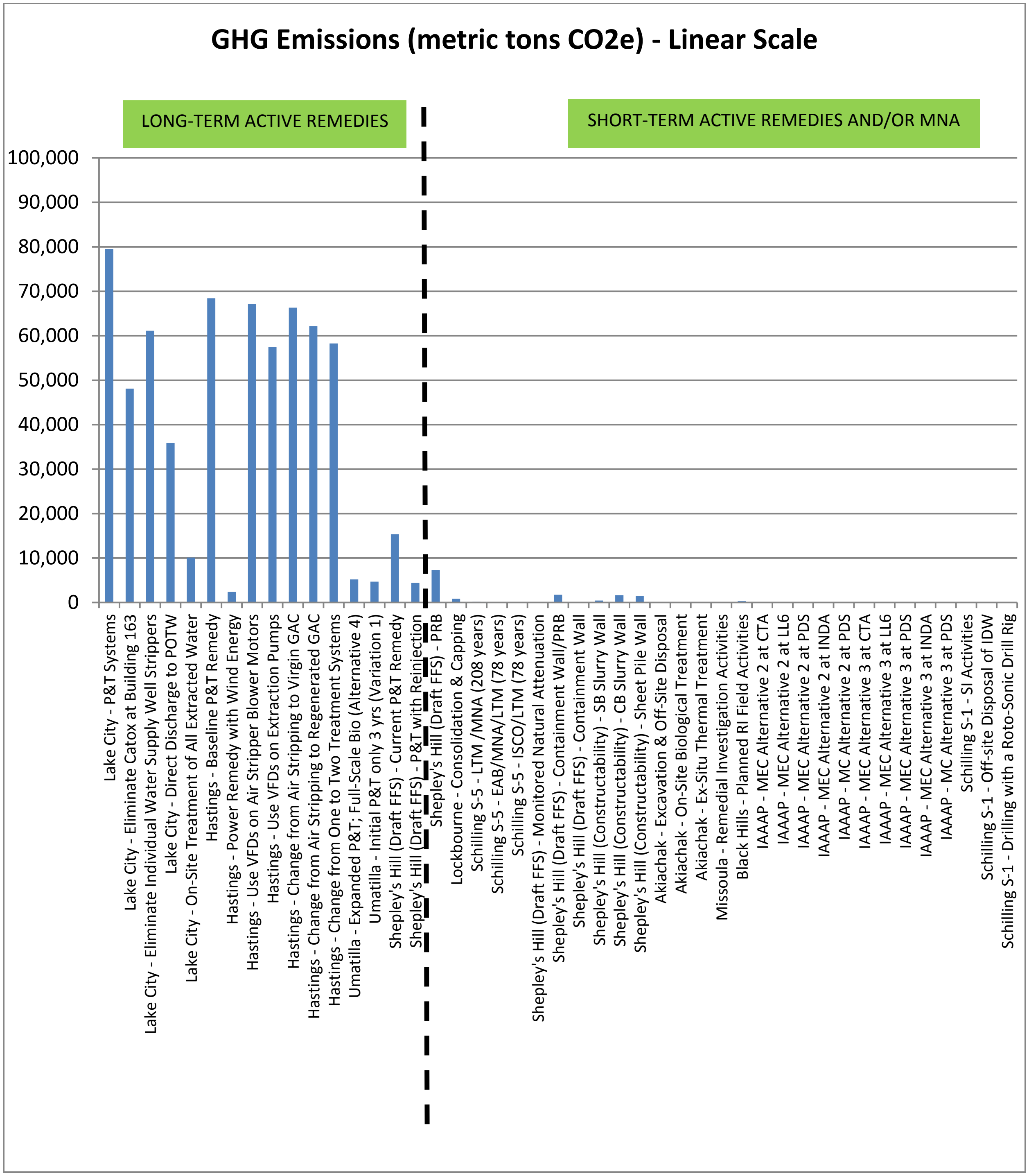

Figure 3-2. Greenhouse Gas Emissions for Pilot Project Alternatives (Linear Scale)

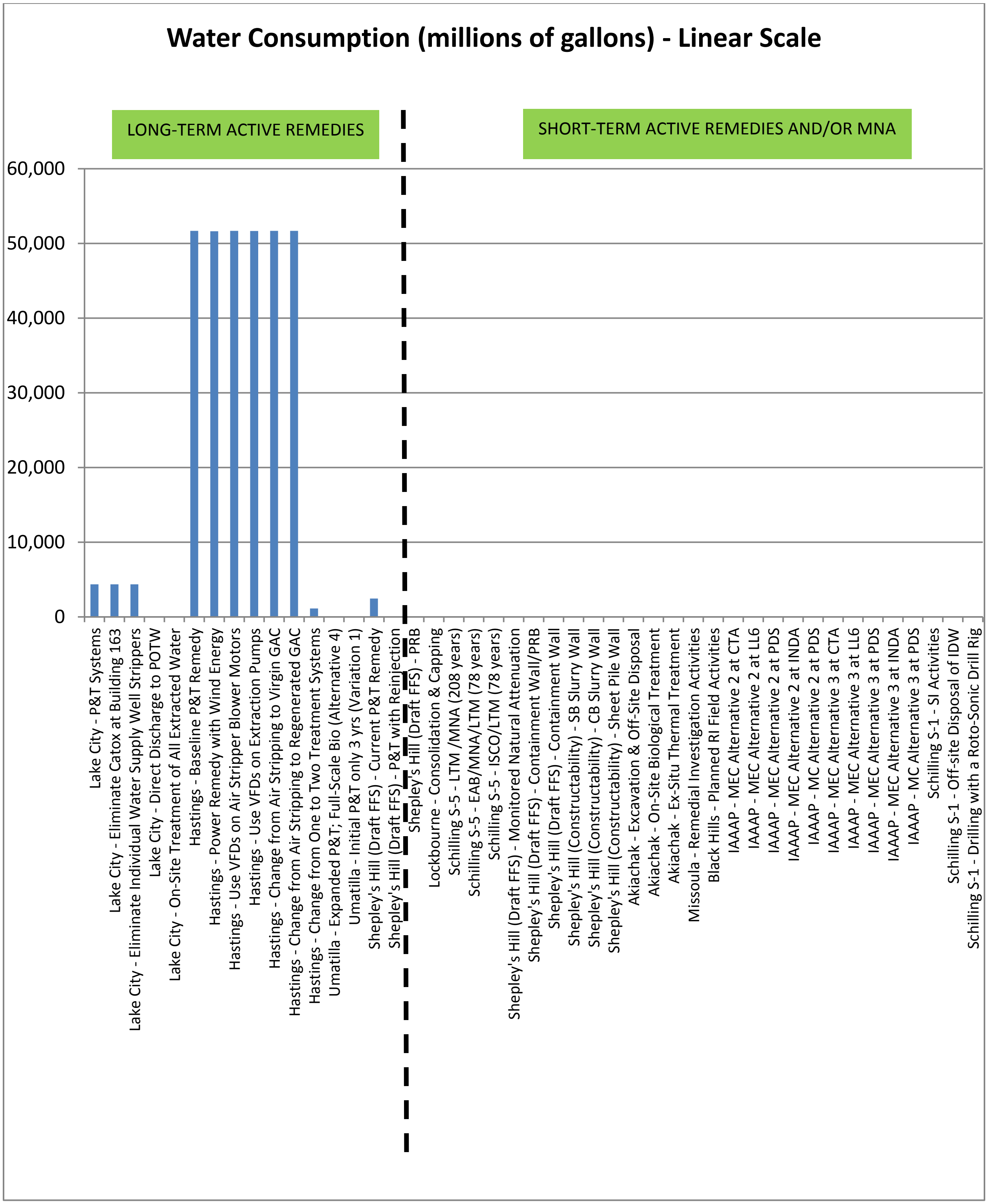

Figure 3-3. Water Consumption for Pilot Project Alternatives (Linear Scale)

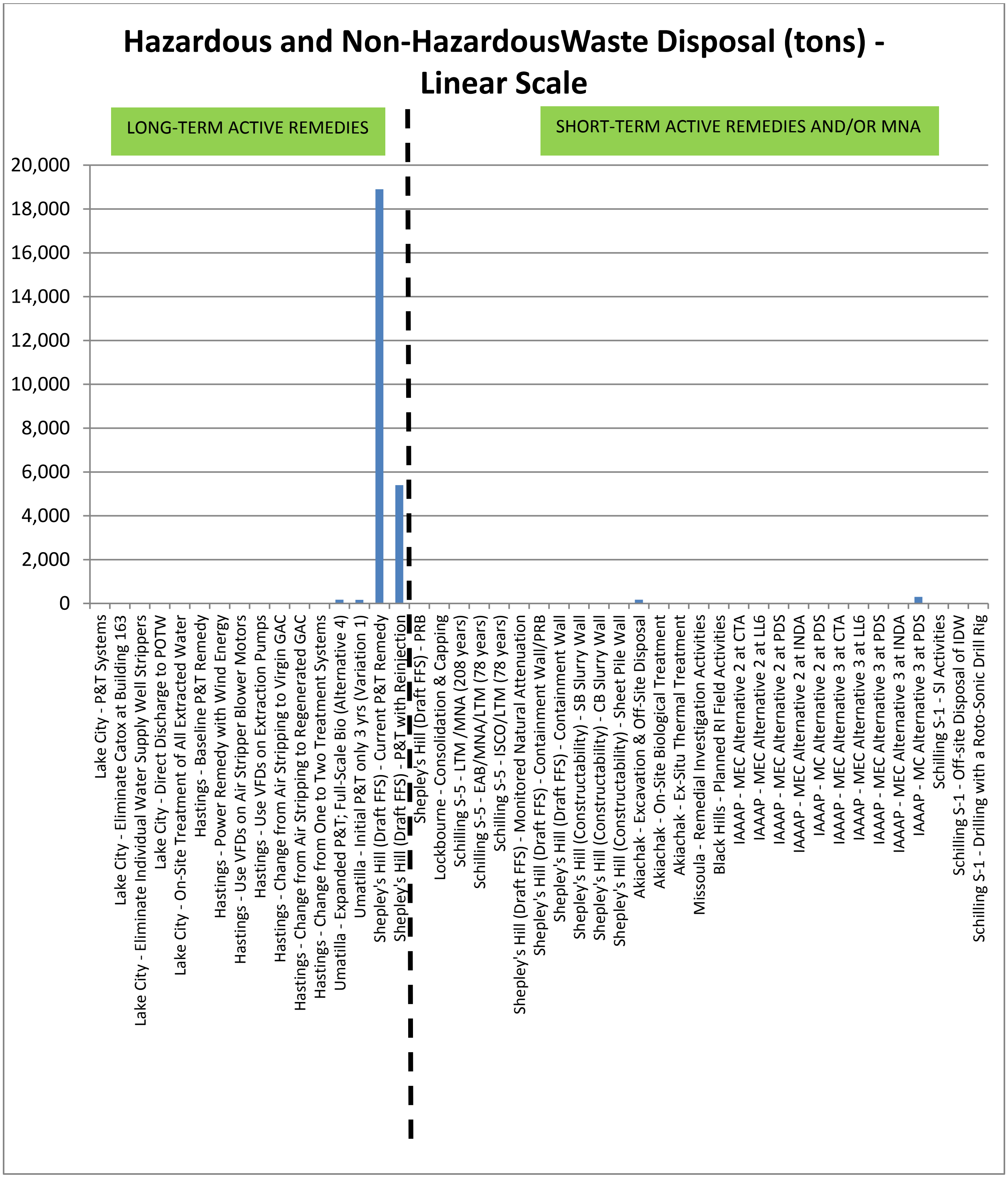

Figure 3-4. Hazardous and Non-Hazardous Waste Disposal for Pilot Project Alternatives (Linear Scale)

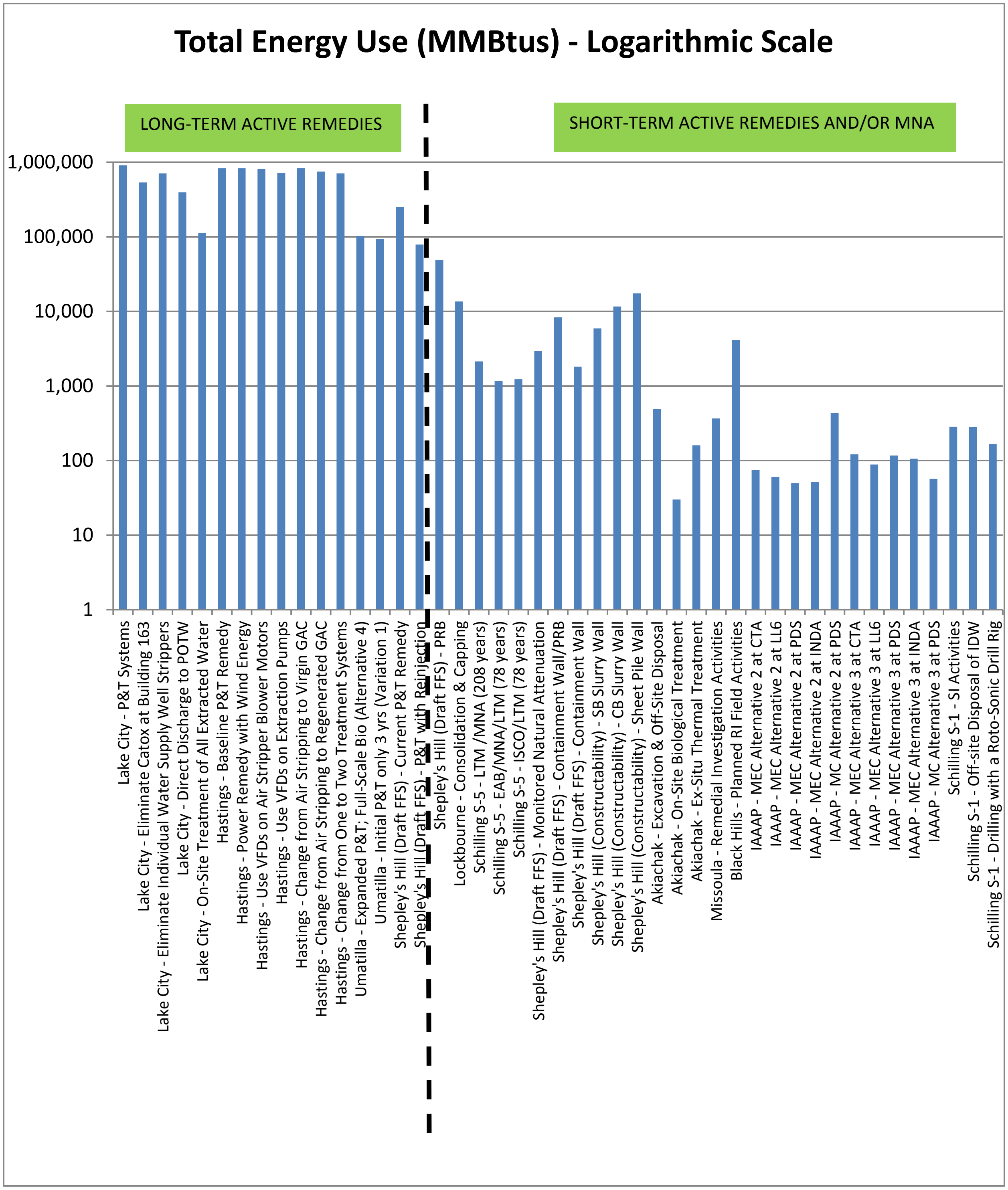

Figure 3-5. Total Energy Use for Pilot Project Alternatives (Logarithmic Scale)

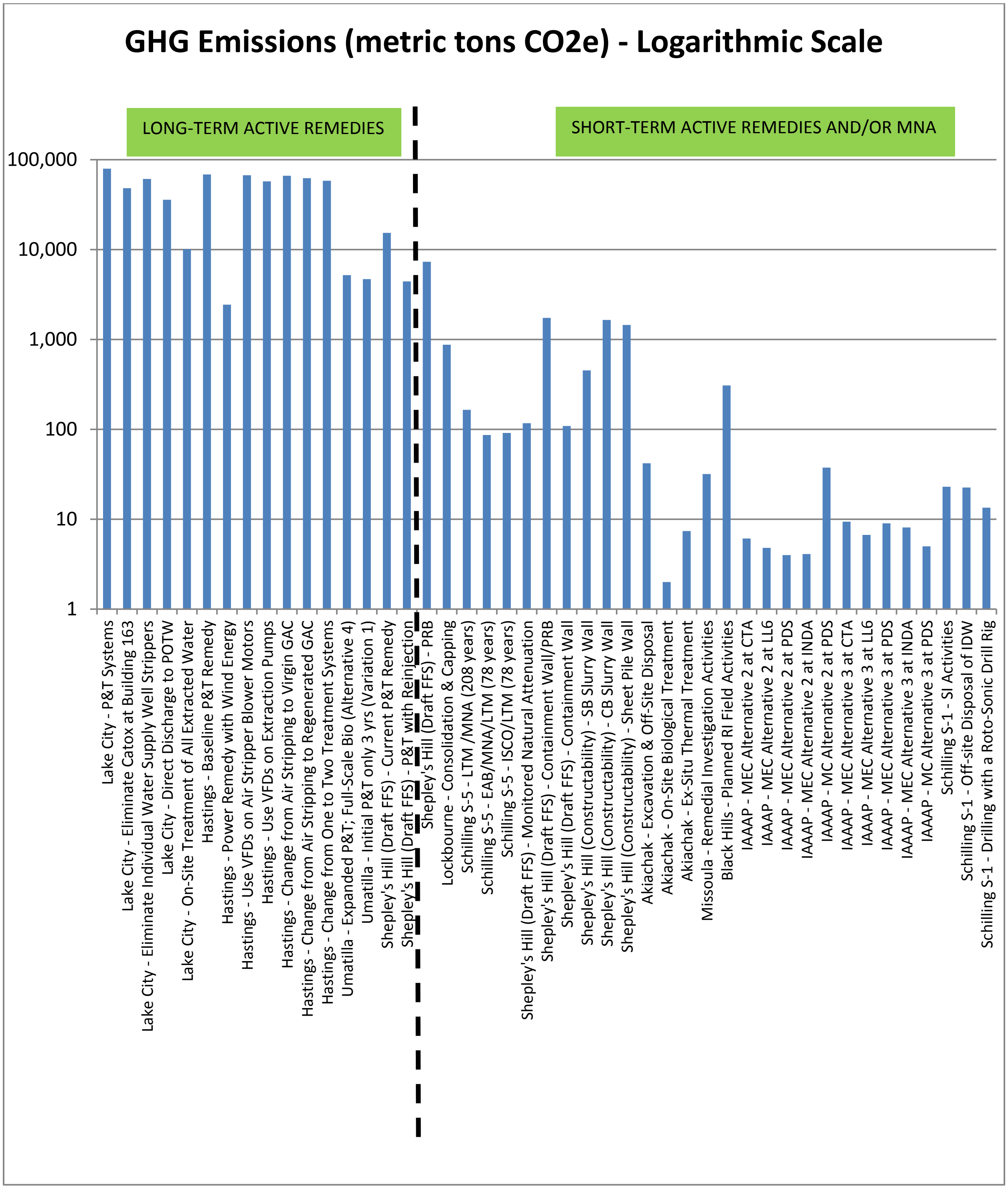

Figure 3-6. Greenhouse Gas Emissions for Pilot Project Alternatives (Logarithmic Scale)

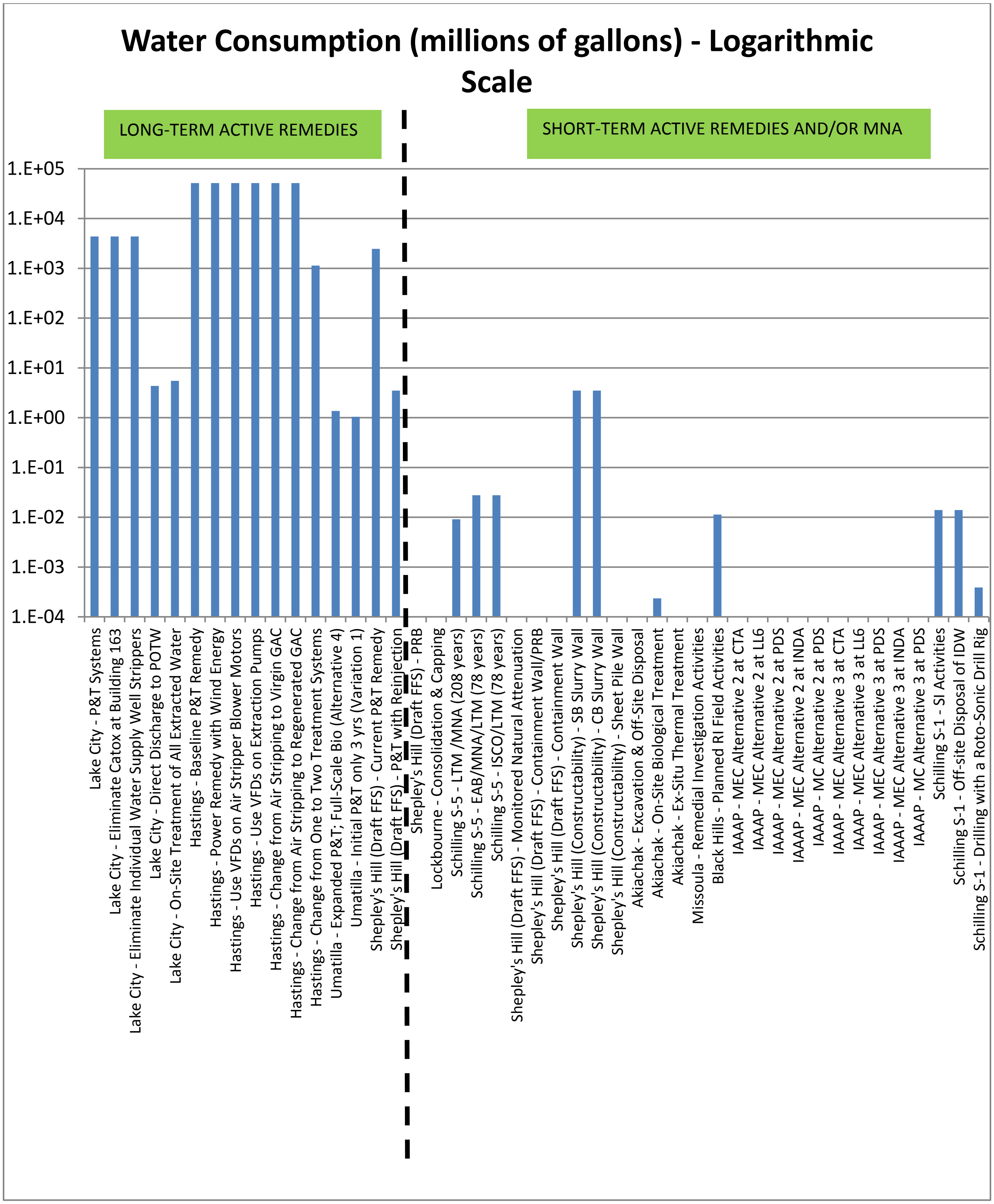

Figure 3-7. Water Consumption for Pilot Project Alternatives (Logarithmic Scale)

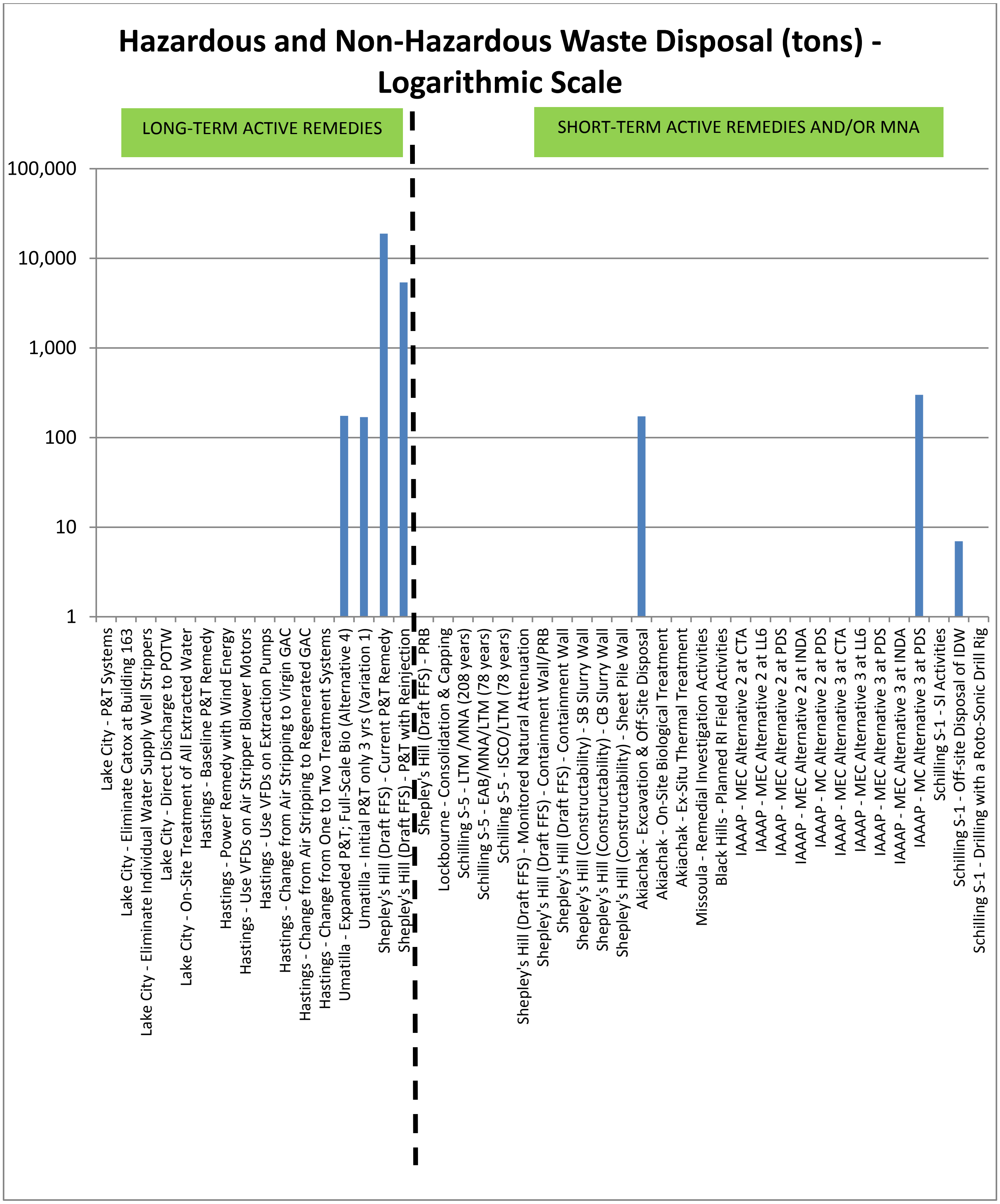

Figure 3-8. Hazardous and Non-Hazardous Waste Disposal for Pilot Project Alternatives (Logarithmic Scale)

3.2.3 Development of a Screening Approach to Evaluate Applicability of Quantitative Footprint Evaluation

The Study results suggest that it is always beneficial to evaluate a list of GSR BMPs for applicability to a project in any phase of the remedial process. Review of GSR BMPs requires minimal time investment (i.e., the Pilots typically required 2-3 hours for review of GSR BMPs). A more detailed quantitative footprint evaluation with a tool such as SiteWise™ requires more effort and resources to perform and document. For projects expected to have small footprints, it may not be cost-effective to perform a quantitative footprint evaluation. For projects expected to have large footprints (generally long-term active remedies) there is a greater potential benefit from quantifying footprints and potential footprint reductions.

The results of the quantitative footprint evaluations for the Pilot Projects (e.g., Figures 3-1 to 3-8) suggest that there is likely a differentiation between long-term active remedies and short-term active remedies. However, some short-term active remedies could also have large footprints, such as in-situ thermal treatment (ISTT), large-scale in-situ chemical oxidation (ISCO), and large-scale dig-and-haul. None of the Pilot Projects included large-scale applications of those short-term active remediation technologies[3]. Therefore, a screening methodology was developed within the Study (based on other work performed by USEPA) to allow a GSR practitioner to easily differentiate sites likely to have high quantitative footprints. This screening approach is detailed in Section 2.1.4 of Appendix A, and is summarized as follows:

- The screening involves a preliminary and simplified evaluation of a project's approximate energy footprint (as a proxy for other footprints such as emissions) in order to determine whether the footprint is significant enough to merit quantitative footprint of GSR metrics with SiteWise™. The screening threshold of 10,000 MMBtus is recommended based on visual inspection of Figures 3-1 and 3-5 (10,000 MMBtus is the approximate total energy use cut-off between "short-term active remedies and/or MNA" and "long-term active remedies" on those figures). This Study indicated very significant potential GSR footprint reductions and associated significant cost savings from implementation of opportunities identified in the GSR Evaluations for projects with energy use above this threshold, with the related potential for this information to be important in remedial decision making (see additional discussion in Section 4). If the preliminary screening indicates a large enough footprint (i.e., above the threshold 10,000 MMBtus of energy use over the course of the remedy), then detailed footprint quantification with SiteWise™ or a similar tool is recommended for inclusion in a GSR Evaluation. If a project falls below the screening threshold of 10,000 MMBtus additional footprint quantification may not be necessary but can be performed if otherwise desired and/or needed to address specific concerns of one or more stakeholders.

- To determine if remedial activities fall above or below the threshold of 10,000 MMBtus using this screening approach, the following approach is recommended:

    1. Identify the top three likely contributors to the remedy's overall footprint based on professional judgment. For example, the top three footprint contributors for a large dig and haul remedy might be equipment operation, transportation and disposal of excavated material, and personnel transportation to and from the site. In Table 3-6 (equivalent to Table 2-2 in Appendix A), quantities for those different activities or materials can be

[3] The alternatives for the Former Schilling Atlas Missile Site S-5 Pilot Project included footprinting of an ISCO alternative, but in that case the potential ISCO treatment was limited in areal extent and duration. The Akiachak FSA Pilot Project included a small-scale dig-and-haul.

entered (using units appropriate for each item).

2. Use the conversion factors in Table 3-6 (i.e., "# of MMBtus in One Physical Unit (approx)") to equate those quantities and physical units into approximate MMBtus of energy use.

3. Sum the calculated MMBtus to produce a rough total for energy use, which can then be compared to the screening threshold of 10,000 MMBtus.

An example of the screening calculation is provided in Table 3-7 for a pump-and-treat system over a 20-year projected operation where the result exceeds the threshold of 10,000 MMBtus. Note that different items have different units (i.e., units appropriate for that item) and those values are then converted into approximate energy use. The screening results would suggest that a quantitative footprint evaluation is merited for the example pump-and-treat system (i.e., high potential for reduction of cost and/or other footprints). Another example of the screening calculation is provided in Table 3-8 for a small short-term dig and haul remedy where the result does not exceed the threshold of 10,000 MMBtus. The screening results for the example short-term dig and haul remedy suggest that a quantitative footprint evaluation is optional, depending on whether or not it is desired and/or needed to address specific concerns of one or more stakeholders. If not, a qualitative consideration of GSR BMPs may suffice.

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Table 3-6
Screening Calculation to Evaluate Applicability of Quantitative Footprinting

Project Name: {insert project name} Threshold Value: 10,000 MMBtus **Item**	**Physical Unit**	**# of MMBtus in One Physical Unit (approx)**	Enter site-specific data for top 3 footprint contributors here ↓ **# of Physical Units Consumed by Remedial Activity**	Calculate MMBtus here using formula below ↓ **# of MMBtus associated with Remedial Activity (Physical Units Consumed x MMBtus per Physical Unit)**
Electricity use	kWh	0.01		
Continuous electric motor operation	HP-hr	0.01		
Natural gas use	ccf or therm	0.1		
Diesel or gasoline use	Gal	0.1		
Onsite heavy equipment use	HP-hr	0.005		
Excavation	Cubic yard	0.002		
Trenching and pipe installation	Linear foot	0.001		
Well installation (including drill rig)	Vertical foot	0.5		
Personnel transportation	Mile	0.005		
Materials or waste transportation	Mile	0.02		
Materials or waste transportation	Ton-mile	0.0033		
Refined materials use	Lb	0.01		
Unrefined materials use	Ton	0.01		
Water discharge to the sanitary sewer	1,000 Gal	0.01		
Waste disposal (drums)	Drum	0.001		
Waste disposal (bulk)	Ton	0.1		
Laboratory analysis	$	0.01		
			Total Energy Use (MMBtus)	

If total for 3 largest items is < 10,000 MMBtus, footprinting may be omitted (if not otherwise desired)

Table 3-7
Example of Screening for Long-Term Active Remedy (Pump and Treat, 20 Years)

Project Name: P&T, 20 Years
Threshold Value: 10,000 MMBtus

Item	Physical Unit	# of MMBtus in One Physical Unit (approx)	Enter site-specific data for top 3 footprint contributors here ↓ # of Physical Units Consumed by Remedial Activity	Calculate MMBtus here using formula below ↓ # of MMBtus associated with Remedial Activity (Physical Units Consumed x MMBtus per Physical Unit)
Electricity use	kWh	0.01	20,000,000	200,000
Continuous electric motor operation	HP-hr	0.01		
Natural gas use	ccf or therm	0.1		
Diesel or gasoline use	Gal	0.1		
Onsite heavy equipment use	HP-hr	0.005		
Excavation	Cubic yard	0.002		
Trenching and pipe installation	Linear foot	0.001		
Well installation (including drill rig)	Vertical foot	0.5		
Personnel transportation	Mile	0.005		
Materials or waste transportation	Mile	0.02		
Materials or waste transportation	Ton-mile	0.0033		
Refined materials use	Lb	0.01		
Unrefined materials use	Ton	0.01		
Water discharge to the sanitary sewer	1,000 Gal	0.01	5,000,000	50,000
Waste disposal (drums)	Drum	0.001		
Waste disposal (bulk)	Ton	0.1		
Laboratory analysis	$	0.01	1,000,000	10,000
			Total Energy Use (MMBtus)	**260,000**

Total for 3 largest items is > 10,000 MMBtus so detailed footprinting should be performed

Table 3-8
Example of Screening for Short-Term Active Remedy (Small Dig and Haul)

Project Name: Small Dig and Haul
Threshold Value: 10,000 MMBtus

Item	Physical Unit	# of MMBtus in One Physical Unit (approx)	Enter site-specific data for top 3 footprint contributors here ↓ # of Physical Units Consumed by Remedial Activity	Calculate MMBtus here using formula below ↓ # of MMBtus associated with Remedial Activity (Physical Units Consumed x MMBtus per Physical Unit)
Electricity use	kWh	0.01		
Continuous electric motor operation	HP-hr	0.01		
Natural gas use	ccf or therm	0.1		
Diesel or gasoline use	Gal	0.1		
Onsite heavy equipment use	HP-hr	0.005	20,000	100
Excavation	Cubic yard	0.002		
Trenching and pipe installation	Linear foot	0.001		
Well installation (including drill rig)	Vertical foot	0.5		
Personnel transportation	Mile	0.005		
Materials or waste transportation	Mile	0.02		
Materials or waste transportation	Ton-mile	0.0033	500,000	1,650
Refined materials use	Lb	0.01		
Unrefined materials use	Ton	0.01		
Water discharge to the sanitary sewer	1,000 Gal	0.01		
Waste disposal (drums)	Drum	0.001		
Waste disposal (bulk)	Ton	0.1	5,000	500
Laboratory analysis	$	0.01		
			Total Energy Use (MMBtus)	2,250

Total for 3 largest items is < 10,000 MMBtus so detailed footprinting should only be performed for the dig and haul remedy if desired and/or needed to address specific concerns of one or more stakeholders

This screening approach was tested using several of the Pilot Project alternatives. A summary of this testing is provided below.

- Lake City (Baseline Alternative)
    - The largest three contributors for the 30 year active remedy duration were assumed to be electricity usage (approximately 22 million kWh), water discharge to sanitary sewer (approximately 4 billion gallons), and natural gas usage (approximately 4 million therms).
    - Based on conversion factors in Table 3-6, this would result in energy use of approximately 660,000 MMBtus, well above the threshold of 10,000 MMBtus
    - The actual energy footprint calculated by SiteWise™ for this alternative in the Pilot Project (i.e., accounting for more contributors, more precise estimates, and more detailed conversion factors) was 911,490 MMBtus over 30 years, also well over the threshold of 10,000 MMBtus.
- Shepley's Hill (Draft FFS Phase- Baseline Alternative)
    - The largest three contributors for the 100 year active remedy duration were assumed to be electricity usage (approximately 14.5 million kWh), water discharge to sanitary sewer (approximately 2 billion gallons), and refined materials usage (approximately 8 million pounds).
    - Based on conversion factors in Table 3-6, this would result in energy use of approximately 245,000 MMBtus, well above the threshold of 10,000 MMBtus.
    - The actual energy footprint calculated by SiteWise™ for this alternative in the Pilot Project (i.e., accounting for more contributors, more precise estimates, and more detailed conversion factors) was 250,035 MMBtus over 100 years, also well over the threshold of 10,000 MMBtus.
- Akiachak - Excavation & Off-Site Disposal
    - The largest three contributors were assumed to be materials or waste transportation (approximately 600,000 ton-miles), on-site heavy equipment use (approximately 16,000 HP-hr), and laboratory analysis (approximately $5,000).
    - Based on conversion factors in Table 3-6, this would result in energy use of approximately 2,110 MMBtus, well below the threshold of 10,000 MMBtus.
    - The actual energy footprint calculated by SiteWise™ for this alternative in the Pilot Project (i.e., accounting for more contributors, more precise estimates, and more detailed conversion factors) was 494 MMBtus, which is also well below the threshold of 10,000 MMBtus. The Project Team noted, however, that there were 21 sites similar to the Akiachak site where the Akiachak GSR evaluation could be applied in the future. The combined energy use at these 21 sites would likely exceed the 10,000 MMBtus threshold. In this case, then, the performance of a quantitative GSR evaluation would be justified due to its potential application to other sites.

The SiteWise™ tool includes much more detail than these screening calculations. For instance, transportation of materials in the screening tool does not differentiate the type of transport (e.g., vehicle, rail, air, or barge) whereas the SiteWise™ tool does account for those details. However, the screening calculations are much quicker and easier to perform and provide an order-of-magnitude result that will help to differentiate projects with relatively large footprints from projects with relatively low footprints. Section 4.8 provides further discussion and an example regarding the potential for relatively high potential reductions in cost and/or other footprints for sites with elevated screening values for approximate energy use.

3.3 SUMMARY OF QUALITATIVE CONSIDERATIONS FOR PILOT PROJECTS

3.3.1 Considerations Regarding Land Use

As discussed earlier, considerations regarding land use include the following:

- Land transferred or made available for potential beneficial use (including habitat/wetland creation)
- Existing ecosystem destruction
- Time frame for land reuse
- Flexibility and breadth of options for site reuse

There were some examples from the Pilot Projects where land use considerations were pertinent, including the following:

- Lockbourne Landfill: The area where waste will be excavated for consolidation under the cap will allow for unrestricted industrial/commercial re-use. In the capped area, land use will be further restricted to not allow any penetration. Additionally, the Project Team stated they would reduce landfill slopes rather than the landfill footprint if less waste is encountered during consolidation, which could lead to a wider variety of potential reuse options for the capped area. Also, the excavation design was sensitive to minimizing the amount of land that needed to be disturbed (i.e., vegetation clearing) which would preserve as much habitat as possible.

- Iowa AAP: The Project Team indicated they will minimize disturbances to land and vegetation in order to preserve habitat for the Indiana Bat, a federally listed endangered species, and other wildlife. In addition, tree removal and the use of heavy equipment are avoided between April 15 and September 15 so as not to disturb the Indiana Bat.

- Fort Missoula Blue Mountain Training Area: The Project Team indicated that one reason for using man-portable geophysics applications versus vehicle-towed geophysics is to minimize disturbance to the habitat (e.g., less clearing).

It is likely that some other sites have more substantial potential tradeoffs between remedy cost and flexibility of future land use for competing alternatives, compared to those observed in the Pilot Projects.

3.3.2 Considerations Regarding Aesthetics

Reductions in items such as odor, noise, dust, and visual impacts associated with the remedial process are included in the list of GSR BMPs. These issues are difficult to quantify, but can be extremely important for project stakeholders at some sites. There were some examples from the Pilot Projects where considerations regarding aesthetics were identified as a concern during consideration of the GSR BMPs, including the following:

- Schilling Air Force Base Atlas Missile Facility S-1: Work was not performed on the weekends in order to avoid disturbing the landowner when he was home.

- Akiachak FSA: On-site work begins early in the morning to minimize disturbances to the community, since most activity in the community occurs in the afternoon.

- Former Black Hills Army Depot: Detonation of recovered munitions (if needed) will be done at the end of the day, with notification procedures as described in the work plan, to mitigate noise disturbance.

- Fort Missoula Blue Mountain Training Area: During detonation of recovered munitions (if needed) sandbags will mitigate noise, and there are also rules regarding weather conditions that help to mitigate noise. Use of man-portable equipment for geophysics will minimize noise and visual disturbance to the public using the trail system, compared to a vehicle towed approach. Also, since some of this work is being performed along a public trails system, the Project Team is aligning schedules to perform trail work on weekdays only, since trail use is heaviest on weekends.

These types of considerations regarding aesthetics are most likely to be a concern when remedial activities are near residential areas.

3.3.3 Considerations Regarding Renewable Energy

As discussed earlier, renewable energy may be applicable to a remedy in several ways:

- Renewable energy may be generated on-site for direct use as part of the remedy (e.g., solar panels used to power a trailer).

- Renewable energy may be associated with the off-site generation of electricity used on-site for the remedy.

In the Pilot Projects, there was no significant on-site generation of renewable energy associated with the baseline alternatives. For the *Former NAD – Hastings* Pilot Project, there is some renewable energy (solar) associated with the office, but it is considered to be negligible as a percentage of the overall energy usage associated with the remedy. The Pilot Project GSR evaluations included some recommendations and/or discussion pertaining to on-site generation of renewable energy, including the following:

- Former NAD – Hastings: One recommendation from the GSR evaluation was to consider powering the remedy with wind energy, and another was to potentially generate renewable energy from the discharge of treated water.

- Umatilla Chemical Depot: The tanks for the corn syrup (bioremediation substrate) require heating, and the Project Team indicated they are considering using solar power (presumably solar thermal) to heat the holding tanks for corn syrup rather than dropping a power line. The GSR evaluation recommended that potential use of renewable energy for that purpose be fully evaluated during the design phase.
- Lockbourne Landfill: Re-using the capped area for wind energy was discussed, but the Project Team indicated that would likely compromise the cap (would require structures that pierce the cap, which the Project Team indicated was not desirable) and also is likely not feasible given the proximity to an active airport runway. Using the capped area for crops (e.g., biodiesel) was also discussed, but the Project Team indicated that would likely cause negative impacts related to sediment and fertilizer runoff at the storm water drainage ditch. However, the GSR evaluation report did mention that adding solar panels for electricity generation is a potential future use of the capped area if designed with non-penetrating (i.e., ballasted) supports.

In addition, one of the case studies in Appendix B (*Beneficial Use of Treated Water: Joint Base Lewis-McChord*) discusses the use of treated water (more than 1,500 gallons per minute) for cooling at a nearby hospital, accomplished by passing the treated water through a heat exchanger for the facility air conditioning system. This is considered a form of on-site renewable energy use, since it offsets other energy use otherwise required for cooling.

GSR BMP D-7 (consider purchase of renewable energy certificates to offset emissions from the remedial activities) was considered potentially "applicable" for some of the Pilot Projects but was not considered feasible for some Pilot Projects and was not otherwise "practical" for the other Pilot Projects, based on feedback from the Project Teams regarding increased costs (i.e., increasing costs would not be allowed by policy at some sites, and reducing costs was a higher priority at other sites). A Memorandum titled *Department of the Army Policy for Renewable Energy Credits*, dated 24 May 2012, states that "the Army shall not purchase RECs solely to meet Federal renewable energy goals," but it is possible that Project Teams might in some cases consider the purchase of RECs to address concerns of one or more stakeholders at a specific site.

With respect to renewable energy associated with off-site generation of electricity used on-site for the remedy, the Pilot Projects indicated a wide variety of results. Some examples are summarized below:

- Akiachak FSA (Baseline Alternative): The percentage of electricity from renewable sources for the region based on eGRID (www.epa.gov/egrid) is approximately 66% (most of which is hydropower), but the amount of energy use for the remedy from renewable energy is still negligible because electricity use represents such a small portion (<0.01%) of the overall energy use for this remedy, which is dominated by transportation and equipment use.

- Black Hills (Baseline Alternative): The percentage of electricity from renewable sources for the region based on eGRID (www.epa.gov/egrid) is approximately 8.8%, but only a small percentage of the overall energy use for the remedy is from electricity, such that the amount of total energy use from renewable energy is negligible for this remedy.

- Shepley's Hill Landfill (Draft FFS Phase, Baseline Alternative): From SiteWise™, total energy usage over 100 years of operation is 250,035 MMBtus, and electricity use accounts for 133,165 MMBtus of that total (pumps, mixers, and heater). Thus, 53% of energy use is electricity. From eGRID (www.epa.gov/egrid), generation mix for the region is 11.3% renewable resources, mostly hydropower and biomass. Thus, 53% x 11.3% = 6.0% of total energy use for the remedy is from renewable resources.

- Umatilla Chemical Depot (Baseline Alternative): According to eGRID (www.epa.gov/egrid), the percentage of electricity from renewable sources for the region is 50.93% (most of which is hydropower). There are other energy uses associated with the remedy. Assuming all other fuels used and all other energy use for production of materials are from non-renewable sources, approximately 13.7% of total energy use is from renewable sources.

These examples illustrate that renewable energy use associated with off-site production of electricity used for a remedy depends on the amount of electricity used, and the mix of renewables used to generate that electricity which varies considerably depending on the location of the site. Note that these observations are made to better understand how the sources of electricity for a specific project impact the remedy footprint (e.g., how much of the electricity comes from hydrothermal versus coal results in different emissions) rather than quantifying how much new renewable electricity is "owned" the Army.

3.3.4 Potential Constraints to Implementation of GSR Opportunities

There are potential constraints that potentially limit implementation of GSR opportunities, including the following:

- Cost
- Schedule
- Contracting
- Program policy
- Regulatory and public reviews/input
- GSR evaluation timing within the remedial phase
- Other project-specific variables and logistics

As discussed earlier, GSR opportunities are potentially "practical" if they are feasible from a technical standpoint and provide net GSR benefits as shown from the economic, social, and environmental metrics and other GSR considerations evaluated in this Study. However, the issues listed above also impact the potential implementability of the GSR opportunities. Examples of these limitations are discussed in Section 4.8. These types of issues can also be addressed as part of "qualitative considerations" during a GSR evaluation.

3.4 ADDITIONAL CASE STUDIES

Appendix B includes several short case studies that illustrate GSR considerations for projects and/or activities beyond those evaluated in the Pilot Projects. The following case studies are presented in Appendix B:

- *Beneficial Use of Treated Water: Joint Base Lewis-McChord*. This case study summarizes footprint reductions associated with beneficial use of over 1,500 gallons per minute of treated water from the remedy, for cooling of a nearby hospital. The treated water is subsequently discharged to a water feature (a creek) in the atrium of the hospital, then to a lined pond on the northeast side of the hospital, and finally to an infiltration pond where it percolates into the shallow aquifer. Even during periods when cooling at the hospital is not needed, the discharge of treated water to the water feature/pond is maintained and is seen as a beneficial use (i.e., maintains flow in the creek). In addition to substantial energy and emission offsets, the water reuse also conserves local water resources and benefits the creek ecosystem. Although this practice did not directly reduce costs for the remedy, it offsets the costs for the hospital to obtain water.

- *Controlled Detonation Chamber (CDC): Multiple MMRP Sites, California*. This case study summarizes findings from a quantitative footprint analysis based on parameters for deploying a Controlled Detonation Chamber (CDC) sequentially at four locations in California. A CDC destroys Munitions and Explosives of Concern (MEC) while protecting humans and the environment from the detonation. Where appropriate, this technology provides an alternative to the traditional practices of open burn/open detonation (OB/OD) and blow-in-place (BIP) for destruction of unexploded ordnance (UXO). In cases where it is unsafe to move the UXO items, a CDC cannot be used. It is expected that the environmental footprints for a CDC will be generally higher than for BIP (or OB/OD) due to the transportation requirements for the CDC unit. This case study was performed to see if the relatively higher GSR footprints for use of a CDC would be sufficiently large to approach or exceed an energy use screening threshold of 10,000 MMBtus. The calculated energy footprint of 609 MMBtus is well below the threshold of 10,000 MMBtus developed in the GSR Study to identify projects mostly likely to benefit from calculating quantitative footprints. This is consistent with the observations from the GSR Study that short-term active remedies have minor footprints, and therefore are likely to benefit less from quantitative footprinting efforts than long-term active remedies.

- *Comparison of Low Flow vs. Passive Diffusion Bag Sampling: Joint Base Lewis-McChord*. This case study summarizes a comparison of footprints for passive diffusion bag (PDB) sampling versus low flow sampling. Currently, 61 wells are sampled for volatile organic compounds, with 56 of those using PDBs for sample collection. Footprint reduction from using PDBs is driven by the reduced time spent in the field. A two-person team can sample 12 wells per day using PDBs while only being able to sample 5 wells per day using low flow methods. More days in the field translates to more vehicle miles, higher accident risk, and more energy and equipment use. Annual impact reductions are summarized as follows:

    - 54% reduction of energy used
    - 55% reduction in GHG emissions
    - 63% reduction in criteria pollutant
    - 59% reduction in accident/injury risk

- *Comparison of the Different Well Installation Techniques: Schilling Air Force Base Atlas Missile Facility S-1, Kansas*. The installation of five monitoring wells at a Formerly Used Defense Site (FUDS) was used as a scenario to model a case study comparing five different methods for monitoring well installation. Drilling methods were included based on frequency of use (cable tool, hollow stem auger, and mud rotary) and potential GSR benefits (direct push and sonic drilling). Results of the case study showed that mud rotary drilling has the largest environmental impact followed by hollow stem auger, sonic drilling, cable tool, and direct push. Several other insights were also discovered including:

    - Handling of Investigation Derived Waste (IDW) has a relatively small impact compared to the other well installation activities.

    - Not surprisingly, transportation of equipment and personnel was responsible for the majority of the environmental impact of the drilling rigs that use the least amount of fuel (cable tool and direct push).

- At locations where direct push well installation is feasible, it creates only 36% of the GHG emissions and 4% of the NOx and SOx emissions that other common technologies such as hollow stem auger generate.

The format of the case studies in Appendix B can potentially be used to highlight other Army GSR cases studies in the future.

Case studies illustrate concepts and/or provide examples, and when those are general concepts they are already incorporated in the GSR BMPs (Attachment A-1 of Appendix A). However, there are site-specific aspects to quantitative evaluation of GSR metrics, and it is generally not advisable assume that a conclusion from a case study for one project applies equally to all other projects.

4.0 FINDINGS AND LESSONS LEARNED FROM PILOT PROJECT GSR EVALUATIONS

4.1 CONSIDERATION AND IMPLEMENTATION OF GSR

Project Teams associated with the Pilot Projects had different levels of interest and contributions regarding GSR. Early and comprehensive engagement of the Project Team (including the Project Team contractor) regarding GSR was found to be important in enhancing the likelihood and the extent to which GSR opportunities would be considered and implemented. Some examples are provided below:

- *Lockbourne Landfill*. The Project Team had already compiled a list of their own GSR BMPs and conducted a thorough review of which of those BMPs could potentially be applicable for this project. Thus, the Project Team had already considered many of the GSR practices prior to the Pilot Project GSR evaluation. The GSR evaluation for this Pilot Project highlighted the considerable attention this Project Team has given to GSR considerations (which for this project were qualitative in nature). The Project Team engaged the land owner and the regulators in the GSR discussions. In addition, GSR language was already included in the Project Team contractor contract, with related contractor GSR engagement.

- *Fort Missoula Blue Mountain Training Area*. The Project Team had extensively considered GSR principles in developing the RI/FS Work Plan, and had already included a page entitled "Sustainability Commitment" on the public project website. The GSR evaluation for this Pilot Project highlighted the extensive consideration of GSR principles by the Project Team, and no significant additional items regarding GSR were suggested, other than the possibility of renting an existing on-site office space if it was determined that an office trailer was necessary. The previous application of numerous GSR BMPs by the Project Team was partly the result of the Project Team's clear intent to incorporate GSR considerations throughout the planning process, which enhanced the integration of GSR considerations throughout the remedial process. It is believed that this was the first Army MMRP project solicitation that included GSR requirements in the bid documents and contract.

Many of the GSR considerations are consistent with approaches that would otherwise be selected to minimize cost or address public concerns, but highlighting GSR during project planning improves the likelihood that those considerations will be accounted for during project planning and execution.

One common element for many of the Pilot Projects was that the project schedule places constraints on the consideration and incorporation of GSR opportunities. All Project Teams indicated that one of the requirements for participation in the Study was that the GSR evaluation and potential implementation of GSR recommendations would not adversely affect the project schedule. As a result, the schedules of some of the projects did not allow for full GSR consideration and incorporation. Early engagement and inclusion of stakeholders regarding GSR, and having the Project Team perform the GSR evaluation (rather than a third party which was the case in the Study), is expected to increase the potential consideration and incorporation of GSR opportunities. It was also noted that GSR evaluations based on a 30 percent design, or a draft final FFS, can be too late for complete GSR consideration within that remedial phase if significant planning and remediation logistics restrict the potential to make subsequent changes. One approach is to perform a conceptual and qualitative GSR evaluation in an early stage of a remedial phase (e.g., early in the design phase), with consideration of a more quantitative GSR evaluation later in the remedial phase when more information is available.

Documentation of the consideration and implementation of GSR recommendations by the Project Teams in the Study pilots was inconsistent (see Appendix C). In some cases GSR was highlighted in Project Teams reports and/or websites, but some Project Teams did not include any description of GSR consideration in project documents, and in others the only documentation of GSR consideration was that identified by the Study Team. In some cases, the consideration and incorporation of GSR was documented in one remedial phase but not carried forward into subsequent phases (e.g., GSR considerations documented in the Proposed Plan were not included in the Decision Document). It is recommended that Project Teams determine during project planning where the GSR consideration and implementation will be documented (i.e., a section and/or appendix of a Project report) and plan for continuity of GSR documentation across multiple remedial phases. More information about GSR documentation is included in the GSR Approach (Appendix A, Section 2.4).

In a number of the Pilot Projects in the Study, GSR contract language needed to be added to the contracts with the project contractor to allow the project contractor to participate in the Study GSR activities. Thus, it is recommended that GSR contract language to be included in Army environmental remediation project contracts to ensure that GSR consideration is in scope for the project contractor(s). Procedures to include GSR contract language are described in the GSR Approach (Section 2.1.8 of Appendix A) and example contract language is included in Attachment A-2 of Appendix A.

4.2 APPLICATION OF GSR FOR DIFFERENT REMEDIAL PHASES

For all remedial phases, the March 2012 DERP Manual instructs DoD Components to consider and implement GSR opportunities when feasible and ensure the use of GSR remediation practices where practicable based on economic and social benefits as well as costs. The overall GSR Approach described in Section 1.5, including consideration of GSR BMPs and documenting the consideration and implementation of GSR opportunities, applies to every phase of the remedial process. The Study results suggest that it is always beneficial to evaluate a list of GSR BMPs for applicability to a project in any phase of the remedy. Review of GSR BMPs requires a minimal time investment (i.e., the Pilots typically required 2-3 hours for review of GSR BMPs). The vast majority of BMPs for GSR apply to every phase of the remedial process, so there is no significant benefit to differentiating separate lists of GSR BMPs by remedial phase. For instance, BMPs related to field investigation are obviously appropriate in the RI phase, but field investigations for pilot studies or treatability studies also occur in the RD phase and during optimization activities in the O&M phase. Similarly, BMPs related to groundwater treatment and disposal are obviously appropriate for a pump and treat (P&T) system in the O&M phase, but similar BMPs could apply to an initial response during the RI phase or to aquifer testing during the RI or RD phase.

Therefore, the process for GSR evaluation presented herein includes review of the full list of BMPs in Attachment A-1 of Appendix A during a GSR evaluation, regardless of remedial phase. The format of the BMPs provided in Attachment A-1 of Appendix A allows the BMPs applicable for the specific project to be differentiated from those not applicable. A further advantage of this approach is that it assists with forward planning for GSR issues. The process of considering the entire BMP checklist during a GSR evaluation, regardless of remedial phase, will prompt consideration regarding how specific GSR practices can be planned for in future phases of the remedial process, even if those practices are not applicable in the current phase.

Use of methodologies with inherent GSR characteristics (e.g., optimization, third party review, and systematic planning), alone and in conjunction with GSR evaluations, can result in significant GSR footprint reductions and related cost savings. The GSR Approach (Appendix A, Section 2.1.1) provides additional detail regarding the use of these methodologies to reduce remediation footprints in various remedial phases.

A detailed quantitative footprint evaluation with a tool such as SiteWise™ requires additional effort and resources to perform and document beyond the GSR BMP consideration described above. The GSR Approach developed in the Study includes a method that can guide the decision as to whether or not quantitative footprints are recommended to be calculated (Section 3.2.3). If a project falls below the screening threshold of 10,000 MMBtus, additional footprint quantification may not be necessary but can be performed if otherwise desired and/or needed to address specific concerns of one or more stakeholders.

The following additional considerations are noted with respect to quantitative evaluation of footprints:

- Quantification of footprints should generally not be performed for the RI phase because footprints for those activities are generally low, and the focus of the RI should be on obtaining the best data quality for making remedy decisions. Application of GSR BMPs, however, is appropriate for every project including the RI phase.

- In general, the phases in which the largest opportunities for environmental footprint reductions are likely (and therefore the phases in which quantitative footprints are potentially most useful) are FS/remedy selection, design (and the follow-on construction), and O&M.

- Quantitative case studies such as those in Appendix B (e.g., comparing sampling methods or drilling techniques) can be qualitatively applied to other projects and remedial phases (including the RI phase), although additional project-specific factors must also be considered.

The March 2012 DERP Manual also includes direction regarding GSR in specific remedy phases, as follows:

- In the FS phase, evaluate remedial alternatives to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems on the environment.

- In the Remedial Action Work Plan (RAWP) in the Remedial Action phase, consider remediation technologies that are conducted in a sustainable manner; are efficient; and are environmentally, economically, and fiscally sound, in order to reduce the footprint of remediation strategies on the environment.

- In the Remedial Operation phase, minimize the environmental footprint as part of optimization performed.

Specific considerations for performing GSR evaluations in the three remedy phases identified in the DERP manual as listed above are discussed in detail in Sections 3.1.1 to 3.1.3 of Appendix A, and considerations for performing GSR evaluations in other remedial phases are discussed in Section 3.1.4 of Appendix A.

The level of information that is needed for the GSR evaluation will vary depending on the degree of quantification required for GSR metrics. For example, in an FS, a conceptual GSR evaluation performed during the alternative development process to incorporate technologies with GSR characteristics would require a relatively low level of quantitative information whereas a detailed comparison of GSR metrics across a series of alternatives would require more quantitative information. Similarly, incorporation of conceptual GSR ideas could occur at an early stage in the design process, with detailed quantification of

GSR metrics performed later in the design

In all remedial phases it is important to identify contracting strategies and constraints early in the process so that GSR can be effectively incorporated into the project (i.e., consider which phases will be combined into separate contracts, what types of contracts will be used, and what level of GSR consideration will be needed for each contract). Examples of contract language for inclusion of GSR in contracts are provided in Examples 2-6 to 2-8 and in Attachment A-2 of Attachment A. Regardless of remedial phase, a GSR evaluation should attempt to anticipate and address elements likely to occur in future remedial phases.

4.2.1 Example of How Data Quality Varies by Remedial Phase

Two separate GSR evaluations were conducted for Shepley's Hill Landfill, one based on a draft version of the FFS, and a subsequent evaluation in the Constructability Phase for one portion of the remedy (a barrier wall for Plow Shop Pond). The results of these two separate evaluations for the same remedy component (barrier wall) are presented below:

Summary of Quantitative Footprint for Barrier Wall in the Draft FFS Phase versus Constructability Phase

GSR Parameter	Unit	Draft FFS Phase*	Constructability Phase (Baseline Scenario)
Energy Use	MMBtus	1,816	5,905
Global Warming Potential	Metric tons CO2e	109	452
Potable Water Use	1,000s of gallons	Negligible	3,500
Refined Materials Use	Lbs	0	3,428
Unrefined Materials Use	Tons	6,597	6,533

**Refers to Alternative B in the December 2010 Draft FFS*

There are substantial differences in the calculated footprints due to the improved accuracy of information available in the constructability phase. The following observations were noted:

- The increases in energy use and global warming potential in the Constructability Phase evaluation versus the Draft FFS-Phase evaluation are mainly caused by:
    - Increases in estimated equipment use (the Draft FFS Phase evaluation assumed that a single excavator would be used for barrier wall construction and SiteWise™ calculated fuel use, whereas the Constructability Phase information provided a much higher estimated fuel use of 500 gallons of diesel per day); and
    - Increases in energy for production of materials (the Constructability Phase evaluation included more material, partially because more detail was provided in pre-construction documents and partially because the updated version of SiteWise™ had additional options for materials input that were not available at the time of the first evaluation, such as bentonite).
- The increase in water use in the Constructability Phase evaluation is due to the fact that water required for the slurry mix was not accounted for in the Draft FFS Phase evaluation.
- The increase in refined materials in the Constructability Phase use is due to the inclusion of anticipated materials needed for well installation during the pre-construction investigation (not

accounted for in the Draft FFS Phase evaluation), and landfill cap extension over the slurry wall (not accounted for in the Draft FFS Phase evaluation).

- The quantity of unrefined materials use remains approximately the same.

Overall, the increase in calculated footprint for the barrier between the Draft FFS Phase and the Constructability Phase is due in large part to the greater level of detail regarding the remedy construction available for the GSR evaluation at this later phase of the remedy. An increase in footprints is not believed to be a general result, because in other cases the additional information available during the Constructability Phase could cause the calculated footprints to decline compared to an earlier FFS phase.

4.2.2 Example of GSR in one Remedial Phase Addressing Items in a Future Remedy Phase

For one aspect of the Shepley's Hill Pilot Project (a barrier wall), an initial GSR evaluation in the Draft FFS Phase indicated that materials use would account for the majority of the energy use and GHG footprints for construction of that barrier wall. In the subsequent Constructability Phase, one resulting objective was to use barrier wall materials and installation methods that would employ sustainability measures to reduce the associated footprints. This illustrates how results of a GSR evaluation in one remedy phase can help a Project Team to focus on items in subsequent remedial phases that have greatest potential to yield improvements with respect to GSR considerations.

4.3 APPLICATION OF GSR FOR DIFFERENT REMEDIATION TECHNOLOGIES

The results of the quantitative footprint evaluations for the Pilot Projects (e.g., Figures 3-1 to 3-8) suggest that there are much higher footprints (especially for energy use and GHG emissions) for long-term active remedies versus short-term active remedies. For the Pilot Projects, these long-term remedies were for P&T (e.g., Hastings, Lake City, Shepley's Hill, Umatilla) and in-situ bioremediation (Umatilla[4]). However, there are other potentially long-term remediation technologies (e.g., soil vapor extraction, air sparging, etc.) that could also have large footprints. Additionally, there are likely some short-term active remedies that could also have very large footprints, such as in-situ thermal treatment or in-situ chemical oxidation. None of the Pilot Projects included large-scale applications of those short-term active remediation technologies[5]. Therefore, a screening methodology was developed within the Study (see Section 3.2.3) to allow a GSR practitioner to easily differentiate sites likely to have large quantitative footprints.

4.4 MOST IMPORTANT DRIVERS FOR SPECIFIC GSR FOOTPRINTS

The Pilot Projects demonstrate that the key contributors to GSR footprints are site-specific. This is illustrated by the following examples for primary contributors to greenhouse gas emissions:

- Akiachak (baseline) – the largest contributors are transport and disposal of excavated soil (80%) and on-site equipment use (18%).

[4] Quantitative project-specific footprints calculated for the Lake City Pilot Project only pertained to the P&T systems. A generic quantitative comparison of bioremediation substrates was performed for that Pilot Project, but the footprints of the project-specific bioremediation systems were not quantified.
[5] The alternatives for the Former Schilling Atlas Missile Site S-5 Pilot project included footprinting of an ISCO alternative, but in that case the potential ISCO treatment was limited in areal extent and duration.

- Lockbourne Landfill (baseline) – nearly the entire contribution (95%) is from on-site equipment use.

- Shepley's Hill (Draft FFS phase, baseline) – the largest contributors are electricity use (36%) and production of chemicals used in water treatment process (34%).

- Umatilla (baseline) – the largest contributors are production of materials for in-situ bio substrate (48%), electricity use (23%), and rail transport of in-situ bio substrate (15%).

- Hastings (baseline) – nearly the entire contribution is from electricity usage for a long-term pump-and-treat system.

This illustrates the variety of potential contributors to GSR footprints, and that the key contributors are site-specific. This confirms the need for site-specific GSR evaluations.

4.5 WORK-AROUNDS FOR SITEWISE™ AND SUGGESTIONS FOR FURTHER TOOL DEVELOPMENT

SiteWise™ greatly facilitates footprint quantification for energy usage, global warming potential, and air criteria pollutant emissions. In addition, it provides assistance with calculating the amount of materials used. In some cases, the user may find it necessary to input information not included as standard SiteWise™ input, or to use intermediate information from SiteWise™ to make other calculations. Lessons learned during the Study led to the development of a number of "work-arounds" for SiteWise™ discussed in Section 3.3 of Appendix A.

Considerations for further development of SiteWise™ include the following:

- SiteWise™ doesn't calculate NOx, SOx, PM, or water use for off-site manufacturing. This is because these items are considered to have a local effect, and would therefore not have an impact on the area immediately surrounding the site. However, the footprints associated with manufacturing of these items can be significant in the location where the material is manufactured, particularly if materials use represents a large portion of the remedial activity. An option to report estimates for these off-site emissions and water use would be useful.

- SiteWise™ does not include sheets that allow costs of alternatives to be reported in a manner consistent with the cost sheet templates provided in Appendix A (i.e., allowing for input of different capital and annual costs in different years, and a discount rate, so that discounting of future costs can be evaluated). Adding such input cost sheets to SiteWise™ would be an improvement.

- In some cases the number of columns provided in the SiteWise™ input sheets is insufficient, and more columns would be an improvement.

Several other metrics included in the GSR Approach (Appendix A) are not currently included as input or output from SiteWise™, such as hazardous or toxic air pollutants, percent of materials from recycling/reuse, percent of potential waste recycled/reused, and one-way trips through residential areas. Similarly, qualitative items such as ecological considerations and aesthetics are not able to be input into a SiteWise™ data file, and therefore cannot be echoed as SiteWise™ output. The output from SiteWise™ would be more comprehensive if these items can be added in some manner.

4.6 GSR APPLICATION FOR MMRP PROJECTS

This Study included GSR evaluations for 12 Pilot Projects, three of which were for MMRP projects. Relatively low footprints (e.g., energy use, greenhouse gas emissions) were determined for the three MMRP Pilot Projects in the GSR Study. Two of these MMRP Pilot Projects pertained to RI activities, and footprints for activities in the RI phase are generally low (discussed earlier). The third MMRP Pilot Project was in the remedy selection phase, and the remedy alternatives (e.g., fencing and institutional controls, limited excavation and disposal) also had relatively low footprints. These results are consistent with the short-term nature of the MMRP activities for those Pilot Projects, compared to long-term active remedies for MMRP and/or non-MMRP projects such as P&T for groundwater.

A case study (included in Appendix B) was performed during the Study to determine approximate footprints for use of a Controlled Detonation Chamber (CDC) at MMRP sites, to see if those footprints would be significantly higher than those observed in the MMRP Pilot Projects (and higher than the screening threshold of 10,000 MMBtus). The case study was based on parameters for deploying a CDC sequentially at four locations in California, based on information provided in the report "*CDC Optimization Demonstration – Draft Final*" by DeMil International, Inc. (August 2005) which evaluated the logistical, regulatory, and economic requirements of deploying a transportable CDC to multiple sites within a limited geographic area. A transportable Model T-10 CDC was used to destroy munitions that were safe to move at the following four locations in California: Fort Hunter Liggett; Mare Island; Camp Roberts; and Seal Beach Naval Weapons Station.

The SiteWise™ tool was used for the case study GSR footprint calculations. No attempt was made to calculate comparative GSR footprints for OB/OD or BIP activities (which would be expected to be lower), since parameters for those approaches to UXO destruction were not documented in the report provided. The following total footprint results were calculated for transportation and use of the CDC at the four locations:

- 609 MMBtu of energy used
- 44 metric tons of CO_2e (equivalent global warming potential of carbon dioxide)
- 0.0823 metric tons of NO_x+SO_x+PM (nitrogen oxides, sulfur oxides, and particulate matter)
- 1,060 lbs of refined materials use (for donor explosive)
- 7.1 tons of waste generation

The calculated footprints for energy use and emissions are minor (though likely larger than for UXO destruction using OB/OD or BIP). For instance, the energy footprint of 609 MMBtus is well below the threshold of 10,000 MMBtus developed in the GSR Study to identify projects mostly likely to benefit from calculating quantitative footprints. This is consistent with the observations from the GSR Study that short-term active remedies have minor footprints, and to the extent that MMRP activities consist of short-term active remediation, quantitative footprints will likely be minor. However, the screening approach developed for the Study can be applied to MMRP sites to evaluate the potential for site-specific footprints for some MMRP projects to be large enough to merit quantitative footprint evaluation.

4.7 COST OF PERFORMING A GSR EVALUATION

GSR evaluations performed during the Study required the following approximate costs:

- Costs for GSR Evaluation Team (third party) = \$5,000 to \$10,000
- Costs for Project Team = \$0 to \$5,000
- Costs for Project Team Contractor = \$0 to \$5,000

For future GSR evaluations, the costs for a typical project should be lower if the Project Team performs the GSR evaluation rather than a third party (though for more complex projects the costs may be higher). The level of effort of the GSR evaluation should be proportional to the expected level of potential GSR gains from the GSR evaluation. The Study included development of a screening tool (see Section 3.2.3) that allows an assessment of likely magnitude of GSR footprints so the Project Team can determine the potential benefits of quantifying GSR footprints for their project. For GSR evaluations that do not include quantification of footprints, the costs for evaluating GSR are expected to be lower.

4.8 POTENTIAL COST AND RESOURCE IMPLICATIONS OF GSR RECOMMENDATIONS FOR PILOT PROJECTS

In this Study, the GSR evaluations included recommendations for some of the Pilot Projects that have the potential to significantly lower resource consumption and related life-cycle costs, if implemented. One example, for the Lake City Army Ammunition Plant Pilot Project, is provided in Table 4-1. As discussed in Section 3.2.3, the screening evaluation suggested in this GSR Approach indicated this project would likely benefit from a quantitative footprint evaluation, because the approximate energy use resulting from the screening calculation was large (i.e., high potential for reduction of cost and/or other footprints). The example in Table 4-1 represents one of several recommendations in the GSR evaluation for that Pilot Project with the potential to significantly reduce costs and/or other footprints.

Table 4-1
Example of Potential Resource and Cost Reductions (If Implemented), Lake City Army Ammunition Plant Pilot Project

Recommendation in GSR Evaluation	
Eliminate catalytic oxidizer for treatment of air-stripper off-gas	
Basis for Recommendation	
• Non-treated air is within installation air permit levels • Would eliminate a 25 horsepower blower and the use of approximately 900,000 cubic feet per month (990 mcf/month) of natural gas	
Examples of Resources Potentially Conserved	
• Total energy use declines by approximately 13,000 MMBtus per year (32%) • GHG emissions decline by approximately metric tons of CO2e per year (31%) • Criteria air pollutant emissions decline by approximately13 metric tons per year (48%)	
Potential Savings	**Up-Front Investment**
Saves ~\$400,000 over 5 years	Negligible

Another example, for the Former NAD – Hastings Pilot Project, is provided in Table 4-2.

Table 4-2
Example of Potential Resource and Cost Reductions (If Implemented), Former NAD – Hastings Pilot Project

Recommendation in GSR Evaluation	
Design pump-and-treat to address two plume lobes with separate treatment plants rather than one centrally located treatment plant, plus implement variable frequency drives for extraction pumps	
Basis for Recommendation	
• Eliminates approximately 20,000 feet of piping • Lowers electrical use due to reduced pumping head plus use of variable frequency drives. • Provides greater treatment flexibility. • Requires an extra building and some duplicate equipment.	
Examples of Resources Potentially Conserved	
Potentially reduces footprints over remedy lifetime (30 years) by the following amounts:	
• Electricity usage – 12 million kWh • Energy – 120,000 MMBtus • CO_2e – 10,000 metric tons	• NO_x - 20 metric tons • SO_x - 30 metric tons • High-density polyethylene – 600,000 lbs
Estimated Costs/Savings	
• Up-Front Savings ~$609,500 • Annual Savings ~$27,000/yr	• Payback Period: Immediate • Lifecycle Savings ~$1,100,000 NPV

These examples highlight the significant resource and cost savings that can be realized through GSR opportunities identified in a GSR evaluation, particularly for projects that the screening method described in Section 3.2.3 predicts as likely to have large footprints (i.e., high potential for reductions in cost and/or other footprints). The quantitative footprint calculations for resource consumption and related cost savings can then be used in project decision-making to determine if the GSR opportunities are potentially "practical", that is if they are feasible from a technical standpoint and provide net GSR benefits as shown from the economic, social, and environmental metrics and other GSR considerations.

Potential project-specific constraints may limit the practicality and implementation of GSR opportunities. These potential constraints include the following:

- Cost
- Schedule

- Contracting
- Program policy
- Regulatory and public reviews/input
- GSR evaluation timing within the remedial phase
- Other project-specific variables and logistics

In many cases in the Pilot Projects, the Project Team indicated that implementation of that GSR opportunity would not occur for one or more of the reasons listed above. A discussion is provided below regarding Pilot Projects that had recommendations in the GSR evaluation with the greatest potential to significantly lower life-cycle costs, with additional discussion of site-specific constraints subsequently noted by the Project Team that limit implementation of those items (note that reductions in other footprints generally coincided with life-cycle cost reductions):

- *Lake City Army Ammunition Plant*. This Pilot Project pertained to several P&T systems in the O&M phase. The GSR opportunities for this Pilot Project were developed during a previously performed optimization evaluation. Examples of potential cost savings associated with specific recommendations in the GSR evaluation included the following (which given the long-term nature of the remedy, perhaps 30 years or more, could reach millions of dollars over the course of the remedy):

    - Eliminate CATOX operation From Building 163 – There should be no significant cost to implement this change and potential cost savings of approximately $76,000/yr. However, the administrative burden would be high due to confirmation that this is allowable under site permits and acceptable to regulators.

    - Eliminate water supply strippers and associated transfer pumps – Assumes a $200,000 up-front cost and savings of approximately $46,000 per year, so the payback period would be less than 5 years. However, it would require up-front costs, and the Project Team indicated there could be funding limitations.

    - Evaluate potential for eliminating air stripping completely at Building 163 with direct discharge to the POTW – No significant up-front costs would be expected, and total savings of approximately $131,500 per year could result from this change (this incorporates the changes in the first recommendation listed above). However, the Project Team indicated this might require a change to a decision document, and if so that would be a significant constraint.

- *Former NAD – Hastings*. This Pilot Project pertained to a P&T system in the design phase. Examples of potential cost savings associated with specific recommendations in the GSR evaluation included the following:

    - Include VFDs for extraction pumps – Requires up-front cost (~$63,000), with potential annual savings of ~$22,400 per year, resulting in a payback period of approximately 3 years and life-cycle savings over 30 years of approximately $376,000 (based on discounting at 3%). The Project Team indicated that there were site-specific factors (e.g., distance to well houses) and field experience from other sites that suggested VFDs on extraction pumps for this project would be problematic.

    - Include VFDs for air stripper blower motors – Requires minimal up-front cost (~$7,500), with potential annual savings of ~$3,300 per year, resulting in a payback period of approximately 3 years and life-cycle savings over 30 years of approximately $60,000 (based on discounting at 3%). The Project Team indicated that it was their opinion that a reduction in air stripper efficiency from application of a VFD was not a cost-effective trade-off for a reduction in electrical usage that a VFD might provide.

- Build Two Treatment Plants – The GSR Evaluation Team estimated this would save up-front costs (~$600,000) and annual savings of ~$27,000 per year, resulting in a life-cycle savings over 30 years of approximately $1.1M (based on discounting at 3%). The Project Team indicated their calculations indicated excessive up-front costs for the two plants, and also indicated concern about potential erosion issues caused by discharge from an additional plant.

- Umatilla Chemical Depot. This Pilot Project was performed in the remedy selection phase, but focused on the recommended alternative (an enhanced version of the current P&T system coupled with bioremediation at the waste lagoon for an initial period of 5 years, with full-scale bioremediation and no P&T thereafter for 10 years) and a variation of that alternative suggested by the Project Team (transition to full scale bioremediation and no P&T after 3 years rather than 5 years). The estimated potential impacts to costs are complicated:

  - Non-discounted capital costs decrease approximately $0.3M due to reduction in the capital cost of bioremediation substrate (and associated transport/injection of the substrate) in the first five years.

  - Non-discounted life-cycle costs decline by $1.5M due to elimination of 2 years of O&M for the P&T system as well as the reduction in capital cost of bioremediation substrate (and associated transport of the substrate) in the first five years.

  - The discounted life-cycle cost only improves slightly (approximately $0.1M) despite the two years of eliminated annual costs and lower capital costs for the bioremediation substrate. The improvement is minimal because significant capital costs for the overall remedy are moved up two years, and 10 years of subsequent annual costs are also moved up two years. Because the discount rate selected by the Project Team of 7% is a fairly high value, the fact that so much cost is accelerated by two years results in just a slight decrease in life-cycle cost.

- Akiachak Federal Scout Armory. This Pilot Project was conducted during the remedial action phase for excavation and disposal of contaminated soil from a remote site (soil transport via barge from Alaska to the mainland US). The timing of this Pilot Project did not allow recommendations to be considered for this project, but there are 21 FSA sites in Alaska with similar parameters and site conditions to Akiachak, and the findings of this evaluation could inform decisions made for future activities at these other sites. Examples of potential cost savings associated with specific recommendations in the GSR evaluation included the following:

  - Assess the feasibility of use of an on-site biological treatment at sites in Alaska in place of excavation and off-site disposal – Estimated cost savings of ~$230,000 for this one-time activity. The Project Team indicated that using this approach for other sites may be limited because of the current regulatory concerns about effectiveness of the biological treatment, but there may be other technologies (e.g., low temperature thermal desorption) that could also be evaluated as an alternative to excavation and disposal if regulatory approval of biological treatment cannot be achieved.

- Assess the feasibility of ex-situ thermal treatment in Bethel, AK in place of off-site disposal - Estimated cost savings of ~$70,000 for this one-time activity. The thermal treatment facility is relatively new, and updated cost estimates would be appropriate for consideration of this option at future sites.

The quantification of GSR recommendations in most of the other Pilot Projects did not show significant decreases in cost. In some of those Pilot Projects, however, there were qualitative GSR recommendations that would likely lower life-cycle costs, but those cost reductions were not quantified (such as potential on-site reuse of mulch generated by the Lockbourne Landfill remedy rather than off-site disposal). In other cases, there were potential cost savings from recommendations that were not quantified because more information would be required to accurately estimate costs (such as potential beneficial reuse of structures). For the Former Schilling Atlas Missile Site S-5 Pilot Project, a stand-alone monitored natural attenuation alternative (MNA) had much lower estimated costs than the alternatives that combined a shorter-term MNA with potential source removal technologies (millions of dollars less) and generally had lower GSR footprints when all alternatives were evaluated over 30 years. However, the stand-alone MNA alternative had higher GSR footprints and nearly comparable estimated costs when the timeframe for MNA was expanded to a longer horizon (based on modeling, 208 years for stand-alone MNA compared to 78 years for source removal combined with shorter term MNA). That Pilot Project did not make a specific recommendation regarding the alternatives; rather the information was supplied to the Project Team who included the information in the Proposed Plan following the CERCLA criteria evaluation. None of the Pilot Projects included GSR recommendations that would add significantly to the overall remedy cost, though some of the GSR recommendations could result in minor cost increases.

Accordingly, the Study found that implementation of the GSR opportunities that were identified is generally expected to result in cost savings, with minimal or no cost increases. When balanced against the costs of performing the GSR evaluation, it is generally expected that some or all of the costs for a project-specific GSR evaluation would be offset by cost savings that result from implementation of GSR opportunities, even if those savings are not quantified. Although for some projects application of GSR may result in a net cost increase, it is expected that Army-wide the consideration and implementation of GSR opportunities will result in a net cost savings (in addition to other quantitative and qualitative improvements) because of the general cost effectiveness of energy conservation, materials use reduction, water conservation, and waste minimization. In particular, as described above, the savings from some GSR recommendations have the potential to far exceed the costs of performing a GSR evaluation, and in some cases savings of millions of dollars can potentially result.

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US EPA, "*Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites,*" Publication Number: EPA 542-R-08-002 (April 2008). http://www.cluin.org/download/remed/Green-Remediation-Primer.pdf

APPENDIX A

Detailed Approach for Performing Green and Sustainable Remediation (GSR) Evaluations in Army Environmental Remediation

DETAILED APPROACH FOR EVALUATING GREEN AND SUSTAINABLE REMEDIATION (GSR) ON ARMY ENVIRONMENTAL PROJECTS

Prepared for:

Office of the Assistant Chief of Staff for Installation Management (OACSIM)
Installation Services Directorate – Environmental Division

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Final Report
August 27, 2012

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PREFACE

The US Army Engineering and Support Center, Huntsville (USAESCH), Environmental and Munitions Center of Expertise (EM CX) contracted Tetra Tech EC, Inc. (Tetra Tech) under Contract W912DQ-08-D-0019, Delivery Order No. ZW02, to help conduct and document a Study that follows the process of considering, incorporating, documenting, and evaluating the benefits of green and sustainable remediation (GSR) practices. This document describes a detailed approach for performing GSR evaluations on Army environmental projects (referred to herein as the "GSR Approach") developed in the above-referenced Study. The Interim Guidance Document (IGD) 10-01: *Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects* (USACE, 5 March 2010) was used as a starting document for the Study. Any questions on the Study or the GSR Approach should be addressed to Carol Dona, Study Project Manager, at DLL-CENWO-PAGEMASTER-HX-E@USACE.ARMY.MIL.

ACRONYMS AND ABBREVIATIONS

ABP	Agent Breakdown Products
AEC	Army Environmental Command
AEPI	Army Environmental Policy Institute
AOC	Area of Concern
ASR	Archives Search Report
BIP	Blow in Place
BMP	Best Management Practice
BMPs	Best Management Practices
BRAC	Base Realignment and Closure
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
Btu	British Thermal Unit
BWM	Biological Warfare Materiel
CA	Chemical Agent
CACM	Chemical Agent Contaminated Medium
CAIS	Chemical Agent Identification Set
CCl_3F	CFC-11 or Freon-11
CCl_4	Carbon tetrachloride
CDC	Controlled Detonation Chamber
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFL	Compact Fluorescent Lighting
CH_2Cl_2	Methylene chloride
CH_3Br	Bromomethane
CH_3CCl_3	1,1,1-Trichloroethane or methyl chloroform
CH_3Cl	Chloromethane
CH_4	Methane
CO_2	Carbon dioxide
CO2e	Equivalent Global Warming Potential of Carbon Dioxide
CRREL	Cold Regions Research and Engineering Laboratory
CSM	Conceptual Site Model
CSS	Chemical Safety Submission
CTC	Cost-to-Complete
DAR	Detector Aided Reconnaissance
DD	Decision Document
DERP	Defense Environmental Restoration Program
DMM	Discarded Military Munitions
DoD	Department of Defense
DQO	Data Quality Objective
ECoP	Environmental Community of Practice
EE/CA	Engineering Evaluation/Cost Analysis
EM CX	Environmental and Munitions Center of Expertise
EP	Engineer Pamphlet
EPAct 2005	Energy Policy Act of 2005
EM	Engineer Manual
ER	Engineer Regulation
ESD	Explanation of Significant Differences
ESOH	Environment, Safety, and Occupational Health
ESS	Explosives Safety Submission
F	Fahrenheit
FS	Feasibility Study

ACRONYMS AND ABBREVIATIONS
(continued)

FUDS	Formerly Used Defense Site
GAC	Granular Activated Carbon
GPO	Geophysical Prove Out
GPS	Global Positioning System
GSR	Green and Sustainable Remediation
GSV	Geophysical System Verification
GWP	Global Warming Potential
HAP	Hazardous Air Pollutant
HDPE	High Density Polyethylene
HE	High Explosive
Hg	Mercury
HP	Horsepower
HQ DA	Headquarters Department of the Army
HQ USACE	Headquarters US Army Corps of Engineers
HRR	Historical Records Review
HRS	Hours or Hazard Ranking System
HTRW	Hazardous, Toxic, and Radiological Waste
HWMU	Hazardous Waste Management Unit
InPR	Inventory Project Report
IRP	Installation Restoration Program
ISM	Incremental Sampling Methodology
ITRC	Interstate Technology & Regulatory Council
kWh	Kilowatt-hours
lbs	Pounds
LED	Light-Emitting Diode
LEED	Leadership in Energy & Environmental Design
LiDAR	Light Detection and Ranging
LTM	Long-Term Monitoring
M2S2	Military Munitions Support Services
MBtu	Metric British Thermal Units
MC	Munitions Constituents
MDAS	Material Documented as Safe
MEC	Munitions and Explosives of Concern
MIP	Membrane Interface Probe
MMBtu	Million Metric British Thermal Units
MMRP	Military Munitions Response Program
MNA	Monitored Natural Attenuation
MRA	Munitions Response Area
MRF	Munitions Related Feature
MRS	Munitions Response Site
MRSPP	Munitions Response Site Prioritization Protocol
N_2O	Nitrous Oxide
NCP	National Contingency Plan
NGB	National Guard Bureau
NOx	Nitrogen Oxides
NTCRA	Non Time Critical Removal Action
O&M	Operations and Maintenance

ACRONYMS AND ABBREVIATIONS (continued)

OACSIM	Office of the Assistant Chief of Staff for Installation Management
OE	Ordnance and Explosives
OMB	Office of Management and Budget
P&T	Pump and Treat
PA	Preliminary Assessment
PCE	Tetrachloroethene
PDT	Project Delivery Team
PG	Professional Geologist
PIP	Public Involvement Plan
PM	Particulate Matter
POL	Petroleum, Oil, or Lubricants
POTW	Publicly Owned Treatment Works
PP	Proposed Plan
PPMV	Parts Per Million by Volume
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QR	Qualitative Reconnaissance
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RCWM	Recovered Chemical Warfare Material
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
ROE	Rights of Entry
RSE	Remediation System Evaluation
SCF	Standard Cubic Feet
SCFM	Standard Cubic Feet Per Minute
SI	Site Inspection or Site Investigation
SiteWise™	Battelle SiteWise™ Green and Sustainable Remediation Tool
SME	Subject Matter Expert
SOW	Statement of Work
SOx	Sulfur Oxides
SRT™	Sustainable Remediation Tool developed for the Air Force
SSFR	Site Specific Final Report
SVE	Soil Vapor Extraction
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TCRA	Time Critical Removal Action
TDEM	Time Domain Electromagnetic Induction
TPP	Technical Project Planning
UFP	Uniform Federal Policy
US EPA	United States Environmental Protection Agency
US	United States
USAESCH	US Army Engineering and Support Center, Huntsville
USFWS	US Fish and Wildlife Service
USACE	United States Army Corps of Engineers
UXO	Unexploded Ordnance

ACRONYMS AND ABBREVIATIONS
(continued)

VFD	Variable Frequency Drive
VTA	Vehicle Towed Array
WAA	Wide Area Assessment

1.0 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide an approach for US Army Project Teams to identify, consider, incorporate, and document Green and Sustainable Remediation (GSR) practices for US Army environmental remediation projects. Topics addressed in this document include the following:

- Planning for a GSR evaluation
- Consideration of GSR Best Management Practices (BMPs)
- Methods for quantitatively evaluating specific GSR "metrics" (i.e., "quantitative GSR footprints") and assessing qualitative GSR considerations (e.g., land use, aesthetics, renewable energy)
- Documenting the GSR evaluation and the consideration/implementation of GSR opportunities

A template report for documenting a GSR evaluation is also provided. This "GSR Approach" assumes a subset of the Project Team for the environmental remedy will typically perform a GSR evaluation as part of routine project work.

1.2 DEFINITION OF GSR AND DOD GSR POLICY

Pursuant to the Department of Defense (DoD) Defense Environmental Restoration Program Manual 4715.20 (DERP Manual) dated March 2012, GSR expands on DoD's current environmental practices and employs strategies for environmental restoration that:

- Use natural resources and energy efficiently;
- Reduce negative impacts on the environment;
- Minimize or eliminate pollution at its source; and
- Reduce waste to the greatest extent possible.

The DERP Manual also explains that GSR uses strategies that consider all environmental effects of remedy implementation and operation and incorporates options to maximize the overall environmental benefit of environmental response actions. The DERP Manual further states that "the DoD component should consider and implement green and sustainable remediation opportunities in current and future remedial activities when feasible" and "…the DoD Component shall, where practicable based on economic and social benefits and costs, ensure green and sustainable remediation practices…".

GSR typically considers environmental factors (e.g., greenhouse gas emissions caused by the remedy), economic factors (e.g., capital and annual costs/savings for implementing GSR recommendations), and societal/community factors (e.g., risks to workers or aesthetic impacts to neighborhoods). GSR is commonly framed as the balancing of the environmental, economic, and societal/community factors associated with implementation of the remedial process. This can be generally translated into the Army concept of "Triple Bottom Line Plus" identified in the *Army Posture Statement* (Feb 2007) illustrated in Figure 1-1. The GSR Approach described herein accounts for mission-related factors by acknowledging that mission-related priorities may place constraints on site-specific remediation decisions that otherwise attempt to balance environmental, economic, and societal/community factors.

Figure 1-1. Pillars of Army Sustainability (Triple Bottom Line Plus), Army Posture Statement, Feb 2007

Pertinent GSR-related excerpts from the DERP Manual are cited below.

- DERP Manual Section 6.d *(Other Environmental Restoration Management Considerations, Green And Sustainable Remediation, pp. 48-49)* states the following:

  "(1) Green and sustainable remediation expands on DoD's current environmental practices and employs strategies for environmental restoration that use natural resources and energy efficiently, reduce negative impacts on the environment, minimize or eliminate pollution at its source, and reduce waste to the greatest extent possible. Green and sustainable remediation uses strategies that consider all environmental effects of remedy implementation and operation and incorporates options to maximize the overall environmental benefit of environmental response actions.

  (2) Opportunities to increase sustainability considerations throughout all phases of remediation (i.e., site investigation, remedy evaluation, design, construction, operation, monitoring, and site closeout) may exist, regardless of the selected remedy.

  (3) The DoD Component should consider and implement green and sustainable remediation opportunities in current and future remedial activities when feasible. The DoD Component should not under most circumstances re-open DDs and agreements that may be in place or under negotiation with environmental regulators.

  (4) Pursuant to [Executive Order 13514], the DoD Component shall, where practicable based on economic and social benefits and costs, ensure green and sustainable remediation practices by increasing energy efficiency; conserving and protecting water resources through efficiency, reuse, and storm water management; eliminating waste, encouraging recycling, and preventing pollution; leveraging agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services; and strengthening the vitality and livability of the communities in which Federal facilities are located."

- DERP Manual Section 4.b.(5).(b), p. 33, states the following for the Feasibility Study phase:

  "3. In accordance with [Executive Order 13423], the DoD Component shall evaluate remedial alternatives to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems on the environment. During remedy evaluation and selection, consideration of optimization and sustainability concepts will improve performance of the remedial action and reduce the remedy footprint. Optimization concepts include development of a conceptual site model, realistic remedial action objectives, performance objectives, and identifying treatment zones and exit strategies."

- DERP Manual Section 4.b.(10), p.39, states the following for the Remedial Action Work Plan (RAWP):

  "The DoD Component shall document in the RAWP how the remedial action will be staged and implemented during remedial action-construction (RA-C). The DoD Component should consider remediation technologies that are conducted in a sustainable manner; are efficient; and are environmentally, economically, and fiscally sound, in order to reduce the footprint of remediation strategies on the environment."

- DERP Manual, Section 6.d (*Other Environmental Restoration Management Considerations, E. Remedy Optimization, p.49*) states the following for Remedy Optimization:

  "(1) The DoD Component shall maximize DERP effectiveness and minimize the DERP financial liabilities and environmental footprint."

Accordingly, in all phases of remediation and for all DoD projects, the March 2012 DERP Manual instructs DoD Components to consider and implement GSR opportunities when feasible and ensure the use of GSR remediation practices where practicable based on economic and social benefits as well as costs. In addition, the March 2012 DERP Manual also includes direction regarding GSR in specific remedy phases, as follows:

- In the FS phase, evaluate remedial alternatives to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems on the environment.

- In the Remedial Action Work Plan (RAWP) in the Remedial Action phase, consider remediation technologies that are conducted in a sustainable manner; are efficient; and are environmentally, economically, and fiscally sound, in order to reduce the footprint of remediation strategies on the environment.

- In the Remedial Operation phase, minimize the environmental footprint as part of optimization performed.

Specific considerations for performing GSR evaluations in the three remedy phases identified in the March 2012 DERP manual (listed above) are discussed in Section 3.1. Also, the DERP Manual indicates that, generally, most documents already in place or in negotiation with the regulators would not be re-opened to consider and/or implement GSR opportunities.

A GSR evaluation generally includes site-specific application of GSR Best Management Practice (BMPs) expected to provide beneficial results with respect to one or more GSR considerations, although those considerations are not always quantified. GSR considerations may involve different levels of quantification:

- Some GSR considerations can be quantified in terms of "GSR metrics" (i.e., quantities that are measured, calculated, or estimated), such as energy use or emissions of greenhouse gases

- Some GSR considerations may not be easily quantified, such as unwanted disturbance to cultural resources or negative visual impacts associated with remedy implementation

The calculation of specific metrics currently pertains to project-specific decision making, but in the future it is expected that some GSR metrics will be tracked in Army program management databases.

1.3 APPLICABILITY OF THIS GSR APPROACH TO IRP AND MMRP SITES

The GSR Approach presented in this document pertains to two types of Army projects:

- Installation Restoration Program (IRP) projects

- Military Munitions Response Program (MMRP) projects

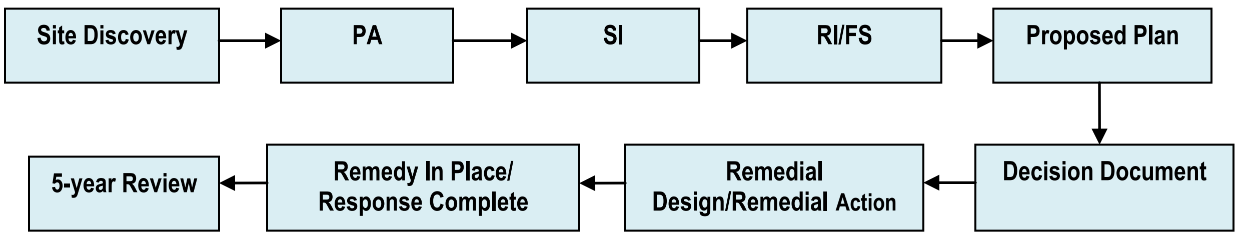
. A brief description of IRP and MMRP projects is provided below:

- The DERP Manual (March 2012) indicates that sites in the IRP category require response actions to address releases of: (a) hazardous substances and pollutants or contaminants; (b) Petroleum, Oil, or Lubricants (POLs) with some exclusions; (c) hazardous wastes or hazardous waste constituents; and (d) explosive compounds released to soil, surface water, sediment, or groundwater as a result of ammunition or explosives production or manufacturing at ammunition plants. The IRP category also includes response activities to address unexploded ordnance (UXO), discarded military munitions (DMM), or munitions constituents (MC) posing an explosive, human health, or environmental hazard that are incidental to an existing IRP site. IRP projects are commonly known as hazardous, toxic, and radiological waste (HTRW) projects and response actions may be conducted on a portion of a site identified as an Area of Concern (AOC), Solid Waste Management Unit (SWMU), or Hazardous Waste Management Unit (HWMU).

- The DERP Manual (March 2012) indicates that sites in the MMRP category include Munitions Response Areas (MRAs) and Munitions Response Sites (MRSs) that require a munitions response. Instead of traditional HTRW contaminants, the response action for MMRP projects is to munitions and explosives of concern (MEC) or munitions constituents (MC). MMRP projects address the explosives safety, human health, and environmental risks posed by these contaminants. An area known or suspected to contain MEC or MC (e.g., firing ranges, munitions burial areas) is identified as a MRA, which is composed of one or more discrete MRSs.

Both IRP and MMRP responses address contaminated environmental media (i.e., soil, groundwater, sediment, surface water, and air) and are conducted under the Defense Environmental Restoration Program (DERP) by the Army consistent with the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). A flow chart depicting the generalized CERCLA response process for IRP and MMRP projects is depicted in Figure 1-2. This GSR Approach is also applicable to work done under other regulatory drivers, such as the Resource Conservation and Recovery Act (RCRA).

Figure 1-2. CERCLA Response Process



Note: Based on Figure 1in the Final Army MMRP RI/FS Guidance (November 2009)

There is substantial overlap in the GSR evaluation process for IRP and MMRP projects, and this document applies to both IRP and MMRP projects. There are also additional considerations that pertain to MMRP projects highlighted in Section 4 of this document to augment the information provided in Sections 2 and 3. The GSR Approach described herein can be applied at Army sites that represent any of the following CERCLA remedial phases:

- Preliminary Assessment (PA);
- Site Inspection (SI);
- Remedial Investigation (RI);
- Feasibility Study (FS);
- Proposed Plan (PP);
- Decision Document (DD) such as a Record of Decision (ROD);
- Remedial Design (RD);
- Time-Critical Removal Action (TCRA) and Non-Time-Critical Removal Action (NTCRA);
- Remedial Action (RA);
- Remedy Operations and Maintenance (O&M) and Long-Term Monitoring (LTM); and
- Closeout

Section 3.1 presents phase-specific considerations for performing GSR evaluations in the three remedy phases explicitly identified in the DERP manual (FS phase, RAWP in the Remedial Action phase, and during remedy optimization in the Remedy Operations phase). Quantitative evaluation of remedy footprints will typically be most applicable to remedy selection (i.e., FS/PP/DD), remedial design, and O&M (particularly for projects with long-term active remediation such as a pump-and-treat system). Note that in some cases (e.g. TCRA) consideration of GSR opportunities may be limited due to urgency of project execution.

1.4 FOOTPRINTS: GSR METRICS AND QUALITATIVE CONSIDERATIONS

The term "footprint" is defined in USEPA's *Methodology for Understanding and Reducing a Project's Environmental Footprint (*February 2012) as follows:

> "The term 'footprint' refers to the quantification of a specific metric that has been assigned a particular meaning. For example, the "carbon footprint" is the quantification of carbon dioxide

(and other greenhouse gases [GHGs]) emitted into the air by a particular activity, facility, or individual. This common footprint measure has been established in the past because emissions of carbon dioxide and other GHGs have been linked to climate change."

USEPA's *Methodology for Understanding and Reducing a Project's Environmental Footprint (*February 2012) indicates that a "metric" refers to a project parameter for which a quantitative value may be derived mathematically, estimated through engineering details, or extracted from past project records with actual data. The term "environmental footprint" in the above-referenced EPA Methodology includes metrics such as energy use and water use as well as air emissions to represent the effects a cleanup project may have on the environment. The term "environmental footprint" can be more broadly defined as "the direct or indirect impact on environmental media and society from remedial activities" (Navy GSR Fact Sheet 2010). This includes quantification of one or more GSR metrics, plus qualitative considerations, typically assessed for a "baseline case" and one or more alternatives to the baseline. This broad definition of "environmental footprint" (i.e., both quantitative and qualitative considerations) is utilized in this GSR Approach.

A list of specific GSR metrics recommended for consideration of quantification in this GSR Approach is presented in Table 1-1, along with qualitative considerations that are more difficult to quantify but may be equally important to consider as part of a GSR evaluation.

Table 1-1
Specific GSR Metrics and Qualitative Considerations
Included in this GSR Approach

Note that any project-specific metrics or other qualitative considerations not listed can be added by inserting a row in the Table

GSR Considerations	Unit
Quantitative Environmental Metrics:	
Energy Use	MMBtus
Global Warming Potential	Metric Tons CO2e
Criteria Air Pollutants (NOx + SOx + PM)	Metric Tons
Hazardous or Toxic Air Pollutants	Pounds
Potable Water Use	Thousands of Gallons
Other Water Use	Thousands of Gallons
Refined Materials	Pounds
Percent of Refined Materials from Recycled or Reused Sources	%
Unrefined Materials	Tons
Percent of Unrefined Materials from Recycled or Reused Sources	%
Non-Hazardous Waste Disposal	Tons
Hazardous Waste Disposal	Tons
Percent of Total Potential Waste Recycled or Reused	%
Quantitative Economic Metrics:	
Life-Cycle Cost, Discounted	$ (net present value)
Life-Cycle Cost, Undiscounted	$
Up-Front Cost	$

Table 1-1 **Specific GSR Metrics and Qualitative Considerations** **Included in this GSR Approach** *Note that any project-specific metrics or other qualitative considerations not listed can be added by inserting a row in the Table*	
Quantitative Societal Metrics:	
Risk for Injuries/Fatalities	Number of Injuries + Fatalities
One-Way Heavy Vehicle Trips through Residential Areas	Number of Trips
Qualitative Considerations:	
Land Transferred or Made Available for Potential Beneficial Use	N/A*
Existing Ecosystem Destruction	N/A*
Time Frame for Land Reuse	N/A*
Flexibility and Breadth of Options for Site Reuse	N/A*
Aesthetics	N/A*
Use of Renewable Energy	N/A*

**N/A = "Not Applicable" – these items are difficult to fully quantify although some quantification may be possible and can be described as part of a GSR evaluation in those cases*

As discussed later in this GSR Approach, calculations for some GSR metrics for Army projects are performed using the SiteWise^{TM} spreadsheet tool. However, some of the quantitative metrics listed in Table 1-1 (and summarized below) must be calculated outside of SiteWise^{TM}. This is discussed in more detail in Section 2.2.3 of this GSR Approach.

1.4.1 Quantifiable Environmental Metrics

The following quantifiable environmental metrics are recommended for consideration as part of a GSR evaluation:

Energy (Measured in MMBtus) - Energy required to conduct work associated with the remedial process comes from electricity (and associated electricity production) or fuels for combustion such as natural gas, diesel, and gasoline. Reducing energy use is a focus of several Executive Orders as detailed in the DERP Manual (March 2012).

Global Warming Potential (Measured in metric tons of CO2e) – An increase in global warming potential (GWP) results from emissions of greenhouse gases. Similarly, a decrease in global warming potential can be achieved by reducing greenhouse gas emissions or otherwise removing greenhouse gases from the atmosphere. Global warming potential of various greenhouse gases is typically expressed (such as in SiteWise^{TM}) as the equivalent global warming potential of carbon dioxide (CO2e), in units of metric tons or pounds (lbs). Global warming potentials for various greenhouse gases are listed in Table 1-2 relative to CO_2. For example, methane has a warming potential 21 times greater than that of CO_2.

Table 1-2 Global Warming Potential for Various Greenhouse Gases	
Greenhouse Gas	**Global Warming Potential* (relative to CO_2)**
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Carbon tetrachloride (CCl_4)	1,400
1,1,1-Trichloroethane (CH_3CCl_3, methyl chloroform)	146
Bromomethane (CH_3Br)	5
Chloromethane (CH_3Cl)	13
Methylene chloride (CH_2Cl_2)	8.7
CFC-11 (CCl_3F, Freon-11)	3,800
** Source: Intergovernmental Panel on Climate Change Assessment Report 4, Chapter 2, Changes in Atmospheric Constituents and in Radioactive Forcing (www.ipcc.ch)*	

Criteria air pollutants (Measured in metric tons of criteria pollutants emitted) – The US Environmental Protection Agency (US EPA) recognizes and has set standards for six criteria pollutants. The three criteria pollutants identified and tracked by federal agencies as part of GSR activities are nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM). The primary source of these three pollutants is the combustion of fossil fuels. Additional information related to the various air pollutants can be found at www.epa.gov/oar. SiteWise™ reports each of these individually, but for this GSR Approach it is assumed those values will be added together and reported as "criteria air pollutants".

Hazardous or toxic air pollutants (Measured in lbs emitted) – US EPA recognizes 188 hazardous air pollutants (HAPs) that generally result from industrial processes. Many of the organic compounds that are the primary contaminants of concern in environmental cleanups are on the list of 188 hazardous air pollutants, including benzene (and other "BTEX" compounds), trichloroethene (TCE), tetrachloroethene (PCE), and vinyl chloride. Various inorganic compounds are also hazardous air pollutants, including mercury compounds, arsenic compounds, and cyanide compounds. These compounds may be released to the air through direct remedial activities at a site or in the manufacturing of remediation materials and chemicals. An example would be air emissions from an air stripper that are not treated. Additional information related to the various air pollutants can be found at www.epa.gov/oar. This GSR metric typically refers only to on-site HAP emissions but can also be extended to electricity generation, materials manufacturing, or off-site services if sufficient information is available.

Potable Water Use (Measured in thousands of gallons) – Potable water is a refined and valued local resource often used in remedial activities. This metric tracks the total potable water use from a public or private potable water distribution system.

Other Water Use (Measured in thousands of gallons) – Various other sources of water (e.g., groundwater, surface water, reclaimed water, etc.) can also be valued local natural resources. This metric tracks the total non-potable water use associated with the remedial process.

Refined Materials (Measured in lbs) – Refined materials typically include treatment chemicals (e.g., hydrogen peroxide) and construction materials (e.g., concrete, steel, and PVC) that require a resource and energy intensive manufacturing process.

Percent of Refined Materials from Recycled or Reused Sources – Using recycled or reused materials helps limit the use of natural resources and also limits the manufacturing process. Maximizing the percent of refined materials from recycled or reused sources is preferred.

Unrefined Materials (Measured in tons) – Unrefined materials require resource extraction and limited processing but do not require an intensive manufacturing process. Examples of unrefined materials used in association with the remedial process include clean soil, sand, gravel, clay, and compost.

Percent of Unrefined Materials from Recycled or Reused Sources – Using recycled or reused materials helps conserve natural resources. Maximizing the percent of unrefined materials from recycled or reused sources is preferred.

Non-Hazardous Waste Disposal (Measured in tons) – Waste that cannot be recycled or reused requires a means of disposal, typically in a landfill. Reducing landfill disposal is preferred. This metric refers only waste generated on-site (e.g., soil or treatment sludge for landfill disposal), not waste generated from off-site activities such as material manufacturing.

Hazardous Waste Disposal (Measured in tons) – Hazardous waste that cannot be recycled or reused requires a means of disposal, which typically includes pre-treatment and disposal in a hazardous waste landfill. Hazardous waste landfill space is limited and is often far from the source of the waste. Reducing disposal in hazardous waste landfills is preferred. This metric refers only to waste generated on-site (e.g., soil or treatment sludge for landfill disposal), not waste generated from off-site activities such as material manufacturing.

Percent of Total Potential Waste Recycled or Reused – Recycling or reusing used materials/waste is a means of reducing the use of natural resources and minimizing use of hazardous or non-hazardous landfill space. Maximizing the percent of total potential waste recycled or reused is preferred.

1.4.2 Quantifiable Economic Metrics

The following quantifiable economic metrics are recommended for consideration as part of a GSR evaluation:

Life-Cycle Cost, Discounted (Measured in US dollars, net present value) – This is the sum of up-front costs (i.e., capital costs that occur in the near term) plus future costs incurred over a specified period of time, with future dollars converted to "net present value" based on a discount rate that accounts for the fact that future dollars are worth less than present day dollars (i.e., the time value of money). Costs may be converted to a time other than present day if desired, but in such cases the specific reference time must be stated (e.g., "2005 Dollars"). Additional information about discounting of future costs is presented in Section 3.2.

Life-Cycle Cost, Undiscounted (Measured in US dollars) – This is the sum of up-front costs (i.e., capital costs that occur in the near term) plus future costs incurred over specified period of time, without any discounting of future costs.

Up-Front Cost (Measured in US dollars) – This is the sum of all up-front costs (i.e., capital costs that occur in the near term) associated with implementing a specific component of the remedial process. These are assumed to occur over a relatively short period of time and are thus denominated in present day dollars unless specified otherwise. If the up-front costs of an alternative are high, it may not be feasible to implement the alternative even if life-cycle costs would ultimately be reduced.

Implementation of a GSR opportunity may have an impact on the life-cycle cost of the remedial process, with respect to the following items that may increase, decrease, or stay the same as a result of the GSR opportunity:

- Up-front costs (i.e., capital costs)
- Annual costs (routine O&M costs and any non-routine remedy upgrade/replacement costs)
- Remedial process duration

In some cases, implementation of a GSR opportunity may increase life-cycle costs, and presumably this type of GSR opportunity will be implemented only if the perceived environmental benefits of the GSR opportunity are determined by project stakeholders to justify the additional costs. For cases where implementation of a GSR opportunity decreases life-cycle cost, but capital costs are high, the alternative might still not be preferred. When there is a capital cost coupled with a lower annual cost, a "payback period" and "return on investment" can be calculated (see Section 3.2).

1.4.3 Quantifiable Societal Metrics

Activities associated with the remedial process are by nature local, with benefits and concerns for the local community and work force. The following quantifiable metrics are generally applicable during the remedial process and are recommended for consideration as part of a GSR evaluation.

Increased Risk (Measured as number of combined fatalities and injuries over the project duration) – This metric reflects the increased risk of serious injury to a worker in the field (operating heavy equipment and/or providing other services) and the increased risk of serious injury associated with transportation (i.e., traffic accidents) resulting from activities related to the remedial process (incurred by participants in the remedial process or innocent bystanders).

One-Way Heavy Vehicle Trips through Residential Areas (Measured as number of trips) – This metric refers to the number of one-way delivery or bulk transport trucks related to site remediation driven through a residential area. Minimizing this metric is preferred in order to both improve safety and reduce nuisances to residents.

1.4.4 Qualitative Considerations

In addition to the quantifiable metrics described above, there are other important considerations appropriate to evaluate as part of a GSR evaluation even if they are not fully quantified. Examples include the following:

- **Land Transferred or Made Available for Potential Beneficial Use** – Remedial activities typically involve restoring the site and making it available for reuse. The potential to make land available for reuse should be addressed as part of a GSR evaluation when pertinent. Restrictions associated with land use should be considered.

- **Existing Ecosystem Destruction** – Remedial activities typically involve heavy equipment traffic on unpaved surfaces, and/or require surfaces to be re-graded or re-paved. These activities can result in destruction of existing ecosystems and reduction in existing ecosystem services such as erosion control, flood control, and nutrient absorption. The potential for ecosystem destruction should be addressed as part of a GSR evaluation when pertinent, even if the land is eventually reused or reestablished.

- **Time Frame for Land Reuse** – Remedial alternatives may differ in the amount of time required to reuse the land. A shorter remedy time frame is generally preferred to allow productive reuse of the land to occur more quickly. Considerations regarding the time frame for land reuse should be addressed as part of a GSR evaluation, when pertinent.

- **Flexibility and Breadth of Options for Site Reuse** – Remedial activities, site closeout activities, and the potential range of site reuse (i.e., flexibility in institutional controls) can be controlled and tailored to allow multiple uses of the site during and after remediation. Multiple site reuse options can lead to considerable resource savings if a site reuse with more restricted land use, but lower resource consumption during the remedy, meets mission and protection of human health and environment goals. Potential tradeoffs between land use restrictions versus intensity of the remediation (i.e., resource consumption) should be addressed as part of a GSR evaluation, when pertinent.

- **Aesthetic Considerations** - Items such as odor, noise, dust, and visual impacts associated with the remedial process should be addressed. These issues may be difficult to quantify, but can be extremely important for project stakeholders.

- **Renewable Energy Use Associated with the Remedy** - Renewable energy is favored because it typically has a lower environmental footprint (especially with respect to air emissions) than conventional energy resources. The extent of renewable energy used in the remedy may be quantified (e.g., as a percentage of total energy used) or may be qualitatively described. For the purpose of this document, the following are defined as renewable energy resources:

  - Biodiesel
  - Crop-based ethanol
  - Landfill gas
  - Electricity generated directly from
    - Wind
    - Geothermal reservoirs
    - Hydroelectric
    - Solar
    - Biomass, including landfill gas
  - Useful heat generated from
    - Geothermal reservoirs
    - Biomass, including landfill gas
    - Solar

  Note that renewable energy generated on-site may be used directly as part of the remedy (e.g., solar panels used to power a trailer), but also may be associated with the off-site generation of electricity used on-site for the remedy. Both potential aspects of renewable energy use associated with a remedy should be addressed qualitatively as part of a GSR evaluation, when pertinent.

On-site renewable energy production can also be accounted for quantitatively in the calculation of emissions from energy use (i.e., will result in lower emissions). Also note that the Energy Policy Act of 2005 (EPAct 2005) defines "renewable energy" as electric energy generated from solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project. The definition of renewable energy used for this Approach (provided above) differs slightly because the focus is to understand how the sources of energy impact the remedy footprint (e.g., how much of the electricity comes from hydrothermal versus coal results in different emissions) rather than quantifying how much new renewable electricity is "owned" by the Army which is the focus of the EPAct05.

1.4.5 Potential Constraints to Implementation of GSR Opportunities

There are potential constraints that may limit implementation of GSR opportunities, including the following:

- Cost
- Schedule
- Contracting
- Program policy
- Regulatory and public reviews/input
- GSR evaluation timing within the remedial phase
- Other project-specific variables and logistics

As discussed earlier, GSR opportunities are potentially "practical" if they are feasible from a technical standpoint and provide net benefits as shown from the economic, social, and environmental metrics and other GSR considerations evaluated in this GSR Approach. However, the issues listed above also impact the potential implementability of GSR opportunities. These types of issues can also be addressed as part of "qualitative considerations" during a GSR evaluation.

1.5 BASICS REGARDING BMPs AND FOOTPRINT QUANITIFICATION

A GSR evaluation generally includes:

- Consideration/application of GSR best management practices (BMPs); and
- Footprint quantification (when appropriate).

Basic information regarding each of these items is described below. A more detailed discussion is presented in Section 2.2.

1.5.1 Basics of Considering BMPs

BMPs for GSR are actions or considerations expected to improve an environmental, social, or economic aspect of the remedial process. As with other industries or activities (e.g., construction, storm water management), many BMPs for GSR have been developed that apply to soil, sediment, and groundwater remediation activities. Significant improvements regarding GSR can be achieved by considering these BMPs, implementing those that most directly apply to the project-specific remedial process, and/or potentially implementing alternate GSR practices identified while considering the BMPs.

Consideration of BMPs requires knowledge of the remedial activities and site conditions to determine which BMPs are applicable, and in some cases further evaluation is needed to determine if implementing a BMP is practical for the specific remedial action. Documenting and tracking the consideration and implementation of BMPs are beneficial, and in many cases it is also appropriate to subsequently quantify the estimated reductions in GSR metrics (discussed later). The GSR evaluation process described in Section 2 of this GSR Approach references a BMP checklist provided as Attachment A-1. An excerpt of the BMP checklist from the "Energy/Emissions –Transportation" category is provided in Example 1-1a. The "Notes" section at the bottom of the BMP table for each BMP includes an assessment of the "GSR Value" that qualitatively discusses the potential reductions in environmental footprint and the costs (or cost savings) associated with implementing the BMP.

<table>
<tr><th colspan="2">Example 1-1a: Considering a BMP and Tracking Implementation</th></tr>
<tr><td>BMP C-2: Reduce the number of trips and/or volume for transported materials, equipment, or waste
Examples:
- Transfer full loads by consolidating shipments from vendors and/or shipments to disposal sites (also share shipments with neighbors if feasible)
- Purchase more concentrated chemicals to reduce transportation weight and/or volume</td><td>Date:
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td>Likely Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="2">Notes (including discussion of pertinent possible value of implementing the BMP):

During a GSR evaluation for an operating pump and treat system in the O&M phase, use 50% sodium hydroxide in place of 20% sodium hydroxide to reduce the mass and volume of material to transport to the site and potentially the number of heavy truck trips to the site. This BMP is under consideration to determine if the footprint reductions from reduced transportation outweigh the potential footprint increases associated with maintaining a proper temperature to prevent the 50% sodium hydroxide from solidifying. The evaluation will determine if this option is practical.</td></tr>
</table>

Example 1-1a illustrates that the stated BMP is potentially applicable, and that further evaluation is planned. Since this BMP still requires further evaluation, the implementation status is "N/A". The example also illustrates a potential need for quantifying footprints, since there is a potential tradeoff identified (transportation needs may be reduced but heating needs and health and safety risk may be increased).

Example 1-1b illustrates how the BMP tracking might change after the BMP is evaluated during the GSR process if another GSR evaluation is performed, and the type of analysis involved in deciding if a BMP is practical. If calculations are needed and are performed, the backup for the calculations should be made available but would generally not be included in the BMP checklist. Some of these types of calculations might be performed with Battelle's SiteWise™ Green and Sustainable Remediation Tool (SiteWise™), which is the Army's preferred tool for quantitative footprint analysis, but could also be performed by hand using similar conversion factors to those used by SiteWise™. Some of the calculations may need to be performed outside of SiteWise™ because they are not incorporated within the tool (e.g., percent of potential waste recycled), as further discussed in Section 2.2.3.3.

Example 1-1b: Considering a BMP and Tracking Implementation (Later in GSR Process)		
BMP C-2: Reduce the number of trips and/or volume for transported materials, equipment, or waste Examples: - Transfer full loads by consolidating shipments from vendors and/or shipments to disposal sites (also share shipments with neighbors if feasible) - Purchase more concentrated chemicals to reduce transportation weight and/or volume		**Date:** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☒ Not Yet ☐ N/A	Likely Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☒ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *During a GSR evaluation for an operating pump and treat system in the O&M phase, use 50% sodium hydroxide in place of 20% sodium hydroxide to reduce the mass and volume of material to transport to the site and potentially the number of heavy truck trips to the site. Further analysis indicates using a 50% solution would save on an annual basis 45 gallons of diesel, eliminate one heavy-duty truck trip, and 6,000 gallons of potable water at the chemical production facility, but would require the use of 30 extra therms of natural gas per year to prevent solidifying. Simple calculations indicate that more energy and potable water are saved from using 50% sodium hydroxide than is consumed by the additional natural gas usage. Implementing the BMP would also result in a small cost savings that is not significant with respect to the overall remedy cost (generally cost neutral). The BMP is therefore practical and scheduled to be implemented.*		

The BMP form illustrated above differentiates implementation status as follows:

- **Fully Implemented -** This BMP has been implemented, and there are no remedial process items where further application of this BMP is merited. This could include items implemented prior to the GSR evaluation.

- **Partially Implemented -** This BMP potentially applies to multiple items, but has only been implemented for some of those items (either prior to the GSR evaluation or as a result of a GSR evaluation) and there are other potential items where further application of this BMP is merited. For example, this would apply in the example above if the change from 20% to 50% sodium hydroxide was implemented, but there are other chemicals where similar changes are possible but evaluations have not yet been performed.

- **Not Yet -** This BMP is planned to be implemented for one or more items because it has been determined to be applicable and practical, but the implementation has not yet occurred.

- **N/A -** This would apply if the BMP has been identified as "not practical" for one of the following reasons: (1) because the BMP is not applicable to the specific project; (2) the BMP has not yet been evaluated; or (3) the BMP has been evaluated and determined to not be practical to implement.

The method for considering BMPs illustrated above allows the BMPs to serve as a type of checklist when performing a GSR evaluation, and also allows for tracking the applicability and implementation of BMPs for a specific project. Tables for tracking the BMP status that are illustrated in Examples 1-1a and 1-1b are included Attachment A-1 for a comprehensive list of GSR BMPs. Templates (MS-Word) are also included in the Template GSR Evaluation Report (see Attachments A-3 and A-4).

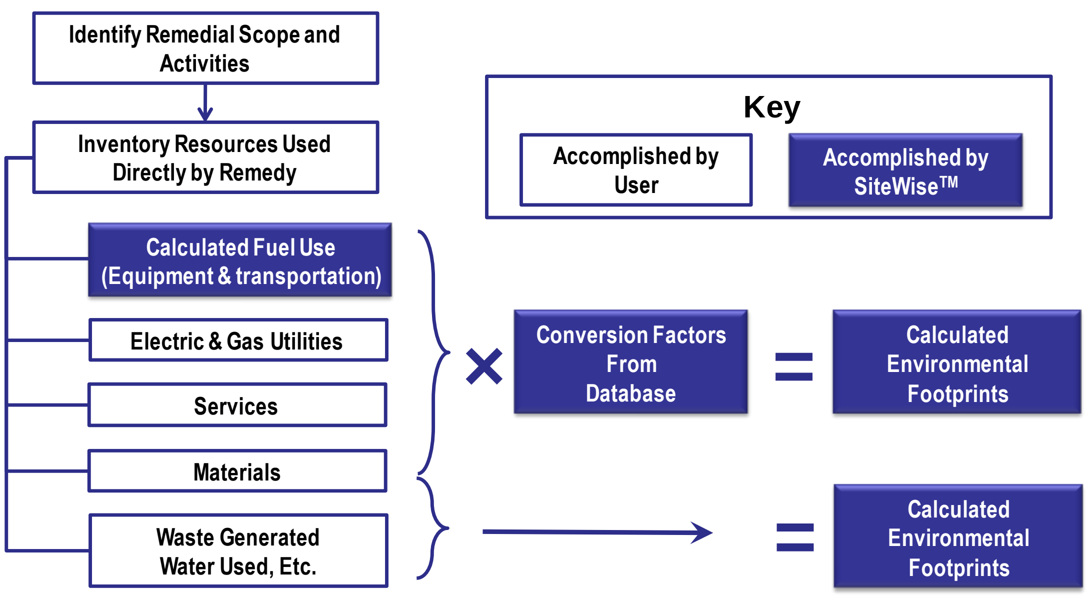
1.5.2 Basics of Footprint Quantification

Section 1.4 and Table 1-1 of this document discuss the quantitative GSR metrics included in this GSR Approach. In many cases, effort to reduce these footprints in a qualitative or semi-quantitative manner with BMPs is suitable. However, in other cases rigorously quantifying some or all of the identified GSR metrics is merited (i.e., footprint quantification). The following are three common reasons for quantifying the overall footprint associated with the remedial process:

- Site-specific or programmatic tracking of quantified GSR metrics
- Analysis of GSR metric footprints for comparing options
- Quantification of GSR footprint reductions from proposed or implemented options

For some of the GSR metrics, quantification is a straightforward accounting of information available from remedial activities (e.g., the amount of refined materials used as part of an in-situ chemical oxidation remedy). For other GSR metrics, intermediate steps are required, such as quantifying the fuel used for a drill rig and the air emissions associated with that fuel use. SiteWise™ is a spreadsheet tool co-developed by Battelle, the Army, the USACE, and the Navy to facilitate these calculations (SiteWise™ is available for download at http://www.ert2.org/t2gsrportal/SiteWise.aspx). The tool structure is flexible to allow consideration of virtually any type of activity during the remedial process. The user provides information such as material use, vehicles and distances for transportation, and equipment use. The information is entered into tables on an "input sheet" by typing values and using drawdown menus. Figure 1-3 illustrates the general footprint process with SiteWise™.

Figure 1-3
General Footprint Process with SiteWise™



Note: The conversion factors in this schematic are included within SiteWise™ and convert SiteWise™ input into quantified GSR footprint metrics

For each remedial alternative evaluated, the calculations are made on various tabs organized by remedial phase and summarized in tables and charts on a summary tab for that alternative. Another summary file presents the data for all alternatives evaluated. The SiteWise™ spreadsheets allow full transparency of all calculations and provide referenced conversion factors for activities and materials. Fuel usage rates are provided for various forms of transportation and various types of equipment. Electricity usage can be entered using one of three methods, including actual lump-sum usage, usage based on fluid head and flow rate, and usage based on motor size. Region-specific emission factors are provided for calculating emissions from electricity generation, to account for different types of electrical generation in different parts of the country. As discussed earlier, SiteWise™ or the metrics from SiteWise™ can also be used to conduct specific calculations to estimate footprint reductions associated with implementing individual BMPs.

An alternate tool for quantitative footprint analysis is SRT™, a Microsoft Excel-based tool developed for the Air Force. Information on the SRT™ tool can be found at the following website:

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

Although SiteWise™ and SRT™ both address GSR, there are differences between these tools. For instance, the structure of SiteWise™ can accommodate a wide range of remedial technologies whereas SRT™ is structured based on specific remedial technologies. The tools have different input structure, different calculation assumptions, and different conversion factors. Because of the flexibility of SiteWise™ across remedial technologies and remedial phases, this approach assumes use of the SiteWise™ tool.

1.6 OUTLINE OF APPROACH FOR CONDUCTING A GSR EVALUATION

The GSR evaluation process outlined below refers to "teams" defined as follows:

- Project Team: Refers to those associated with implementation of the remedial process for the project being evaluated. This may include USACE, Base Realignment and Closure (BRAC), Army Environmental Command (AEC), Army National Guard, and/or contractor Project Delivery Team (PDT) members.

- GSR Evaluation Team: Refers to the personnel that would perform the GSR evaluation. For the purposes of this Approach, this person or persons are hereafter referred to as the GSR Evaluation Team. A subset of the Project Team typically will perform the GSR Evaluation, in some cases augmented by individuals who are otherwise not directly involved in the day-to-day aspects of the remediation. For example, a GSR evaluation at an Active Army Installation project could be performed by a team comprised of the environmental remediation manager (ERM), the project contractor, and the installation environmental manager (EM). In the case of a Remedial System Evaluation (RSE) optimization for an Active Army installation, the GSR evaluation could be performed by a team comprised of the ERM, the installation EM, the installation contractor(s), and the manager for the RSE (e.g., a member of the USACE). It is noted that in some situations where the project contractor is tasked contractually with performance of the GSR evaluation, the "GSR Evaluation Team" could be the contractor. The GSR Evaluation Team is differentiated from the Project Team in this Approach because it is important that the subset of personnel performing the GSR Evaluation, that is, the GSR Evaluation Team, communicate effectively with the overall Project Team in the decision-making process to determine the feasibility and practicality of implementing GSR opportunities identified by the GSR Evaluation Team.

A general process for a GSR evaluation that incorporates consideration of BMPs, and includes footprint quantification where appropriate, is outlined below (more details for each step are provided in Section 2.0):

1. **Planning** – This step has two main sub-items:

   - *Integrate GSR within Overall Project Planning*. The Project Team should consider the potential incorporation of overall project planning, practices, and methodologies that encourage resource conservation and efficiency (i.e., inherently consistent with GSR). Examples include the following:

     - Optimization - provides the potential for resource conservation through optimization of remedial systems or processes.

     - Third party review - provides the opportunity for experts in remediation to give a fresh look and to draw on their expertise (e.g., suggest alternate technologies or approaches not currently being considered).

     - Systematic planning - allows the project to look forward and coordinate future activities with current activities (e.g., a decision document that allows transition from a resource intensive approach such as P&T to a less intensive approach such as MNA).

     - Stakeholder involvement – allows concerns of stakeholders to be considered during the development and evaluation of GSR opportunities (e.g., preference regarding removal versus re-use of existing site infrastructure).

     If the project phase includes preparation of a decision document or the document for public review preceding the decision document (i.e., a proposed plan), the language in those documents should be flexible enough to allow for consideration of GSR practices during remedy design, construction, and operation.

   - *Other Planning Activities for a Site-Specific GSR Evaluation*. These planning activities include the following:

     - Establish intent to implement GSR when feasible
     - Determine who will perform the GSR evaluation (i.e., the members of the Project Team who will be on the GSR Evaluation Team and any members outside the Project Team if applicable)
     - Perform screening to evaluate applicability of quantitative footprinting
     - Establish GSR evaluation objectives and scope
     - Determine how GSR will be included and documented in the overall project remedial process
     - Evaluate contract strategy for project regarding GSR (consider which phases will be combined into separate contracts, what types of contracts will be used, and what level of GSR consideration will be needed for each contract)
     - Establish timing of the GSR evaluation(s) within the current project phase
     - Develop and include contract language for GSR inclusion in the project

2. **Identification and Analysis of GSR Opportunities** – This step has several sub-items:

   - *Review Information and Fill Data Gaps*. The GSR Evaluation Team reviews project documents and evaluates how GSR applies to the project. The BMP checklist (see Attachment A-1) is reviewed to identify the extent to which the GSR BMPs have already been considered or applied and additional cases where BMPs could potentially be applied moving forward. It is assumed that the GSR Evaluation Team will typically be a subset of the Project Team, and it is important that the GSR Evaluation Team exchange information and GSR ideas with the overall Project Team. The BMP checklist in Attachment A-1 is recommended as an outline to guide these discussions. If the GSR evaluation will include footprint quantification, pertinent information is obtained from project documents and/or Project Team communications. Pertinent cost information is obtained to determine the cost impacts of any proposed GSR BMPs or remedial options. For MMRP projects, Section 4 (which discusses additional considerations for MMRP projects) should be reviewed.

   - *Fill Out GSR BMP Checklist Tables*. The GSR Evaluation Team (ideally with assistance from the overall Project Team) fills out the BMP checklists based on the activities described above.

   - *Perform Quantitative Footprinting (When Applicable)*. If footprint quantification has been selected as part of the evaluation process, the GSR Evaluation Team quantifies the footprint using SiteWise™ and other calculations for addressing GSR metrics not directly considered by SiteWise™.

   - *Document GSR Evaluation Findings and Recommendations*. Based on the results of the BMP review and footprint quantification, the GSR Evaluation Team documents the information reviewed (including the finalized BMP checklists), and also presents the quantitative footprint assumptions, input values, and results. Qualitative considerations regarding GSR are also presented. Findings and recommendations from the GSR evaluation are documented and provided to the overall Project Team for consensus on the final recommendations from the GSR evaluation. It is expected that GSR metrics will be tracked in Army program management databases in the future, and GSR metrics and related information from the GSR recommendations as agreed on by the Project Team should be entered into Army databases as required and/or appropriate. Documentation of a GSR evaluation may be a full "GSR Evaluation Report" or a less formal document. In some cases a GSR Evaluation Report will become part of the formal record of the project, and in other cases the documentation of findings and recommendations of the GSR evaluation may be an internal report or memorandum. A template GSR Evaluation Report is included as Attachment A-3, and an example GSR evaluation report (i.e., filled in version of the template) is included as Attachment A-4.

3. **Consideration and Implementation of GSR Opportunities –** The results of the GSR evaluation are reviewed by the Project Team, and site-specific recommendations are considered. The GSR recommendations considered feasible (i.e., practical) are then implemented. In some cases, recommendations may only be partially implemented, or implemented in a modified form.

4. **Documentation of GSR Consideration and Implementation in Project Documents –** The results of the GSR evaluation may be incorporated as a section and/or appendix of a Project

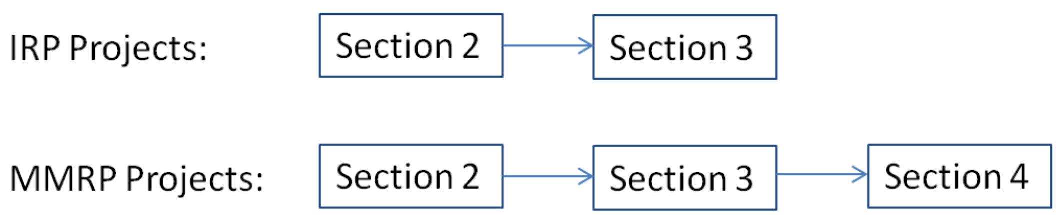
report (e.g., as part of a Feasibility Study, Remedial Design, or Remediation System Evaluation report). In some cases, the entire GSR Evaluation Report will be included as a stand-alone report or Appendix, and in other cases the GSR evaluation results may simply be summarized in a formal Project document or provided as a memorandum. One goal of this step is to document that GSR items were considered and GSR recommendations were implemented when feasible. Another goal is to document the assumptions used in the GSR evaluation. The use of tracking tables for each GSR recommendation, as described later in this GSR Approach, allows the Project Team to document and explain the basis of each GSR recommendation and the implementation status. Such tracking tables for GSR recommendations can be updated throughout the project with reasons provided for implementation or rejection of each recommendation.

This process is described in more detail in the following sections of this document.

1.7 STRUCTURE OF THIS DOCUMENT

The approach presented in this document applies equally to IRP and MMRP projects. A schematic of the applicability of each section is presented on Figure 1-4. All sections of this document apply to MMRP projects. For IRP projects, Section 4 ("Added Considerations for Applying GSR to MMRP Projects") can be skipped. For MMRP projects, Sections 2 and 3 should be read prior to Section 4.

Figure 1-4
Order for Reading this Document (IRP and MMRP Projects)



The remainder of this document is structured as follows:

- Section 2 describes the GSR evaluation process in more detail and includes detailed discussion regarding the following:
    - Planning related to a GSR evaluation
    - Identification and analysis of GSR opportunities
    - Consideration and implementation of GSR opportunities
    - Documentation of GSR consideration and implementation

- Section 3 presents additional consideration for the following activities associated with this process:
    - Tailoring the GSR process to specific phases of the remedial process
    - Issues regarding calculation of life-cycle cost
    - Suggested work-arounds for SiteWise™
    - Addressing tradeoffs between GSR considerations

- Section 4 presents additional considerations for applying the process to MMRP sites:
    - Additional BMP Considerations for MMRP Projects
    - Anticipated site-specific GSR Comparisons for MMRP Projects

- Section 5 presents a list of references used to prepare this document.

Additional information is provided in attachments, as follows:

- The BMP checklists are included as Attachment A-1

- Examples of contracting language for GSR in Army Projects is included in Attachment A-2

- A template GSR Evaluation Report is included as Attachment A-3, which also includes the following electronic files:

    - MS-Word File for Report Text including GSR BMP Tracking Tables
    - MS-Excel Table for Presenting Costs
    - MS-Excel Table for Comparing GSR Metrics/Considerations

- An example GSR Evaluation Report (i.e., filled in version of the template) is included as Attachment A-4, which also includes the following electronic files:

    - MS-Word File for Report Text including GSR BMP Tracking Tables
    - MS-Excel Table for Presenting Costs
    - MS-Excel Table for Comparing GSR Metrics/Considerations
    - SiteWise™ Files for the Example

- A suggested GSR evaluation checklist to complement other Remediation System Evaluation (RSE) checklists for remedy optimization within the Remedial Operation phase of a remedy is included in Attachment A-5

2.0 GSR EVALUATION PROCESS

This section provides addition detail regarding the GSR Approach outlined in Section 1.6, which includes the following general steps:

1. Planning
2. Identification and Analysis of GSR Opportunities
3. Consideration and Implementation of GSR Opportunities
4. Documentation of GSR Consideration and Implementation

It is recommended that GSR evaluations be conducted in conjunction with other Project Team activities such as Feasibility Studies, design reports, and RSEs.

2.1 PLANNING

2.1.1 Integrate GSR within Overall Project Planning

Before initiating a GSR evaluation the Project Team should first evaluate if the overall planning of the remediation project has or should consider incorporation of general practices and methodologies that encourage resource conservation and efficiency (i.e., inherently consistent with GSR). Some "practices" with inherent GSR characteristics are summarized in Table 2-1.

Table 2-1
Practices with Inherent GSR Characteristics

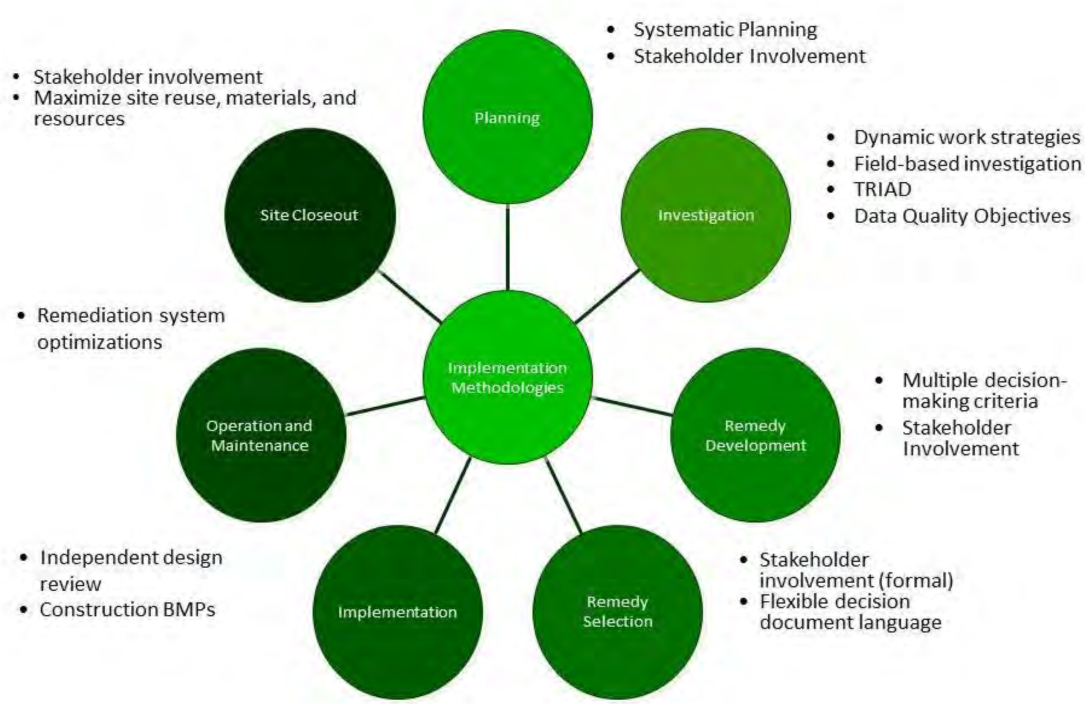
Remedial Phase	Practice
Systematic planning and stakeholder involvement (all remedial phases)	Include stakeholder interests ➢ Early inclusion makes the remedial process more efficient and helps build stakeholder trust and support ➢ Planning for best beneficial reuse of site
Site Investigation	Collecting appropriate and adequate data ➢ Provides accurate definition of area(s)/contaminants to be remediated ➢ Leads to selection of the most appropriate remedy ➢ Helps to determine if active remediation is necessary
Remedy Selection	Balance from CERCLA multi-criteria decision-making process ➢ Already include aspects of the economic (cost), social (public acceptance), and environmental (protection of human health and the environment) GSR pillars Writing flexible decision document language ➢ Allows for changes in the remedy over time ➢ Allows for maximum inclusion of GSR opportunities that conserve/protect resources
Design	Design optimization ➢ Reduces costs and better utilizes resources ➢ Often results in corresponding reduction in GSR footprints (energy, water use, greenhouse gas emissions, etc.)

Table 2-1 Practices with Inherent GSR Characteristics	
Remedial Phase	**Practice**
Construction	Using construction BMPs (e.g., grey water use) ➢ Conserves/protects resources
Remedy Operation	Remedy optimization ➢ Improvement of GSR footprint metrics (energy and water conservation, waste minimization, etc.) often results in cost reductions ➢ Provides opportunity to consider/implement GSR based on evolving understanding of site conditions and system operation over time
Site Closeout	Maximizing reuse/recycling of on-site resources (e.g., buildings and equipment) and maximizing beneficial reuse of site* ➢ Conserves resources, increases economic/social value of site

** Fiscal law prevents additional FUDS/DERA spending that would benefit the landowner (e.g., solar panels or wind turbines)*

Methodologies with inherent GSR characteristics for different phases within the remedial process are illustrated in Figure 2-1.

Figure 2-1. Methodologies that Encourage Resource Conservation and Efficiency (i.e., Inherently Consistent with GSR)



General methodologies which have inherent GSR characteristics that span multiple remedial phases include the following:

- **Optimization**. Holistic remedial system or process optimization (e.g., RSE or Value Engineering Study) is inexorably linked with GSR (i.e., optimization may improve GSR metrics, and GSR evaluations can be included as part of holistic optimization evaluations). Although these evaluations are typically performed during remedy selection, system design, and system operation, opportunities to optimize remedial processes, such as optimization of sample collection strategies, also exist in the remedial investigation phase.

- **Third Party Review**. This general methodology has inherent GSR characteristics that can be applied in all remedial phases, and can be combined with optimization (i.e., a third party remedial system evaluation or a value engineering study of a design). Third party review brings both outside expertise and a fresh look at the remedial process as outlined by the Project Team, thus broadening the consideration of potential remedial options and increasing the potential for resource conservation.

- **Systematic Planning**. Use of a systematic planning process allows for efficiency and optimization in all remedial phases both within the planning process itself and project execution, potentially resulting in conservation of resources through efficiency and informed project decisions. Specific examples of systematic planning include:

    - The USACE technical project planning (TPP) (brochure: http://www.environmental.usace.army.mil/pdf/TTP_brochure.pdf; full document: http://140.194.76.129/publications/eng-manuals/em200-1-2/)
    - The TRIAD (www.clu-in.org/download/char/epa-542-f-10-010.pdf) and data quality objective (DQO) (http://www.epa.gov/quality/qs-docs/g4-final.pdf) approaches introduced by EPA
    - The performance based management approach advocated by ITRC and the Air Force (http://www.itrcweb.org/Documents/RPO-6.pdf)

- **Flexible Decision Document Language.** If the project phase includes preparation of a decision document or the document for public review preceding the decision document (i.e., a proposed plan), the language for those documents should be flexible enough to allow for consideration of GSR practices during remedy design, construction, and operation. Language that allows flexibility for sequencing of the remedy to more sustainable alternatives as the site conditions change is one example (see Example 2-1).

Example 2-1: Language in Decision Document to Allow Sequencing to More Sustainable Alternatives as Site Conditions Change

- Based on contaminant concentration or mass recovery rate changes over time, as well as other considerations such as {insert site-specific considerations}, the remedy will transfer from Pump-and-Treat to a more passive approach such as Monitored Natural Attenuation…

Language that allows flexibility by describing performance standards that need to be achieved rather than prescribing specific materials or construction is another example (see Example 2-2, which includes two examples of typical proposed plan language and compares this language with suggested alternative language that would facilitate inclusion of the GSR practices in the Decision Document).

Example 2-2: Alternative Proposed Plan Language

- GSR suggestion: Use mulch from on-site brush clearing to mix with fertilizer as a substitute for the landfill top soil cover
  - Typical PP language: “6 inches of topsoil”
  - Alternative GSR language: “6 inches of cover material suitable for establishing and supporting the vegetation selected for the cover”
- GSR suggestion: Retain portion of concrete creek structure instead of complete removal
  - Typical PP language: “Remove the reinforced concrete structure in the West Ditch and consolidate the debris underneath the proposed cap to improve surface water drainage at the landfill”
  - Alternative GSR language: “Remove the reinforced concrete structure to the extent that is necessary to improve surface water drainage at the landfill while maintaining structural integrity of the landfill slope and future cover”

2.1.2 Establish Intent to Implement GSR When Feasible

The Project Team should establish intent to implement recommendations from the GSR evaluation when feasible and schedule the GSR evaluation so that the results can be meaningfully considered and implemented within the overall remedial process. It is recommended that GSR evaluations be conducted in association with other remedial activities to streamline process and avoid duplication of effort.

2.1.3 Determine Who will Perform and Review the GSR Evaluation

It is assumed in this Approach that the GSR Evaluation Team will typically be comprised of a subset of the Project Team (including their contractors), which may in some cases be augmented by individuals who are otherwise not directly involved in the day-to-day aspects of the remediation (i.e., an internal GSR expert) or by a third-party (e.g., a separate contractor). If the GSR Evaluation Team will include a contractor it is imperative that GSR language be included into the Scope of Work (SOW) or Performance Work Statement (PWS) for the contract. GSR contract language is discussed in detail in Section 2.1.8, and example contract language is provided in Section 2.1.8 and Attachment A-2.

The roles of the different members on the GSR Evaluation Team should be discussed. Once established, the GSR Evaluation Team can then discuss schedule and deliverables (which should be established in the SOW/PWS) for the GSR evaluation, and discuss how the GSR BMP checklist (see Attachment A-1) will be completed. The following should also be discussed:

- Identification of pertinent documents/reports
- How that information will be distributed
- Identification of site contacts with specific types of information

There is also opportunity during these discussions for identification of stakeholder concerns, sensitivities, and/or confidentiality issues.

2.1.4 Perform Screening to Evaluate Applicability of Quantitative Footprint Evaluation

The following considerations are noted with respect to quantitative evaluation of footprints:

- Quantification of footprints should generally not be performed for the RI phase because footprints for those activities are generally low, and the focus of the RI should be on obtaining best data quality for making remedy decisions.

- In general, the most useful phases for quantitative footprints are FS/remedy selection, design, and O&M.

It is always beneficial to evaluate a list of GSR BMPs for applicability to a project in any phase of the remedial process (i.e., only requires several hours). However, a detailed quantitative footprint evaluation with a tool such as SiteWise™ requires more effort and resources to perform and document, so it is advisable to consider if a quantitative footprint evaluation should be performed. For projects expected to have small footprints, it may not be cost-effective to perform a quantitative footprint evaluation. For projects expected to have large footprints (generally long-term active remedies) there is a greater potential benefit from quantifying footprints and potential footprint reductions.

A screening method to evaluate the applicability of quantitative footprint evaluation is described in Table 2-2. The screening involves a preliminary and simplified evaluation of a project's approximate energy footprint (as a proxy for other footprints such as emissions) in order to determine whether the footprint is large enough to merit more involved calculations with SiteWise™. If this preliminary screening indicates a large enough footprint (defined below as more than 10,000 MMBtus of energy use over the course of the remedy[1]), then detailed footprint quantification with SiteWise™ or a similar tool is recommended for inclusion in a GSR Evaluation. If a project falls below the screening threshold of 10,000 MMBtus, additional footprint quantification may not be necessary but can be performed if otherwise desired and/or needed to address specific concerns of one or more stakeholders.

To determine if remedial activities fall above or below the threshold of 10,000 MMBtus using this screening approach, the following approach is recommended:

1. Identify the top three likely contributors to the remedy's overall footprint based on professional judgment. For example, the top three footprint contributors for a large dig and haul remedy might be equipment operation, transportation and disposal of excavated material, and personnel transportation to and from the site. In Table 2-2, quantities for those different activities or

[1] The screening threshold of 10,000 MMBtus was determined from the results of 12 pilots in the *Final Study Report: Evaluation of Consideration and Incorporation of Green and Sustainable Remediation (GSR) Practices in Army Environmental Remediation*, August 27, 2012, as an approximate value to differentiate between projects with large environmental footprints (i.e., greatest potential for reduction of cost and/or other footprints) and projects with less significant environmental footprints. That report can be found on the following web page by searching "publications": https://casi.erdc.usace.army.mil/focusareas/green_remediation/

materials can be entered (using units appropriate for each item).

2. Use the conversion factors in Table 2-2 (i.e., "# of MMBtus in One Physical Unit (approx)") to equate those quantities and physical units into approximate MMBtus of energy use.

3. Sum the calculated MMBtus to produce a rough total for energy use, which can then be compared to the screening threshold of 10,000 MMBtus.

An example of the screening calculation is provided in Example 2-3 for a pump-and-treat system over a 20-year projected operation where the result exceeds the threshold of 10,000 MMBtus. Note that different items have different units (i.e., units appropriate for that item) and those values are then converted into approximate energy use. The screening results would suggest that a quantitative footprint evaluation is merited for the pump and treat system. Another example of the screening calculation is provided in Example 2-4 for a small short-term dig and haul remedy where the result does not exceed the threshold of 10,000 MMBtus. The screening results for the short-term dig and haul remedy suggest that a quantitative footprint evaluation is optional, depending on whether or not it is desired and/or needed to address specific concerns of one or more stakeholders. If not, a qualitative consideration of GSR BMPs may suffice.

2.1.5 Establish GSR Evaluation Objectives and Scope

The GSR Evaluation Team, in conjunction with the overall Project Team, reviews the GSR evaluation process and why this GSR evaluation is being conducted. Typical questions to ask are:

- Will the GSR identification be used to support remedy selection or implementation?
- Will the GSR evaluation primarily address an existing set of remedial activities (planned or operating), or will the GSR evaluation primarily address a comparison of competing options?
- Are there any GSR reporting requirements?[2]
- Is inclusion of GSR important for funding?

The scope of the GSR evaluation should be consistent with the remedial phase and current conceptual site model (CSM). The need for quantitative footprint evaluation, in addition to qualitative review of GSR BMPs, should be established. The quantification of footprints requires increased effort. The benefits of quantitative footprinting increase with increased project size, duration, and cost. Therefore small, relatively short and inexpensive projects may merit only a qualitative consideration of GSR BMPs, whereas larger projects would merit quantitative footprinting in addition to consideration of the BMPs (see Section 2.1.4).

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[2] Currently there are no program-level GSR reporting requirements for the DoD or Army

Table 2-2
Screening Calculation to Evaluate Applicability of Quantitative Footprinting

Project Name: {insert project name}
Threshold Value: 10,000 MMBtus

Item	Physical Unit	# of MMBtus in One Physical Unit (approx)	Enter site-specific data for top 3 footprint contributors here ↓ **# of Physical Units Consumed by Remedial Activity**	Calculate MMBtus here using formula below ↓ **# of MMBtus associated with Remedial Activity (Physical Units Consumed x MMBtus per Physical Unit)**
Electricity use	kWh	0.01		
Continuous electric motor operation	HP-hr	0.01		
Natural gas use	ccf or therm	0.1		
Diesel or gasoline use	Gal	0.1		
Onsite heavy equipment use	HP-hr	0.005		
Excavation	Cubic yard	0.002		
Trenching and pipe installation	Linear foot	0.001		
Well installation (including drill rig)	Vertical foot	0.5		
Personnel transportation	Mile	0.005		
Materials or waste transportation	Mile	0.02		
Materials or waste transportation	Ton-mile	0.0033		
Refined materials use	Lb	0.01		
Unrefined materials use	Ton	0.01		
Water discharge to the sanitary sewer	1,000 Gal	0.01		
Waste disposal (drums)	Drum	0.001		
Waste disposal (bulk)	Ton	0.1		
Laboratory analysis	$	0.01		
			Total Energy Use (MMBtus)	

If total for 3 largest items is < 10,000 MMBtus, footprinting may be omitted (if not otherwise desired)

Example 2-3
Example of Screening for Long-Term Active Remedy (Pump and Treat, 20 Years)

Project Name: P&T, 20 Years
Threshold Value: 10,000 MMBtus

Item	Physical Unit	# of MMBtus in One Physical Unit (approx)	# of Physical Units Consumed by Remedial Activity (Enter site-specific data for top 3 footprint contributors here ↓)	# of MMBtus associated with Remedial Activity (Physical Units Consumed x MMBtus per Physical Unit) (Calculate MMBtus here using formula below ↓)
Electricity use	kWh	0.01	20,000,000	200,000
Continuous electric motor operation	HP-hr	0.01		
Natural gas use	ccf or therm	0.1		
Diesel or gasoline use	Gal	0.1		
Onsite heavy equipment use	HP-hr	0.005		
Excavation	Cubic yard	0.002		
Trenching and pipe installation	Linear foot	0.001		
Well installation (including drill rig)	Vertical foot	0.5		
Personnel transportation	Mile	0.005		
Materials or waste transportation	Mile	0.02		
Materials or waste transportation	Ton-mile	0.0033		
Refined materials use	Lb	0.01		
Unrefined materials use	Ton	0.01		
Water discharge to the sanitary sewer	1,000 Gal	0.01	5,000,000	50,000
Waste disposal (drums)	Drum	0.001		
Waste disposal (bulk)	Ton	0.1		
Laboratory analysis	$	0.01	1,000,000	10,000
			Total Energy Use (MMBtus)	**260,000**

Total for 3 largest items is > 10,000 MMBtus so detailed footprinting should be performed

Example 2-4
Example of Screening for Short-Term Active Remedy (Small Dig and Haul)

Project Name: Small Dig and Haul
Threshold Value: 10,000 MMBtus

Item	Physical Unit	# of MMBtus in One Physical Unit (approx)	Enter site-specific data for top 3 footprint contributors here ↓ # of Physical Units Consumed by Remedial Activity	Calculate MMBtus here using formula below ↓ # of MMBtus associated with Remedial Activity (Physical Units Consumed x MMBtus per Physical Unit)
Electricity use	kWh	0.01		
Continuous electric motor operation	HP-hr	0.01		
Natural gas use	ccf or therm	0.1		
Diesel or gasoline use	Gal	0.1		
Onsite heavy equipment use	HP-hr	0.005	20,000	100
Excavation	Cubic yard	0.002		
Trenching and pipe installation	Linear foot	0.001		
Well installation (including drill rig)	Vertical foot	0.5		
Personnel transportation	Mile	0.005		
Materials or waste transportation	Mile	0.02		
Materials or waste transportation	Ton-mile	0.0033	500,000	1,650
Refined materials use	Lb	0.01		
Unrefined materials use	Ton	0.01		
Water discharge to the sanitary sewer	1,000 Gal	0.01		
Waste disposal (drums)	Drum	0.001		
Waste disposal (bulk)	Ton	0.1	5,000	500
Laboratory analysis	$	0.01		
			Total Energy Use (MMBtus)	2,250

Total for 3 largest items is < 10,000 MMBtus so detailed footprinting should only be performed for the dig and haul remedy if desired and/or needed to address specific concerns of one or more stakeholders

2.1.6 Determine How GSR will be Included and Documented in the Overall Project Remedial Process

GSR is a relatively new concept and not explicitly part of the conventional CERCLA process. Documentation options may include the following:

- A detailed GSR evaluation can be included as a section in a project document

- A summary of the consideration and implementation of GSR can be included in a project document, typically with reference to a more detailed GSR evaluation in an appendix or as a stand-alone document (in some cases the detailed GSR evaluation may stay internal to the Project Team)

- Tracking forms to summarize status of GSR recommendations (discussed in more detail in Section 2.2.4), which can be placed throughout project documents and between remedial phases

Example 2-5 illustrates inclusion of GSR in a Proposed Plan.

Example 2-5: Inclusion of GSR in Proposed Plan

Within the Proposed Plan, this GSR section followed the traditional discussion of the CERCLA statutory criteria for the preferred remedy (In-Situ Treatment with MNA):

The DERP Manual (March 2012) directs the use of GSR strategies (when feasible) for remedial actions that:

- ► Use natural resources and energy efficiently;
- ► Reduce negative impacts on the environment;
- ► Minimize or eliminate pollution at its source; and
- ► Reduce waste to the greatest extent possible.

The Green and Sustainable Remediation (GSR) Analysis Report {insert reference for the actual report for the specific site}, which is included in the Administrative Record File, was performed to compare the In-Situ Treatment with MNA alternative to the LTM/MNA alternative. The results of the GSR evaluation indicate that the LTM alternative is generally less sustainable than the In-Situ Treatment with MNA alternative.

{a summary of comparative GSR metrics from the GSR evaluation was then provided}

2.1.7 Establish Timing of the GSR Evaluation within the Current Project Phase

The timing of the GSR evaluation within the remedial phase is also an important consideration. Balance in the following items is required:

- The information available needs to be sufficient for a GSR evaluation
- The timing needs to be early enough in the project phase to not require regulator re-review of documents

The level of information that is needed for the GSR evaluation will vary depending on the degree of quantification required for GSR metrics. For example, in an FS, a conceptual GSR evaluation performed during the alternative development process to incorporate technologies with GSR characteristics would require a relatively low level of quantitative information whereas a detailed comparison of GSR metrics across a series of alternatives would require more quantitative information. Similarly, incorporation of conceptual GSR ideas could occur at an early stage in the design process, with detailed quantification of GSR metrics performed later in the design. See Section 3.1 for more detailed information on the timing and types of GSR evaluations within the FS and Design phases.

2.1.8 Develop and Include Contract Language for GSR Inclusion in the Project

If a contractor is being used to help plan and/or perform the GSR evaluation, contract language should be utilized to allow inclusion of GSR by the contractor in the project. At a minimum, it is recommended that some GSR language be included to ensure that GSR is within scope for the Contractor. GSR language should be included in the performance work statement (PWS) if the contract for the project is to be awarded. If the project is operating under an existing contract, the contract should be examined to determine if GSR is within scope; if GSR is not within scope, a contract modification may be considered.

Examples of *prescriptive, performance-based, and performance-based with incentive* contract language are included in Examples 2-6, 2-7, and 2-8 respectively. These examples represent a subset of a larger set of examples for contract language included in Attachment A-2. For the examples below, and the examples in Attachment A-2, other project-specific contracting factors could also be included for general sustainability considerations such as sustainable materials procurement. If the contract is to be awarded, consideration should be given to adding a GSR technical evaluation factor, with weighting of the factor representing the importance of GSR with respect to other technical evaluation factors.

Example 2-6: Contract Language: Fixed Price, Prescriptive

- Remediation System Evaluation (RSE) GSR SOW Language (FP) for Army Environmental Command RSEs Performed by EM CX:
  - ► *Sustainability Analysis*. The contractor shall evaluate the carbon footprint and other resource impacts of the current remedial or corrective actions at the installations. The RSE shall consider sustainability (relative to this baseline) in developing the recommended changes to the actions at the site. The potential use of alternative energy sources or energy recovery shall be evaluated and appropriate recommendations shall be included in the RSE report. The evaluation will require the use of tools such as the Air Force Sustainable Remediation Tool spreadsheet or the Battelle SiteWise software.

Example 2-7: Contract Language: Performance Based with GSR Technical Evaluation Sub-Factor

- Example PWS language
  - ► The Contractor shall consider and implement green response/remediation strategies and applications to maximize sustainability, reduce energy and water usage, promote carbon neutrality, promote industrial materials reuse and recycling, and protect and preserve land resources, consistent with Defense Environmental Restoration Program (DERP) GSR policy (March 2012 DERP Manual). The Contractor shall present green remediation options and approaches, including cost analyses, in its work plans, maintain records of "green-related" activities, and report this information to the COR in its project status reports.

- Example basis of award language technical evaluation sub-factor
  - ► Sustainable Practices: Proposal demonstrates consideration of green and sustainable remediation practices in all aspects of the technical approach and project execution, and provides logic for acceptance or rejection of implementing such.

Example 2-8: Contract Language: Performance Based with Incentive
(note that this language directs both GSR and innovative technologies to be considered)

The language below is for a Performance-Based Contract for RI/FS work on a specific project

Innovative Technologies (IT) and Green and Sustainable Remediation (GSR)
[include in scope section of work statement]

- It is USACE's goal to incorporate IT and GSR practices into all phases of this project when feasible.
- Statutory requirements (e.g., CERCLA evaluation criteria) for this project take precedence over the IT and GSR initiative.
- All work performed under this Contract shall comply with {insert policy or guidance}
- Where applicable, the Contractor shall follow {insert title(s) and reference(s) of current Army and/or USACE Guidance for incorporation of Green and Sustainable Practices into Environmental Remediation Projects}
- To the extent practical, the Contractor shall consider and implement green and sustainable remediation (GSR) strategies and applications to:
    - maximize sustainability
    - reduce waste
    - reduce energy and water usage
    - increase energy efficiency and minimize the use of non-renewable energy
    - conserve and efficiently manage resources and materials
    - promote carbon neutrality
    - reduce direct and indirect greenhouse gas and other emissions
    - promote reuse and recycling
    - fostering green and healthy communities and working landscapes which balance ecological, economic and social goals
    - integrate the remedy with the end use where possible and encouraging green and sustainable re-development
    - maximize habitat value and create habitat when possible
    - protect and preserve land resources
- At a minimum, the Contractor shall utilize the following GSR practices on this project:
    - The TRIAD approach to project planning, work strategies, and sampling and analytical technologies.
    - The SiteWise™ Tool, latest version, during the FS to quantify the environmental footprints of remedial alternatives and possibly during the RI planning stages to assess the footprint of different investigation technologies.
- The Contractor is encouraged to develop, plan, and implement additional innovative and GSR approaches to the work. Examples include, but are not limited to passive/no-flow sampling techniques; direct push drilling; use of clean diesel or biofuels; remote data collection, multi increment sampling; carbon offsets; renewable energy; field screening; mobile laboratories; waste minimization; and innovative approaches to public involvement.
- All work plans and reports generated by the Contractor in performance of this work shall include a discussion of the innovative technologies and GSR practices proposed/performed for the relevant scope of work.
- Specific incentives include:

{Add incentives – See Attachment A-2 for a Specific Example}

2.2 IDENTIFICATION AND ANALYSIS OF GSR OPPORTUNITIES

2.2.1 Review Information and Fill Data Gaps

The following items should be accomplished:

- Perform a preliminary review of project documents and evaluate how GSR applies to the project.

- Review the BMP checklist (see Attachment A-1) based on initial review of project documents to identify the extent to which the GSR BMPs have already been considered or applied, and to identify additional cases where BMPs could potentially be applied in the future.

- Exchange information and GSR ideas using the BMP checklist in Attachment A-1 as an outline to guide the discussion. This should be an open discussion where the overall Project Team shares knowledge about the project, using the BMP checklists as a guide so that all pertinent GSR issues are addressed. The BMP checklists in Attachment A-1 include a section for site-specific BMPs that may be developed during these discussions.

- If the GSR evaluation will include footprint quantification, extract pertinent information from project documents and/or Project Team communications, and address any data gaps.

- Obtain pertinent cost information, such as electricity and natural gas monthly usage and related cost information.

- For MMRP projects, review Section 4 of this document, which discusses additional considerations for MMRP projects.

The project documents available for a GSR evaluation will vary based on the remedial phase. For projects in the planning phase or early remedial investigation phase, documentation may be limited to a preliminary assessment or site inspection.

- Table 2-3 outlines the documents that should be available for review for each remedial phase for IRP projects.

- Table 2-4 outlines the documents that should be available for review for each remedial phase for MMRP projects.

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Table 2-3
Typical Documents Available for Review (by Remedial Phase), IRP Projects

Remedial Phase	Typical Documents
Preliminary Assessment (PA)	• Preliminary Assessment Reports • Inventory Project Report (InPR) • TPP Meeting Minutes and Memorandum • CSM
Site Inspection (SI)	• Preliminary Assessment and Site Inspection Reports
Remedial Investigation (RI)	• Preliminary Assessment and Site Inspection Reports • Interim Field Investigation Reports • Engineering Evaluation/Cost Analysis (EE/CA) Report • Removal Action Report for a TCRA or NTCRA • Public Involvement Plan (PIP)
Feasibility Study (FS)	• RI Report, including Baseline Human Health and Ecological Risk Assessments • Pilot Test or Treatability Study Reports
Remedial Design (RD)	• RI Report • FS Report • Pilot Test or Treatability Study Reports • Decision Documents
Remedy Implementation	• RI Report • FS Report • Pilot Test or Treatability Study Reports • Decision Documents • 100% Design or Remedial Action Work Plan
O&M	• Decision Documents • 100% Design or Remedial Action Work Plan • Remedial Action Report • As-Built Diagrams • O&M Manual • O&M Reports (typically an Annual Report)
Site closure	• Remedial Action Report • As-Built Diagrams • O&M Manual • O&M Reports (typically an Annual Report) • Land Reuse and/or Zoning Plans
During all remedial phases it is appropriate to consider: • Systematic Planning Documents • Zoning Plans • Future Land Reuse Plans	

Table 2-4
Typical Documents Available for Review (by Remedial Phase), MMRP Projects

Remedial Phase	Documents
Preliminary Assessment (PA)	• Site specific information documents • Zoning, Future Reuse Plans • HRR Report, or ASR • Inventory Project Report (InPR) • Aerial Photograph Interpretation Report • TPP Meeting Minutes and Memorandum • CSM • Munitions Response Site Prioritization Protocol (MRSPP) Scores
Site Inspection (SI)	• Zoning, Future Reuse Plans • HRR Report, ASR and PA Report • InPR • Aerial Photograph Interpretation Report • TPP Meeting Minutes and Memorandum • CSM • MRSPP Scores
Remedial Investigation (RI)	• Zoning, Future Reuse Plans • PA and SI Reports • Interim Field Investigation Reports • Engineering Evaluation/Cost Analysis (EE/CA) Report • Removal Action Report for a TCRA or NTCRA • ASR • HRR Report • CSMs • Public Involvement Plan (PIP) • MRSPP Scores (revised after each phase, and in some cases every year) • TPP Meeting Minutes and Memoranda • Explosives Safety Submission (ESS)/Chemical Safety Submission (CSS) • RI Work Plan/UFP QAPP • Geophysical Prove Out (GPO) Report and/or Geophysical System Verification (GSV) Report • Site Specific Final Report (SSFR) for an NTCRA
Feasibility Study (FS)	• RI Report, including Baseline Human Health and Ecological Risk Assessments • Pilot Test or Treatability Study Reports
Remedial Design (RD)	• RI Report • FS Report • Proposed Plan • Pilot Test or Treatability Study Reports • Decision Documents

Table 2-4 Typical Documents Available for Review (by Remedial Phase), MMRP Projects	
Remedial Phase	**Documents**
Remedy Implementation (Remedy In Place / Response Complete)	• RI Report • FS Report • Pilot Test or Treatability Study Reports • Decision Documents • 100% Design or Remedial Action Work Plan
LTM / Five-Year Review	• Decision Documents • 100% Design or Remedial Action Work Plan • Remedial Action Report • As-Built Diagrams • O&M Manual • O&M Reports (typically an Annual Report)
Site closure	• Remedial Action Report • As-Built Diagrams • O&M Manual • O&M Reports (typically an Annual Report) • Long Term Management Plan • Land Reuse/Zoning Plans
During all remedial phases it is appropriate to consider: • Systematic Planning Documents • Zoning Plans • Future Land Reuse Plans	

Some information needed for the GSR evaluation may not be readily available in project documents. A typical example is electric bills that indicate electrical usage and cost per kilowatt-hour (both of which may vary by season). As the GSR evaluation proceeds, it is important that the sources of data are identified, as well as the relative confidence and/or potential variability in those data.

2.2.2 Fill Out GSR BMP Checklist Tables

Review and consideration of BMPs are central to this portion of the process. This can be accomplished by reviewing BMP checklists (see Attachment A-1). The BMPs are divided into the following categories:

A. Planning
B. Characterization and/or Remedy Approach
C. Energy/Emissions - Transportation
D. Energy/Emissions - Equipment Use
E. Materials & Off-Site Services
F. Water Resource Use
G. Waste Generation, Disposal, and Recycling
H. Land Use, Ecosystems, and Cultural Resources
I. Safety and Community
J. Other Site-Specific BMPs

Analysis of BMPs during this phase of the process considers project-specific information and focuses on the project-specific considerations, advantages, or limitations for implementing individual BMPs. The analysis likely addresses the following questions for each BMP:

- Is the BMP applicable for the project? (e.g., BMP D-8 regarding lighting options and motion sensors is not applicable to an in-situ remedy that involves injecting reagents into the subsurface at outdoor injection points during the day)

- What are the limitations for applying the BMP for the project?

- Are there specific GSR metrics that might significantly increase or decrease by implementing the BMP?

- What are the likely costs impacts (qualitative, perhaps supported by simple calculations) of implementing the BMP (e.g., significant cost savings, cost neutral, significant cost increase)? Note the term "significant" is project-specific, but is intended to differentiate major changes from very small potential increases or decreases relative to the overall project.

- Based on the above estimated footprint changes and limitations, is implementing the BMP recommended because it is practical and provides value?

- What additional information might be needed to help with the above analysis?

The GSR BMPs were designed to be general so that they are broadly applicable and do not become outdated as related Federal guidance or policy (e.g., regarding procurement of materials with recycled content, low impact design, renewable energy certificates, etc.) is modified in the future. Application of the GSR BMPs should consider specific guidance and policy in place at the time the GSR evaluation is performed.

The BMPs included in Attachment A-1 are listed below, by category. Some of the BMPs could be placed in more than one category, but each is placed in just one of the categories. Each BMP is identified by the category letter plus a number (e.g., B-3). It is intended the BMP checklists in Attachment A-1 can be edited directly in Word format when a GSR evaluation is performed. In a case where several distinct actions can be taken with respect to the same BMP, it is possible to create multiple entries for the specific BMP by copying the specific BMP table in Attachment C-3 multiple times, and assigning an additional number for identification (e.g., C-3.1 and C-3.2 could represent two distinct actions that both pertain to BMP C-3). Also note that the BMPs listed below and included in Attachment A-1 generically apply to both IRP and MMRP projects. Additional considerations regarding the BMPs for MMRP projects are highlighted in Section 4.1.

2.2.2.1 BMPs for Planning

A-1. Develop a culture of GSR within the Project Team and encourage GSR ideas from project staff, and review similar projects from other sites for possible transfer/adoption of GSR ideas

A-2. Incorporate a section on GSR in project meetings, work plans, and reports

A-3. Identify and periodically update a list of key stakeholders and their concerns with respect to GSR considerations

A-4. Schedule activities for appropriate seasons and/or time of day to reduce delays caused by weather conditions and fuel needed for heating or cooling

Examples:

- Work at night in summer to avoid heat stress
- Perform field activities in summer to take advantage of longer daylight

A-5. Prepare, store, and distribute documents electronically

A-6. Utilize teleconferences rather than meetings when feasible

A-7. Incorporate green and sustainable remediation (GSR)specifications into solicitations and contracts

Examples:

- Follow pertinent green procurement policies
- Select hotel chains with "green" policies
- Select laboratories that utilize renewable energy
- Include GSR in the request for proposal, as well as any incentives for GSR incorporation
- Include GSR as one of the technical evaluation factors for contract award

A-8. Integrate schedules to allow for resource sharing and fewer days of field mobilization

A-9. Tailor the remedy cleanup goals such that they are appropriate for anticipated end-use of the property, rather than assuming a more conservative exposure scenario with more stringent cleanup goals

A-10. Conduct thorough review of project documents and historical records to minimize required scope of investigation

Examples:

- IRP projects: determine if there are previous aquifer tests that can be used for groundwater modeling rather than conducting new aquifer tests
- MMRP projects: perform careful review of historic documents, aerial photographs, and other existing information to reduce the footprint of land that needs to be disturbed for thorough investigation and remediation
- MMRP projects: use IRP sampling data to supplement and enhance the MMRP field program (if available)

A-11. Use language in work plans, proposed plans, and decision documents that maximizes flexibility to allow GSR recommendations to be implemented

Examples:

- Designation of a "suitable growth media" for a landfill cap cover material rather than "top soil"
- Allow for "treatment technologies that achieve adequate levels of treatment" rather than specifying only one treatment technology

2.2.2.2 <u>BMPs for Characterization and/or Remedy Approach</u>

B-1. Develop and routinely update a conceptual site model (CSM) to use as a basis for making remedial process decisions

B-2. Perform regular optimization evaluations to improve efficiency of current or planned actions and/or develop alternative remedial approaches that might shorten remedy duration or otherwise improve the net environmental benefit of the remedy, including use of any methodologies, such as TRIAD (www.triadcentral.org), systematic planning (technical project planning), value engineering studies, and remedial system evaluations, expected to optimize the planning and/or execution of the project

B-3. Use appropriate characterization or remedy approach based on site conditions

Examples:

- Consider in-situ and passive remedy options that offer adequate protectiveness
- Consider in-situ bioremediation if conditions are already anaerobic and constituents are conducive to reductive dechlorination
- Compare source removal versus in-situ and ex-situ remedial options
- Consider different technologies for impacted areas with higher and lower concentrations
- Use realistic times to remedy closeout (i.e., estimations through modeling) rather than assumed remedy timeframes (e.g., 30 years, which is often used for evaluation of FS alternatives)
- MMRP projects: evaluate man-portable DGM instruments versus vehicle-towed array (VTA) instruments and inclusion of detector-aided reconnaissance (DAR)
- MMRP projects: evaluate best alternative for destruction of munitions (e.g., blow in place versus consolidated shot versus controlled detonation chamber)

B-4. Establish decision points to trigger a change from one technology to another or from one remedy alternative to another

Examples:

- Change vapor treatment from thermal oxidation to granular activated carbon (GAC) media based on flow rates and concentrations
- Remove a treatment polishing step if influent to that step already meets discharge criteria
- Move to Monitored Natural Attenuation (MNA) if specific concentration thresholds in groundwater are met

B-5. Focus sampling efforts to meet objectives of the specific remedial phase (e.g., sampling during O&M should be focused on evaluating remedy performance and not on thorough plume characterization)

Examples:

- Eliminate sampling parameters as appropriate
- Reduce sampling frequency as appropriate
- Reduce sample locations as appropriate
- Enhance monitoring program as appropriate
- MMRP projects: consider Incremental Sampling Methodology (ISM) versus discrete sampling for MC characterization

B-6. Consider real-time measurements and dynamic work plans to reduce mobilizations and improve effectiveness of investigation efforts

Examples:

- Field test kits (e.g., test kits for sulfate)
- Field screening instruments (e.g., x-ray fluorescence for lead or photoionization detectors for volatile organics)
- Drive point sensor technologies (e.g., membrane interface probe or "MIP")
- Visual staining or odor
- Establish excavation extent based on real-time data collected as excavation proceeds and use GPS to accurately delineate excavation areas
- MMRP projects: use GPS and/or the same equipment that was used for detection to confirm anomaly signatures prior to excavating
- MMRP projects: consider incorporating field screening methods (e.g., X-ray fluorescence, EXPRAY and explosives test kits, as appropriate or applicable) into the field program to refine sampling locations and reduce the quantities of samples submitted for off-site laboratory analysis
- MMRP projects: consider use of advanced electromagnetic sensors (e.g., MetalMapper) for better subsurface item identification to reduce digging requirements

B-7. Consider use of existing site structures/infrastructure or mobilization of temporary structures versus new construction

Examples:

- Buildings (e.g., for treatment building or field office)
- Concrete slabs or foundations
- Wells
- Existing excavations for storm water control

B-8. Establish project-specific decision points to limit extent of remediation

Examples:

- Project-specific cleanup levels based on a site-specific risk assessment (coordinated with risk assessment experts) rather than generic cleanup levels, if it results in lower footprints for key metrics and is acceptable to all stakeholders
- MMRP projects: dig stopping rules and anomaly prioritization/detection criteria to minimize false positives

B-9. Consider leaving in place structures whose removal is not necessary (i.e., foundations, underground pillars, etc.)

2.2.2.3 <u>BMPs for Energy/Emissions – Transportation</u>

C-1. Reduce the number of trips for personnel

Examples:

- Encourage carpooling
- Use telemetry systems and webcams to remotely transmit data directly to project offices to avoid trips

C-2. Reduce the number of trips and/or volume for transported materials, equipment, or waste

Examples:

- Transfer full loads by consolidating shipments from vendors and/or shipments to

disposal sites (also share shipments with neighbors if feasible)
- Purchase more concentrated chemicals to reduce transportation weight and/or volume

C-3. Reduce trip lengths

Examples:

- Dispose of waste at closest appropriate facility
- Purchase materials, equipment, and services from local vendors
- Use locally produced supplies
- Select most efficient transportation route

C-4. Use alternate fuels or other options for transportation when possible

Examples:

- Compressed natural gas
- Biodiesel blends
- Ethanol blends
- Hybrid and/or electric
- Rail lines versus trucks
- Use a fuel efficient passenger car rather than a pickup truck if task allows

2.2.2.4 BMPs for Energy/Emissions – Equipment Use

D-1. Consider and implement approaches to minimize engine idle times

D-2. Ensure peak operating efficiency of equipment to reduce energy use and emissions

Examples:

- Perform preventative maintenance and operate equipment per manufacturer instructions
- Perform retrofits involving low-maintenance multi-stage filters for cleaner engine exhaust
- Use synthetic oil to extend operating life (and reduce waste oil)
- Purchase newer equipment with reduced emissions

D-3. Use alternate fuel options for equipment when possible

Examples:

- Compressed natural gas
- Biodiesel
- Ethanol blends
- Ultra-low sulfur diesel, wherever available (and as required by engines with PM traps)
- Recycled oil (ensure compliance with operating requirements/warranties)

D-4. Select appropriate equipment and/or power source for the job

Examples:

- Avoid using large excavators for small earthmoving projects
- Use direct push methods when possible to reduce drilling duration
- Compare potential use of electricity versus battery versus generator

D-5. Use variable frequency drives on motors (e.g., pumps, blowers), or replace oversized motors with properly sized motors

D-6. Identify options for generating renewable energy for direct use in the remedial activities and/or for alternate use at or near the project site

Examples:

- Solar, wind, landfill gas (micro turbines), combined heat and power, geothermal heat exchange
- Applications for remote areas such as solar pumps or solar flares (if demand is not continuous, the need for a battery backup may be avoided)
- Generate power or heat exchange from water to be discharged

D-7. Consider purchase of renewable energy certificates (RECs) to offset emissions from the remedial activities (note that a Memorandum titled Department of the Army Policy for Renewable Energy Credits, dated 24 May 2012, states that "the Army shall not purchase RECs solely to meet Federal renewable energy goals," but it is possible that Project Teams might in some cases consider the purchase of RECs to address concerns of one or more stakeholders at a specific site)

D-8. Design/modify housing required for above-ground treatment components for energy-efficiency

Examples:

- Passive lighting
- Compact fluorescent lighting (CFL) or light-emitting diode (LED) lighting
- Timers and/or motion control sensors for lighting
- Shading
- Minimize heating and cooling needs (building size, insulation, etc.)

D-9. For remedies that involve groundwater or air extraction, optimize extraction to reduce flow rates (potentially beneficial with respect to energy use, materials usage, water resources, waste disposal, etc.)

D-10. Consider pulsing for extraction and/or injection of water or air to maximize mass removal per unit of time or energy, by extracting higher concentrations

D-11. Run electrical equipment during times of lower electric demand if possible (this does not reduce energy use but could lower cost and also can lower stress on the energy grid during periods of peak demand)

2.2.2.5 BMPs for Materials & Off-Site Services

E-1. Use materials that are made from recycled materials

Examples:

- Steel
- Asphalt
- Plastics
- Concrete

E-2. Optimize the amount of materials used

Examples:

- Experiment with different material amounts/doses

- Consider alternate materials
- Use timers or feedback loops and process controls for dosing
- MMRP projects: minimize quantities of donor explosives for MEC destruction

E-3. Utilize less refined materials when feasible

Examples:

- Limestone instead of sodium hydroxide for pH adjustment
- Native fill instead of select fill

E-4. Identify opportunities for using by-products or "waste" materials from local sources in place of refined chemicals or materials

Examples:

- Cheese whey, molasses, compost, or off-spec food products for inducing anaerobic conditions
- Crushed concrete for use as fill
- Concrete from coal combustion byproducts

E-5. Reduce demand on Publicly Owned Treatment Works (POTWs)

Examples:

- Discharge treated water to groundwater or to surface water rather than POTW
- Minimize amount of water requiring treatment

2.2.2.6 BMPs for Water Resource Use

F-1. Minimize water consumption

Examples:

- Sensors to turn off water when not needed
- Low flow fittings
- Minimize water needs for irrigation (landscape choices, use of mats and mulch)

F-2. Preferentially use less refined water resources when feasible

Examples:

- Use extracted groundwater instead of potable water for chemical blending
- Capture and store rain/storm water for future use
- Employ rumble grates with a closed-loop gray-water washing system

F-3. Use extracted and treated water for beneficial purposes

Examples:

- Irrigation
- Potable water
- Industrial process water

F-4. Promote groundwater recharge

Examples:

- Recharge extracted and treated water when beneficial uses of the water are not identified and reinjection is practical
- Minimize site area covered by impervious surfaces to reduce runoff and maximize infiltration (unless such capping is a specific component of the remedial action)

F-5. Maintain water quality by preventing nutrient loading to surface water or groundwater

Examples:

- Use phosphate-free detergents instead of organic solvents or acids to decontaminate sampling equipment (if not required for some contaminants)

2.2.2.7 <u>BMPs for Waste Generation, Disposal, and Recycling</u>

G-1. Minimize drill cuttings and all other investigation derived waste (including personal protection equipment)

Examples:

- Direct push or sonic drilling to reduce drill cuttings
- Low-flow sampling or passive diffusion bags (if applicable) to reduce purge water
- When possible place drill cuttings on-site rather than off-site disposal

G-2. Segregate excavated soil in pre-planned staging areas so that "clean" material can be deposited on-site and/or reused rather than transported for off-site disposal

G-3. Consider on-site treatment and re-use of soil instead of off-site disposal

Examples:

- Land farming
- Above ground soil vapor extraction (SVE)

G-4. Minimize need to transport and dispose hazardous waste

Examples:

- Consider delisting listed hazardous waste if waste is not characteristically hazardous waste
- Segregate hazardous waste and non-hazardous waste

G-5. When possible avoid/minimize use of hazardous/toxic materials that may require special handling or disposal

Examples:

- Cleaning solutions
- Pesticides
- Disposable batteries (use rechargeable batteries)
- MMRP projects: minimize Chemical Agent Contaminated Media (CACM) at RCWM sites.

G-6. Recycle or reuse materials rather than disposing of them

Examples:

- Cardboard
- Plastics
- Concrete
- Asphalt
- Steel and other metals
- Recovered oil/product
- Mulch/compost
- MMRP projects - recycle recovered Material Documented as Safe (MDAS) after inspection and certification that the remnants are free of explosive hazards

2.2.2.8 BMPs for Land Use, Ecosystems, and Cultural Resources

H-1. Minimize erosion and soil transport to surface water bodies

Examples:

- Quickly restore any vegetated areas disrupted by equipment or vehicles
- Institute appropriate erosion controls during excavation such as silt fencing

H-2. Minimize disturbances to land

Examples:

- Establish well-defined traffic patterns for onsite activities to minimize disturbed areas
- Consider non-intrusive investigation techniques (e.g., geophysical methods) to identify items like USTs and buried drums

H-3. Preserve/restore ecosystems to the extent possible

Examples:

- Limit the removal of trees and vegetation
- Attempt to transplant disturbed shrubs and small trees to other locations
- Use native species for re-vegetation
- Retrieve dead trees during excavation and later reposition them as habitat snags
- Select and place suitably sized and typed stones into water beds and banks
- Undercut surface water banks in ways that mirror natural conditions
- Cut back rather than remove trees, bushes, vegetation

H-4. Minimize drawdown of the water table in sensitive areas such as wetlands or areas subject to subsidence

H-5. Construct wells and other remedial process infrastructure (piping, buildings, etc.) to minimize restrictions to anticipated future use of the site

H-6. Preserve/restore cultural resources to the extent possible

Examples:

- Protected lands such as wildlife refuges, national parks, and wilderness areas
- Culturally sensitive sites such as cemeteries, native burials, and archaeological finds
- Buildings or land parcels with historical significance

H-7. Document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources

Examples:

- photodocument conditions prior to clearing brush
- MMRP projects: photodocument conditions prior to BIP

2.2.2.9 BMPs for Safety and Community

I-1. Minimize and mitigate noise, light and odor disturbance during all phases of the remedial process, to the extent practicable

I-2. Minimize dust during construction activities by spraying water or techniques such as laying biodegradable mats, tarps, or materials (already in EM385-1-1)

I-3. Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts

I-4. Minimize drawdown of the water table in areas that could impact production rates at supply wells and/or irrigation wells

I-5. Minimize amount of time that heavy machinery is needed to enhance safety

I-6. Minimize handling of dangerous chemicals by selecting alternate chemicals and/or engineering to minimize contact with chemicals (for MMRP projects, there is enhanced risk related to explosion potential and exposure to chemical agents (CA) and agent breakdown products (ABP) associated with RCWM responses)

I-7. Contribute to local economy when possible

Examples:

- Consider leasing local office space
- Purchase or lease equipment from local vendors
- Hire workers from local community

I-8. Utilize on-site construction practices and PPE requirements for anticipated exposure scenarios rather than an overly conservative level of protectiveness that is more resource intensive

Example:

- Utilize general construction PPE protectiveness, which is less personnel and equipment resource intensive, rather than HTRW PPE protectiveness, when applying a non-hazardous soil cover for a HTRW landfill

2.2.2.10 Other Site-Specific BMPs

This would include any project-specific BMPs not identified in the BMP list presented above. These may include any BMPs that would be associated with the Army mission factor, such as security or readiness.

2.2.3 Perform Quantitative Footprinting (When Applicable)

The GSR footprint includes GSR metrics such as the amount of energy used, the amount of greenhouse gases emitted, and the amount of potable water consumed. In this GSR Approach, the footprint of a baseline option (and alternatives to the baseline) also includes an evaluation of costs. The approach to estimating costs is detailed in Section 3.2.

2.2.3.1 Guidelines for Setting Limits

Footprint quantification can help with reporting of GSR metric footprints for activities associated with a specific phase of the remedial process, and can also be helpful in evaluating BMPs. Therefore, footprint quantification, in some manner, is typically encouraged as part of the GSR analysis phase, even if footprint quantification is not specifically required. The most labor-intensive aspects of footprint quantification are information gathering and the reporting/explanation of results. A fundamental question for footprint quantification therefore is “What information is needed and what information is extraneous?” The following are general guidelines to follow when undertaking footprint quantification:

- Limit the scope of the quantification to the information needed. For example, if footprint quantification is undertaken to evaluate potential footprint reductions from implementing a BMP, footprint quantification need only focus on those components of the remedial process influenced by the BMP.

- Limit information gathering only to those items that are significant contributors. For example, the manufacturing of the nitrile gloves used for personal protection equipment during an in-situ chemical oxidation remedy is likely a small contributor to the overall footprint and need not be considered when quantifying the footprint of the entire remedial phase for that project or even a single injection event. A rule of thumb is to use an estimated 5% cutoff for the remedial activity being evaluated by asking one or more the following questions and excluding items from the analysis that do not meet one or more of the 5% cutoff criteria:

    - 5% of the transportation miles

        Example: Routine annual transportation includes weekly operator visits that are 20 miles roundtrip (approximately 50 visits per year, for a total of approximately 1,000 miles per year), one delivery of GAC that requires a round-trip distance of 400 miles, and one sampling round that involves 10 days of technician travel with a round-trip distance of 50 miles each day (500 miles). Travel by the project manager for the Five-Year Review (50 miles roundtrip) or even a non-routine annual inspection need not be included in the analysis.

    - 5% of equipment in horsepower hours per day (HP-hrs/day), considered separately for fuel-powered equipment and electricity

        Example: Routine electric motor usage includes 5 HP of continuous extraction pump usage (120 HP-hrs per day) and 10 HP of continuous blower usage (240 HP-hrs per day). Intermittent operation of the 0.5 HP sump pump (less than 1 HP-hr per day) need not be considered.

    - 5% of the refined material use

        Example: Chemical injection involves the use of 12,000 pounds of potassium permanganate per year. The 50 gallons of 6% sodium thiosulfate (approximately 25 pounds) that is potentially used per year for oxidant neutralization need not be considered. A caveat would exist if there is a specific reason for giving special consideration due to extreme impacts that might result from a small quantity of a specific material.

    - 5% of the unrefined material use

        Example: 1,000 cubic feet of sand is used as bedding for conveyance piping. The 5 cubic feet of sand used for the sand pack around the extraction well need not be considered.

    - 5% of the non-labor cost (applies to materials only)

        Example: Total annual non-labor cost for a P&T remedy is approximately $55,000 for GAC, electricity, and laboratory analysis. If annual cost for bag filters is less than $1,000, the bag filters are a sufficiently small component of the total materials costs and need not be considered for the GSR footprint quantification. A caveat would exist if there is a specific reason for giving special consideration due to extreme impacts that might result from a material that has a small cost relative to the other materials.

- With respect to materials, utilities, and off-site services, generally limit information (quantity and accuracy of estimate) to that which has been gathered for the purpose of cost-estimating. For example, if paper clips and reams of papers were not itemized for costing purposes, they should not be itemized in a GSR evaluation.

A similar outcome can be obtained if the footprint evaluator uses professional judgment to exclude insignificant contributors.

2.2.3.2 Guidelines for Information Accuracy

Typically, more detailed and accurate information is available in the design and implementation phases than during the remedy selection phase. The uncertainty and variation in the remedial parameters (e.g., expected time frame for P&T operation or the total quantity of injected reagent) are often the largest sources of uncertainty for footprint quantification. As the remedial process progresses and footprint quantification is updated, it is preferable to update the input information for the footprint quantification. A few examples are as follows:

- Diesel Equipment Use – During remedy selection diesel fuel usage may be estimated using rules of thumb based on general activity (e.g., soil excavation). During remedy design, however, discussions with a contractor may help pinpoint the type of equipment (including HP rating) to be used and the estimated number of hours of operation or the fuel usage from a similar project. This information is likely more accurate than the estimate during remedy selection. Finally, during remedy O&M, the contractor may be able to track fuel usage during the project and forecast total fuel usage based on these actual field measurements.

- Electrical Equipment – During remedy selection, electricity use may need to be estimated based on projected power requirements (e.g., total head, flow rate, and estimated pump efficiencies for an extraction pump). During remedy design flow rates and total head calculations may be refined and actual pumps may be selected, which likely provides more accurate information. During remedy O&M, actual electricity use may be available from bills or meters.

- Transportation – During remedy selection, material types and projected quantities may be known, but the supplier and the distance from the supplier to the site may not be known. In this case, an assumed distance is merited. During design, the manufacturer may be known and the distance and mode of transportation can be better determined. During remedy implementation or remedy O&M, it may be possible to identify the actual amount of fuel used for transport.

In each of the above cases, as the remedial process moves into a subsequent phase, the quality of the input information for footprint quantification improves.

2.2.3.3 Using SiteWise™ for Footprint Quantification

Table 2-5 summarizes footprint metrics used as input to SiteWise™ and footprint metrics calculated by SiteWise™, as well as footprint metrics not incorporated within SiteWise™ (Version 2.0 was the current version at time this GSR Approach was being prepared). The latest version of SiteWise™ available at the time of the GSR evaluation should be used.

<table>
<tr><th colspan="2">Table 2-5
SiteWise™ Input/Output for Footprint Quantification(d)</th></tr>
<tr><th>GSR Metrics that are SiteWise™ Input</th><th>Output Calculated by SiteWise™</th></tr>
<tr><td>• Potable Water Use (a)
• Other Water Use (a)
• Refined Materials (b)
• Unrefined Materials (b)
• Non-Hazardous Waste Disposal
• Hazardous Waste Disposal</td><td rowspan="3">• Total Energy Used - Total
• Global Warming Potential – Total
• Criteria Air Pollutants
• Risk for Injuries/Fatalities
• Water Use (a)
• Refined Materials (b)
• Unrefined Materials (b)</td></tr>
<tr><th>Not SiteWise™ Input or Output</th></tr>
<tr><td>• Hazardous or Toxic Air Pollutants
• Percent of Refined Materials from Recycling/Reuse
• Percent of Unrefined Materials from Recycling/Reuse
• Percent of Total Potential Waste Recycled/Reused
• Life-Cycle Cost(c)
    o Net Present Value (Discounted)
    o Undiscounted
• Up-Front Cost
• One-Way Heavy Vehicle Trips through Residential Areas</td></tr>
<tr><td colspan="2">(a) SiteWise™ calculates "water use" associated with off-site electrical generation. It does not distinguish that water use as "potable" or "non-potable", and that water use is counted as "other water use" (i.e., non-potable) for this GSR Approach. SiteWise™ also provides several ways to input on-site water use. The user needs to keep track of these items to report the metrics for "potable water use" versus "other water use".

(b) SiteWise™ does not specifically request or calculate the quantity of refined or unrefined materials. It helps calculate the amount of well casing material, construction materials, and well decommissioning materials used. It requests the amount of treatment chemicals used and the amount of GAC used. Examples of refined materials are well casing, treatment chemicals, GAC, and HDPE. Examples of unrefined materials are sand and gravel. The user needs to separately sum quantities of refined and unrefined materials (some of which may be completely external to SiteWise™ calculations).

(c) SiteWise™ allows one total remedy cost (either discounted or undiscounted, but not both) to be entered as input on each input sheet, but does not provide for calculation of net-present value of future costs (based on discounting) within the tool.

(d) Information is current as of April 2012 (SiteWise™ Version 2.0).</td></tr>
</table>

Some of the metrics listed in Table 2-5 (and summarized below) must be calculated outside of SiteWise™ (and in some cases the results of those calculations can serve as input to SiteWise™). Examples of calculations for metrics performed outside of SiteWise™ are presented in shaded example boxes below. The following additional notes pertain to the quantification of GSR metrics not directly quantified by SiteWise™:

- Potable Water Use – This is based on project-specific information (and can be input to SiteWise™).

- Other Water Use – This is based on project-specific information. This can in some cases be input to SiteWise^{TM} but can also be the result of a calculation within SiteWise^{TM} related to generation of off-site electricity.
- Refined Materials – This refers to items such as steel, plastics, and treatment chemicals. The total amount of refined materials can be calculated as part of the information gathering stage potentially complemented by the use of SiteWise^{TM} to quantify some items such as weight of well casing material based on well dimensions(steel or PVC), or the weight of HDPE liner based on dimensions.
- Unrefined Materials – This refers to items such as sand/gravel, concrete, cement, and soil. The total amount of unrefined materials can be calculated as part of the information gathering stage potentially complemented by the use of SiteWise^{TM} to quantify some items such as weight of sand used for filter pack in a well based on well dimensions.
- Non-Hazardous Waste Disposal – This is based on project-specific information that can be input to SiteWise^{TM}.
- Hazardous Waste Disposal – This is based on project-specific information that can be input to SiteWise^{TM}.
- Hazardous or Toxic Air Pollutants – This information is calculated based on project-specific information such as the HAP emissions from a soil vapor extraction (SVE) or P&T system that are not treated. This is not calculated within SiteWise^{TM}, and an example of this calculation is presented in Example 2-9.

Example 2-9: Calculation for Hazardous or Toxic Air Pollutants

This only applies for cases with untreated air emissions such as from an air stripper with no vapor phase carbon. Assumptions for this example:

- All hazardous air pollutants for project are emitted from air stripper off-gas. Hazardous air pollutants from off-site electricity generation and materials manufacturing are also present but not calculated by SiteWise.
- Average influent concentration over 30-year period is 12.5 ug/L TCE (50% of design influent concentration of 25 ug/L TCE).
- Average groundwater extraction rate over 30-year period is 3,275 gpm
- Complete removal of TCE by air strippers, which is then emitted to atmosphere:

$$12.5\ \frac{\mu g}{L} \times 3{,}275\,\frac{gal}{min} \times 3.785\,\frac{L}{gal} \times 1{,}440\,\frac{min}{day} \times 365\,\frac{days}{yr} \times 30yrs \times 10^{-9}\,\frac{kg}{\mu g}$$

$$\times\, 2.2\,\frac{lbs}{kg} = 5{,}375 \text{ lbs TCE}$$

- Percent of Refined Materials from Recycling/Reuse – The total amount of refined materials is discussed above. The percent from recycling/reuse would be based on project-specific information and might require additional information from a vendor. This is not calculated within SiteWise^{TM}, and an example of this calculation is presented in Example 2-10. Regenerated

GAC can be considered 90% reused material and 10% new material.

Example 2-10: Calculation for Percent of Refined and Unrefined Materials from Recycling/Reuse

Water that collects in an excavation area is treated using 500 lbs of GAC (assumed to be regenerated) and 500 lbs of a pulp cellulose material made from alder wood (assumed to be a recycled material). In addition, an estimated 10,000 lbs of gravel from a local quarry is used to fill in the excavation, and 1,000 lbs of plastic liner (not from recycled material) is used. These are the only materials used for this phase of the remedy. The GAC and plastic liner are considered a refined material, whereas the alder wood and gravel are considered to be an unrefined material.

- Since the GAC is regenerated, 90% of the GAC (i.e., 450 lbs) is assumed to be from recycled material and 50 lbs is assumed to be new material. Thus, based on the GAC and the plastic, the percentage of the refined materials from recycled material is:

$$450 / (500 + 1{,}000) = 30\%$$

- The alder wood is assumed to represent a recycled material, but the gravel is not. Therefore, the percentage of the unrefined materials from recycled material is:

$$500 / (500 + 10{,}000) = 4.8\%$$

- Percent of Unrefined Materials from Recycling/Reuse – The total amount of unrefined materials is discussed above. The percent from recycling/reuse would be based on project-specific information, such as the amount of crushed concrete that might have been used in place of gravel or the amount of concrete that includes coal combustion by-products. This is not calculated within SiteWise™, and an example of this calculation is presented in Example 2-10 (above).

- Percent of Total Potential Waste Recycled/Reused – This is based on project-specific information regarding waste generation and how much of the waste was able to be diverted from disposal in a landfill. This is not calculated within SiteWise™, and an example of this calculation is presented in Example 2-11.

Example 2-11: Calculation for Percent of Total Potential Waste Recycled/Reused

Mulch generated by tree removal, estimated at 20 tons, is recycled for use on site. Other site non-hazardous waste disposed off-site amounts to 175 tons:

- The total non-hazardous waste disposal is 175 tons.

- The % of potential waste recycled is calculated as follows:

$$20 / (20 + 175) = 21\%$$

- Life-Cycle Cost, Net Present Value (Discounted) – Implementation of a GSR opportunity may have an impact on the life-cycle cost of the remedial process, with respect to the following items that may increase, decrease, or stay the same as a result of the GSR opportunity: up-front costs (i.e., capital costs that occur in the near term); annual costs; and remedy duration. Life-cycle cost in net present value is the sum of up-front costs plus future costs incurred over specified period of time, with future dollars converted to "net present value" based on a discount rate that accounts for the fact that future dollars are worth less than present day dollars. This is not calculated within SiteWise^{TM}. Additional information about discounting of future costs, including an example, is presented in Section 3.2.
- Life-Cycle Cost, Undiscounted – The sum of up-front costs (i.e., capital costs that occur in the near term) plus future costs incurred over specified period of time, without any discounting of future costs. This is not calculated within SiteWise^{TM}. An example is provided in Section 3.2.
- Up-Front Cost – The sum of all up-front costs (i.e., capital costs that occur in the near term) associated with implementing a specific component of the remedial process. These are assumed to occur over a relatively short period of time and are thus assumed to occur in present day dollars unless specified otherwise. This is not calculated within SiteWise^{TM}. If the up-front costs of an alternative are high, it may not be feasible to implement the alternative even if life-cycle costs would ultimately be reduced.
- One-Way Heavy Vehicle Trips through Residential Areas – This is based on project-specific information and is not calculated within SiteWise^{TM}. An example of this calculation is presented in Example 2-12.

Example 2-12: Calculation for One-Way Heavy Vehicle Trips through Residential Areas

Assume two alternatives are being considered for soil remediation:

- Excavation, on-site treatment, disposal onsite
- Excavation and off-site disposal

Assume the access road to the site requires a truck to drive by approximately 10 rural residences on a small road. For the first alternative, the only heavy vehicle trips are to deliver heavy equipment to the site and to pick up the equipment from the site, estimated to require 6 one-way trips during the remedy. For the second alternative, there are 6 one way trips to deliver heavy equipment to the site and to pick up the equipment from the site, plus an estimated 80 one-way trips for dump trucks entering and leaving the site, for a total of 86 one-way trips.

2.2.4 Document GSR Evaluation Findings and Recommendations

Based on the results of the BMP checklist review and footprint quantification, the GSR Evaluation Team should document the information reviewed (including the finalized BMP checklists), and also present the results of quantitative footprinting (assumptions, input values, and results) as well as qualitative considerations. Findings and recommendations from the GSR evaluation should also be documented. Furthermore, it is expected that GSR metrics will be tracked in Army program management databases in the future, and GSR metrics and related information should be entered into Army databases as required and/or appropriate.

Documentation of a GSR evaluation may be in the form of a full "GSR Evaluation Report" or a less formal document. In some cases a GSR Evaluation Report will become part of the formal record of the project, and in other cases the documentation of findings and recommendations of the GSR evaluation may be an internal report or memorandum for the Project Team. A template GSR Evaluation Report is included as Attachment A-3, and an example GSR Evaluation Report (i.e., filled in version of the template) is included as Attachment A-4. Attachments A-3 and A-4 include templates in MS-Word format for report text, and also include templates in MS-Excel format for presenting costs (including discounting), and comparing GSR metrics and qualitative considerations, for a baseline remedy and variations to the baseline.

In general, a comprehensive GSR Evaluation Report should include the following:

- Brief introduction explaining the purpose of the GSR evaluation
- List of project documents reviewed (and calls/meetings pertaining to the GSR evaluation as appropriate)
- Brief discussion of remedial activities and/or alternatives included in the GSR evaluation
- Highlight examples of GSR already implemented by the Project Team prior to the GSR evaluation (reference list of GSR BMPs as appropriate)
- Bullet list of key findings critical to understanding the subsequent GSR recommendations
    - *Quantitative Footprint Results*. If the overall footprint of existing or planned activities for the current remedial phase is calculated as part of the analysis, those results would be discussed in this portion of the report. The calculations and assumptions would typically be included as an attachment to the GSR Evaluation Report. See Attachment A-4 for an example.
    - *Qualitative Considerations.* A discussion of qualitative consideration such as land use, habitat destruction, aesthetics, and use of renewable energy.
    - *Potential Constraints to Implementation of GSR Opportunities*. A discussion of items that might limit implementation of GSR opportunities such as cost constraints, schedule constraints, contracting constraints, regulatory and public reviews/input, GSR evaluation timing within the remedial phase, and other project-specific variables and logistics.
- GSR recommendations, which will include (as appropriate) references to footprint calculations and results for competing alternatives, and presentation of assumptions used for the footprint calculations (the calculations and/or assumptions may be attachments to the GSR Evaluation Report)
- Updated BMP checklist for the project (as an attachment)

Table 2-6 provides a format for presenting each recommendation from a GSR evaluation. This format identifies the basis for the recommendation, and the current status of the implementation of the recommendation. This format allows the consideration and implementation of the recommendations to be tracked over time. If there are no plans to implement the recommendation, the reasons should be documented in the explanation of implementation status.

Table 2-6
Format for Documenting Recommendations (and Tracking Implementation)

Recommendation:	Current Date:
	Date of Original Recommendation:
Basis for Recommendation (Include discussion of cost impacts and value if appropriate):	
Resources Conserved: ☐ Hazardous air pollutants ☐ GHG emissions (CO2e) ☐ Energy ☐ Water ☐ Waste ☐ Criteria pollutants ☐ Safety/Community ☐ Materials ☐ Land-use	
Qualitative Net Cost Impact Over 5 Years, No Discounting ☐ Cost Increase ☐ Cost Savings ☐ Cost Neutral ☐ N/A	☐ Recommended action otherwise required? If checked, required by:
Level of Up-Front Investment Included in 5 Year Cost Impact: ☐ Negligible ☐ < $10,000 ☐ $10,001 - $50,000 ☐ $50,001 - $100,000 ☐ $100,001 - $500,000 ☐ > $500,000	
Attachment(s) to report with footprint assumptions and calculations:	
Implementation Status: ☐ Fully ☐ Partially ☐ Not Yet ☐ Not Planned	Explanation of Status:

2.3 CONSIDERATION AND IMPLEMENTATION OF GSR OPPORTUNITIES

The results of the GSR evaluation are reviewed by the overall Project Team, and site-specific recommendations are considered. The GSR recommendations considered practical are expected to vary depending on the specific circumstances and constraints of each project. Constraints that may impact consideration and implementation of GSR opportunities include the following:

- Cost
- Schedule
- Contracting
- Program policy
- Regulatory and public reviews/input
- GSR evaluation timing within the remedial phase
- Other project-specific variables and logistics

Some examples of considerations include the following:

- If changes are needed to a decision document to achieve GSR benefits, the administrative effort and potential negative consequences for other aspects of the remedy must be considered

- A contractor working under a fixed-price contract may not want to incur the up-front costs of implementing a GSR recommendation that has long-term benefits

- Regulator notification and/or approval may be necessary for changes in environmental restoration conditions (e.g., changing of a substrate injected for in-situ bioremediation)

In some cases, GSR recommendations may only be partially implemented, or implemented in a modified form.

2.4 DOCUMENTATION OF GSR CONSIDERATION AND IMPLEMENTATION

To show that GSR has been considered and/or implemented when feasible (per DERP policy) it is important to document what GSR opportunities were identified and considered, and the reasons why GSR opportunities were or were not implemented. This information may be incorporated as a section and/or appendix of a Project report (e.g., as part of a Feasibility Study, Remedial Design, or Remediation System Evaluation report). Options include the following:

- In some cases the entire GSR Evaluation Report will be included as a stand-alone report or Appendix.

- In other cases the GSR evaluation results may simply be summarized in a formal Project document/memorandum.

The goal of this step is to document that GSR items were considered and GSR recommendations were implemented when feasible. The use of tracking tables for each GSR recommendation (see Table 2-6 above) allows the Project Team to document the basis of each GSR recommendation, the implementation status, and an explanation of the implementation status. Such tracking tables for GSR recommendations should be updated over time, with reasons provided regarding the implementation or rejection of each recommendation.

3.0 SPECIAL CONSIDERATIONS

3.1 TAILORING THE GSR EVALUATION PROCESS TO SPECIFIC REMEDIAL PHASE

For all remedial phases, the March 2012 DERP Manual instructs DoD Components to consider and implement GSR opportunities when feasible and ensure the use of GSR remediation practices where practicable based on economic and social benefits as well as costs. The overall GSR Approach described in Section 2.0, including consideration of GSR BMPs and documenting the consideration and implementation of GSR opportunities, applies to every phase of the remedial process. It is always beneficial to evaluate a list of GSR BMPs for applicability to a project in any phase of the remedy. Review of GSR BMPs requires a minimal time investment (i.e., 2-3 hours for review of GSR BMPs). The vast majority of BMPs for GSR apply to every phase of the remedial process, so there is no significant benefit to differentiating separate lists of GSR BMPs by remedial phase. For instance, BMPs related to field investigation are appropriate in the RI phase, but field investigations for pilot studies or treatability studies also occur in the RD phase and during optimization activities in the O&M phase. Similarly, BMPs related to groundwater treatment and disposal are appropriate for a pump and treat (P&T) system in the O&M phase, but similar BMPs may apply to an initial response during the RI phase or to aquifer testing during the RI or RD phase.

Therefore, the process for GSR evaluation presented herein includes review of the full list of BMPs in Attachment A-1 during a GSR evaluation, regardless of remedial phase. The format of the BMPs provided in Attachment A-1 allows the BMPs applicable for the specific project to be differentiated from those not applicable. A further advantage of this approach is that it assists with forward planning for GSR issues. The process of considering the entire BMP checklist during a GSR evaluation, regardless of remedial phase, will prompt consideration regarding how specific GSR practices can be planned for in future phases of the remedial process, even if those practices are not applicable in the current phase.

A detailed quantitative footprint evaluation with a tool such as SiteWise™ requires additional effort and resources to perform and document. This GSR Approach includes a method to guide the decision as to whether or not quantitative footprinting is recommended (Section 2.1.4). If a project falls below the screening threshold of 10,000 MMBtus, additional footprint quantification may not be necessary but can be performed if otherwise desired and/or needed to address specific concerns of one or more stakeholders.

The following additional considerations are noted with respect to quantitative evaluation of footprints:

- Quantification of footprints should generally not be performed for the RI phase because footprints for those activities are generally low, and the focus of the RI should be on obtaining the best data quality for making remedy decisions. Application of GSR BMPs, however, is appropriate for every project including the RI phase.

- In general, the phases in which the largest opportunities for environmental footprint reductions are likely (and therefore the phases in which quantitative footprints are potentially most useful) are FS/remedy selection, design (and the follow-on construction), and O&M.

The March 2012 DERP Manual also includes direction regarding GSR in specific remedy phases, as follows:

- In the FS phase, evaluate remedial alternatives to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems on the environment.

- In the Remedial Action Work Plan (RAWP) in the Remedial Action phase, consider remediation technologies that are conducted in a sustainable manner; are efficient; and are environmentally, economically, and fiscally sound, in order to reduce the footprint of remediation strategies on the environment.

- In the Remedial Operation phase, minimize the environmental footprint as part of optimization performed.

Specific considerations for performing GSR evaluations in the three remedy phases identified in the DERP manual as listed above are discussed below, followed by considerations for performing GSR evaluations in other remedial phases. Note that in all remedial phases it is important to identify contracting strategies and constraints early in the process so that GSR can be effectively incorporated into the project (i.e., consider which phases will be combined into separate contracts, what types of contracts will be used, and what level of GSR consideration will be needed for each contract). Examples of contract language for inclusion of GSR in contracts are provided in Examples 2-6 to 2-8 and in Attachment A-2.

3.1.1 Feasibility Study Phase

During the FS phase, it is recommended the comparative analyses of alternatives based on the CERCLA criteria be performed and documented separately from a comparative analysis of alternatives based on GSR considerations. Because the GSR aspects of the remedy currently have no required statutory status, this separation makes clear the differentiation between the non-statutory regulatory status of GSR aspects compared to the statutory status of the CERCLA criteria. However, per direction in the March 2012 DERP Manual, Project Teams should utilize the GSR analysis to "evaluate remedial alternatives to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems on the environment."

Thus, Project Teams should strive to include GSR principles in development and evaluation of the FS alternatives. This includes the following:

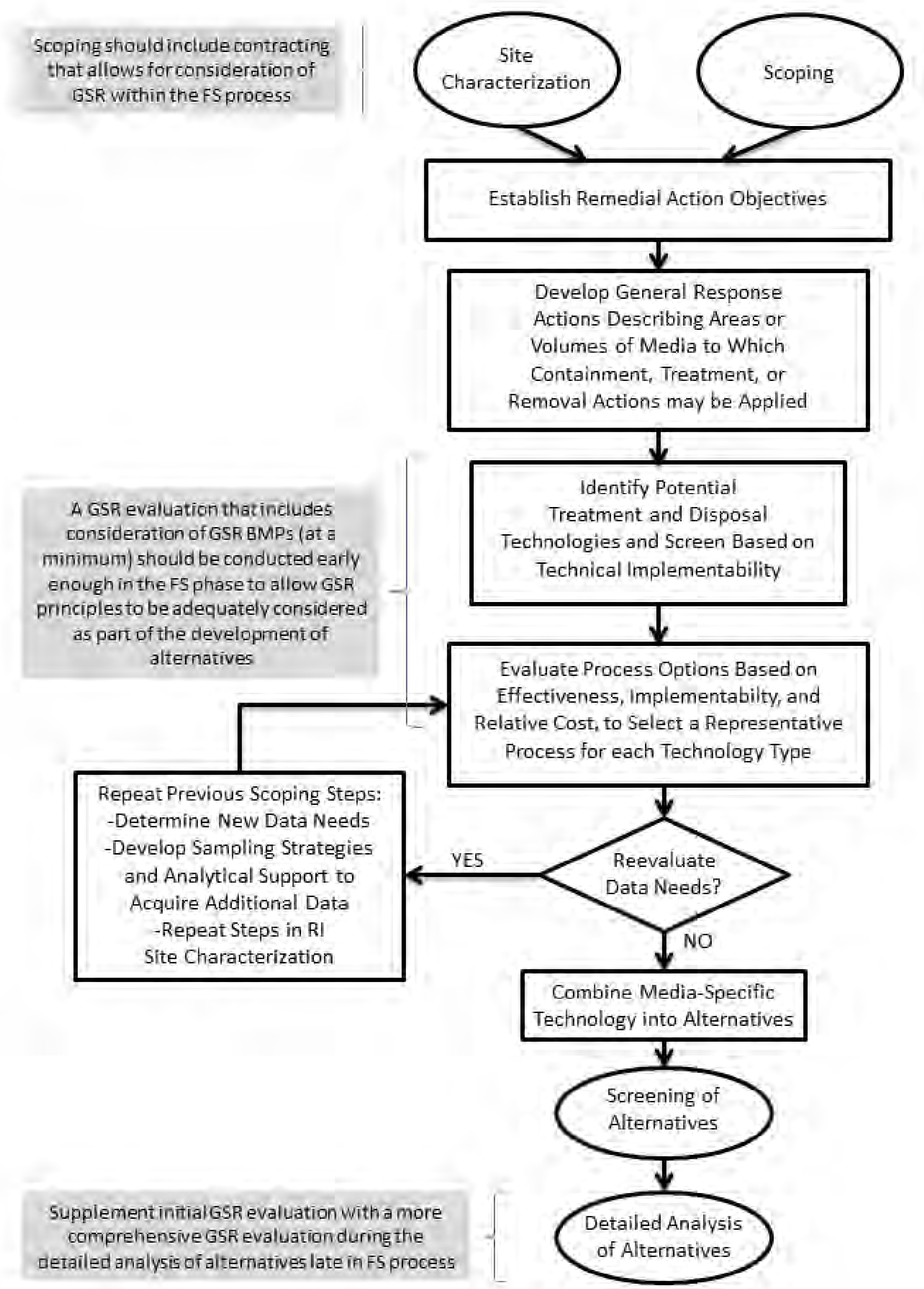
- Consideration and potential implementation of GSR BMPs (see Attachment A-1)\

- Consideration of technologies with inherently GSR characteristics (e.g., disposal technologies that allow for beneficial reuse of the treated media; technologies that use a natural process such phytoremediation and monitored natural attenuation) and technologies that use existing infrastructure.

Examples 3-2 to 3-4 presented in Section 3-4 of this GSR Approach illustrate approaches that can be used to compare GSR attributes of competing alternatives considered in an FS as a companion process to the CERCLA comparative analysis of alternatives.

Figure 3-1 illustrates suggested timing of potential GSR evaluations within the overall FS process. This figure adds to Figure 4-1 of USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (October 1988). A GSR evaluation that includes consideration of GSR BMPs (at a minimum) should be conducted early enough in the FS phase to allow GSR principles to be adequately considered as part of the development of alternatives. If this does not occur early enough, the Project Team and project stakeholders may be too constrained by the preliminary set of alternatives to subsequently consider other alternatives that may result from GSR considerations. An initial GSR evaluation performed early in the FS process can then be supplemented with a more comprehensive GSR evaluation during the detailed analysis of alternatives late in the FS process, when improved information is available for a more quantitative analysis.

Figure 3-1. Suggested Timing of a GSR Evaluation within the Overall FS Process

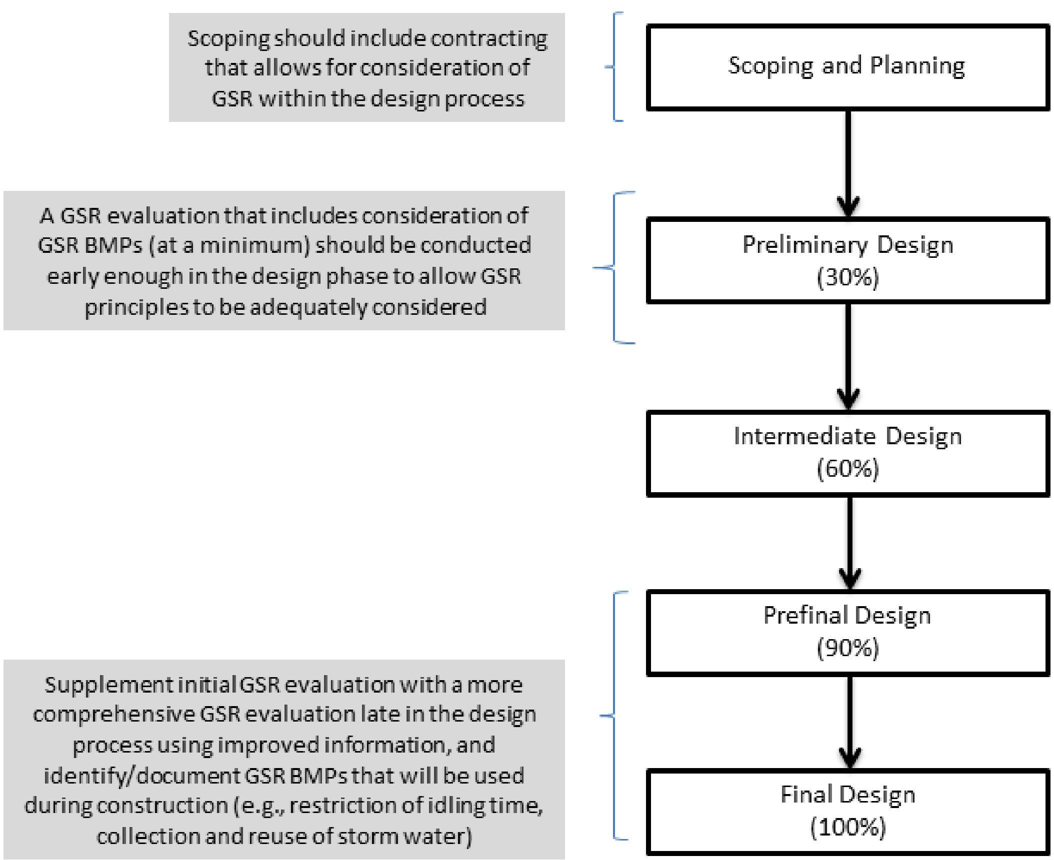


The base flow chart for this figure is from Figure 4-1 of USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (October 1988). The shaded boxes illustrate suggested timing of a GSR evaluation within the FS process.

3.1.2 Remedial Action Work Plan/Remedy Design in the Remedial Action Phase

Per direction in the March 2012 DERP Manual, during the preparation of the RAWP, Project Teams should "consider remediation technologies that are conducted in a sustainable manner; are efficient; and are environmentally, economically, and fiscally sound, in order to reduce the footprint of remediation strategies on the environment." Figure 3-2 illustrates suggested timing of a GSR evaluation within the overall RAWP/Remedy Design process. Similar to the FS Phase, it is important during the design phase to incorporate GSR early in the design process, ideally during the development of the preliminary (30 percent) design. If GSR considerations are not included early enough in the design process, the Project Team and project stakeholders may be too constrained by the preliminary design to consider changes to the design that could result in substantive environmental footprint reductions. An initial GSR evaluation performed early in the design process can then be supplemented with a more comprehensive GSR evaluation during the detailed final design when more detailed and/or precise information is available for more quantitative footprint calculation(s). The more comprehensive GSR evaluation should also include identification and documentation in the design of GSR BMPs that will be used during construction (e.g., restriction of idling time, collection and reuse of storm water).

Figure 3-2 Suggested Timing of a GSR Evaluation within the Overall Design Process



The base flow chart for this figure is a generalized depiction of the typical design process, though not all projects include every design component indicated on this figure.

3.1.3 Remedy Optimization in the Remedy Operations Phase

The March 2012 DERP Manual specifically indicates that, as part of remedy optimization during the Remedy Operations (RA-O) phase, "the DoD Component shall maximize DERP effectiveness and minimize the DERP financial liabilities and environmental footprint." The direction to minimize the environmental footprint can most easily be achieved by including a GSR evaluation within any remedy optimization performed in the RA-O phase. Because the Remedial System Evaluation (RSE) process is the commonly used process by the USACE for performing optimization, a suggested "GSR Evaluation Checklist" that complements other RSE optimization checklists has been developed and is included in Attachment A-5. It is expected that this checklist would be used within RSEs and would also be applicable to other optimization approaches.

GSR evaluations performed during the O&M phase will have greater opportunities to use actual quantities and rates (e.g., pumping rates, electricity or fuel usage) than during other remedial phases. GSR evaluations performed during the O&M phase should use field-determined data whenever possible, whereas a GSR evaluation for an earlier remedial phase (e.g., design) will likely need to rely more on estimated quantities and rates.

In many cases the O&M phase will require a long period of time, perhaps years or decades (such as for many P&T systems). For projects where a long-term O&M phase is anticipated, quantifying footprints for the O&M phase may have greater significance than for other remedial phases because the benefits of environmental footprint reductions apply over a long period of time. This can be verified for specific sites using the screening approach described earlier (Section 2.1.4). Similarly, the capital costs that might be required to implement some GSR opportunities may be more practical if the subsequent benefits will accrue over an extended period of construction and O&M.

3.1.4 Other Remedy Phases

During the RI phase, special attention should be placed on collecting data for GSR consideration that go beyond delineating soil or groundwater impacts. For example, the RI should identify characteristics of the site that would be useful in evaluating the potential use of renewable energy in a future remedy, and/or identify scarce resources (e.g., potable water) that could be an important GSR consideration in subsequent remedial phases. In addition, emphasis should be placed on adequate delineation of the contamination and contaminant environment so the most effective technologies are chosen for the remediation and only the areas necessary to meet statutory CERCLA/RCRA requirements are remediated. Regardless of remedial phase, a GSR evaluation should attempt to anticipate and address elements likely to occur in future remedial phases. Also, as previously mentioned, in all remedial phases it is important to identify contracting strategies and constraints early in the process so that GSR can be effectively incorporated into the project (i.e., consider which phases will be combined into separate contracts, what types of contracts will be used, and what level of GSR consideration will be needed for each contract). Examples of contract language for inclusion of GSR in contracts are provided in Examples 2-6 to 2-8 and in Attachment A-2.

3.2 ISSUES REGARDING CALCULATION OF LIFE-CYCLE COST

As discussed earlier, implementation of a GSR opportunity may have an impact on the life-cycle cost of the remedial process, with respect to the following items that may increase, decrease, or stay the same as a result of the GSR opportunity: up-front costs (i.e., capital costs that occur in the near term); annual costs, which can include non-routine equipment replacement/upgrade costs; and remedy duration.

Ideally, estimates for up-front costs and/or changes to annual costs resulting from implementation of GSR recommendations are available based on project-specific information. If such cost estimates are not available, the GSR Evaluation Team can suggest estimates for such costs based on previous experience, and ask the overall Project Team for consensus regarding those estimates. If consensus cannot be achieved, independent engineering cost estimates can be obtained.

Life-cycle cost should generally be presented two ways:

- Net-present value (future costs are discounted)
- Undiscounted

Most private and public organizations discount future costs because current dollars are worth more than future dollars. For example, it is generally preferable to spend \$100,000 every year for 10 years than to spend \$1,000,000 in 1 year, because any money not spent can be otherwise invested for a positive return over the remaining years. The net present value for a cash flow in a future year is calculated by applying an appropriate discount rate to that cash flow according to the following equation.

$$PV = \frac{FV}{(1+i)^n} = C \times FV$$

PV is the present value
FV is the value in year "n" (i.e., future value)
i is the discount rate
C is the discount factor, which equals $1/(1+i)^n$

If there are cash flows in multiple years, the cash flow from each year is discounted to the present value. The life-cycle cost in net present value is the sum of the up-front costs (assumed to be in present day dollars) and all future costs discounted to present value.

The discount rate is an interest rate that makes the investor indifferent to the value of present-day dollars versus future dollars. Each year, the U.S. Office of Management and Budget (OMB) releases a revision to OMB Circular No. A-94: "*Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*." These annual revisions establish updated discount rate guidelines for the "real discount rate", which applies to cost-effectiveness evaluations for government projects. The discount rate differs depending on the project duration. The OMB "real discount rate" for 1995, 2000, 2005, and 2010 is listed in Table 3-1 for project durations of 5, 7, 10, and 30 years. OMB suggests using linear interpolation for determining appropriate discount rates for projects with intermediate durations. For projects with durations of greater than 30 years, OMB suggests using the 30-year discount rate.

Table 3-1
OMB Real Discount Rate versus Time

Year	**Project Duration**			
	5-Year	**7-Year**	**10-Year**	**30-Year**
1995	4.5%	4.6%	4.8%	4.9%
2000	3.9%	4.0%	4.0%	4.2%
2005	2.0%	2.3%	2.5%	3.1%
2010	1.6%	1.9%	2.2%	2.7%

* *Source: www.whitehouse.gov/sites/default/files/omb/assets/a94/dischist.pdf*

There is often disagreement over the discount rate that should be applied to government projects. For this reason, it is good practice for the Project Team to clearly identify the discount rate being applied and/or discuss the discount rate to be applied with the other project stakeholders. It is good practice to also calculate life-cycle costs without discounting.

A simple example of a life-cycle cost analysis with and without discounting is presented in Example 3-1. For this example, there is:

- An assumed 10-year project duration
- Up-front costs of $200,000 in year 0 (present-day dollars)
- Annual savings (negative cost) of 40,000 per year over the following 10 years.

The example illustrates the concept of discounting of future costs for discount rates of 2% and 5%, the summation of up-front and discounted annual costs to determine net present value (NPV), and the determination of a pay-back period based on no discounting and discounting. In this example, the NPV of the option evaluated, for the 10-year life cycle, is a savings of $159,303 using a 2% discount rate, or a savings of $108,869 using a 5% discount rate. With no discounting, there would be a savings of $200,000 (i.e., the net difference between the up-front cost of $200,000 and the sum of annual savings over 10 years which is $400,000). The payback period is determined based on the cumulative cash flow. With no discounting payback of the initial investment occurs in 5 years. With discounting, the payback period occurs in 6 years (using either a 2% or 5% discount rate). The stakeholders would determine if the up-front investment of $200,000 and the payback period of 5 to 6 years are acceptable.

Example 3-1
Example Illustrating Life-Cycle Cost, Discounting, and Payback Period Based on Cumulative Cash Flow

year	up-front cost	annual cost no discounting		present value of cost each year			cumulative cash flow		
				2%	5%		no discounting	2%	5%
0	$200,000	$0		$200,000	$200,000		$200,000	$200,000	$200,000
1	$0	-$40,000		-$39,216	-$38,095		$160,000	$160,784	$161,905
2	$0	-$40,000		-$38,447	-$36,281		$120,000	$122,338	$125,624
3	$0	-$40,000		-$37,693	-$34,554		$80,000	$84,645	$91,070
4	$0	-$40,000		-$36,954	-$32,908		$40,000	$47,691	$58,162
5	$0	-$40,000		-$36,229	-$31,341		$0	$11,462	$26,821
6	$0	-$40,000		-$35,519	-$29,849		-$40,000	-$24,057	-$3,028
7	$0	-$40,000		-$34,822	-$28,427		-$80,000	-$58,880	-$31,455
8	$0	-$40,000		-$34,140	-$27,074		-$120,000	-$93,019	-$58,529
9	$0	-$40,000		-$33,470	-$25,784		-$160,000	-$126,489	-$84,313
10	$0	-$40,000		-$32,814	-$24,557		-$200,000	-$159,303	-$108,869
Net Present Value (NPV)->				-$159,303	-$108,869				

***positive dollar value is a "cost", negative dollar value is a "savings"**

Detailed costs analysis (such as the example presented above) provides greatest value when the estimates of up-front and annual costs have some certainty, and when the duration used for the calculation is well defined. For analysis of BMPs, it is often appropriate to limit the level of effort by more qualitatively evaluating up-front cost, life-cycle cost or savings, and payback period, perhaps supported with simple calculations. A template for a cost analysis (MS-Excel) is included in Attachments A-3 and A-4.

3.3 SUGGESTED WORK-AROUNDS FOR SITEWISE™

SiteWise™ greatly facilitates footprint quantification for energy usage, global warming potential, and air criteria pollutant emissions. In addition, it provides assistance with calculating the amount of materials used. In some cases, the user may find it necessary to input information not included as standard SiteWise™ input, or to use intermediate information from SiteWise™ to make other calculations. The following is a list of "work-arounds" to address some of these issues.

3.3.1 Variable Frequency Drives

If a motor name plate rating is known but there is a variable frequency drive (VFD) – Calculate the electricity usage as follows:

$$kWh = \frac{HP \times L_v}{\eta_m \times \eta_v} \times \frac{0.746\ kW}{1\ HP} \times hours$$

kWh = kilowatt-hours of electricity
HP = horsepower
L_V *= percent of VFD full load (or speed in Hertz divided by 60 Hertz)*
η_m *= motor efficiency = absent other information assume 0.75*
η_v *= VFD efficiency = absent other information assume 0.75*
hours = hours of operation over time frame of project
0.746 = conversion factor for HP to kW

3.3.2 Using the Different Tabs on the SiteWise™ Input Sheet

It is not required to rigidly follow the remedial phase tabs in the SiteWise™ input (i.e., "Remedial Investigation", "Remedial Action Construction", "Remedial Action Operation", and "Longterm Monitoring"). This input structure for SiteWise™ may not always be appropriate for a specific remedy (or remedy component), and the user can be more flexible as long as the user documents what is being input into each tab. For example, if an operating has both pump and treat and bioremediation, the operating pump-and-treat information can be entered into the "Remedial Investigation" tab and the bioremediation information can be entered into the "Remedial Action Operation" tab to keep the results for each technology separated. Also, if there are multiple (more than 6) instances of one type of activity (e.g.., more than 6 trips falling under the category of "Personnel Transport – Road"), entries will need to be either combined or distributed over multiple input tabs on the SiteWise™ input sheet.

3.3.3 Equipment Use Input

SiteWise™ determines outputs for equipment use based on the type of equipment being used (excavator, loader, etc.) and the volume of material to be moved by that piece of equipment. Based on the input volume of material, SiteWise™ automatically selects what it believes to be an appropriately sized piece of equipment (i.e., the more material to be moved, the larger the piece of equipment it selects). Based on the equipment size, SiteWise™ then estimates a fuel consumption rate per hour, a production rate per hour, and the number of hours of equipment based on the production rate. Energy use, CO2e, and other footprints are calculated based on the number of hours and the fuel consumption rate. There are several issues with this:

- The equipment may be used for purposes other than excavation or moving material.
- If it is used to move material, there is no way to tell SiteWise™ how far the material will be moved or how difficult it will be to move that material (which would influence how many hours of equipment operation it will actually take).
- The Project Team may have an estimate for how long the equipment will be used for, but not how much material it will move.
- The "production rates" found in the SiteWise™ lookup tables often lead to underestimates for equipment operating hours. If an attempt is made to increase the operating hours artificially by inputting a greater volume of material to be moved, SiteWise™ switches to using a larger piece of equipment with a higher production rate.
- SiteWise™ may select an equipment size not appropriate for the particular site. This could occur if an excavator will be used for trenching, where the total amount of material to be moved is large but a smaller excavator will be used to match the trench size, or if the Project Team only has access to an excavator of a certain size.

A few options exist for "work-arounds" that will allow the equipment use calculated by SiteWise™ to match more closely with site-specific conditions:

- If the amount of fuel use is known, that can be input directly in SiteWise™ as an "internal combustion engine" (with input for type of fuel, fuel consumption rate, and number of hours so that total amount of fuel used is accounted for).
- If the approximate size and operating hours for the equipment are known, the equipment can be input under "trenching" or "diesel and gasoline pumps".
- If the production rate and footprints for the particular piece of equipment are known, the lookup table values can be modified to include this more accurate data. It should be noted that issues exist with changing the lookup table in SiteWise™ Version 2. In the "master" input sheet, values need to be changed in both the "Look Up Table" tab and the "Look Up Table Defaults" tab in order for these changes to be preserved when an alternative is generated and then subsequently re-imported into SiteWise™. Unfortunately, this changes the look up table defaults for all other alternatives generated using that input sheet.

3.3.4 Materials Use Input

SiteWise™ includes options for many common materials used during various remedial phases, but in some cases the remedy being footprinted may use a material not included in SiteWise™. Options for entering materials not included in SiteWise™ include:

- Choosing the material from those available in SiteWise™ that is most similar to the one being used at the site. For example, bioremediation at a site may involve the use of corn syrup, which is not a material listed in SiteWise™. In this case, the "vegetable oil" option in SiteWise™ may act as a surrogate for footprinting purposes, since production of the two materials would likely result in similar energy use, CO_2e emissions, and other impacts. In cases such as this, where one material is used to represent another for the purposes of SiteWise™ input, this substitution should be clearly described in the GSR evaluation report.

- Adding footprint data for the material to the SiteWise™ lookup table, if such information is available. This option, when possible, is more appropriate when one of the goals of quantitative footprinting is to evaluate several materials as alternatives to each other (for example, if SiteWise™ was being used to determine which bioremediation substrate option would lead to the lowest overall remedy footprint). In this case, a reliable source should be used for footprint data, and use of this source should be clearly documented.

- If the material being represented in SiteWise™ accounts for a large portion of the entire remedy footprint, the degree of uncertainty about the footprints for the materials should be noted. The conclusions drawn from SiteWise™ outputs in such a case may be sensitive to the assumptions that were made regarding materials production and use.

3.3.5 Off-Site Contributions to Priority Pollutants

SiteWise™ doesn't calculate NOx, SOx, PM, or water use for off-site manufacturing. This is because these items are considered to have a local effect, and would therefore not have an impact on the area immediately surrounding the site. However, the footprints associated with manufacturing of these items can be significant in the location where the material is manufactured, particularly if materials use represents a large portion of the remedial activity. In cases such as these where those footprints are large, it may be useful to separately estimate the NOx, SOx, PM, and water use footprints associated with off-site manufacturing (i.e., external to SiteWise™) based on literature values, in order to have a more complete picture of a remedy's impacts.

3.3.6 Other items

It is further noted that the intermediate calculation spreadsheets for SiteWise™ (e.g., Remedial Investigation.xls, Remedial Action Construction.xls) have cells for additional user input. These cells for additional user input can be used if the user has specific project information for input and prefers to bypass some of calculations on the SiteWise™ input sheet. Also, see Section 2.2.3.3 for examples of calculations for GSR metrics not calculated by SiteWise™.

3.4 ADDRESSING TRADEOFFS BETWEEN GSR CONSIDERATIONS

A fundamental limitation of GSR evaluations is the fact that there are numerous GSR metrics and qualitative considerations (see Table 1-1), and in many cases implementing an alternative resulting from a GSR evaluation will be positive for some GSR considerations and negative for others. For instance, purchasing recycled materials may be a positive action, but those recycled materials may require much greater transport distance than the alternative. These types of tradeoffs can be difficult to address. One approach is to assign weights to each GSR consideration, and scores for each alternative with respect to that GSR consideration, so each alternative can be assigned a total score. However, assignment of the weights and scores is somewhat arbitrary, and this approach easily bogs down.

A more common approach for comparing alternatives is to assign each key GSR consideration a qualitative rating for each alternative (such as “good”, “fair”, or “poor”) and then to refer to those ratings (which may be in the form of charts or tables) when providing the GSR recommendations. Example 3-2 illustrates this type of approach. In Example 3-2 there is a baseline alternative and two other alternatives. A qualitative assignment of “poor”, “fair”, or “good” is made for each GSR consideration (the basis for these assignments would be explained within the GSR evaluation report). Alternative 1 seems to be better for many GSR considerations, and not worse for others, so it seems preferable to the baseline from a GSR perspective. Alternative 2 is better than Alternative 1 for a few GSR considerations (e.g., percent of refined materials from recycled or reused sources and use of renewable energy), but the up-front costs are worse. This illustrates a tradeoff that can be discussed in the GSR evaluation report and ultimately resolved by project stakeholders.

Example 3-2: Comparing Alternatives Using a Table of Qualitative Ratings (Text)*

Note that any project-specific metrics or other qualitative considerations not listed can be added by inserting a row in the Table

GSR Metrics and Considerations	Baseline	Alternative 1	Alternative 2
Quantitative Environmental Metrics:			
Energy Use	Fair	Good	Good
Global Warming Potential	Fair	Good	Good
Criteria Air Pollutants	Fair	Good	Good
Hazardous or Toxic Air Pollutants	n/a	n/a	n/a
Potable Water Use	Good	Good	Good
Other Water Use	n/a	n/a	n/a
Refined Materials	Poor	Fair	Fair
Percent of Refined Materials from Recycled or Reused Sources	Poor	Poor	Good
Unrefined Materials	Poor	Fair	Fair
Percent of Unrefined Materials from Recycled or Reused Sources	Poor	Poor	Poor
Non-Hazardous Waste Disposal	Fair	Good	Good
Hazardous Waste Disposal	Poor	Good	Good
Percent of Total Potential Waste Recycled or Reused	Poor	Good	Good
Quantitative Economic Metrics:			
Life-Cycle Cost, Discounted	Poor	Fair	Fair
Life-Cycle Cost, Undiscounted	Poor	Fair	Fair
Up-Front Cost	Poor	Good	Fair
Quantitative Societal Metrics:			
Risk for Injuries/Fatalities	Good	Good	Good
One-Way Heavy Vehicle Trips through Residential Areas	n/a	n/a	n/a
Qualitative Considerations:			
Land Transferred or Made Available for Potential Beneficial Use	n/a	n/a	n/a
Existing Ecosystem Destruction	Good	Good	Good
Time Frame for Land Reuse	Good	Good	Good
Flexibility and Breadth of Options for Site Reuse	Good	Good	Good
Aesthetics	Fair	Good	Good
Use of Renewable Energy	Poor	Poor	Fair

**These are qualitative by nature and the basis of such ratings should be discussed in the GSR evaluation report*

The same type of analysis illustrated in Example 3-2 can be presented in a more visual manner by assigning colors to the ratings, as illustrated in Example 3-3. One limitation of this approach is it loses meaning if not printed in color (unless symbols or text are used in addition to the colors to differentiate the ratings when printed in black and white, as illustrated in Example 3-3).

Example 3-3: Comparing Alternatives Using a Table of Qualitative Ratings (Color)*

Note that any project-specific metrics or other qualitative considerations not listed can be added by inserting a row in the Table

Legend

+ good or desired (green)
o fair or neutral (yellow)
- poor or undesirable (red)

GSR Metrics and Considerations	Baseline	Alternative 1	Alternative 2
Quantitative Environmental Metrics:			
Energy Use	o	+	+
Global Warming Potential	o	+	+
Criteria Air Pollutants	o	+	+
Hazardous or Toxic Air Pollutants	n/a	n/a	n/a
Potable Water Use	+	+	+
Other Water Use	n/a	n/a	n/a
Refined Materials	-	o	o
Percent of Refined Materials from Recycled or Reused Sources	-	-	+
Unrefined Materials	-	o	o
Percent of Unrefined Materials from Recycled or Reused Sources	-	-	-
Non-Hazardous Waste Disposal	o	+	+
Hazardous Waste Disposal	-	+	+
Percent of Total Potential Waste Recycled or Reused	-	+	+
Quantitative Economic Metrics:			
Life-Cycle Cost, Discounted	-	o	o
Life-Cycle Cost, Undiscounted	-	o	o
Up-Front Cost	-	+	o
Quantitative Societal Metrics:			
Risk for Injuries/Fatalities	+	+	+
One-Way Heavy Vehicle Trips through Residential Areas	n/a	n/a	n/a
Qualitative Considerations:			
Land Transferred or Made Available for Potential Beneficial Use	n/a	n/a	n/a
Existing Ecosystem Destruction	+	+	+
Time Frame for Land Reuse	+	+	+
Flexibility and Breadth of Options for Site Reuse	+	+	+
Aesthetics	o	+	+
Use of Renewable Energy	-	-	o

**These are qualitative by nature and the basis of such ratings should be discussed in the GSR evaluation report*

Templates (MS-Excel) for the types of comparisons illustrated in Examples 3-2 and 3-3 are included in Attachments A-3 and A-4. Another approach when comparing alternatives (e.g., to a baseline alternative) is to include the following sections in the GSR Evaluation Report for each alternative evaluated:

- GSR considerations that improve in this alternative versus the baseline
- GSR considerations that worsen in this alternative versus the baseline

Example 3-4 illustrates this type of approach for a case where an alternative provides improvements for several key GSR considerations versus the baseline, but requires increased up-front costs and may result in short-term concerns regarding noise and odor. Again, this approach allows tradeoffs to be identified in the GSR evaluation report and ultimately resolved by project stakeholders.

Example 3-4: Summarizing Key GSR Considerations that Improve and Worsen

The following key GSR considerations would improve in this alternative versus the baseline:

- Total energy use would decline by approximately 40,000 MMBtus (30%) due to reduction of electrical usage and natural gas usage.
- GHG emissions would decline by approximately 5,000 metric tons of CO2e (35%) due to reduction of electrical usage and natural gas usage.
- Criteria air pollutant emissions would decline by approximately 50 metric tons (50%) due to reduction of electrical usage and natural gas usage.
- Life cycle cost would decrease by approximately $2 Million over 20 years (discounted, 3 percent discount rate)

The following key GSR considerations would worsen in this alternative versus the baseline:

- Additional up-front costs of $600,000 are required
- The new treatment process may result in some odors and noise for nearby residents for approximately 1 month during construction

One or more preferred alternatives will often become evident when using the approaches illustrated in Examples 3-2 to 3-4, based on a preponderance of "good" ratings and/or many GSR considerations that improve versus a baseline alternative (particularly if those "good" ratings and/or improvements are for GSR considerations most important to project stakeholders). Similarly, some alternatives will be rejected if there are "poor" ratings and/or worsened GSR considerations that are critically important for one or more project stakeholders. In cases where the tradeoffs cause ambiguous interpretations, the pros and cons of each alternative should be presented for consideration of the overall Project Team and project stakeholders. Although aspects of this ratings approach are qualitative, this approach is likely to garner more consensus than an approach with numerical ratings and weights.

4.0 ADDED CONSIDERATIONS FOR APPLYING GSR TO MMRP PROJECTS

> **NOTE:**
>
> **For MMRP projects, Sections 2 and 3 should be read prior to Section 4. For IRP projects, this section can be skipped.**

The MMRP category under DERP is applicable to Formerly Used Defense Sites (FUDS), Base Realignment and Closure (BRAC), active Army, National Guard Bureau (NGB), and Air Force installations that meet the eligibility criteria established for the MMRP. As stated in Section 1, the DERP Manual (March 2012) indicates that sites in the sites in the MMRP category include MRAs and MRSs that require a munitions response. This includes identification, investigation, and remediation of MEC or MC, including the subsets of RCWM and CA and ABPs. Many characteristics of an MMRP project and the manner in which an MMRP project is executed are similar to those of an IRP project, such as the investigation and restoration of environmental media (i.e., soil, sediment, groundwater, surface water, air quality) and the CERCLA response process phases that must be followed. MMRP projects may also involve responses related to HTRW contamination; however, unlike IRP projects, MMRP projects have the added complexity of investigating, characterizing, treating and removing MEC and MC. Actions to reduce the explosives safety risks associated with MEC and explosive soil and the acute toxicity of CA must also be considered. This added complexity routinely involves different activities and equipment than those typically used for an IRP project. Nevertheless, the overall GSR evaluation approach and most of the GSR BMPs are similar for projects involving HTRW contamination and MEC/MC contamination.

Relevant USACE and AEC technical guidance documents for MMRP projects include the following (document dates and links are provided in "Section 5.0: References"):

- Engineer Regulation (ER) 200-3-1, "*Environmental Quality, FUDS Program Policy*". This provides requirements for the management and execution of the FUDS Program.

- ER 385-1-95, "*Safety and Health Requirements for MEC Operations*." This provides safety and health requirements and responsibilities for MEC operations, military munitions response actions, and any other ammunition and explosives activity.

- ER 1110-1-263, "*Chemical Data Quality Management for HTRW Activities*." This provides requirements for the MC aspects of MMRP.

- ER 1110-1-8153 "*Military Munitions Support Services*". This establishes USACE responsibilities and an overview of the MMRP.

- Engineer Pamphlet (EP) 75-1-2, "*Munitions and Explosives of Concern (MEC) Support during Hazardous, Toxic, and Radioactive Waste (HTRW) and Construction Activities*." This provides requirements for MEC Support during HTRW and Construction Activities.

- EP 75-1-3, "*Recovered Chemical Warfare Materiel Response Process*." This provides implementation guidance for military munitions response actions involving RCWM.

- HQ Department of the Army (HQ DA), "*Interim Guidance for Biological Warfare Materiel (BWM) and Non-Stockpile Chemical Warfare Material (CWM) Response Activities"* as amended.

This provides guidance for BWM and CWM responses. The guidance has been amended as of 23 April 2007 to allow CAIS that contain dilute CA or industrial chemicals to be treated as hazardous waste, with the exception of CAIS that may contain dilute nerve agent or neat CA.

- EP 200-1-18, "*Five-Year Reviews of Military Munitions Response Projects*." This provides procedural guidance for implementing Five-Year Reviews. .

- EP 1110-1-18, "*Military Munitions Response Process*." This provides implementation guidance for military munitions response actions.

- Engineer Manual (EM) 385-1-97, "*Explosives – Safety and Health Requirements Manual*." This provides procedures for activities and operations involving explosives related work.

- EM 1110-1-1200, "*CSMs for Ordnance and Explosives (OE) and HTRW Activities*." This provides procedural guidance to develop Conceptual Site Models at sites potentially containing UXO/ DMM, HTRW, or both.

- EM 1110-1-4009, "*Military Munitions Response Actions*." This provides engineering considerations for military munitions response actions.

- AEC, "*Program Manual for MMRP Active Installations*". This provides Remedial Project Managers with the information, resources and tools to implement the MMRP. The guidance contains details on eligibility criteria under both the MMRP and IRP and definitions of MMRP terms.

- AEC, "*Final U*S *Army MMRP, Munitions Response, RI/FS Guidance*". This provides RI/FS guidance for MMRP Sites.

4.1 ADDITIONAL BMP CONSIDERATIONS FOR MMRP PROJECTS

The BMPs presented in Section 2.4.2 (and Attachment A-1) are intended to be generally applicable for both IRP and MMRP projects, and the full set of BMPs should be reviewed for both IRP and MMRP projects. For example, BMP C-1 to "reduce the number of trips for personnel" applies to all types of projects in all remedial phases. As with IRP projects, some of the BMPs will not be applicable to specific MMRP projects, and for those, the checkbox for "applicable" on the BMP table (in Attachment A-1) should be left unchecked.

The added complexity of addressing MEC and MC for MMRP projects routinely involves different activities and equipment than those on IRP projects. The BMP categories discussed in Section 2.4.2 are listed below, along with discussion for each BMP category regarding additional considerations for MMRP projects.

A. *Planning* – The BMPs in this category are sufficiently general that they equally apply to IRP and MMRP projects. For MMRP projects, ensure that the TPP process is implemented to incorporate all stakeholders and stakeholder concerns early with an end use goal in mind. Specific plans, besides a project Work Plan, are required for MMRP projects depending on the remedial phase and anticipated contaminants. Examples include an Explosive Site Plan (ESP), Explosive Safety Submission (ESS), Chemical Site Plan, Chemical Safety Submission (CSS), etc.

B. *Characterization and/or Remedy Approach* – The remedial process for IRP projects involves development, use, and routine updating of a CSM, eliminating redundant treatment processes, and transitioning from active to passive remedies at appropriate times. These BMPs are most suitable for chemical contamination, particularly if the remedial operations occur over a relatively long period of time. Although integrated CSMs for MEC and MC are prepared for MMRP projects, the approaches for IRP projects are somewhat difficult to translate directly to the process for addressing MMRP contaminants because of the increased heterogeneity associated with MEC and MC. The distribution of MEC and MC is not necessarily controlled by the same physical processes as HTWR contamination. As a result, BMPs for addressing MMRP contaminants often aim to streamline the investigation process where practical to limit field time and exposure to explosive and CA hazards while providing for sufficiently thorough investigation and removal. The following are a few specific examples:

- Develop Data Quality Objectives (DQOs) for anomaly prioritization/detection criteria to minimize false positives and excessive excavation of cultural debris (i.e., dig stopping rules, quality control [QC] feedback loops, etc.);

- Reduce errors in anomaly reacquisition in the field using GPS and/or the same equipment that was used for detection to confirm anomaly signatures prior to excavating;

- Consider incorporating field screening methods (e.g., X-ray fluorescence, EXPRAY and explosives test kits, as appropriate or applicable) into the field program, in site-specific cases where these would be effective, to refine sampling locations and reduce the quantities of samples submitted for off-site laboratory analysis. There are inherent limitations on data quality level (e.g., screening versus definitive) associated with these field screening methods which may impact DQOs and data uses (i.e., delineation versus risk assessment). These limitations should be evaluated and found to be acceptable by the Project Team prior to implementing;

- Use the minimum quantities of donor explosives for MEC destruction;

- If acceptable with respect to DQOs and regulatory agencies, consider using Incremental Sampling Methodology (ISM) versus discrete sampling for MC characterization. ISM can be an efficient means to obtain accurate mean soil concentration for a large area (with the exception of some field analytical methods) by reducing the number of samples required to be analyzed by an off-site laboratory and minimizing the field time associated with characterizing a large area.

- Evaluate the application of man-portable DGM instruments versus VTA instruments and the inclusion of DAR against the project DQOs. Assessment of production rates (approximately 1 acre/day for man-portable data collection versus 8 to 10 acres/day for VTA instruments), vegetation clearing requirements, and site accessibility may be helpful for evaluating fuel usage and terrain impacts based on the project duration.

- Evaluate the application of Wide Area Assessment (WAA) alternatives/survey platforms including high altitude (e.g., light detection and ranging [LiDAR] and orthophotography) and low altitude (e.g., airborne geophysics such as helicopter-mounted and fixed wing aircraft DGM applications) versus traditional ground-based DGM survey platforms for characterization against the project DQOs and goals. Assessment of production rates (approximately 300 to 700 acres/day for low altitude airborne methods versus 1 to 10 acres/day for man-portable and VTA applications), site coverage, site condition limitations/preparation requirements, and DQOs should be considered. Although airborne methods have the ability to collect data rapidly over a large survey area, the detection capabilities of low altitude platforms are much lower than ground-based systems (particularly for small munitions) and the use is limited to sites that are relatively flat and free of trees, shrubs, and other obstacles. High altitude platforms have the ability to identify MRFs such as craters, berms, and target circles that may require more extensive investigation; however, use on heavily vegetated sites or developed sites is not appropriate. WAA technologies are typically performed in a layered approach, with the types of technologies and sequencing dependent upon the needs of the Project Team.

C. *Energy/Emissions – Transportation* – The BMPs in this category are focused on reducing transportation distance and/or the number of trips for personnel and/or equipment. These BMPs apply equally to IRP and MMRP projects. Some additional considerations for MMRP projects include the following:

- For MMRP activities, specially trained personnel (known as Unexploded Ordnance [UXO] Technicians) are required that may not be available locally. For MMRP projects, options for minimizing transport of personnel may be reduced based on the location of the site and availability of qualified UXO Technicians.

- There may be specific transportation and mobilization requirements for a controlled detonation chamber (CDC) that limit options for minimizing number of trips or trip distances.

- RCWM responses require specific equipment and structures such as air monitoring equipment, vapor containment structure (VCS), on-site disposal equipment for Chemical Agent Identification Set (CAIS) that must be mobilized to the site. In addition, there is limited availability for off-site disposal of wastes (i.e., RCWM disposal facilities are likely not located in close proximity to the site).

Footprint analysis using SiteWise™ may be helpful for evaluating potential options or arrangements related to the items presented above.

D. *Energy/Emissions - Equipment Use* – Specific equipment, such as time domain electromagnetic (TDEM) instruments and magnetometers for digital geophysical mapping (DGM), seem specific to MMRP projects, but can also be used for IRP projects to identify subsurface piping and tanks. This relatively small equipment with relatively low power demand is not generally subject to BMPs because the information and the quality of the data are much too significant relative to the potential savings in power usage. MMRP projects may require more use of battery powered equipment than IRP sites, and care should be taken to operate and maintain equipment in a manner that prolongs battery life. Heavy equipment used on MMRP projects (e.g., large mowers to clear vegetation or excavators and loaders) is similar to the equipment used on IRP projects. For IRP projects, large mowers might be used to maintain a landfill cap and excavators, loaders, and other equipment are used for soil excavation and grading. Major differences between IRP and MMRP projects might include the attachments to the equipment (e.g., a rotary screen attachment or armored cabs for MMRP sites), the usage of a CDC for MEC destruction, and construction/operation of a VCS for RCWM sites. These differences, however, do not substantially affect the application of BMPs (e.g., reducing idle times, selecting the appropriate equipment for the job, ensure peak operating efficiency to reduce energy use and emissions, or use biofuels) or how the equipment might be modeled in SiteWise™. If the application or equipment type cannot be specifically identified in SiteWise™, the equipment horsepower and operating hours can be used to calculate fuel usage as discussed in Section 3.4.

Consumable materials that may be used in reasonable quantities during munitions response activities but are not used on IRP projects and are not well represented in SiteWise™ include detonators or donor explosives used for destruction of MEC whether using blow-in-place (BIP) or consolidated methodologies. If donor explosives are used in substantial quantity at a site, a surrogate "treatment chemical" from SiteWise™ (e.g., fertilizer) would need to be used as a place holder unless more specific information can be identified for the explosives used.

E. *Materials & Off-Site Services* – The BMPs for this category focus on using materials from recycled products, using less-refined materials where practical, optimizing the amount of materials and services used, and using proven environmentally-friendly service providers. These BMPs apply equally to the MMRP and IRP activities.

F. *Water Resource Use* - The BMPs for this category focus on reducing water use, using water of lesser quality when feasible, and finding a beneficial reuse of water that has been extracted and treated. These BMPs apply equally to the MMRP and IRP activities although the use of extracted and treated water would not typically apply to MMRP activities.

G. *Waste Generation, Disposal, and Recycling* – Specific BMPs that apply to MMRP projects include the following:

- Recycle recovered Material Documented as Safe (MDAS) after inspection and certification that the remnants are free of explosive hazards; and
- Minimize Chemical Agent Contaminated Media (CACM) at RCWM sites.

For MMRP projects, specific landfills must be used based on agents and concentrations, and this may limit options for transport and disposal of wastes. For instance, there are only three locations in the United States where CA contaminated soil is accepted.

H. *Land Use, Ecosystems, and Cultural Resources* – The BMPs for this category focus on minimizing impact to land and ecosystems, and apply equally to the MMRP and IRP activities. These impacts may be greater at some MMRP sites, where BIPs can destroy ecosystems and cultural resources. These impacts should be minimized when possible. One of the BMPs (H-7) is to document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources. An example for MMRP projects is to photodocument conditions prior to BIP. Another specific BMP that may apply to a greater extent in MMRP activities (though it can apply to IRP projects as well) is to use historic documents, aerial photographs, and other existing information to reduce the footprint of land that needs to be disturbed for thorough investigation and remediation.

I. *Safety and Community* – Worker and community safety is a primary concern related to all work on IRP and MMRP projects. The BMPs included in the IRP approach apply equally to MMRP activities. For IRP projects, emphasis is placed on reducing exposure to hazardous chemicals, hazardous waste, and physical/biological hazards. In some cases, these safety issues for IRP projects include hazards immediately dangerous to human health. Additional considerations for MMRP projects include the following:

- Minimize exposure to explosion potential; and
- Minimize exposure to CA and ABP associated with RCWM responses.

Regardless of the type of hazard (physical, chemical or explosive), the ultimate goal for both IRP and MMRP is to have the fewest people exposed to the least amount of hazards for the shortest amount of time.

4.2 ANTICIPATED SITE-SPECIFIC GSR COMPARISONS FOR MMRP PROJECTS

A GSR evaluation will typically have a baseline option, plus consideration of alternatives to the baseline option. In some cases the alternatives will be evaluated qualitatively with respect to GSR considerations (i.e., based on BMPs), and in other cases a more quantitative comparison will be performed based on footprint analysis. This is true for both IRP and MMRP projects.

These types of comparisons are inherently project-specific, which is why one of the alternatives cannot universally be defined as a BMP. For MMRP projects, alternatives that might be compared in a GSR evaluation include (but are not limited to) the following:

- <u>Methods for MEC destruction</u>. The use of a CDC (stationary or mobile) versus consolidated shot detonations versus BIP single detonations. Note that the safety considerations (i.e., acceptable to move/transport classification) associated with handling and transporting/storing MEC should be considered as part of the GSR evaluation because the munitions-specific safety hazards will ultimately dictate which destruction method will be used.

- <u>Methods for anomaly detection</u>. The use of DGM in the man-portable application versus DGM using a VTA versus “mag &flag” versus DAR on terrestrial sites. The use of low-altitude airborne DGM survey platforms versus traditional ground-based (man-portable and/or VTA) for WAA application on terrestrial sites. For underwater sites, the use of boat-towed DGM platforms (single sensor or array) in transects or 100% coverage versus side-scan sonar, multibeam sonar, laser-line scan systems, and towed cameras for WAA and/or characterization.

- <u>Methods for soil sampling</u>. The collection of soil samples using ISM methodology versus 7-wheel CRREL methodology vs. discrete sampling.

- <u>Methods for distinguishing practice munitions from MEC</u>. The use of X-ray devices to cull non-high explosive (HE) rounds versus BIP of all recovered MEC. Certain munitions are available in both practice and HE varieties and can be distinguished using either X-ray or destruction using donor explosives/jet perforators. Unnecessary BIP events may increase the spread of chlorinated naphthalene, the fill used in the practice version.

- <u>Methods for remediation of small arms ammunition (SAA)</u>. Comparison of the standard cleanup approaches such as ITRC “*Characterization and Remediation of Soils at Closed Small Arms Firing Ranges*” (January 2003) or US EPA Region 2 “*Best Management Practices for Lead at Outdoor Shooting Ranges*” (June 2005) for MMRP projects that include SAA.

- <u>Methods for handling CA contaminated media</u>. On-site treatment of waste streams (i.e., segregating hazardous from non-hazardous media) for CA contaminated soils. Special considerations are associated with the off-site transport of CA contaminated soils since only a few landfills exist that will accept this material.

- Methods for removal of subsurface anomalies. Manual excavation of subsurface anomalies versus bulk soil removal and sifting.

- Methods for providing electrical power for infrastructure. Hard-wired power versus generator usage for site infrastructure during response actions.

- Timing of RCWM operations. Natural lighting (i.e., day time operations) versus night time operations for RCWM operations to consider impacts related to heat stress, scheduling, and visibility. Such operations require specialized PPE that enhances potential for heat stress.

- Methods for protecting the public. The use of VCS versus evacuation for RCWM sites. The use of other engineering controls (i.e., sandbag or water mitigation, blast mats, open front barricades) versus evacuation for conventional MMRP sites.

- Methods for vegetation removal and disposal. Alternative brush handling techniques.

- Methods for navigation and anomaly relocation. Alternative navigation techniques.

When performing a GSR evaluation for an MMRP project, the list above should be reviewed to determine if a project-specific GSR evaluation is appropriate. The screening approach described in Section 2.1.4 can help determine if quantitative footprint evaluation is appropriate.

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USAEC, "*Program Management Manual for MMRP Active Installations*" (September 2009). http://aec.army.mil/usaec/cleanup/mmrp00_activeinstall.pdf

US EPA, "*Methodology for Understanding and Reducing a Project's Environmental Footprint*," Publication Number: EPA 542-R-12-002 (February 2012) http://www.epa.gov/oswer/greenercleanups/pdfs/methodology.pdf

US EPA Region 2, *"Best Management Practices for Lead at Outdoor Shooting Ranges"* Publication Number: EPA-902-B-01-001 (June 2005). http://www.epa.gov/region2/waste/leadshot/epa_bmp.pdf

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ATTACHMENT A-1

GSR Best Management Practice (BMP) Checklists

Note:
These checklists are available as part of the template report (Attachment A-3) in MS-Word format, and can be modified by the user. Check-boxes can be checked and un-checked by right-clicking on the checkbox, selecting "properties", and then selecting "checked" or "not checked".

BMP Category A: Planning

BMP A-1: Develop a culture of GSR within the Project Team and encourage GSR ideas from project staff, and review similar projects from other sites for possible transfer/adoption of GSR ideas	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP A-2: Incorporate a section on GSR in project meetings, work plans, and reports	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

<table>
<tr><td colspan="2">BMP A-3: Identify and periodically update a list of key stakeholders and their concerns with respect to GSR considerations</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP A-4: Schedule activities for appropriate seasons and/or time of day to reduce delays caused by weather conditions and fuel needed for heating or cooling
Examples:
- Work at night in summer to avoid heat stress
- Perform field activities in summer to take advantage of longer daylight</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP A-5: Prepare, store, and distribute documents electronically	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP A-6: Utilize teleconferences rather than meetings when feasible	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP A-7: Incorporate green specifications into solicitations and contracts Examples: - Follow pertinent green procurement policies - Select hotel chains with "green" policies - Select laboratories that utilize renewable energy	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP A-8: Integrate schedules to allow for resource sharing and fewer days of field mobilization	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP A-9: Tailor the remedy cleanup goals such that they are appropriate for anticipated end-use of the property, rather than assuming a more conservative exposure scenario with more stringent cleanup goals	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP A-10: Conduct thorough review of project documents and historical records to minimize required scope of investigation Examples: - IRP projects: determine if there are previous aquifer tests that can be used for groundwater modeling rather than conducting new aquifer tests - MMRP projects: perform careful review of historic documents, aerial photographs, and other existing information to reduce the footprint of land that needs to be disturbed for thorough investigation and remediation - MMRP projects: use IRP sampling data to supplement and enhance the MMRP field program (if available)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

<table>
<tr><td colspan="2">BMP A-11: Use language in work plans, proposed plans, and decision documents that maximizes flexibility to allow GSR recommendations to be implemented
Examples:
- Designation of a “suitable growth media” for a landfill cap cover material rather than “top soil”
- Allow for “treatment technologies that achieve adequate levels of treatment” rather than specifying only one treatment technology</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category B: Characterization and/or Remedy Approach

BMP B-1: Develop and routinely update a conceptual site model (CSM) to use as a basis for making remedial process decisions		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP B-2: Perform regular optimization evaluations to improve efficiency of current or planned actions and/or develop alternative remedial approaches that might shorten remedy duration or otherwise improve the net environmental benefit of the remedy, including use of any methodologies, such as TRIAD (www.triadcentral.org), systematic planning (technical project planning), value engineering studies, and remedial system evaluations, expected to optimize the planning and/or execution of the project		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td colspan="2">BMP B-3: Use appropriate characterization or remedy approach based on site conditions
Examples:
- Consider in-situ and passive remedy options that offer adequate protectiveness
- Consider in-situ bioremediation if conditions are already anaerobic and constituents are conducive to reductive dechlorination
- Compare source removal versus in-situ and ex-situ remedial options
- Consider different technologies for impacted areas with higher and lower concentrations
- Use realistic times to remedy closeout (i.e., estimations through modeling) rather than assumed remedy timeframes (e.g., 30 years, which is often used for evaluation of FS alternatives)
- MMRP projects: evaluate man-portable DGM instruments versus vehicle-towed array (VTA) instruments and inclusion of detector-aided reconnaissance (DAR)
- MMRP projects: evaluate best alternative for destruction of munitions (e.g., blow in place versus consolidated shot versus controlled detonation chamber)</td><td>Date:

☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
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</table>

<table>
<tr><td colspan="2">BMP B-4: Establish decision points to trigger a change from one technology to another or from one remedy alternative to another
Examples:
- Change vapor treatment from thermal oxidation to granular activated carbon (GAC) media based on flow rates and concentrations
- Remove a treatment polishing step if influent to that step already meets discharge criteria
- Move to Monitored Natural Attenuation (MNA) if specific concentration thresholds in groundwater are met</td><td>Date:

☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
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BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td>BMP B-5: Focus sampling efforts to meet objectives of the specific remedial phase (e.g., sampling during O&M should be focused on evaluating remedy performance and not on thorough plume characterization)
Examples:
- Eliminate sampling parameters as appropriate
- Reduce sampling frequency as appropriate
- Reduce sample locations as appropriate
- Enhance monitoring program as appropriate
- MMRP projects: consider Incremental Sampling Methodology (ISM) versus discrete sampling for MC characterization</td><td>Date:

☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
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</table>

<table>
<tr><td>BMP B-6: Consider real-time measurements and dynamic work plans to reduce mobilizations and improve effectiveness of investigation efforts
Examples:
- Field test kits (e.g., test kits for sulfate)
- Field screening instruments (e.g., x-ray fluorescence for lead or photoionization detectors for volatile organics)
- Drive point sensor technologies (e.g., membrane interface probe or “MIP”)
- Visual staining or odor
- Establish excavation extent based on real-time data collected as excavation proceeds and use GPS to accurately delineate excavation areas
- MMRP projects: use GPS and/or the same equipment that was used for detection to confirm anomaly signatures prior to excavating
- MMRP projects: consider incorporating field screening methods (e.g., X-ray fluorescence, EXPRAY and explosives test kits, as appropriate or applicable) into the field program to refine sampling locations and reduce the quantities of samples submitted for off-site laboratory analysis
- MMRP projects: consider use of advanced electromagnetic sensors (e.g., MetalMapper) for better subsurface item identification to reduce digging requirements</td><td>Date:

☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
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</table>

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td colspan="2">BMP B-7: Consider use of existing site structures/infrastructure or mobilization of temporary structures versus new construction
Examples:
- Buildings (e.g., for treatment building or field office)
- Concrete slabs or foundations
- Wells
- Existing excavations for storm water control</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
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</table>

<table>
<tr><td colspan="2">BMP B-8: Establish project-specific decision points to limit extent of remediation
Examples:
- Project-specific cleanup levels based on a site-specific risk assessment (coordinated with risk assessment experts) rather than generic cleanup levels, if it results in lower footprints for key parameters and is acceptable to all stakeholders
- MMRP projects: dig stopping rules and anomaly prioritization/detection criteria to minimize false positives</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
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</table>

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td colspan="2" rowspan="2">BMP B-9: Consider leaving in place structures whose removal is not necessary (i.e., foundations, underground pillars, etc.)</td><td>Date:</td></tr>
<tr><td>☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category C: Energy/Emissions – Transportation

BMP C-1: Reduce the number of trips for personnel Examples: - Encourage carpooling - Use telemetry systems and webcams to remotely transmit data directly to project offices to avoid trips	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP C-2: Reduce the number of trips and/or volume for transported materials, equipment, or waste Examples: - Transfer full loads by consolidating shipments from vendors and/or shipments to disposal sites (also share shipments with neighbors if feasible) - Purchase more concentrated chemicals to reduce transportation weight and/or volume	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category C: Energy/Emissions – Transportation

BMP C-3: Reduce trip lengths Examples: - Dispose of waste at closest appropriate facility - Purchase materials, equipment, and services from local vendors - Use locally produced supplies - Select most efficient transportation route	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP C-4: Use alternate fuels or other options for transportation when possible Examples: - Compressed natural gas - Biodiesel blends - Ethanol blends - Hybrid and/or electric - Rail lines versus trucks - Use a fuel efficient passenger car rather than a pickup truck if task allows	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category D: Energy/Emissions – Equipment Use

BMP D-1: Consider and implement approaches to minimize engine idle times	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP D-2: Ensure peak operating efficiency of equipment to reduce energy use and emissions Examples: - Perform preventative maintenance and operate equipment per manufacturer instructions - Perform retrofits involving low-maintenance multi-stage filters for cleaner engine exhaust - Use synthetic oil to extend operating life (and reduce waste oil) - Purchase newer equipment with reduced emissions	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category D: Energy/Emissions – Equipment Use

BMP D-3: Use alternate fuel options for equipment when possible Examples: - Compressed natural gas - Biodiesel - Ethanol blends - Ultra-low sulfur diesel, wherever available (and as required by engines with PM traps) - Recycled oil (ensure compliance with operating requirements/warranties)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP D-4: Select appropriate equipment and/or power source for the job Examples: - Avoid using large excavators for small earthmoving projects - Use direct push methods when possible to reduce drilling duration - Compare potential use of electricity versus battery versus generator	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category D: Energy/Emissions – Equipment Use

BMP D-5: Use variable frequency drives on motors (e.g., pumps, blowers), or replace oversized motors with properly sized motors	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP D-6: Identify options for generating renewable energy for direct use in the remedy and/or for alternate use at or near the project site Examples: - Solar, wind, landfill gas (microturbines), combined heat and power, geothermal heat exchange - Applications for remote areas such as solar pumps or solar flares (if demand is not continuous, the need for a battery backup may be avoided) - Generate power or heat exchange from water to be discharged	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category D: Energy/Emissions – Equipment Use

BMP D-7: Consider purchase of renewable energy certificates (RECs) to offset emissions from the remedial activities (note that a Memorandum titled Department of the Army Policy for Renewable Energy Credits, dated 24 May 2012, states that "the Army shall not purchase RECs solely to meet Federal renewable energy goals," but it is possible that Project Teams might in some cases consider the purchase of RECs to address concerns of one or more stakeholders at a specific site)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP D-8: Design/modify housing required for above-ground treatment components for energy-efficiency Examples: - Passive lighting - Compact fluorescent lighting (CFL) or light-emitting diode (LED) lighting - Timers and/or motion control sensors for lighting - Shading - Minimize heating and cooling needs (building size, insulation, etc.)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

<table>
<tr><td colspan="2" rowspan="2">BMP D-9: For remedies that involve groundwater or air extraction, optimize extraction to reduce flow rates (potentially beneficial with respect to energy use, materials usage, water resources, waste disposal, etc.)</td><td>Date:</td></tr>
<tr><td>☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
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<table>
<tr><td colspan="2" rowspan="2">BMP D-10: Consider pulsing for extraction and/or injection of water or air to maximize mass removal per unit of time or energy, by extracting higher concentrations</td><td>Date:</td></tr>
<tr><td>☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
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☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category D: Energy/Emissions – Equipment Use

<table>
<tr><td colspan="2">BMP D-11: Run electrical equipment during times of lower electric demand if possible (this does not reduce energy use but could lower cost and also can lower stress on the energy grid during periods of peak demand)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category E: Materials & Off-Site Services

BMP E-1: Use materials that are made from recycled materials Examples: - Steel - Asphalt - Plastics - Concrete	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP E-2: Optimize the amount of materials used Examples: - Experiment with different material amounts/doses - Consider alternate materials - Use timers or feedback loops and process controls for dosing - MMRP projects: minimize quantities of donor explosives for MEC destruction	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category E: Materials & Off-Site Services

BMP E-3: Utilize less refined materials when feasible Examples: - Limestone instead of sodium hydroxide for pH adjustment - Native fill instead of select fill	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP E-4: Identify opportunities for using by-products or "waste" materials from local sources in place of refined chemicals or materials Examples: - Cheese whey, molasses, compost, or off-spec food products for inducing anaerobic conditions - Crushed concrete for use as fill - Concrete from coal combustion byproducts	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category E: Materials & Off-Site Services

<table>
<tr><td colspan="2">BMP E-5: Reduce demand on Publicly Owned Treatment Works (POTWs)
Examples:
- Discharge treated water to groundwater or to surface water rather than POTW
- Minimize amount of water requiring treatment</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category F: Water Resource Use

<table>
<tr><td colspan="2">BMP F-1: Minimize water consumption
Examples:
- Sensors to turn off water when not needed
- Low flow fittings
- Minimize water needs for irrigation (landscape choices, use of mats and mulch)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP F-2: Preferentially use less refined water resources when feasible
Examples:
- Use extracted groundwater instead of potable water for chemical blending
- Capture and store rain/storm water for future use
- Employ rumble grates with a closed-loop gray-water washing system</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
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☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP F-3: Use extracted and treated water for beneficial purposes
Examples:
- Irrigation
- Potable water
- Industrial process water</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP F-4: Promote groundwater recharge
Examples:
- Recharge extracted and treated water when beneficial uses of the water are not identified and reinjection is practical
- Minimize site area covered by impervious surfaces to reduce runoff and maximize infiltration (unless such capping is a specific component of the remedial action)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category F: Water Resource Use

<table>
<tr><td colspan="2">BMP F-5: Maintain water quality by preventing nutrient loading to surface water or groundwater
Examples:
- Use phosphate-free detergents instead of organic solvents or acids to decontaminate sampling equipment (if not required for some contaminants)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category G: Waste Generation, Disposal, and Recycling

BMP G-1: Minimize drill cuttings and all other investigation derived waste (including personal protection equipment) Examples: - Direct push or sonic drilling to reduce drill cuttings - Low-flow sampling or passive diffusion bags (if applicable) to reduce purge water - When possible place drill cuttings on-site rather than off-site disposal	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP G-2: Segregate excavated soil in pre-planned staging areas so that "clean" material can be deposited on-site and/or reused rather than transported for off-site disposal	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category G: Waste Generation, Disposal, and Recycling

BMP G-3: Consider on-site treatment and re-use of soil instead of off-site disposal Examples: - Land farming - Above ground soil vapor extraction (SVE)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP G-4: Minimize need to transport and dispose hazardous waste Examples: - Consider delisting listed hazardous waste if waste is not characteristically hazardous waste - Segregate hazardous waste and non-hazardous waste - Maintaining the non-hazardous land fill classification instead of reclassifying to a hazardous landfill so that OSHA's HAZWOPER standard for cleanup operations does not need to be implemented	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category G: Waste Generation, Disposal, and Recycling

BMP G-5: When possible avoid/minimize use of hazardous/toxic materials that may require special handling or disposal Examples: - Cleaning solutions - Pesticides - Disposable batteries (use rechargeable batteries) - MMRP projects: minimize Chemical Agent Contaminated Media (CACM) at RCWM sites.	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP G-6: Recycle or reuse materials rather than disposing of them Examples: - Cardboard - Plastics - Concrete - Asphalt - Steel and other metals - Recovered oil/product - Mulch/compost - MMRP projects - recycle recovered Material Documented as Safe (MDAS) after inspection and certification that the remnants are free of explosive hazards	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category H: Land Use, Ecosystems, and Cultural Resources

BMP H-1: Minimize erosion and soil transport to surface water bodies Examples: - Quickly restore any vegetated areas disrupted by equipment or vehicles - Institute appropriate erosion controls during excavation such as silt fencing	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP H-2: Minimize disturbances to land Examples: - Establish well-defined traffic patterns for onsite activities to minimize disturbed areas - Consider non-intrusive investigation techniques (e.g., geophysical methods) to identify items like USTs and buried drums	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP H-3: Preserve/restore ecosystems to the extent possible Examples: - Limit the removal of trees and vegetation - Attempt to transplant disturbed shrubs and small trees to other locations - Use native species for re-vegetation - Retrieve dead trees during excavation and later reposition them as habitat snags - Select and place suitably sized and typed stones into water beds and banks - Undercut surface water banks in ways that mirror natural conditions - Cut back rather than remove trees, bushes, vegetation	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP H-4: Minimize drawdown of the water table in sensitive areas such as wetlands or areas subject to subsidence	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP H-5: Construct wells and other remedial process infrastructure (piping, buildings, etc.) to minimize restrictions to anticipated future use of the site	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP H-6: Preserve/restore cultural resources to the extent possible Examples: - Protected lands such as wildlife refuges, national parks, and wilderness areas - Culturally sensitive sites such as cemeteries, native burials, and archaeological finds - Buildings or land parcels with historical significance	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

<table>
<tr><td colspan="2">BMP H-7: Document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources
Examples:
- Photodocument conditions prior to clearing brush
- MMRP projects: photodocument conditions prior to BIP</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category I: Safety and Community

BMP I-1: Minimize and mitigate noise, light and odor disturbance during all phases of the remedial process, to the extent practicable	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-2: Minimize dust during construction activities by spraying water or techniques such as laying biodegradable mats, tarps, or materials (already in EM385-1-1)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-3: Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-4: Minimize drawdown of the water table in areas that could impact production rates at supply wells and/or irrigation wells	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-5: Minimize amount of time that heavy machinery is needed to enhance safety	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-6: Minimize handling of dangerous chemicals by selecting alternate chemicals and/or engineering to minimize contact with chemicals (for MMRP projects, there is enhanced risk related to explosion potential and exposure to chemical agents (CA) and agent breakdown products (ABP) associated with RCWM responses)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-7: Contribute to local economy when possible Examples: - Consider leasing local office space - Purchase or lease equipment from local vendors - Hire workers from local community	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-8: Utilize on-site construction practices and PPE requirements for anticipated exposure scenarios rather than an overly conservative level of protectiveness that is more resource intensive Examples: - Utilize general construction PPE protectiveness, which is less personnel and equipment resource intensive, rather than HTRW PPE protectiveness, when applying a non-hazardous soil cover for a HTRW landfill	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category J: Other Site-Specific BMPs

BMP J-1:		**Date:**
		☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP J-2:		**Date:**
		☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

ATTACHMENT A-2

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) Contracting Language

- Example of US Army Corps of Engineers (USACE) Environmental and Munitions Center of Expertise (EM CX) GSR Language for a Firm Fixed Price, Prescriptive Contract

- Example of Army Environmental Command (AEC) GSR Contract Language for a Performance-Based Acquisition

- Examples of Formerly Used Defense Site (FUDS) Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) Contracting Language, with Instructions for Use on Different FUDS Contract Types

Note: For the examples in Attachment A-2 other project-specific factors, including general sustainability considerations such as sustainable materials procurement, could also be included in the contract depending on the project and the procurement procedures

Example of US Army Corps of Engineers (USACE) Environmental and Munitions Center of Expertise (EM CX) GSR Language for a Firm Fixed Price, Prescriptive Contract

Example of Scope of Work language for a Remediation System Evaluation (RSE) Remedy Optimization

Sustainability Analysis. The contractor shall evaluate the current carbon footprint and other resource impacts of the current remedial or corrective actions at the installations. The RSE shall consider sustainability (relative to this baseline) in developing the recommended changes to the actions at the site. The potential use of alternative energy sources or energy recovery shall be evaluated and appropriate recommendations shall be included in the RSE report. The evaluation may require the use of tools such as the Air Force Sustainable Remediation Tool spreadsheet or the Battelle SiteWise™ software.

Example of Army Environmental Command (AEC) GSR Contract Language for a Performance-Based Acquisition

Example of Performance Work Statement Contract Language

The Contractor shall consider and implement green response/remediation strategies and applications to maximize sustainability, reduce energy and water usage, promote carbon neutrality, promote industrial materials reuse and recycling, and protect and preserve land resources, consistent with Defense Environmental Restoration Program (DERP) GSR policy (March 2012 DERP Manual). The Contractor shall present green remediation options and approaches, including cost analyses, in its work plans, maintain records of "green-related" activities, and report this information to the COR in its project status reports.

Example of Basis of Award GSR Technical Evaluation Subcriterion

Sustainable Practices: Proposal demonstrates consideration of green and sustainable remediation practices in all aspects of the technical approach and project execution, and provides logic for acceptance or rejection of implementing such.

Examples of Formerly Used Defense Site (FUDS) Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) Contracting Language with Instructions for Use on Different FUDS Contract Types

Table of Contents

Acronyms

A-E	Architect-Engineer
BMP	best management practice
COR	contracting officer's representative
D&F	determination & findings
DoD	Department of Defense
EP	Engineering Pamphlet
FAR	Federal Acquisition Regulation
FFP	firm-fixed price
FUDS	Formerly Used Defense Site(s)
GSA	General Services Administration
GSR	green and sustainable remediation
HTRW	hazardous, toxic, and radioactive waste
ID/IQ	indefinite delivery/indefinite quantity
IT	innovative technology(ies)
KO	contracting officer
LCA	life-cycle analysis
MATOC	multiple-award task order contract
PBC	performance-based contract
PDT	project delivery team
PWS	performance work statement
SATOC	multiple-award task order contract
SOW	statement of work
USACE	United States Army Corps of Engineers

1.0 Introduction

Recent Department of Defense (DoD) and U.S. Army guidance and policy address green and sustainable remediation (GSR) and innovative technology (IT) use on U.S. Army Corps of Engineers (USACE) projects. GSR uses strategies that consider all environmental effects of remedy implementation and operation and incorporates options to maximize the overall environmental benefit of environmental response actions. It is USACE's goal to consider, to the extent practical, GSR practices during all phases of remediation projects and to implement GSR practices when feasible (DoD 2012). It is also USACE's goal to utilize IT to the extent practical during all phases of projects to reduce costs, expedite project schedules, minimize risk and maximize effectiveness (USACE 2000). To successfully utilize GSR practices and IT on environmental projects, appropriate language must be included in the contract. After the Project Delivery Team (PDT), which includes the contracting officer (KO) and/or the Contracting Officer's Representative (COR), has selected the appropriate contract type that will be used, the template language in this section may be incorporated into the statement of work (SOW) or performance work statement (PWS), as applicable. Specific language is provided for each of the contract types listed in the table of contents.

The example contract language is provided as a template. Notes to users are included in bracketed italics. The contract language is in green text. The PDT is responsible for modifying the language to meet the GSR and IT requirements of the project. These requirements must be clearly defined, achievable, measurable, and enforceable.

1.1 Prescriptive vs. Performance-Based Contracting Approaches

A prescriptive SOW is typically used when there is little uncertainty regarding what is necessary to complete the scope of work. The prescriptive SOW describes specifically and in detail what the Contractor must do.

A performance-based PWS is used when there is significant uncertainty regarding what work is required to accomplish the performance objectives or when specialized experience is needed to develop the best approach to accomplishing the work. The PWS lists the performance objectives that must be accomplished by the contractor; the means and details are not specified by the Government.

In practice, a SOW/PWS may have both prescriptive and performance-based elements, and the overall approach is determined by the predominant nature of the solicitation.

In this guidance document, the terms "prescriptive" and "performance-based" typically refer to the nature of the GSR/IT requirements and not necessarily the overall contract approach, though in many cases they may be the same. However in some cases, a prescriptive SOW may include performance-based GSR/IT requirements, and in others, a performance-based PWS may include prescriptive GSR/IT requirements. Even when a performance-based approach to GSR and/or IT is used, there are administrative components that should be prescribed in detail, such as planning, tracking, and reporting/documenting the GSR and IT elements of the project.

1.2 Fixed-Fee and Award-Fee Contracts

Although the contract language in this document is applicable for fixed-fee contracts, it should be noted that the Contractor cannot be provided a financial incentive to implement GSR/IT on this contract type, since the fee is fixed. If GSR/IT must be implemented on fixed-fee contracts, it is recommended to use a prescriptive approach requiring certain GSR/IT elements to be performed or provided.

Award-fee incentives (see FAR 16.404) are a useful tool for incentivizing GSR/IT on performance-based contracts (PBCs), both cost-reimbursable and firm-fixed-price. The rationale for determination of the earned award-fee must be included in the contract or task-order solicitation and should be modified by the

PDT on a project-specific basis. This rationale may be a numerical calculation (for quantitative goals) or a judgemental evaluation by the Government (for qualitative goals). It is important to note that on some projects, GSR/IT award-fees may only be one component of the total award-fee (e.g., it may also include a schedule incentive award-fee component).

2.0 A-E ID/IQ Contracts and Task Orders

Architect-Engineer (A-E) contracts may used for environmental services when architectural or engineering expertise is required to complete the scope of work. Their use is governed by Engineering Pamphlet (EP) 715-1-7 (Procurement - A-E Contracting), EP 715-1-5 (A-E Contracting Guide - Hazardous, Toxic, Radioactive Waste (HTRW) Contracting), and the Federal Acquisition Regulation (FAR) (Subpart 36.6 A-E Services). On an A-E base contract, firms compete for an Indefinite Delivery/Indefinite Quantity (ID/IQ) base contract based on qualifications. An A-E base contract selection can result in one firm or a pool of firms. Once an A-E base contact is in place, the Government may award individual task orders to the firm(s) in accordance with existing regulations. GSR and IT must be considered in a broad sense in the base contract, and again in more detail at the task order level.

2.1 A-E ID/IQ Base Contract

To incorporate GSR and IT when soliciting firms for an A-E ID/IQ base contract, GSR/IT should be included as a factor in the evaluation criteria determining the best qualified contractor(s). The solicitation should summarize the GSR/IT policy and indicate that extra consideration will be given to bidders who demonstrate GSR/IT experience on previous projects and in resumes of personnel they present in their proposal. Consideration should also be given to GSR practices and IT employed by the bidder in their approach to the sample problem, if applicable.

Template contract language for A-E base ID/IQ contracts is included in Appendix A.

2.2 A-E Firm-Fixed-Price Task Order

A firm-fixed price (FFP) task order provides for a price that is not subject to any adjustment on the basis of the contractor's cost in performing the contract. This contract type places upon the contractor maximum risk and full responsibility for all costs and resulting profit or loss. It provides maximum incentive for the contractor to control costs and perform effectively and imposes a minimum administrative burden upon the contracting parties. (FAR 16.201-1)

2.2.1 A-E Firm-Fixed-Price Performance-Based Task Order

In order to incorporate GSR and IT into a FFP performance-based task order, the recommended approach is to specify minimum GSR and IT for the contractor to provide and encourage the contractor to develop and implement additional GSR and IT. This is done by using a financial incentive for GSR/IT incorporation. USACE Interim Guidance 10-01 (USACE 2009) and the FAR (Subpart 16.4) provide guidance on this approach. The GSR/IT incentive amount, goals, weighting factors, and payment justification process may be modified as necessary. A Determination and Findings (D&F) may be required to justify the use of the incentive. An example D&F memorandum is included as Appendix I.

Template contract language for A-E FFP performance-based task orders is included in Appendix B.

2.2.2 A-E Firm-Fixed-Price Prescriptive Task Order

If the PDT knows exactly which GSR practices (e.g., evaluation using SiteWise™, membrane interface probe screening, etc.) and IT are desired for a project, those may be contracted using a FFP prescriptive approach. In this case, the GSR practice(s) and IT are specified in detail in the SOW, along with appropriate tracking and documentation requirements where applicable. Because the Government is not relying on the contractor to brainstorm potential GSR and IT opportunities, this contract language does not need the explanation for why GSR/IT is required. Also, no incentive is necessary. The cost/benefit for the prescribed GSR/IT will be built into the bid price.

Template contract language for A-E FFP prescriptive task orders is included in Appendix C.

2.3 A-E Cost-Reimbursable Task Order (with fixed fee, award fee, or incentive fee)
Cost-reimbursement types of contracts provide for payment of allowable incurred costs. These contracts establish an estimate of total cost for the purpose of obligating funds and establishing a ceiling that the contractor may not exceed (except at its own risk) without the approval of the KO. They are only used when work requirements cannot be defined sufficiently to allow for a fixed-price type contract or when uncertainties do not permit costs to be estimated with sufficient accuracy to use a fixed-price contract. (FAR 16.301).

2.3.1 A-E Cost-Reimbursable Performance-Based Task Order
Utilizing performance-based GSR/IT requirements on a cost-reimbursable task order is similar to doing so on a FFP task order; however, additional Government oversight and approval processes are necessary because implementation of GSR and IT may impact the cost to the Government.

Proposed GSR or IT enhancements in each individual task order must be supported with life-cycle analyses (LCAs) to the project and/or the environment (i.e., water/energy consumption reduction, impacts of waste minimization, etc). The life-cycle cost analyses should include the net cost or net savings to the project by implementing that particular element into the project. Although these LCAs should be required as a rule, the PDT may waive the requirement on a case-by-case basis or allow a qualitative LCA to be performed in lieu of a quantitative one. This may be the case where GSR best management practices (BMPs) are included without performing a quantitative LCA.

The contract language must also explain how GSR and IT implementation will affect the fixed-fee, award-fee, or incentive-fee for the task order. Thus, the language for a cost-reimbursable task order is similar to that for a FFP task order; however, it is revised to include additional Government oversight, life-cycle analyses, and fee impact explanation.

Template contract language for A-E cost-reimbursable performance-based task orders is included in Appendix D.

2.3.2 A-E Cost-Reimbursable Prescriptive Task Order
The contract language for a cost-reimbursable prescriptive task order is the same as the language for a FFP prescriptive task order.

Template contract language for A-E cost-reimbursable prescriptive task orders is included in Appendix C.

3.0 MATOCs and MATOC Task Orders
Multiple-Award Task Order Contracts (MATOCs) are a form of ID/IQ contract often used to procure environmental remediation, investigation, and other environmental services. The base contract solicitation reasonably describes the general scope, nature, complexity, and purpose of the environmental services the Government will acquire under the contract. On a MATOC base contract, firms compete to be selected into a pool of firms. The Government may then place task orders which are competed amongst the firms in the pool. Like A-E ID/IQ contracts, on MATOCs GSR and IT must be considered in a broad sense in the base contract, and again in more detail at the task order level.

3.1 MATOC ID/IQ Base Contract
Incorporation of GSR into a MATOC base contract is done with an approach similar to that used in an A-E base contract.

Template contract language for MATOC base ID/IQ contracts is included in Appendix A.

3.2 MATOC Firm-Fixed-Price Task Order
3.2.1 MATOC Firm-Fixed-Price Performance-Based Task Order
Performance-based task orders on MATOCs are similar to those on A-E contracts, however there are a few differences because the MATOC task orders are competed. They may be competed on the basis of best value, low bid, or low bid technically acceptable.

3.2.1.1 MATOC Firm-Fixed-Price Performance-Based Task Order - Best Value
A best value contract approach awards the task order to the contractor whose proposal provides the best value based on the evaluation factors set forth in the solicitation (SOW or PWS). Evaluation factors may include, but are not limited to: past performance, technical approach, management approach, green and sustainable practices, price, and warranty considerations. The approach to GSR and IT on a MATOC FFP performance-based, best value selection task order is to specify minimum GSR practices or IT and include an incentive to encourage additional GSR and IT. However, because the task order is competed, the PWS must also include evaluation criteria that focus on GSR and IT.

Template contract language for MATOC FFP performance-based, best value selection task orders is included in Appendix E.

3.2.1.2 MATOC Firm-Fixed-Price Performance-Based Task Order - Low Bid Technically Acceptable
This contract language is the same as the language for a MATOC FFP performance-based task order except for a minor change to the Basis of Award language. In order to avoid potential disputes with unselected bidders, it is imperative to include language in the solicitation that the contract will include a GSR/IT incentive. The language in Appendix F satisfies this requirement.

Template contract language for MATOC FFP performance-based, low bid technically acceptable selection task orders is included in Appendix F.

3.2.2 MATOC Firm-Fixed-Price Prescriptive Task Order - Low Bid
This contract language is the same as the language for an A-E FFP prescriptive task order. Cost is the only evaluation factor.

Template contract language for MATOC FFP prescriptive, low bid selection task orders is included in Appendix C.

3.3 MATOC Cost-Reimbursable Task Order (with fixed fee, award fee, or incentive fee)
3.3.1 MATOC Cost-Reimbursable Performance-Based Task Order – Best Value Selection
This contract language is the same as the language for an A-E cost-reimbursable performance-based task order, except a GSR/IT evaluation factor is added.

Template contract language for MATOC cost-reimbursable, performance-based , best value selection task orders is included in Appendix G.

3.3.2 MATOC Cost-Reimbursable Prescriptive Task Order

This contract language is the same as the language for an A-E cost-reimbursable prescriptive task order, except a GSR/IT evaluation factor focusing on the prescribed GSR/IT is added.

Template contract language for MATOC cost-reimbursable prescriptive, best value selection task orders is included in Appendix H.

4.0 8(a) Set-Aside Contracts

Named for Section 8(a) of the Small Business Act, this program was created to help small and disadvantaged businesses compete in the marketplace. It also helps these companies gain access to federal and private procurement markets. The PDT may use this contracting mechanism to sole-source an award of up to $4M to an 8(a) firm in the program.

The contracting language for incorporating GSR and IT into 8(a) set-aside contracts is the same as the language used for A-E task orders.

4.1 8(a) Firm-Fixed-Price Contract

4.1.1 8(a) Firm-Fixed-Price Performance-Based Contract

Template contract language for 8(a) set-aside FFP PBCs is included in Appendix B.

4.1.2 8(a) Firm-Fixed-Price Prescriptive Contract

Template contract language for 8(a) set-aside FFP prescriptive contracts is included in Appendix C.

4.2 8(a) Cost-Reimbursable Contract (fixed fee, award fee, or incentive fee)

4.2.1 8(a) Cost-Reimbursable Performance-Based Contract

Template contract language for 8(a) set-aside cost-reimbursable PBC is included in Appendix D.

4.2.2 8(a) Cost-Reimbursable Prescriptive Contract

Template contract language for 8(a) set-aside cost-reimbursable prescriptive contracts is included in Appendix C.

5.0 SATOCs and SATOC Task Orders

A Single-Award Task Order Contract (SATOC) base contract solicitation is similar to a MATOC, except that only one firm is selected from those submitting bids on the base contract. The Government may then sole-source task orders to that firm for the duration of the contract.

The contracting language for incorporating GSR and IT into SATOC base contracts and task orders is the same as the language used for MATOC base contracts and task orders.

5.1 SATOC Base Contract

Template contract language for SATOC base ID/IQ contracts is included in Appendix A.

5.2 SATOC Firm-Fixed-Price Task Order

5.2.1 SATOC Firm-Fixed-Price Performance-Based Task Order

Template contract language for SATOC FFP performance-based task orders is included in Appendix B.

5.2.2 SATOC Firm-Fixed-Price Prescriptive Task Order

Template contract language for SATOC FFP prescriptive contracts is included in Appendix C.

5.3 SATOC Cost-Reimbursable Task Order (fixed fee, award fee, or incentive fee)

5.3.1 SATOC Cost-Reimbursable Performance-Based Task Order

Template contract language for SATOC cost-reimbursable performance-based task orders is included in Appendix D.

5.3.2 SATOC Cost-Reimbursable Prescriptive Task Order

Template contract language for SATOC cost-reimbursable prescriptive task orders is included in Appendix C.

6.0 GSA Contracts

The General Services Administration (GSA) Schedule program is directed and managed by GSA and provides Federal agencies with a simplified process for obtaining commercial supplies and services at prices associated with volume buying. Indefinite delivery contracts are awarded to provide supplies and services at stated prices for given periods of time. GSA Schedule contracts may be competed among at least three firms on the GSA schedule, or alternatively, they may be sole-sourced for awards up to $150K.

6.1 GSA Competitive Contract

The contracting language for incorporating GSR and IT into GSA Schedule competitive contracts is the same as the language used for MATOC task orders.

6.1.1 GSA Competitive Firm-Fixed-Price Contract

6.1.1.1 GSA Competitive Firm-Fixed-Price Performance-Based Contract

6.1.1.1.1 GSA Competitive Firm-Fixed-Price Performance-Based Contract - Best Value

Template contract language for GSA competitive FFP performance-based, best value selection contracts is included in Appendix E.

6.1.1.1.2 GSA Competitive Firm-Fixed-Price Performance-Based Contract - Low Bid Technically Acceptable

In order to avoid potential disputes with unselected bidders, it is imperative to include language in the solicitation that the contract will include a GSR/IT incentive. The language in Appendix F satisfies this requirement.

Template contract language for GSA competitive FFP performance-based, low bid technically acceptable selection contracts is included in Appendix F.

6.1.1.2 GSA Competitive Firm-Fixed-Price Prescriptive Contract - Low Bid

Template contract language for GSA competitive FFP prescriptive, low bid selection contracts is included in Appendix C.

6.1.2 GSA Competitive Cost-Reimbursable Contract (fixed fee, award fee, or incentive fee)

6.1.2.1 GSA Competitive Cost-Reimbursable Performance-Based Contract

Template contract language for GSA competitive cost-reimbursable performance-based, best value selection contracts is included in Appendix G.

6.1.2.2 GSA Competitive Cost-Reimbursable Prescriptive Contract

Template contract language for GSA competitive cost-reimbursable prescriptive, best value selection contracts is included in Appendix H.

6.2 GSA Sole-Source Contract

The contracting language for incorporating GSR and IT into GSA Schedule sole-source contracts is the same as the language used for A-E task orders.

6.2.1 GSA Sole-Source Firm-Fixed-Price Contract

6.2.1.1 GSA Sole-Source Firm-Fixed-Price Performance-Based Contract

Template contract language for GSA sole-source FFP Performance-Based Contracts (PBCs) is included in Appendix B.

6.2.1.2 GSA Sole-Source Firm-Fixed-Price Prescriptive Contract

Template contract language for GSA sole-source FFP prescriptive contracts is included in Appendix C.

6.2.2 GSA Sole-Source Cost-Reimbursable Contract (fixed fee, award fee, or incentive fee)

6.2.2.1 GSA Sole-Source Cost-Reimbursable Performance-Based Contract

Template contract language for GSA sole-source cost-reimbursable PBCs is included in Appendix D.

6.2.2.2 GSA Sole-Source Cost-Reimbursable Prescriptive Contract

Template contract language for GSA sole-source cost-reimbursable prescriptive contracts is included in Appendix C.

7.0 Considerations for FUDS Projects

For Formerly Used Defense Sites (FUDS) projects there are a few additional considerations and clarifications. The FUDS program sets goals for the use of PBCs in implementation of projects. Although A-E task orders are not written in typical PWS format, they are classified as PBCs because of the nature of the services provided. Thus, A-E task orders qualify as PBCs under the FUDS program.

An additional consideration is that FUDS program regulations do not allow funds to be spent on community improvement or social benefit that is not directly related/required pursuant to the cleanup at an approved FUDS project. Thus, certain GSR activities may be prohibited on FUDS projects.

8.0 References

Department of Defense (DoD). 2012. DoD Manual 4715.20: Defense Environmental Restoration Program (DERP) Management. March 9.

General Services Administration (GSA). 2005. Federal Acquisition Regulation. March.

U.S. Army Corps of Engineers (USACE). 1993. EP 715-1-5: Procurement - Architect-Engineer Contracting Guide - Hazardous, Toxic, Radioactive Waste (HTRW) Contracting. August 10.

USACE. 2000. ER 200-1-1: Environmental Quality - Policy and General Requirements for the Environmental Innovative Technology Program. May 30.

USACE. 2004. ER 200-3-1: Environmental Quality - Formerly Used Defense Sites (FUDS) Program Policy. May 10.

USACE. 2012. EP 715-1-7: Procurement - Architect-Engineer Contracting. February 29.

USACE. 2010. Interim Guidance 10-01: Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects. March 5.

Appendix A
GSR and IT Contracting Language Template for:

- A-E Base ID/IQ Contracts
- MATOC Base ID/IQ Contracts
- SATOC Base ID/IQ Contracts

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) *[Include in scope section (for MATOCs, Section C) of work statement.]*

- It is USACE's goal to consider, to the extent practical, GSR practices on all task orders of this contract and to implement GSR practices when feasible. It is also USACE's goal to utilize IT to the extent practical on all task orders of this contract to reduce costs, expedite project schedules, minimize risk and maximize effectiveness.
- Statutory requirements (e.g., CERCLA evaluation criteria) take precedence over the GSR/IT initiative.
- All work performed under this Contract shall comply with:
  - DoD Manual 4715.20 on Defense Environmental Restoration Program (DERP) Management, 9 March 2012.
  - ER 200-1-1: Policy and General Requirements for the Environmental Innovative Technology Program
- Where applicable, the Contractor shall follow:
  - USACE Interim Guidance 10-01 - Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects (http://www.environmental.usace.army.mil/pdf/IG%2010-01%2003_05_10%20doc.pdf);
  - The 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects, developed for the Department of Army Office of the Assistant Secretary for Installation Management (OACSIM), including completion of the Best Management Practices (BMP) Checklists for each task order.
- To the extent practical, the Contractor shall consider GSR practices to *[Add any other GSR goals specific to the project.]*:
  - reduce the environmental footprint of project activities
  - maximize sustainability
  - reduce waste
  - reduce energy and water usage
  - increase energy efficiency and minimize the use of non-renewable energy
  - conserve and efficiently manage resources and materials
  - promote carbon neutrality
  - reduce direct and indirect greenhouse gas and other emissions
  - promote reuse and recycling
  - fostering green and healthy communities and working landscapes which balance ecological, economic and social goals
  - integrate the remedy with the end use where possible and encouraging green and sustainable re-development
  - maximize habitat value and create habitat when possible
  - protect and preserve land resources
  - mimimize or eliminate pollution at its source
- The Contractor shall implement GSR practices when and where they make sense, per DoD policy.
- During all phases of projects, the Contractor shall consider and implement IT to:
  - reduce costs
  - expedite project schedules
  - minimize risk
  - maximize effectiveness
- Minimum GSR and IT requirements may be specified on a task order basis.
- The Contractor may be encouraged to develop, plan, and implement additional GSR/IT approaches to the work.
- All work plans and reports generated by the Contractor in performance of task orders on this contract shall document for the relevant scope of work: *[The PDT should consider providing a GSR/IT tracking sheet to be used by the Contractor.]*

- the GSR and IT that was considered,
- the GSR and IT that was implemented, and
- the reasons that considered GSR and IT was or was not implemented.

GSR and IT Evaluation Factor *[Include in solicitation Evaluation Factors for Award (for MATOCs/SATOCs, in Section M). The PDT is responsible for establishing the weighting/relative importance of this factor.]*
The proposal shall demonstrate:

- Project and personnel experience reflecting expertise in GSR, IT, and innovative approaches to investigation and remediation;
- Thorough consideration of GSR and IT in all aspects of the sample problem *[if applicable]* technical approach and project execution, and provision of logic for acceptance or rejection of their implementation; and
- Understanding of the procedures for tracking and documenting GSR and IT throughout the contract.

Appendix B
GSR and IT Contracting Language Template for:

- A-E FFP Performance-Based Task Orders
- 8(a) Set-Aside FFP Performance-Based Contracts
- SATOC FFP Performance-Based Task Orders
- GSA Sole-Source FFP PBCs

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) *[Include in scope section of work statement. Note that this example is for an RI/FS and should be tailored as necessary to suit the project scope.]*

- It is USACE's goal to consider, to the extent practical, GSR practices in all phases of this project and to implement GSR practices when feasible. It is also USACE's goal to utilize IT to the extent practical in all phases of this project to reduce costs, expedite project schedules, minimize risk and maximize effectiveness.
- Statutory requirements (e.g., CERCLA evaluation criteria) for this project take precedence over the GSR/IT initiative.
- All work performed under this Contract shall comply with:
  - DoD Manual 4715.20 on Defense Environmental Restoration Program (DERP) Management, 9 March 2012.ER 200-1-1: Policy and General Requirements for the Environmental Innovative Technology Program
- Where applicable, the Contractor shall follow:
  - USACE Interim Guidance 10-01 - Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects (http://www.environmental.usace.army.mil/pdf/IG%2010-01%2003_05_10%20doc.pdf);
  - The 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects, developed for the Department of Army Office of the Assistant Secretary for Installation Management (OACSIM).
- To the extent practical, the Contractor shall consider GSR practices to: *[Add any other GSR goals specific to the project.]*
  - reduce the environmental footprint of project activities
  - maximize sustainability
  - reduce waste
  - reduce energy and water usage
  - increase energy efficiency and minimize the use of non-renewable energy
  - conserve and efficiently manage resources and materials
  - promote carbon neutrality
  - reduce direct and indirect greenhouse gas and other emissions
  - promote reuse and recycling
  - fostering green and healthy communities and working landscapes which balance ecological, economic and social goals
  - integrate the remedy with the end use where possible and encouraging green and sustainable re-development
  - maximize habitat value and create habitat when possible
  - protect and preserve land resources
  - mimimize or eliminate pollution at its source
- The Contractor shall implement GSR practices when and where they make sense, per DoD policy.
- During all phases of projects, the Contractor shall consider and implement IT to:
  - reduce costs
  - expedite project schedules
  - minimize risk
  - maximize effectiveness
- At a minimum, the Contractor shall utilize the following GSR practices and IT on this project: *[The PDT should modify this list or specify these minimum requirements as necessary for each contract/task order. If there is a long list of GSR/IT being specified, the PDT should consider listing the GSR practices and IT according to the work breakdown structure (WBS).]*
  - The TRIAD approach to project planning, work strategies, and sampling and analytical technologies.

- The SiteWise™ Tool, latest version, during the FS to quantify the environmental footprints of remedial alternatives and possibly during the RI planning stages to assess the footprint of different investigation technologies.
- Completion of Best Management Practice (BMP) Checklists developed in the USACE 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects.

- The Contractor is encouraged to develop, plan, and implement additional GSR/IT approaches to the work. Examples include, but are not limited to *[The PDT should modify these examples as necessary.]* passive/no-flow sampling techniques; direct push drilling; use of clean diesel or biofuels; remote data collection, multi increment sampling; carbon offsets; renewable energy; field screening; mobile laboratories; waste minimization; GSR BMPs; and innovative approaches to public involvement.
- All work plans and reports generated by the Contractor in performance of task orders on this contract shall document for the relevant scope of work *[The PDT should consider providing a GSR/IT tracking sheet to be used by the Contractor.]*:
  - the GSR and IT that was considered,
  - the GSR and IT that was implemented, and
  - the reasons that considered GSR and IT was or was not implemented.
- The Contract will include a performance incentive for incorporation of GSR practices and IT. Details of the incentive measurement, calculation, and payment are included in Section X.X. *[Reference the appropriate section.]*

GSR and IT Incentive *[Include in payment section of work statement. The PDT must do some constructive thinking to establish project-specific incentive goals, weighting factors, and incentive amount as needed. Incentivizing IT is less quantitative than incentivizing GSR. Thus, the IT incentive will primarily be captured in the "other" goal category below and will require qualitative justification by the Contractor and extra scrutiny by the PDT. Note that this example was for an RI/FS scope, and goals and weighting may be different for other types of work.]*
The Contract will include a performance incentive for the incorporation of GSR and IT. The incentive will be equal to 2% *[modify % as needed]* of the total contract amount (less G&A and fees), and will be measured and paid at appropriate milestone intervals.

The incentive goals (g_i) are: *[The PDT shall modify these goals as necessary. The percent goal for each item may be anything 0-100%. The sum does not have to, and in most cases will not, equal 100%]*

- Waste minimization/diversion – 50%
- Energy savings/green energy – 50%
- Water savings – 50%
- Other (includes other goals listed in Section X.X.X *[Reference the appropriate section.]* and those proposed by the Contractor) - 100%

The weighting factors (w_i) for the incentive goals will be: *[The PDT shall modify these factors as necessary. Remember to check that $\Sigma w_i = 1$]*

- Waste minimization/diversion – 0.3
- Energy savings/green energy – 0.1
- Water savings – 0.1
- Other – 0.5

With the appropriate milestone payment invoice, the Contractor shall include a brief narrative documenting the level of goal achievement. When comparison of a reduction to a baseline is required for calculating the level of goal achievement, the industry standard/conventional practice shall be used as the baseline. *[Other baselines may be applicable, such as the current electrical consumption during*

operations.] For the "Other" category, the Contractor may make a qualitative justification of the level of achievement; however, the final decision will be made by USACE. An example calculation is below:

- Total contract = $1,000,000
- Potential incentive = 2% * $1,000,000 = $20,000
- Goals achieved (c_i) by contractor:
  - Waste minimization – 50%
  - Energy savings – 25%
  - Water savings – 40%
  - Other – 80%
- Paid incentive = $\Sigma\, w_i\, (c_i/g_i)$ * *potential incentive*
  (0.3 * 50/50 + 0.1 * 25/50 + 0.1 * 40/50 + 0.5 * 80/100) * $20,000 = $16,600

Appendix C
GSR and IT Contracting Language Template for:

- A-E FFP Prescriptive Task Orders
- A-E Cost-Reimbursable Prescriptive Task Orders
- MATOC FFP Prescriptive, Low Bid Selection Task Orders
- 8(a) Set-Aside FFP Prescriptive Contracts
- 8(a) Set-Aside Cost-Reimbursable Prescriptive Contracts
- SATOC FFP Prescriptive Contracts
- SATOC Cost-Reimbursable Prescriptive Task Orders
- GSA Competitive FFP Prescriptive, Low Bid Selection Contracts
- GSA Sole-Source FFP Prescriptive Contracts
- GSA Sole-Source Cost-Reimbursable Prescriptive Contracts

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) *[include in scope section of work statement]*

- The Contractor shall utilize the following GSR practices and IT on this project: *[Examples provided. Insert additional practices or delete these practices as necessary depending on the type of work being contracted.]*
  - the TRIAD approach to project planning, work strategies, and sampling and analytical technologies
  - the SiteWise™ Tool, latest version, during the FS to quantify the environmental footprints of remedial alternatives and possibly during the RI planning stages to assess the footprint of different investigation technologies
  - Completion of Best Management Practice (BMP) Checklists developed in the USACE 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects.
  - a solar-powered groundwater extraction well pump
  - passive/no-flow sampling techniques
  - direct push drilling
  - use of clean diesel or biofuels
  - remote data collection
  - multi increment sampling
  - carbon offsets
  - renewable energy *[Requires a goal. For GSR practices which can be quantitatively measured, a goal should be provided, in either percent or absolute terms.]*
  - field screening
  - mobile laboratories
  - waste minimization *[requires a goal]*
- All work plans and reports generated by the Contractor in performance of task orders on this contract shall document for the relevant scope of work *[The PDT should consider providing a GSR/IT tracking sheet to be used by the Contractor.]*:
  - the GSR and IT that was considered,
  - the GSR and IT that was implemented, and
  - the reasons that considered GSR and IT was or was not implemented.
- When applicable (e.g., waste minimization), the contractor shall submit quantitative documentation to justify GSR/IT goal achievement. The Government must approve of the justification prior to authorizing payment to the Contractor. When comparison of a reduction to a baseline is required, the industry standard/conventional practice shall be used as the baseline. *[Other baselines may be applicable, such as the current electrical consumption during operations.]*

Appendix D
GSR and IT Contracting Language Template for:

- A-E Cost-Reimbursable Performance-Based Task Orders
- 8(a) Set-Aside Cost-Reimbursable PBCs
- SATOC Cost-Reimbursable Performance-Based Task Orders
- GSA Sole-Source Cost-Reimbursable PBCs

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) *[Include in scope section of work statement.]*

- It is USACE's goal to consider, to the extent practical, GSR practices in all phases of this project and to implement GSR practices when feasible. It is also USACE's goal to utilize IT to the extent practical in all phases of this project to reduce costs, expedite project schedules, minimize risk and maximize effectiveness.
- Statutory requirements (e.g., CERCLA evaluation criteria) for this project take precedence over the GSR/IT initiative.
- All work performed under this Contract shall comply with:
  - DoD Manual 4715.20 on Defense Environmental Restoration Program (DERP) Management, 9 March 2012.
  - ER 200-1-1: Policy and General Requirements for the Environmental Innovative Technology Program
- Where applicable, the Contractor shall follow:
  - USACE Interim Guidance 10-01 - Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects (http://www.environmental.usace.army.mil/pdf/IG%2010-01%2003_05_10%20doc.pdf);
  - The 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects, developed for the Department of Army Office of the Assistant Secretary for Installation Management (OACSIM).
- To the extent practical, the Contractor shall consider GSR practices to: *[Add any other GSR goals specific to the project.]*
  - reduce the environmental footprint of project activities
  - maximize sustainability
  - reduce waste
  - reduce energy and water usage
  - increase energy efficiency and minimize the use of non-renewable energy
  - conserve and efficiently manage resources and materials
  - promote carbon neutrality
  - reduce direct and indirect greenhouse gas and other emissions
  - promote reuse and recycling
  - fostering green and healthy communities and working landscapes which balance ecological, economic and social goals
  - integrate the remedy with the end use where possible and encouraging green and sustainable re-development
  - maximize habitat value and create habitat when possible
  - protect and preserve land resources
  - mimimize or eliminate pollution at its source
- The Contractor shall implement GSR practices when and where they make sense, per DoD policy.
- During all phases of projects, the Contractor shall consider and implement IT to:
  - reduce costs
  - expedite project schedules
  - minimize risk
  - maximize effectiveness
- At a minimum, the Contractor shall utilize the following GSR practices and IT on this project: *[The PDT should modify this list or specify these minimum requirements as necessary for each contract/task order. If there is a long list of GSR/IT being specified, the PDT should consider listing the GSR practices and IT according to the work breakdown structure (WBS).]*
  - The TRIAD approach to project planning, work strategies, and sampling and analytical technologies.

- The SiteWise™ Tool, latest version, during the FS to quantify the environmental footprints of remedial alternatives and possibly during the RI planning stages to assess the footprint of different investigation technologies.
- Completion of Best Management Practice (BMP) Checklists developed in the USACE 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects.

- The Contractor is encouraged to develop, plan, and implement additional GSR/IT approaches to the work. Examples include, but are not limited to *[The PDT should modify these examples as necessary.]* passive/no-flow sampling techniques; direct push drilling; use of clean diesel or biofuels; remote data collection, multi increment sampling; carbon offsets; renewable energy; field screening; mobile laboratories; waste minimization; GSR BMPs; and innovative approaches to public involvement.
- Prior to implementing a GSR enhancement or IT, the Contractor must submit a life-cycle cost/benefit analysis for the project and/or the environment. The analysis should include the net cost or net savings to the project by implementing that particular element into the project. The Government will review the analysis and make the final determination on whether to proceed with implementation of the enhancement. The Contractor may request in writing relief from this requirement or that a qualitative LCA be allowed on a case-by-case basis. This may be the case where GSR BMPs are included without performing a quantitative LCA. The Government has sole discretion over the waiving of this requirement.
- *[include for award-fee contracts]* For implemented GSR/IT modifications which reduce cost to the Government, the Contractor will receive incentive fee increases *[The formula for this fee increase must be established elsewhere in the solicitation.]* for the cost savings which accrue during the contract period of performance (POP). For GSR practices and IT which reduce future costs (i.e., after the POP), the fee increase will be negotiated on a case-by-case basis at the Government's discretion. In some cases, a GSR/IT modification may actually increase project costs, but still be approved by the Government because it helps achieve other Army GSR goals of improving the community or environment. In those cases, the Contractor's fee will be increased proportionately (i.e., at the same percentage rate as the target fee on the initial cost target), and the cost increase will not impact the Contractor's incentive fee calculation.
- All work plans and reports generated by the Contractor in performance of task orders on this contract shall document for the relevant scope of work *[The PDT should consider providing a GSR/IT tracking sheet to be used by the Contractor.]*:
  - the GSR and IT that was considered,
  - the GSR and IT that was implemented, and
  - the reasons that considered GSR and IT was or was not implemented.
- Whether the Contractor is proactive or negligent in proposing GSR and IT will be factored into the Contractor's performance ratings and evaluations.

GSR and IT Award Fee *[Only for award-fee contracts, include this section in the payment section of work statement. The PDT must do some constructive thinking to establish project-specific incentive goals, weighting factors, and award-fee amount as needed. Incentivizing IT is less quantitative than incentivizing GSR. Thus, the IT incentive will primarily be captured in the "other" goal category below and will require qualitative justification by the Contractor and extra scrutiny by the PDT. Note that this example was for an RI/FS scope, and goals and weighting may be different for other types of work.]*
The Contract will include an award-fee for the incorporation of GSR and IT. The award-fee will be equal to 2% *[modify % as needed]* of the total contract amount (less G&A and fees), and will be measured and paid at appropriate milestone intervals.

The incentive goals (g_i) are: *[The PDT shall modify these goals as necessary. The percent goal for each item may be anything 0-100%. The sum does not have to, and in most cases will not, equal 100%]*

- Waste minimization/diversion – 50%

- Energy savings/green energy – 50%
- Water savings – 50%
- Other (includes other goals listed in Section X.X.X *[Reference the appropriate section.]* and those proposed by the Contractor) - 100%

The weighting factors (w_i) for the incentive goals will be: *[The PDT shall modify these factors as necessary. Remember to check that* $\Sigma w_i = 1$*]*

- Waste minimization/diversion – 0.3
- Energy savings/green energy – 0.1
- Water savings – 0.1
- Other – 0.5

With the appropriate milestone payment invoice, the Contractor shall include a brief narrative documenting the level of goal achievement. When comparison of a reduction to a baseline is required for calculating the level of goal achievement, the industry standard/conventional practice shall be used as the baseline. *[Other baselines may be applicable, such as the current electrical consumption during operations.]* For the "Other" category, the Contractor may make a qualitative justification of the level of achievement; however, the final decision will be made by USACE. An <u>example calculation</u> is below:

- Total contract = $1,000,000
- Potential award-fee = 2% * $1,000,000 = $20,000
- Goals achieved (c_i) by contractor:
  - Waste minimization – 50%
  - Energy savings – 25%
  - Water savings – 40%
  - Other – 80%
- Paid award-fee = $\Sigma w_i (c_i/g_i)$ * *potential incentive*
  (0.3 * 50/50 + 0.1 * 25/50 + 0.1 * 40/50 + 0.5 * 80/100) * $20,000 = $16,600

Appendix E
GSR and IT Contracting Language Template for:

- MATOC FFP Performance-Based, Best Value Selection Task Orders
- GSA Competitive FFP Performance-Based, Best Value Selection Contracts

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) *[Include in scope section of work statement. Note that this example is for an RI/FS and should be tailored as necessary to suit the project scope.]*

- It is USACE's goal to consider, to the extent practical, GSR practices in all phases of this project and to implement GSR practices when feasible. It is also USACE's goal to utilize IT to the extent practical in all phases of this project to reduce costs, expedite project schedules, minimize risk and maximize effectiveness.
- Statutory requirements (e.g., CERCLA evaluation criteria) for this project take precedence over the GSR/IT initiative.
- All work performed under this Contract shall comply with:
  - DoD Manual 4715.20 on Defense Environmental Restoration Program (DERP) Management, 9 March 2012.
  - ER 200-1-1: Policy and General Requirements for the Environmental Innovative Technology Program
- Where applicable, the Contractor shall follow:
  - USACE Interim Guidance 10-01 - Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects (http://www.environmental.usace.army.mil/pdf/IG%2010-01%2003_05_10%20doc.pdf);
  - The 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects, developed for the Department of Army Office of the Assistant Secretary for Installation Management (OACSIM).
- To the extent practical, the Contractor shall consider GSR practices to: *[Add any other GSR goals specific to the project.]*
  - reduce the environmental footprint of project activities
  - maximize sustainability
  - reduce waste
  - reduce energy and water usage
  - increase energy efficiency and minimize the use of non-renewable energy
  - conserve and efficiently manage resources and materials
  - promote carbon neutrality
  - reduce direct and indirect greenhouse gas and other emissions
  - promote reuse and recycling
  - fostering green and healthy communities and working landscapes which balance ecological, economic and social goals
  - integrate the remedy with the end use where possible and encouraging green and sustainable re-development
  - maximize habitat value and create habitat when possible
  - protect and preserve land resources
  - mimimize or eliminate pollution at its source
- The Contractor shall implement GSR practices when and where they make sense, per DoD policy.
- During all phases of projects, the Contractor shall consider and implement IT to:
  - reduce costs
  - expedite project schedules
  - minimize risk
  - maximize effectiveness
- At a minimum, the Contractor shall utilize the following GSR practices and IT on this project: *[The PDT should modify this list or specify these minimum requirements as necessary for each contract/task order. If there is a long list of GSR/IT being specified, the PDT should consider listing the GSR practices and IT according to the work breakdown structure (WBS).]*
  - The TRIAD approach to project planning, work strategies, and sampling and analytical technologies.

- The SiteWise™ Tool, latest version, during the FS to quantify the environmental footprints of remedial alternatives and possibly during the RI planning stages to assess the footprint of different investigation technologies.
- Completion of Best Management Practice (BMP) Checklists developed in the USACE 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects.

- The Contractor is encouraged to develop, plan, and implement additional GSR/IT approaches to the work. Examples include, but are not limited to *[The PDT should modify these examples as necessary.]* passive/no-flow sampling techniques; direct push drilling; use of clean diesel or biofuels; remote data collection, multi increment sampling; carbon offsets; renewable energy; field screening; mobile laboratories; waste minimization; GSR BMPs; and innovative approaches to public involvement.
- All work plans and reports generated by the Contractor in performance of task orders on this contract shall document for the relevant scope of work *[The PDT should consider providing a GSR/IT tracking sheet to be used by the Contractor.]*:
  - the GSR and IT that was considered,
  - the GSR and IT that was implemented, and
  - the reasons that considered GSR and IT was or was not implemented.
- The Contract will include a performance incentive for incorporation of GSR practices and IT. Details of the incentive measurement, calculation, and payment are included in Section X.X. *[Reference the appropriate section.]*

GSR and IT Incentive *[Include in payment section of work statement. <u>The PDT must do some constructive thinking to establish project-specific incentive goals, weighting factors, and incentive amount as needed.</u> Incentivizing IT is less quantitative than incentivizing GSR. Thus, the IT incentive will primarily be captured in the "other" goal category below and will require qualitative justification by the Contractor and extra scrutiny by the PDT. Note that this example was for an RI/FS scope, and goals and weighting may be different for other types of work.]*
The Contract will include a performance incentive for the incorporation of GSR and IT. The incentive will be equal to 2% *[modify % as needed]* of the total contract amount (less G&A and fees), and will be measured and paid at appropriate milestone intervals.

The incentive goals (g_i) are: *[The PDT shall modify these goals as necessary. The percent goal for each item may be anything 0-100%. The sum does not have to, and in most cases will not, equal 100%]*

- Waste minimization/diversion – 50%
- Energy savings/green energy – 50%
- Water savings – 50%
- Other (includes other goals listed in Section X.X.X *[Reference the appropriate section.]* and those proposed by the Contractor) - 100%

The weighting factors (w_i) for the incentive goals will be: *[The PDT shall modify these factors as necessary. Remember to check that $\Sigma w_i = 1$]*

- Waste minimization/diversion – 0.3
- Energy savings/green energy – 0.1
- Water savings – 0.1
- Other – 0.5

With the appropriate milestone payment invoice, the Contractor shall include a brief narrative documenting the level of goal achievement. When comparison of a reduction to a baseline is required for calculating the level of goal achievement, the industry standard/conventional practice shall be used as the baseline. *[Other baselines may be applicable, such as the current electrical consumption during*

operations.] For the "Other" category, the Contractor may make a qualitative justification of the level of achievement; however, the final decision will be made by USACE. An example calculation is below:

- Total contract = $1,000,000
- Potential incentive = 2% * $1,000,000 = $20,000
- Goals achieved (c_i) by contractor:
  - Waste minimization – 50%
  - Energy savings – 25%
  - Water savings – 40%
  - Other – 80%
- Paid incentive = $\Sigma\, w_i\, (c_i/g_i)$ * *potential incentive*
  (0.3 * 50/50 + 0.1 * 25/50 + 0.1 * 40/50 + 0.5 * 80/100) * $20,000 = $16,600

GSR and IT Evaluation Factor *[Add this factor to the Basis of Award section evaluation criteria. The PDT is responsible for establishing the weighting/relative importance of this factor.]*
The proposal shall demonstrate:

- Project and personnel experience reflecting expertise in GSR, IT, and innovative approaches to investigation and remediation;
- Thorough consideration of GSR and IT in all aspects of the technical approach and project execution, and provision of logic for acceptance or rejection of their implementation; and
- Understanding of the procedures for tracking and documenting GSR and IT throughout the project.

Appendix F
GSR and IT Contracting Language Template for:

- MATOC FFP Performance-Based, Low Bid Technically Acceptable Selection Task Orders
- GSA Competitive FFP Performance-Based, Low Bid Technically Acceptable Selection Contracts

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) *[Include in scope section of work statement. Note that this example is for an RI/FS and should be tailored as necessary to suit the project scope.]*

- It is USACE's goal to consider, to the extent practical, GSR practices in all phases of this project and to implement GSR practices when feasible. It is also USACE's goal to utilize IT to the extent practical in all phases of this project to reduce costs, expedite project schedules, minimize risk and maximize effectiveness.
- Statutory requirements (e.g., CERCLA evaluation criteria) for this project take precedence over the GSR/IT initiative.
- All work performed under this Contract shall comply with:
  - DoD Manual 4715.20 on Defense Environmental Restoration Program (DERP) Management, 9 March 2012.
  - ER 200-1-1: Policy and General Requirements for the Environmental Innovative Technology Program
- Where applicable, the Contractor shall follow:
  - USACE Interim Guidance 10-01 - Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects (http://www.environmental.usace.army.mil/pdf/IG%2010-01%2003_05_10%20doc.pdf);
  - The 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects, developed for the Department of Army Office of the Assistant Secretary for Installation Management (OACSIM).
- To the extent practical, the Contractor shall consider GSR practices to: *[Add any other GSR goals specific to the project.]*
  - reduce the environmental footprint of project activities
  - maximize sustainability
  - reduce waste
  - reduce energy and water usage
  - increase energy efficiency and minimize the use of non-renewable energy
  - conserve and efficiently manage resources and materials
  - promote carbon neutrality
  - reduce direct and indirect greenhouse gas and other emissions
  - promote reuse and recycling
  - fostering green and healthy communities and working landscapes which balance ecological, economic and social goals
  - integrate the remedy with the end use where possible and encouraging green and sustainable re-development
  - maximize habitat value and create habitat when possible
  - protect and preserve land resources
  - mimimize or eliminate pollution at its source
- The Contractor shall implement GSR practices when and where they make sense, per DoD policy.
- During all phases of projects, the Contractor shall consider and implement IT to:
  - reduce costs
  - expedite project schedules
  - minimize risk
  - maximize effectiveness
- At a minimum, the Contractor shall utilize the following GSR practices and IT on this project: *[The PDT should modify this list or specify these minimum requirements as necessary for each contract/task order. If there is a long list of GSR/IT being specified, the PDT should consider listing the GSR practices and IT according to the work breakdown structure (WBS).]*
  - The TRIAD approach to project planning, work strategies, and sampling and analytical technologies.

- The SiteWise™ Tool, latest version, during the FS to quantify the environmental footprints of remedial alternatives and possibly during the RI planning stages to assess the footprint of different investigation technologies.
- Completion of Best Management Practice (BMP) Checklists developed in the USACE 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects.

- The Contractor is encouraged to develop, plan, and implement additional GSR/IT approaches to the work. Examples include, but are not limited to *[The PDT should modify these examples as necessary.]* passive/no-flow sampling techniques; direct push drilling; use of clean diesel or biofuels; remote data collection, multi increment sampling; carbon offsets; renewable energy; field screening; mobile laboratories; waste minimization; GSR BMPs; and innovative approaches to public involvement.
- All work plans and reports generated by the Contractor in performance of task orders on this contract shall document for the relevant scope of work *[The PDT should consider providing a GSR/IT tracking sheet to be used by the Contractor.]*:
  - the GSR and IT that was considered,
  - the GSR and IT that was implemented, and
  - the reasons that considered GSR and IT was or was not implemented.
- The Contract will include a performance incentive for incorporation of GSR practices and IT. Details of the incentive measurement, calculation, and payment are included in Section X.X. *[Reference the appropriate section.]*

GSR and IT Incentive *[Include in payment section of work statement. The PDT must do some constructive thinking to establish project-specific incentive goals, weighting factors, and incentive amount as needed. Incentivizing IT is less quantitative than incentivizing GSR. Thus, the IT incentive will primarily be captured in the "other" goal category below and will require qualitative justification by the Contractor and extra scrutiny by the PDT. Note that this example was for an RI/FS scope, and goals and weighting may be different for other types of work.]*
The Contract will include a performance incentive for the incorporation of GSR and IT. The incentive will be equal to 2% *[modify % as needed]* of the total contract amount (less G&A and fees), and will be measured and paid at appropriate milestone intervals.

The incentive goals (g_i) are: *[The PDT shall modify these goals as necessary. The percent goal for each item may be anything 0-100%. The sum does not have to, and in most cases will not, equal 100%]*

- Waste minimization/diversion – 50%
- Energy savings/green energy – 50%
- Water savings – 50%
- Other (includes other goals listed in Section X.X.X *[Reference the appropriate section.]* and those proposed by the Contractor) - 100%

The weighting factors (w_i) for the incentive goals will be: *[The PDT shall modify these factors as necessary. Remember to check that $\Sigma w_i = 1$]*

- Waste minimization/diversion – 0.3
- Energy savings/green energy – 0.1
- Water savings – 0.1
- Other – 0.5

With the appropriate milestone payment invoice, the Contractor shall include a brief narrative documenting the level of goal achievement. When comparison of a reduction to a baseline is required for calculating the level of goal achievement, the industry standard/conventional practice shall be used as the baseline. *[Other baselines may be applicable, such as the current electrical consumption during*

operations.] For the "Other" category, the Contractor may make a qualitative justification of the level of achievement; however, the final decision will be made by USACE. An example calculation is below:

- Total contract = $1,000,000
- Potential incentive = 2% * $1,000,000 = $20,000
- Goals achieved (c_i) by contractor:
  - Waste minimization – 50%
  - Energy savings – 25%
  - Water savings – 40%
  - Other – 80%
- Paid incentive = $\Sigma\, w_i\, (c_i/g_i)$ * *potential incentive*
  (0.3 * 50/50 + 0.1 * 25/50 + 0.1 * 40/50 + 0.5 * 80/100) * $20,000 = $16,600

GSR and IT Requirements *[Add this language to the "Minimum Requirements for Technical Acceptability" section.]*
In order to be considered technically acceptable, the proposal must demonstrate:

- Project and personnel experience reflecting expertise GSR, IT, and innovative approaches to investigation and remediation;
- Thorough consideration of GSR and IT in all aspects of the technical approach and project execution, and provision of logic for acceptance or rejection of their implementation; and
- Understanding of the procedures for tracking and documenting GSR and IT throughout the project.

Appendix G
GSR and IT Contracting Language Template for:

- MATOC Cost-Reimbursable, Performance-Based , Best Value Selection Task Orders
- GSA Competitive Cost-Reimbursable Performance-Based, Best Value Selection Contracts

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) *[Include in scope section of work statement.]*

- It is USACE's goal to consider, to the extent practical, GSR practices in all phases of this project and to implement GSR practices when feasible. It is also USACE's goal to utilize IT to the extent practical in all phases of this project to reduce costs, expedite project schedules, minimize risk and maximize effectiveness.
- Statutory requirements (e.g., CERCLA evaluation criteria) for this project take precedence over the GSR/IT initiative.
- All work performed under this Contract shall comply with:
  - DoD Manual 4715.20 on Defense Environmental Restoration Program (DERP) Management, 9 March 2012.
  - ER 200-1-1: Policy and General Requirements for the Environmental Innovative Technology Program
- Where applicable, the Contractor shall follow:
  - USACE Interim Guidance 10-01 - Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects (http://www.environmental.usace.army.mil/pdf/IG%2010-01%2003_05_10%20doc.pdf);
  - The 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects, developed for the Department of Army Office of the Assistant Secretary for Installation Management (OACSIM).
- To the extent practical, the Contractor shall consider GSR practices to: *[Add any other GSR goals specific to the project.]*
  - reduce the environmental footprint of project activities
  - maximize sustainability
  - reduce waste
  - reduce energy and water usage
  - increase energy efficiency and minimize the use of non-renewable energy
  - conserve and efficiently manage resources and materials
  - promote carbon neutrality
  - reduce direct and indirect greenhouse gas and other emissions
  - promote reuse and recycling
  - fostering green and healthy communities and working landscapes which balance ecological, economic and social goals
  - integrate the remedy with the end use where possible and encouraging green and sustainable re-development
  - maximize habitat value and create habitat when possible
  - protect and preserve land resources
  - mimimize or eliminate pollution at its source
- The Contractor shall implement GSR practices when and where they make sense, per DoD policy.
- During all phases of projects, the Contractor shall consider and implement IT to:
  - reduce costs
  - expedite project schedules
  - minimize risk
  - maximize effectiveness
- At a minimum, the Contractor shall utilize the following GSR practices and IT on this project: *[The PDT should modify this list or specify these minimum requirements as necessary for each contract/task order. If there is a long list of GSR/IT being specified, the PDT should consider listing the GSR practices and IT according to the work breakdown structure (WBS).]*
  - The TRIAD approach to project planning, work strategies, and sampling and analytical technologies.

- The SiteWise™ Tool, latest version, during the FS to quantify the environmental footprints of remedial alternatives and possibly during the RI planning stages to assess the footprint of different investigation technologies.
- Completion of Best Management Practice (BMP) Checklists developed in the USACE 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects.

- The Contractor is encouraged to develop, plan, and implement additional GSR/IT approaches to the work. Examples include, but are not limited to *[The PDT should modify these examples as necessary.]* passive/no-flow sampling techniques; direct push drilling; use of clean diesel or biofuels; remote data collection, multi increment sampling; carbon offsets; renewable energy; field screening; mobile laboratories; waste minimization; GSR BMPs; and innovative approaches to public involvement.
- Prior to implementing a GSR enhancement or IT, the Contractor must submit a life-cycle cost/benefit analysis for the project and/or the environment. The analysis should include the net cost or net savings to the project by implementing that particular element into the project. The Government will review the analysis and make the final determination on whether to proceed with implementation of the enhancement. The Contractor may request in writing relief from this requirement or that a qualitative LCA be allowed on a case-by-case basis. This may be the case where GSR best management practices (BMPs) are included without performing a quantitative LCA. The Government has sole discretion over the waiving of this requirement.
- *[include for award-fee contracts]* For implemented GSR/IT modifications which reduce cost to the Government, the Contractor will receive incentive fee increases *[The formula for this fee increase must be established elsewhere in the solicitation.]* for the cost savings which accrue during the contract period of performance (POP). For GSR practices and IT which reduce future costs (i.e., after the POP), the fee increase will be negotiated on a case-by-case basis at the Government's discretion. In some cases, a GSR/IT modification may actually increase project costs, but still be approved by the Government because it helps achieve other Army GSR goals of improving the community or environment. In those cases, the Contractor's fee will be increased proportionately (i.e., at the same percentage rate as the target fee on the initial cost target), and the cost increase will not impact the Contractor's incentive fee calculation.
- All work plans and reports generated by the Contractor in performance of task orders on this contract shall document for the relevant scope of work *[The PDT should consider providing a GSR/IT tracking sheet to be used by the Contractor.]*:
  - the GSR and IT that was considered,
  - the GSR and IT that was implemented, and
  - the reasons that considered GSR and IT was or was not implemented.
- Whether the Contractor is proactive or negligent in proposing GSR and IT will be factored into the Contractor's performance ratings and evaluations.

GSR and IT Award Fee *[Only for award-fee contracts, include this section in the payment section of work statement. The PDT must do some constructive thinking to establish project-specific incentive goals, weighting factors, and award-fee amount as needed. Incentivizing IT is less quantitative than incentivizing GSR. Thus, the IT incentive will primarily be captured in the "other" goal category below and will require qualitative justification by the Contractor and extra scrutiny by the PDT. Note that this example was for an RI/FS scope, and goals and weighting may be different for other types of work.]*
The Contract will include an award-fee for the incorporation of GSR and IT. The award-fee will be equal to 2% *[modify % as needed]* of the total contract amount (less G&A and fees), and will be measured and paid at appropriate milestone intervals.

The incentive goals (g_i) are: *[The PDT shall modify these goals as necessary. The percent goal for each item may be anything 0-100%. The sum does not have to, and in most cases will not, equal 100%]*

- Waste minimization/diversion – 50%

- Energy savings/green energy – 50%
- Water savings – 50%
- Other (includes other goals listed in Section X.X.X *[Reference the appropriate section.]* and those proposed by the Contractor) - 100%

The weighting factors (w_i) for the incentive goals will be: *[The PDT shall modify these factors as necessary. Remember to check that* $\Sigma w_i = 1$*]*

- Waste minimization/diversion – 0.3
- Energy savings/green energy – 0.1
- Water savings – 0.1
- Other – 0.5

With the appropriate milestone payment invoice, the Contractor shall include a brief narrative documenting the level of goal achievement. When comparison of a reduction to a baseline is required for calculating the level of goal achievement, the industry standard/conventional practice shall be used as the baseline. *[Other baselines may be applicable, such as the current electrical consumption during operations.]* For the "Other" category, the Contractor may make a qualitative justification of the level of achievement; however, the final decision will be made by USACE. An <u>example calculation</u> is below:

- Total contract = $1,000,000
- Potential award-fee = 2% * $1,000,000 = $20,000
- Goals achieved (c_i) by contractor:
  - Waste minimization – 50%
  - Energy savings – 25%
  - Water savings – 40%
  - Other – 80%
- Paid award-fee = $\Sigma w_i (c_i/g_i)$ * *potential incentive*
  (0.3 * 50/50 + 0.1 * 25/50 + 0.1 * 40/50 + 0.5 * 80/100) * $20,000 = $16,600

GSR and IT Evaluation Factor *[Add this factor to the Basis of Award section evaluation criteria. The PDT is responsible for establishing the weighting/relative importance of this factor.]*

The proposal shall demonstrate:

- Project and personnel experience reflecting expertise in GSR, IT, and innovative approaches to investigation and remediation;
- Thorough consideration of GSR and IT in all aspects of the technical approach and project execution, and provision of logic for acceptance or rejection of their implementation; and
- Understanding of the procedures for tracking and documenting GSR and IT throughout the project.

Appendix H
GSR and IT Contracting Language Template for:

- MATOC Cost-Reimbursable Prescriptive, Best Value Selection Task Orders
- GSA Competitive Cost-Reimbursable Prescriptive, Best Value Selection Contracts

Green and Sustainable Remediation (GSR) and Innovative Technologies (IT) *[include in scope section of work statement]*

- The Contractor shall utilize the following GSR practices and IT on this project: *[Examples provided. Insert additional practices or delete these practices as necessary depending on the type of work being contracted.]*
  - the TRIAD approach to project planning, work strategies, and sampling and analytical technologies
  - the SiteWise™ Tool, latest version, during the FS to quantify the environmental footprints of remedial alternatives and possibly during the RI planning stages to assess the footprint of different investigation technologies
  - Completion of Best Management Practice (BMP) Checklists developed in the USACE 2012 Detailed Approach for Evaluating GSR on Army Environmental Projects.
  - a solar-powered groundwater extraction well pump
  - passive/no-flow sampling techniques
  - direct push drilling
  - use of clean diesel or biofuels
  - remote data collection
  - multi increment sampling
  - carbon offsets
  - renewable energy *[Requires a goal. For GSR practices which can be quantitatively measured, a goal should be provided, in either percent or absolute terms.]*
  - field screening
  - mobile laboratories
  - waste minimization *[requires a goal]*
- All work plans and reports generated by the Contractor in performance of task orders on this contract shall document for the relevant scope of work *[The PDT should consider providing a GSR/IT tracking sheet to be used by the Contractor.]*:
  - the GSR and IT that was considered,
  - the GSR and IT that was implemented, and
  - the reasons that considered GSR and IT was or was not implemented.
- When applicable (e.g., waste minimization), the contractor shall submit quantitative documentation to justify GSR/IT goal achievement. The Government must approve of the justification prior to authorizing payment to the Contractor. When comparison of a reduction to a baseline is required, the industry standard/conventional practice shall be used as the baseline. *[Other baselines may be applicable, such as the current electrical consumption during operations.]*

GSR and IT Evaluation Factor *[Add this factor to the Basis of Award section evaluation criteria. The PDT is responsible for establishing the weighting/relative importance of this factor.]*
The proposal shall demonstrate:

- Project and personnel experience reflecting expertise in GSR, IT, and innovative approaches to investigation and remediation;
- Thorough understanding of the prescribed GSR and IT, including the technical approach and execution of them; and
- Understanding of the procedures for tracking and documenting GSR and IT throughout the project.

Appendix I
Example Determination & Findings Memorandum for GSR and IT Incentive

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE KY 40201-0059

HTTP://WWW.LRL.USACE.ARMY.MIL

CELRL-ED-E 19 December 2011

DETERMINATION AND FINDINGS

SUBJECT: Justification of Incentive in Conjunction with Firm-Fixed-Price Contract

1. References
   a. Federal Acquisition Regulation (FAR); March 2005; Part 1, Subpart 16.2 – Fixed-Price Contracts
   b. Department of Defense (DoD) Manual 4715.20, Acting Under Secretary of Defense for Acquisition, Technology, and Logistics, 9 March 2012, Subject: Defense Environmental Restoration Program (DERP) Management.
   c. Interim Guidance 10-01, Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects, U.S. Army Corps of Engineers (USACE), Environmental and Munitions Center of Expertise, March 5, 2010.

2. Findings
   CELRL intends to utilize a firm-fixed-price (FFP) task order on Architect-Engineer (A-E) contract W912PP-09-D-0016 to perform engineering and environmental services at the Former Lockbourne Air Force Base (LAFB) within the Formerly Used Defense Sites (FUDS) program. A GSR incentive award is justified for use in conjunction with this task order, based on the following findings:
   a. Consideration of GSR practices, and implementation of them when feasible, is required by DoD policy, reference 1b above.
   b. Incentive awards are the recommended mechanism for incorporating GSR practices into contracts, per USACE guidance, reference 1c above.
   c. An incentive award is applicable and suitable in accordance with the FAR, reference 1a above, given that the Project Delivery Team (PDT) has found:
      - it is neither feasible nor effective to devise predetermined objective incentive targets applicable to cost, schedule, and technical performance for GSR consideration and implementation;
      - an incentive will enhance the likelihood of meeting acquisition objectives, motivating the contractor toward exceptional performance and providing the Government with the flexibility to evaluate both actual performance and the conditions under which it was achieved;
      - the additional administrative effort and cost required to monitor and evaluate performance are justified by the expected benefits as documented in the risk and cost benefit analysis (Attachment A).

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE KY 40201-0059

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3. Determination

Based upon the above findings, it is the PDT's determination that a GSR incentive-award contract component may be used and will provide the best approach to achieving the Government mission's objectives.

____
John Doe
Technical Manager, CELRL-ED-E

____
Jane Doe
Chief, Environmental Engineering Compliance Section, CELRL-ED-E

____
John Doe 2
Chief, Contraction Division, CELRL-CT

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE KY 40201-0059

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Attachment A
Risk and Cost Benefit Analysis

Risk/Benefit	Analysis	Mitigation (if applicable)
Schedule Risk	Additional effort to consider GSR practices may delay achievement of performance objectives.	The PDT will maintain regular communication with contractor to ensure that only GSR practices which have a high probability of net-zero or net-positive schedule impacts are considered.
Cost/Funding Risk	Additional contractor costs to consider GSR practices may inflate project cost.	By using a GSR incentive, the contractor is encouraged to focus on GSR practices which have a positive cost impact (i.e., they are likely to save more money than they cost). The use of a firm-fixed price contract freezes cost risk when initial contract negotiations are finalized.
Scope Risk	There is not significant scope risk.	N/A
Administrative Effort Risk	Additional contract and technical administrative government effort will be required to manage and evaluate the contractor's consideration and implementation of GSR practices.	The contractor will be required to provide quantitative and qualitative justification of what portion of the incentive they have earned, thus reducing the evaluation burden on the Government. The Government retains the right to make a final unilateral decision. Additional effort is justified by benefits below.
Compliance Benefit	Consideration and, when feasible, implementation of GSR practices brings the project into compliance with the latest DoD policy and USACE guidance, and supports the USACE Innovative Technology Advocacy Program.	N/A
Cost Benefit	The implementation of promising GSR practices is likely to reduce total project costs by optimizing the work performed, reducing waste, and streamlining project execution.	N/A
Visibility Benefit	Consideration and implementation of GSR practices enhances public and customer perception of USACE and the DERP and creates lasting value for the local and greater community.	N/A
Environmental Benefit	The use of GSR practices reduces the net environmental impact of investigation, study, and remediation.	N/A

ATTACHMENT A-3

Template GSR Evaluation Report

Also Includes the Following Electronic Attachments:

- *MS-Word File for Report Text including GSR BMP Tracking Tables*
- *MS-Excel Table for Presenting Costs*
- *MS-Excel Table for Comparing GSR Metrics/Considerations*

Note:

This template report is available in MS-Word format, and can be modified by the user. Check-boxes in forms can be checked and un-checked by right-clicking on the checkbox, selecting "properties", and then selecting "checked" or "not checked".

TEMPLATE GSR EVALUATION REPORT

GREEN AND SUSTAINABLE REMEDIATION (GSR) EVALUATION:

[PROJECT NAME]
[SITE NAME AND LOCATION]

Prepared for:

[name of person or organization receiving report]
[address line 1]
[address line 2]
[address line 3]

[Contract No. XX]
[Delivery Order No. XX]

Prepared by:

[name of person or organization sending report]
[address line 1]
[address line 2]
[address line 3]

DD Month YYYY

CONTENTS

<u>List of Figures</u>

<u>List of Tables</u>

List of Appendices

Appendix A: GSR Best Management Practice (BMP) Tables

Appendix B: Assumptions for SiteWise^{TM} Input and Other Calculations: Baseline Remedy

Appendix C: Supporting Information and/or Calculations for Footprinting Alternatives

- Appendix C-1: Alternative 1 [Name of alternative]
- Appendix C-2: Alternative 2 [Name of alternative]
- Etc.

PREFACE

The preface may include information about the contract the GSR was performed under, a list of who performed the GSR evaluation, contact information for project representatives, etc. It can also be omitted.

Project Representatives		
Name	**Organization**	**Email**
[name 1]	[organization – role/title]	[email address]
[name 2]	[organization – role/title]	[email address]
[name 3]	[organization – role/title]	[email address]

ACRONYMS AND ABBREVIATIONS

List all acronyms and abbreviations included in report text

1.0 INTRODUCTION

1.1 PURPOSE OF THIS GSR EVALUATION

Provide a brief introduction that includes the following information:

- The person or organization who initiated the GSR evaluation and the motivation for doing so

- The person or group of people conducting the GSR evaluation and their role in the overall project

- A brief definition and description of Green and Sustainable Remediation (GSR). According to the Department of Defense (DoD) Defense Environmental Restoration Program Manual 4715.20 (DERP Manual) dated March 2012, GSR expands on DoD's current environmental practices and employs strategies for environmental restoration that:

    - Use natural resources and energy efficiently;
    - Reduce negative impacts on the environment;
    - Minimize or eliminate pollution at its source; and
    - Reduce waste to the greatest extent possible.

  The DERP Manual also explains that GSR uses strategies that consider all environmental effects of remedy implementation and operation and incorporates options to maximize the overall environmental benefit of environmental response actions. The DERP Manual further states that "the DoD component should consider and implement green and sustainable remediation opportunities in current and future remedial activities when feasible" and "…the DoD Component shall, where practicable based on economic and social benefits and costs, ensure green and sustainable remediation practices…".

- The objectives of the evaluation. These may include:

    - Identify opportunities to incorporate GSR practices in the current or a future remedial phase

    - Highlight GSR practices already being implemented in the project

    - Qualitatively and (in many cases) quantitatively evaluate the environmental footprints for one or more alternatives being considered

- Any other pertinent information related to the overall purpose and goals of the evaluation, as appropriate.

1.2 TECHNICAL OVERVIEW: [PROJECT NAME]

1.2.1 <u>Overview of Project Location, Setting, and Contamination</u>

Provide a brief description of the project and the associated site. This should include site location, surrounding area, property owner or operating entity and any contractors involved in site operations, historic uses, contaminants of concern, and any previous remediation activities.

1.2.2 Remedial Phase and Status

Indicate the current remedial phase (e.g., Feasibility Study, Remedy Design, O&M) and remedial activities that are occurring for this project or are anticipated in the near future. Include a description of the current or planned remedy components (i.e., the baseline alternative) as well as any alternatives to the baseline being considered (include anticipated remedy durations of the remediation activities to the extent known).

1.3 DOCUMENTS REVIEWED AND CALLS/MEETINGS CONDUCTED

The following project documents were reviewed for this evaluation:

- List any project-related documents on which the evaluation was based or which provided pertinent information

Briefly list significant meetings or phone calls conducted related to the evaluation and important items discussed. Include dates and participants in the table below.

Table 1-1
Meeting Participants, DD Month YYYY

Participants			
Name	**Organization**	**Phone**	**Email**
[name 1]	[organization – role/title]	XXX-XXX-XXXX	[email address]
[name 2]	[organization – role/title]	XXX-XXX-XXXX	[email address]
[name 3]	[organization – role/title]	XXX-XXX-XXXX	[email address]

1.4 STRUCTURE OF THIS REPORT

This GSR evaluation report is structured as follows:

- Section 1: Introduction
- Section 2: Key GSR Findings
    - Review of GSR BMPs
    - Quantitative Footprint Analysis for Baseline Scenario
    - Quantitative Footprint Analysis for Potential Alternative(s) to Baseline
    - Other Qualitative Considerations
- Section 3: GSR Recommendations

If footprint quantification is included in the evaluation, it should be noted here if supporting information and calculations for quantitative aspects of the evaluation are provided in appendices and/or electronic attachments.

2.0 KEY GSR FINDINGS

2.1 REVIEW OF BEST MANAGEMENT PRACTICES (BMPs)

2.1.1 GSR BMP Tables Completed for the GSR Evaluation

The GSR BMP tables in Appendix A are used as an outline to consider and summarize previous implementation of GSR principles for the existing remedy, and to identify potential GSR opportunities not previously implemented. Table 2-1 summarizes information entered on the BMP tables in Appendix A, specifically with respect to the number of BMPs that appear to be applicable for this project, the number of BMPs that appear to be practical for this project, the number of BMPs that have been implemented prior to this GSR evaluation, and the number of BMPs that may be associated with potential cost savings for this project. Here "practical" is defined as being feasible from a technical standpoint and providing net GSR benefits as shown from the economic, social, and environmental metrics and other GSR considerations evaluated in this Study for the individual Project Pilot. Other Project Team limitations such as schedule, regulatory constraints, and site-specific logistics also impact the potential implementability of the GSR opportunities.

Table 2-1
Summary of BMP Applicability and Implementation from BMP Tables in Appendix A

	BMP Category								
	A. Planning	B. Characterization and/or Remedy Approach	C. Energy/Emissions Transportation	D. Energy/Emissions Equipment Use	E. Materials & Off-site Services	F. Water Resource Use	G. Waste Generation, Disposal, and Recycling	H. Land Use, Ecosystems, and Cultural Resources	I. Safety and Community
Total Number of BMPs	11	9	4	11	5	5	6	7	8
Number of Applicable BMPs									
Number of Practical BMPs									
Number of BMPs Implemented Prior to GSR Evaluation									
- Fully									
- Partially									
- Not Yet									
Number of Practical BMPs Likely to Result in Significant Cost Savings									

2.1.2 Key Findings Regarding GSR BMPs

Consider an introductory sentence regarding the overall applicability of the GSR BMPs in Appendix A to this specific project. Then include the following (add sub-bullets as needed):

- Examples of GSR BMPs already considered or incorporated prior to the GSR evaluation include (but are not limited to) the following:
  - Provide a brief (i.e., one sentence) description of the BMP being referred to, followed by one or more examples of the site-specific application of the BMP
- The GSR evaluation suggests several GSR BMPs that are potentially practical that the overall Project Team could consider moving forward. Some examples include the following:
  - Provide a brief (i.e., one sentence) description of the BMP being referred to, followed by the project-specific suggestion for applying the BMP
- Some GSR BMPs are not practical to implement because of other project-specific constraints. Examples include the following:
  - Provide a brief (i.e., one sentence) description of the BMP being referred to, followed by a brief explanation of why it is not practical for the project

2.2 QUANTITATIVE FOOTPRINT ANALYSIS FOR BASELINE SCENARIO

Include this section only if quantitative footprint analysis was performed as a part of the GSR evaluation. If quantitative footprint evaluation was not performed, use this section to explain why (and eliminate subsections 2.2.x). If a screening method was used to evaluate the applicability of quantitative footprint evaluation, briefly discuss the results here.

2.2.1 Overview of Baseline Scenario

List and briefly describe all remedy components included in the footprint quantification and other project-specific information needed. These items may include:

- Remedy duration (also indicate whether footprints are annual or remedy total – usually a remedy total is preferred)
- Materials use (material types and quantities)
- Personnel transportation (including vehicle type, number of trips, distance traveled, and number of passengers, if known)
- Equipment and materials transportation (weight of load and distance transported)
- Electrical equipment use (including actual usage from electrical bills and/or known information about equipment type, equipment horsepower, operating time, and other information required for footprinting)

- Fueled equipment use (including actual fuel usage if tracked and/or equipment type, equipment horsepower, operating time, volume of material to be moved, and other information required for footprinting)
- Water use (including potable water purchased from a public supply or water removed from an aquifer so that it is no longer available for use – differentiate between potable water and non-potable water)
- Water sent to a Publicly Owned Treatment Works (POTW) in gallons or gallons per minute
- Waste disposal (including whether the waste is hazardous or non-hazardous, the number of trips to disposal facility, the amount disposed per trip, and the distance to disposal)
- Laboratory analysis (cost in dollars)
- Labor hours spent on-site (number of workers and number of hours each worker spends on-site) above and beyond operation of heavy equipment
- Annual costs and capital costs (the capital costs include "up-front" costs that occur in the near term as well as non-routine remedy upgrade/replacement costs that may occur in future years)

Describe major assumptions and/or gaps in information.

2.2.2 Summary of Quantitative Footprint Results, Baseline Scenario

Reference the appendix that describes input to SiteWise™ (or any other footprint quantification tool) and other supporting calculations. This appendix should contain a much more detailed description than the overview provided above, and should clearly indicate what assumptions were made if some information was not available. If applicable, include the file name for any electronically attached files, such as SiteWise™ input and output MS-Excel files. Fill out Table 2-2.

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Table 2-2
Summary of Quantitative Footprint for Baseline Scenario
[Indicate whether values are annual or remedy total]

Note that any project-specific metrics or other qualitative considerations not listed can be added by inserting a row in the Table

GSR Parameter	Unit	Value
Environmental		
Energy use	MMBtu	
Global warming potential	Metric tons CO2e	
Criteria air pollutant emissions	Metric tons (NOx+SOx+PM)	
Hazardous air pollutant emissions	Lbs	
Potable water use	1,000s of gallons	
Other water use	1,000s of gallons	
Refined materials use	Lbs	
% of refined materials from recycled material	%	
Unrefined materials use	Ton	
% of unrefined materials from recycled material	%	
Non-hazardous waste disposal	Ton	
Hazardous waste disposal	Ton	
% of potential waste that is recycled or re-used	%	
Economic		
Life-cycle cost, discounted *	$	
Life-cycle cost, undiscounted	$	
Up-front cost	$	
Societal		
Predicted number of project-related injuries or fatalities	Number of injuries or fatalities	
One-way heavy vehicle trips through residential area	Trips	
Other Qualitative Considerations		
Land Transferred or Made Available for Potential Beneficial Use	**	
Existing Ecosystem Destruction	**	
Time Frame for Land Reuse	**	
Flexibility and Breadth of Options for Site Reuse	**	
Aesthetics	**	
Use of Renewable Energy	**	

** State the discount rate. An appendix for this alternative should include spreadsheets showing cost discounting calculations and the discounting rate applied.*

*** Indicate "N/A" if the consideration does not apply for the project being evaluated, or indicate the section of the report in which the qualitative consideration is discussed.*

2.2.3 Key Findings from Quantitative Footprint Analysis, Baseline Scenario

Include observations and findings based on the quantitative footprinting results:

- List primary contributors to total energy use for the baseline remedy. These may be grouped by type of activity (e.g., electrical use, fuel use, materials production, transportation of materials/equipment, transportation of personnel) or by remedy component (e.g., extraction pump operation, treatment plant operation, bioremediation injections, sampling and analysis):

  - For each contributor, provide a brief description of the item, the amount of energy used (MMBtus) and the percentage of the total energy usage represented by the item. If the item represents a large percentage of the total energy use, consider dividing it into sub-components.

  - It is helpful to include a pie chart or bar chart showing each key contributor to the total energy use (group minor contributors as "other").

- List primary contributors to total GHG emissions for the baseline remedy (using same grouping approach as energy use):

  - For each key contributor, provide a brief description of the item, the amount of GHG emissions (metric tons) and the percentage of the total GHG emissions represented by the item. If the item represents a large percentage of the total GHG emissions, consider dividing it into sub-components.

  - It is helpful to include a pie chart or bar chart showing each key contributor to the total GHG emissions (group minor contributors as "other").

- Briefly discuss primary contributors to total priority pollutant (i.e., NOx, SOx, and PM) emissions for the baseline remedy. For the largest contributors, provide a brief description of the item, the amount of criteria air pollutants emitted and/or the percentage of the total criteria air pollutant emissions represented by the item (as appropriate). If the primary contributors to NOx, SOx, or PM are not the same, consider discussing each pollutant separately. If the primary contributors are very different from the primary contributors to energy use or GHG emissions, include a brief discussion about why this is the case.

- Continue to list and briefly discuss primary contributors to each of the other GSR parameters with a quantifiable footprint. For the largest contributors, provide a brief description of the item and the percentage of the total represented by the item (as appropriate). If the primary contributors are very different from the primary contributors to energy use or GHG emissions, include a brief discussion about why this is the case.

- If a parameter was not quantified, but a known project-site activity may contribute to footprints for that parameter, indicate why quantification was not feasible or practical.

2.3 QUANTITATIVE FOOTPRINT ANALYSIS FOR ALTERNATIVE 1

This section should be repeated for each alternative being footprinted. Each alternative should also have its own appendix describing input to SiteWise^{TM} (or other footprint quantification tool) and other supporting calculations.

2.3.1 Overview of Alternative 1

Briefly discuss the basis for consideration of this alternative, including any GSR considerations. Similar to the overview of the baseline scenario, list and briefly describe all remedy components included in the footprint quantification and other project-specific information needed. If the alternative is a simple variation on another alternative, it may be possible to limit the description to modifications from that other alternative that will affect the remedy footprint (i.e., in those cases, remedy components that are unchanged do not need to be re-stated). If the alternative is a major change from the baseline and other alternatives, then a full description should be provided. Also indicate anticipated capital costs required to implement the alternative (include "up-front" costs that occur in the near term as well as non-routine remedy upgrade/replacement costs that may occur in future years) and potential cost savings.

2.3.2 Summary of Quantitative Footprint Results for Alternative 1 versus Baseline

Reference the appendix in which input to SiteWise™ (or other footprint quantification tool) and other supporting calculations are described. This appendix should contain a much more detailed description than the overview provided above, and should clearly indicate what assumptions were made if some information was not available. If applicable, include the file name for any electronically attached files, such as SiteWise™ input and output MS-Excel files. Fill out Table 2-3 (or a subset of the table limited to key parameters metrics of interest for comparison to the baseline).

{Intentionally Left Blank}

Table 2-3
Summary of Key Quantitative Footprint for Baseline versus Alternative 1
[Indicate whether values are annual or remedy total]

Note that any project-specific metrics or other qualitative considerations not listed can be added by inserting a row in the Table

GSR Parameter	Unit	Value
Environmental		
Energy use	MMBtu	
Global warming potential	Metric tons CO2e	
Criteria air pollutant emissions	Metric tons (NOx+SOx+PM)	
Hazardous air pollutant emissions	Lbs	
Potable water use	1,000s of gallons	
Other water use	1,000s of gallons	
Refined materials use	Lbs	
% of refined materials from recycled material	%	
Unrefined materials use	Ton	
% of unrefined materials from recycled material	%	
Non-hazardous waste disposal	Ton	
Hazardous waste disposal	Ton	
% of potential waste that is recycled or re-used	%	
Economic		
Life-cycle cost, discounted *	$	
Life-cycle cost, undiscounted	$	
Up-front cost	$	
Societal		
Predicted number of project-related injuries or fatalities	Number of injuries or fatalities	
One-way heavy vehicle trips through residential area	Trips	
Other Qualitative Considerations		
Land Transferred or Made Available for Potential Beneficial Use	**	
Existing Ecosystem Destruction	**	
Time Frame for Land Reuse	**	
Flexibility and Breadth of Options for Site Reuse	**	
Aesthetics	**	
Use of Renewable Energy	**	

** State the discount rate. An appendix for this alternative should include spreadsheets showing cost discounting calculations and the discounting rate applied.*
*** Indicate "N/A" if the consideration does not apply for the project being evaluated, or indicate the section of the report in which the qualitative consideration is discussed.*

Next indicate any key observations from these results. In some cases this will be a summary of results for the specific alternative, in a format similar to that used to describe results for the baseline alternative. In other cases, it will be a summary of the comparison of results between the baseline and this alternative.

This section does not necessarily need to include all GSR parameters. Key metrics for which there is a change in footprints from the baseline should always be included. However, metrics for which there is no quantifiable footprint may be omitted, and metrics for which the footprint is unchanged from the baseline may be omitted if not otherwise desired.

2.3.3 Primary Footprints That Would Improve for Alternative 1

List key footprints that would improve in this alternative versus the baseline (or versus another alternative):

- For each key parameter, indicate the amount by which the footprint would change, the percent change this represents, and the primary reason(s) for this change.

2.3.4 Primary Footprints That Would Worsen for Alternative 1

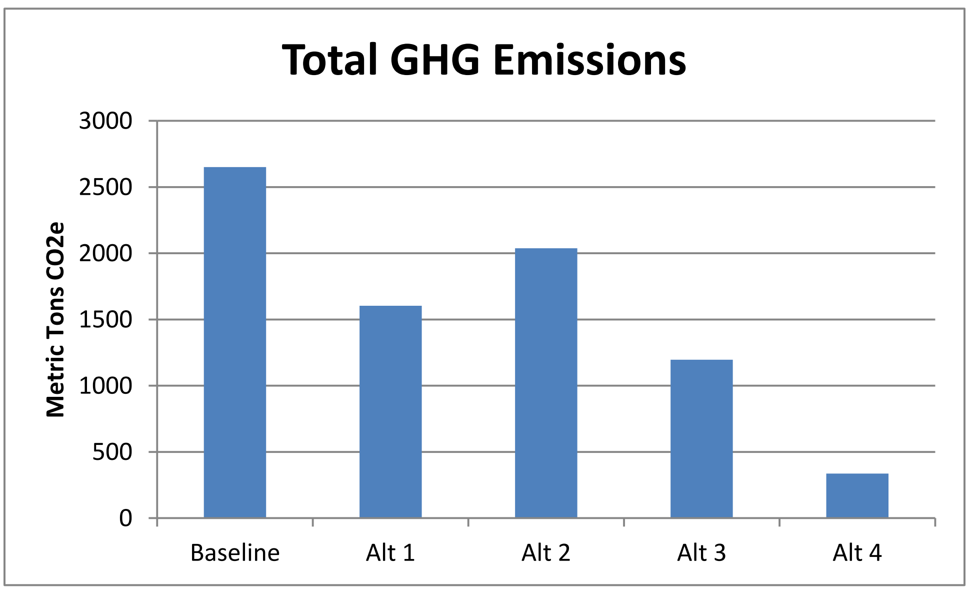
List key footprints that would worsen in this alternative versus the baseline (or versus another alternative):

- For each key parameter, indicate the amount by which the footprint would change, the percent change this represents, and the primary reason(s) for this change.

2.4 COMPARISON OF KEY METRICS BY ALTERNATIVE

If there are multiple alternatives, it is useful to provide figures (see example below) showing values for key metrics for all alternatives so they can be compared to each other. SiteWise™ can produce these types of charts in the Final Summary file, or they can be produced external to SiteWise™.

Table 2-4
Summary of GHG Emissions by Alternative



Use as many charts and/or tables as needed to illustrate the comparisons. If there are tradeoffs (i.e., a specific alternative is better for some metrics but worse for others) provide discussion regarding the tradeoffs and which metrics are most important to stakeholders.

Comparisons between alternatives can be presented in a highly visual manner by assigning colors to the ratings, as illustrated for a subset of GSR considerations in the example below. There are several possible formats for such comparisons. Table 2-5 illustrates colors and symbols. It is important to use symbols or text in addition to the colors (as illustrated on Table 2-5) to differentiate the ratings when printed in black and white. Alternatively, text such as "good", "fair" and "poor" could be used, with or without color. A template spreadsheet in MS-Excel with several possible formats (color and text) is provided electronically with this template report, and includes flexibility to add rows for additional metrics and considerations as desired.

Table 2-5
Comparison of Alternatives with Respect to GSR Considerations

Note that any project-specific metrics or other qualitative considerations not listed can be added by inserting a row in the Table

Legend

+ good or desired (green)
o fair or neutral (yellow)
- poor or undesirable (red)

GSR Metrics and Considerations	Baseline	Alternative 1	Alternative 2
Quantitative Environmental Metrics:			
Energy Use	o	+	+
Global Warming Potential	o	+	+
Criteria Air Pollutants	o	+	+
Hazardous or Toxic Air Pollutants	n/a	n/a	n/a
Potable Water Use	+	+	+
Other Water Use	n/a	n/a	n/a
Refined Materials	-	o	o
Percent of Refined Materials from Recycled or Reused Sources	-	-	+
Unrefined Materials	-	o	o
Percent of Unrefined Materials from Recycled or Reused Sources	-	-	-
Non-Hazardous Waste Disposal	o	+	+
Hazardous Waste Disposal	-	+	+
Percent of Total Potential Waste Recycled or Reused	-	+	+
Quantitative Economic Metrics:			
Life-Cycle Cost, Discounted	-	o	o
Life-Cycle Cost, Undiscounted	-	o	o
Up-Front Cost	-	+	o
Quantitative Societal Metrics:			
Risk for Injuries/Fatalities	+	+	+
One-Way Heavy Vehicle Trips through Residential Areas	n/a	n/a	n/a
Qualitative Considerations:			
Land Transferred or Made Available for Potential Beneficial Use	n/a	n/a	n/a
Existing Ecosystem Destruction	+	+	+
Time Frame for Land Reuse	+	+	+
Flexibility and Breadth of Options for Site Reuse	+	+	+
Aesthetics	o	+	+
Use of Renewable Energy	-	-	o

**These are qualitative by nature and the basis of such ratings should be discussed in the GSR evaluation report*

2.5 OTHER QUALITATIVE CONSIDERATIONS

The following items should be included here (if applicable):

- Existing ecosystem destruction

- Land transferred or made available for potential beneficial use

- Time frame for land reuse

- Flexibility and breadth of options for site reuse

- Aesthetic considerations

- Renewable energy use associated with the remedy – this may include renewable energy generated on-site, alternative fuels for vehicles or equipment, or electricity use from a renewable power supply. To determine an approximate value for percent of electricity from renewable sources, the local utility company can be contacted, or the renewable versus non-renewable mix for the region can be found at http://cfpub.epa.gov/egridweb/. Keep in mind that electricity use is typically not the only form of energy use for a remedy, so the percentage of electricity provided by renewable sources should be multiplied by the percentage of total energy use from on-site electricity use. For example, if 20% of the electricity is provided by renewable energy, and 50% of the total energy use is from electricity, then 10% of the total energy use is from renewable energy (assuming no other project-related renewable energy use).

- Any other project-specific GSR considerations not addressed elsewhere.

Also include discussion of other items that may impact consideration and implementation of GSR opportunities, including the following:

- Cost
- Schedule
- Contracting
- Regulatory and public reviews/input
- GSR evaluation timing within the remedial phase
- Other project-specific variables and logistics

3.0 GSR RECOMMENDATIONS

GSR recommendations are summarized in the form of tracking tables, as follows:

Table Number	Recommendation
3-1	3.1 - Include a one-line description of each recommendation here
3-2	3.2 -
3-3	3.3 -

The tracking table format allows the implementation status of the recommendation to be updated as the project progresses. Note that using an MS-Word version of the tracking table, check-boxes can be checked and un-checked by right-clicking on the checkbox, selecting “properties”, and then selecting “checked” or “not checked”.

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Table 3-1
Tracking Table for Recommendation 3.1

<table>
<tr><td colspan="3" rowspan="2">Recommendation:

3.1 - Include a one-line description of each recommendation here</td><td>Current Date:
DD/MM/YY</td></tr>
<tr><td>Date of Original Recommendation:
DD/MM/YY</td></tr>
<tr><td colspan="4">Basis for Recommendation (Include discussion of cost impacts and value if appropriate):

Discuss GSR-related considerations here. Include footprint reductions (if quantified).</td></tr>
<tr><td colspan="4">Resources Conserved:
☐ Hazardous air pollutants ☐ GHG emissions (CO2e) ☐ Energy ☐ Water ☐ Waste
☐ Criteria pollutants ☐ Safety/Community ☐ Materials ☐ Land-use</td></tr>
<tr><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
☐ Cost Increase ☐ Cost Savings
☐ Cost Neutral ☐ N/A</td><td colspan="2">☐ Recommended action otherwise required?
If checked, required by:</td></tr>
<tr><td colspan="4">Level of Up-Front Investment Included in 5 Year Cost Impact:
☐ Negligible ☐ < $10,000 ☐ $10,001 - $50,000
☐ $50,001 - $100,000 ☐ $100,001 - $500,000 ☐ > $500,000</td></tr>
<tr><td colspan="4">Attachment(s) to report with footprint assumptions and calculations:</td></tr>
<tr><td>Implementation Status:

☐ Fully
☐ Partially
☐ Not Yet
☐ Not Planned</td><td colspan="3">Explanation of Status:</td></tr>
</table>

Fill in the above table and check all checkboxes that apply. . Note that using an MS-Word version of the tracking table, check-boxes can be checked and un-checked by right-clicking on the checkbox, selecting “properties”, and then selecting “checked” or “not checked”.

Include a separate table for each recommendation made.

FIGURES

[Insert Figures from separate Word or PDF File(s)]

APPENDIX A

GSR Best Management Practice (BMP) Tables

- **Fill in Appendix A tables as appropriate based on project-specific information**

- **Check-boxes in forms can be checked and un-checked by right-clicking on the checkbox, selecting “properties”, and then selecting “checked” or “not checked”.**

BMP Category A: Planning

BMP A-1: Develop a culture of GSR within the Project Team and encourage GSR ideas from project staff and review similar projects from other sites for possible transfer/adoption of GSR ideas	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP A-2: Incorporate a section on GSR in project meetings, work plans, and reports	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category A: Planning

<table>
<tr><td colspan="2">BMP A-3: Identify and periodically update a list of key stakeholders and their concerns with respect to GSR considerations</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP A-4: Schedule activities for appropriate seasons and/or time of day to reduce delays caused by weather conditions and fuel needed for heating or cooling
Examples:
- Work at night in summer to avoid heat stress
- Perform field activities in summer to take advantage of longer daylight</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category A: Planning

BMP A-5: Prepare, store, and distribute documents electronically		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP A-6: Utilize teleconferences rather than meetings when feasible		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP Category A: Planning

BMP A-7: Incorporate green specifications into solicitations and contracts Examples: - Follow pertinent green procurement policies - Select hotel chains with "green" policies - Select laboratories that utilize renewable energy	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP A-8: Integrate schedules to allow for resource sharing and fewer days of field mobilization	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category A: Planning

<table>
<tr><td colspan="2">BMP A-9: Tailor the remedy cleanup goals such that they are appropriate for anticipated end-use of the property, rather than assuming a more conservative exposure scenario with more stringent cleanup goals</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP A-10: Conduct thorough review of project documents and historical records to minimize required scope of investigation
Examples:
- IRP projects: determine if there are previous aquifer tests that can be used for groundwater modeling rather than conducting new aquifer tests
- MMRP projects: perform careful review of historic documents, aerial photographs, and other existing information to reduce the footprint of land that needs to be disturbed for thorough investigation and remediation
- MMRP projects: use IRP sampling data to supplement and enhance the MMRP field program (if available)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category A: Planning

<table>
<tr><td colspan="2">BMP A-11: Use language in work plans, proposed plans, and decision documents that maximizes flexibility to allow GSR recommendations to be implemented
Examples:
- Designation of a “suitable growth media” for a landfill cap cover material rather than “top soil”
- Allow for “treatment technologies that achieve adequate levels of treatment” rather than specifying only one treatment technology</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category B: Characterization and/or Remedy Approach

BMP B-1: Develop and routinely update a conceptual site model (CSM) to use as a basis for making remedial process decisions	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP B-2: Perform regular optimization evaluations to improve efficiency of current or planned actions and/or develop alternative remedial approaches that might shorten remedy duration or otherwise improve the net environmental benefit of the remedy, including use of any methodologies, such as TRIAD (www.triadcentral.org), systematic planning (technical project planning), value engineering studies, and remedial system evaluations, expected to optimize the planning and/or execution of the project	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td colspan="2">BMP B-3: Use appropriate characterization or remedy approach based on site conditions
Examples:
- Consider in-situ and passive remedy options that offer adequate protectiveness
- Consider in-situ bioremediation if conditions are already anaerobic and constituents are conducive to reductive dechlorination
- Compare source removal versus in-situ and ex-situ remedial options
- Consider different technologies for impacted areas with higher and lower concentrations
- Use realistic times to remedy closeout (i.e., estimations through modeling) rather than assumed remedy timeframes (e.g., 30 years, which is often used for evaluation of FS alternatives)
- MMRP projects: evaluate man-portable DGM instruments versus vehicle-towed array (VTA) instruments and inclusion of detector-aided reconnaissance (DAR)
- MMRP projects: evaluate best alternative for destruction of munitions (e.g., blow in place versus consolidated shot versus controlled detonation chamber)</td><td>Date:

☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP B-4: Establish decision points to trigger a change from one technology to another or from one remedy alternative to another
Examples:
- Change vapor treatment from thermal oxidation to granular activated carbon (GAC) media based on flow rates and concentrations
- Remove a treatment polishing step if influent to that step already meets discharge criteria
- Move to Monitored Natural Attenuation (MNA) if specific concentration thresholds in groundwater are met</td><td>Date:

☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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</table>

BMP Category B: Characterization and/or Remedy Approach

BMP B-5: Focus sampling efforts to meet objectives of the specific remedial phase (e.g., sampling during O&M should be focused on evaluating remedy performance and not on thorough plume characterization) Examples: - Eliminate sampling parameters as appropriate - Reduce sampling frequency as appropriate - Reduce sample locations as appropriate - Enhance monitoring program as appropriate - MMRP projects: consider Incremental Sampling Methodology (ISM) versus discrete sampling for MC characterization	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP B-6: Consider real-time measurements and dynamic work plans to reduce mobilizations and improve effectiveness of investigation efforts Examples: - Field test kits (e.g., test kits for sulfate) - Field screening instruments (e.g., x-ray fluorescence for lead or photoionization detectors for volatile organics) - Drive point sensor technologies (e.g., membrane interface probe or "MIP") - Visual staining or odor - Establish excavation extent based on real-time data collected as excavation proceeds and use GPS to accurately delineate excavation areas - MMRP projects: use GPS and/or the same equipment that was used for detection to confirm anomaly signatures prior to excavating - MMRP projects: consider incorporating field screening methods (e.g., X-ray fluorescence, EXPRAY and explosives test kits, as appropriate or applicable) into the field program to refine sampling locations and reduce the quantities of samples submitted for off-site laboratory analysis - MMRP projects: consider use of advanced electromagnetic sensors (e.g., MetalMapper) for better subsurface item identification to reduce digging requirements	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category B: Characterization and/or Remedy Approach

BMP B-7: Consider use of existing site structures/infrastructure or mobilization of temporary structures versus new construction Examples: - Buildings (e.g., for treatment building or field office) - Concrete slabs or foundations - Wells - Existing excavations for storm water control	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP B-8: Establish project-specific decision points to limit extent of remediation Examples: - Project-specific cleanup levels based on a site-specific risk assessment (coordinated with risk assessment experts) rather than generic cleanup levels, if it results in lower footprints for key parameters and is acceptable to all stakeholders - MMRP projects: dig stopping rules and anomaly prioritization/detection criteria to minimize false positives	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td colspan="2">BMP B-9: Consider leaving in place structures whose removal is not necessary (i.e., foundations, underground pillars, etc.)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category C: Energy/Emissions – Transportation

BMP C-1: Reduce the number of trips for personnel Examples: - Encourage carpooling - Use telemetry systems and webcams to remotely transmit data directly to project offices to avoid trips	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP C-2: Reduce the number of trips and/or volume for transported materials, equipment, or waste Examples: - Transfer full loads by consolidating shipments from vendors and/or shipments to disposal sites (also share shipments with neighbors if feasible) - Purchase more concentrated chemicals to reduce transportation weight and/or volume	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category C: Energy/Emissions – Transportation

<table>
<tr><td colspan="2">BMP C-3: Reduce trip lengths
Examples:
- Dispose of waste at closest appropriate facility
- Purchase materials, equipment, and services from local vendors
- Use locally produced supplies
- Select most efficient transportation route</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP C-4: Use alternate fuels or other options for transportation when possible
Examples:
- Compressed natural gas
- Biodiesel blends
- Ethanol blends
- Hybrid and/or electric
- Rail lines versus trucks
- Use a fuel efficient passenger car rather than a pickup truck if task allows</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category D: Energy/Emissions – Equipment Use

BMP D-1: Consider and implement approaches to minimize engine idle times		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? (“N/A” if “Practical” not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP D-2: Ensure peak operating efficiency of equipment to reduce energy use and emissions Examples: - Perform preventative maintenance and operate equipment per manufacturer instructions - Perform retrofits involving low-maintenance multi-stage filters for cleaner engine exhaust - Use synthetic oil to extend operating life (and reduce waste oil) - Purchase newer equipment with reduced emissions		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? (“N/A” if “Practical” not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP Category D: Energy/Emissions – Equipment Use

BMP D-3: Use alternate fuel options for equipment when possible
Examples:

- Compressed natural gas
- Biodiesel
- Ethanol blends
- Ultra-low sulfur diesel, wherever available (and as required by engines with PM traps)
- Recycled oil (ensure compliance with operating requirements/warranties)

Date:

☐ Applicable

☐ Evaluated

☐ Practical

Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A

Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

BMP D-4: Select appropriate equipment and/or power source for the job
Examples:

- Avoid using large excavators for small earthmoving projects
- Use direct push methods when possible to reduce drilling duration
- Compare potential use of electricity versus battery versus generator

Date:

☐ Applicable

☐ Evaluated

☐ Practical

Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A

Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

BMP Category D: Energy/Emissions – Equipment Use

BMP D-5: Use variable frequency drives on motors (e.g., pumps, blowers), or replace oversized motors with properly sized motors	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP D-6: Identify options for generating renewable energy for direct use in the remedy and/or for alternate use at or near the project site Examples: - Solar, wind, landfill gas (microturbines), combined heat and power, geothermal heat exchange - Applications for remote areas such as solar pumps or solar flares (if demand is not continuous, the need for a battery backup may be avoided) - Generate power or heat exchange from water to be discharged	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category D: Energy/Emissions – Equipment Use

<table>
<tr><td colspan="2">BMP D-7: Consider purchase of renewable energy certificates (RECs) to offset emissions from the remedial activities (note that a Memorandum titled Department of the Army Policy for Renewable Energy Credits, dated 24 May 2012, states that “the Army shall not purchase RECs solely to meet Federal renewable energy goals,” but it is possible that Project Teams might in some cases consider the purchase of RECs to address concerns of one or more stakeholders at a specific site)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP D-8: Design/modify housing required for above-ground treatment components for energy-efficiency
Examples:
- Passive lighting
- Compact fluorescent lighting (CFL) or light-emitting diode (LED) lighting
- Timers and/or motion control sensors for lighting
- Shading
- Minimize heating and cooling needs (building size, insulation, etc.)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category D: Energy/Emissions – Equipment Use

BMP D-9: For remedies that involve groundwater or air extraction, optimize extraction to reduce flow rates (potentially beneficial with respect to energy use, materials usage, water resources, waste disposal, etc.)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP D-10: Consider pulsing for extraction and/or injection of water or air to maximize mass removal per unit of time or energy, by extracting higher concentrations	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category D: Energy/Emissions – Equipment Use

<table>
<tr><td colspan="2">BMP D-11: Run electrical equipment during times of lower electric demand if possible (this does not reduce energy use but could lower cost and also can lower stress on the energy grid during periods of peak demand)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category E: Materials & Off-Site Services

<table>
<tr><td colspan="2">BMP E-1: Use materials that are made from recycled materials
Examples:
- Steel
- Asphalt
- Plastics
- Concrete</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP E-2: Optimize the amount of materials used
Examples:
- Experiment with different material amounts/doses
- Consider alternate materials
- Use timers or feedback loops and process controls for dosing
- MMRP projects: minimize quantities of donor explosives for MEC destruction</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category E: Materials & Off-Site Services

<table>
<tr><td colspan="2">BMP E-3: Utilize less refined materials when feasible
Examples:
- Limestone instead of sodium hydroxide for pH adjustment
- Native fill instead of select fill</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP E-4: Identify opportunities for using by-products or “waste” materials from local sources in place of refined chemicals or materials
Examples:
- Cheese whey, molasses, compost, or off-spec food products for inducing anaerobic conditions
- Crushed concrete for use as fill
- Concrete from coal combustion byproducts</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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</table>

BMP Category E: Materials & Off-Site Services

<table>
<tr><td colspan="2">BMP E-5: Reduce demand on Publicly Owned Treatment Works (POTWs)
Examples:
- Discharge treated water to groundwater or to surface water rather than POTW
- Minimize amount of water requiring treatment</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category F: Water Resource Use

BMP F-1: Minimize water consumption Examples: - Sensors to turn off water when not needed - Low flow fittings - Minimize water needs for irrigation (landscape choices, use of mats and mulch)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP F-2: Preferentially use less refined water resources when feasible Examples: - Use extracted groundwater instead of potable water for chemical blending - Capture and store rain/storm water for future use - Employ rumble grates with a closed-loop gray-water washing system	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category F: Water Resource Use

BMP F-3: Use extracted and treated water for beneficial purposes Examples: - Irrigation - Potable water - Industrial process water	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP F-4: Promote groundwater recharge Examples: - Recharge extracted and treated water when beneficial uses of the water are not identified and reinjection is practical - Minimize site area covered by impervious surfaces to reduce runoff and maximize infiltration (unless such capping is a specific component of the remedial action)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category F: Water Resource Use

<table>
<tr><td colspan="2">BMP F-5: Maintain water quality by preventing nutrient loading to surface water or groundwater
Examples:
- Use phosphate-free detergents instead of organic solvents or acids to decontaminate sampling equipment (if not required for some contaminants)</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
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</table>

BMP Category G: Waste Generation, Disposal, and Recycling

BMP G-1: Minimize drill cuttings and all other investigation derived waste (including personal protection equipment) Examples: - Direct push or sonic drilling to reduce drill cuttings - Low-flow sampling or passive diffusion bags (if applicable) to reduce purge water - When possible place drill cuttings on-site rather than off-site disposal	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP G-2: Segregate excavated soil in pre-planned staging areas so that "clean" material can be deposited on-site and/or reused rather than transported for off-site disposal	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category G: Waste Generation, Disposal, and Recycling

BMP G-3: Consider on-site treatment and re-use of soil instead of off-site disposal Examples: - Land farming - Above ground soil vapor extraction (SVE)		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP G-4: Minimize need to transport and dispose hazardous waste Examples: - Consider delisting listed hazardous waste if waste is not characteristically hazardous waste - Segregate hazardous waste and non-hazardous waste - Maintaining the non-hazardous land fill classification instead of reclassifying to a hazardous landfill so that OSHA's HAZWOPER standard for cleanup operations does not need to be implemented		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP Category G: Waste Generation, Disposal, and Recycling

<table>
<tr><td colspan="2">BMP G-5: When possible avoid/minimize use of hazardous/toxic materials that may require special handling or disposal
Examples:
- Cleaning solutions
- Pesticides
- Disposable batteries (use rechargeable batteries)
- MMRP projects: minimize Chemical Agent Contaminated Media (CACM) at RCWM sites.</td><td>Date:

☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
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</table>

<table>
<tr><td colspan="2">BMP G-6: Recycle or reuse materials rather than disposing of them
Examples:
- Cardboard
- Plastics
- Concrete
- Asphalt
- Steel and other metals
- Recovered oil/product
- Mulch/compost
- MMRP projects - recycle recovered Material Documented as Safe (MDAS) after inspection and certification that the remnants are free of explosive hazards</td><td>Date:

☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category H: Land Use, Ecosystems, and Cultural Resources

BMP H-1: Minimize erosion and soil transport to surface water bodies Examples: - Quickly restore any vegetated areas disrupted by equipment or vehicles - Institute appropriate erosion controls during excavation such as silt fencing	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP H-2: Minimize disturbances to land Examples: - Establish well-defined traffic patterns for onsite activities to minimize disturbed areas - Consider non-intrusive investigation techniques (e.g., geophysical methods) to identify items like USTs and buried drums	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category H: Land Use, Ecosystems, and Cultural Resources

BMP H-3: Preserve/restore ecosystems to the extent possible Examples: - Limit the removal of trees and vegetation - Attempt to transplant disturbed shrubs and small trees to other locations - Use native species for re-vegetation - Retrieve dead trees during excavation and later reposition them as habitat snags - Select and place suitably sized and typed stones into water beds and banks - Undercut surface water banks in ways that mirror natural conditions - Cut back rather than remove trees, bushes, vegetation	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP H-4: Minimize drawdown of the water table in sensitive areas such as wetlands or areas subject to subsidence	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category H: Land Use, Ecosystems, and Cultural Resources

<table>
<tr><td colspan="2">BMP H-5: Construct wells and other remedial process infrastructure (piping, buildings, etc.) to minimize restrictions to anticipated future use of the site</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

<table>
<tr><td colspan="2">BMP H-6: Preserve/restore cultural resources to the extent possible
Examples:
- Protected lands such as wildlife refuges, national parks, and wilderness areas
- Culturally sensitive sites such as cemeteries, native burials, and archaeological finds
- Buildings or land parcels with historical significance</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category H: Land Use, Ecosystems, and Cultural Resources

<table>
<tr><td colspan="2">BMP H-7: Document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources
Examples:
- Photodocument conditions prior to clearing brush
- MMRP projects: photodocument conditions prior to BIP</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
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☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):</td></tr>
</table>

BMP Category I: Safety and Community

BMP I-1: Minimize and mitigate noise, light and odor disturbance during all phases of the remedial process, to the extent practicable	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-2: Minimize dust during construction activities by spraying water or techniques such as laying biodegradable mats, tarps, or materials (already in EM385-1-1)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category I: Safety and Community

BMP I-3: Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? (“N/A” if “Practical” not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP I-4: Minimize drawdown of the water table in areas that could impact production rates at supply wells and/or irrigation wells		**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? (“N/A” if “Practical” not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP Category I: Safety and Community

BMP I-5: Minimize amount of time that heavy machinery is needed to enhance safety	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-6: Minimize handling of dangerous chemicals by selecting alternate chemicals and/or engineering to minimize contact with chemicals (for MMRP projects, there is enhanced risk related to explosion potential and exposure to chemical agents (CA) and agent breakdown products (ABP) associated with RCWM responses)	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category I: Safety and Community

BMP I-7: Contribute to local economy when possible Examples: - Consider leasing local office space - Purchase or lease equipment from local vendors - Hire workers from local community	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? (“N/A” if “Practical” not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP I-8: Utilize on-site construction practices and PPE requirements for anticipated exposure scenarios rather than an overly conservative level of protectiveness that is more resource intensive Examples: - Utilize general construction PPE protectiveness, which is less personnel and equipment resource intensive, rather than HTRW PPE protectiveness, when applying a non-hazardous soil cover for a HTRW landfill	**Date:** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? (“N/A” if “Practical” not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP):	

BMP Category J: Other Site-Specific BMPs

<table>
<tr><td colspan="2">BMP J-1:</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
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<table>
<tr><td colspan="2">BMP J-2:</td><td>Date:
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
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</table>

Appendix B

Assumptions for SiteWise Input and Other Calculations,
[Project Name] Pilot GSR Evaluation:

Baseline Scenario

<u>Include</u>

- **Text Description of SiteWise Input**
- **Other Supporting Calculations and/or Information**
- **Cost Spreadsheets**

Appendix B
Assumptions for SiteWise Input and Other Calculations
[Project Name] GSR Evaluation:

Baseline Scenario

[Name of SiteWise directory in which related input and output files are located]

List and briefly describe all remedy components included in the footprint quantification and other project-specific information needed. This will likely be similar to the information provided in Section 2.2.1 of the report. These items may include:

- Remedy duration (also indicate whether footprints are annual or remedy total)
- Materials use (material types and quantities)
- Personnel transportation (including vehicle type, number of trips, distance traveled, and number of passengers, if known)
- Equipment and materials transportation (weight of load and distance transported)
- Electrical equipment use (including actual usage from electrical bills and/or known information about equipment type, equipment horsepower, operating time, and other information required for footprinting)
- Fueled equipment use (including actual fuel usage if tracked and/or equipment type, equipment horsepower, operating time, volume of material to be moved, and other information required for footprinting)
- Water use (including potable water purchased from a public supply or water removed from an aquifer so that it is no longer available for use)
- Water sent to a POTW (gallons or gallons per minute)
- Waste disposal (including whether the waste is hazardous or non-hazardous, the number of trips to disposal facility, the amount disposed per trip, and the distance to disposal)
- Laboratory analysis (cost in dollars)
- Labor hours spent on-site (number of workers and number of hours each worker spends on-site)

Indicate what information is represented in each tab of the SiteWise input sheet (this also outlines how the notes in this appendix are organized):

- [Remedy Component 1] – Uses "Remedial Investigation" tab of the SiteWise input sheet
- [Remedy Component 2] – Uses "Remedial Action Construction" tab of the SiteWise input sheet
- [Remedy Component 3] – Uses "Remedial Action Operations" tab of the SiteWise input sheet
- [Remedy Component 4] – Uses "Longterm Monitoring" tab of the SiteWise input sheet

For each section of SiteWise, all the sections are listed, with pertinent information added only for those sections of the input sheet where data were added.

Baseline Scenario – Overview

Other calculations done outside of SiteWise include the following (these will be discussed in detail following the SiteWise input notes):

- Hazardous air pollutants
- Refined material use
- Unrefined material use
- Tons of non-hazardous waste
- Tons of hazardous waste
- Project-related risks
- Heavy truck trips through residential areas

Costs for the remedy should also be discussed here. These include up-front cost, discounted life-cycle cost, and undiscounted lifecycle cost. A spreadsheet should be attached showing the discount rate and discounting calculations.

Baseline Scenario – Remedy Component 1

Scope of Work

List, in bullet format, all items associated with this component of the remedy. The main purpose of this section is to assemble all items that will go into one tab of SiteWise. This section should focus on listing the quantities for each item, and noting where data is not available and assumptions are made for the purposes of SiteWise input.

The actual values input to SiteWise should be catalogued beginning on the next page. For each entry, it is important to note the actual number that was entered into SiteWise **and** the basis for that number (including any calculations required to obtain that number) so that the reader can understand the reason for each value input to SiteWise. Also indicate all items selected from dropdown menus for each entry in SiteWise. Note where "surrogates" were used and what component of the project each surrogate represents (i.e., if SiteWise does not have inputs for a certain material, piece of equipment, or activity used for the project and one of the entries that is available in SiteWise was used to represent that item).

Note that some of the inputs for SiteWise may change as newer versions of the SiteWise software become available. Be sure that the inputs included in this appendix match those needed for SiteWise.

Baseline Scenario – Remedy Component 1

<u>Input into "[Name of SiteWise tab]" tab of SiteWise Input Sheet.xls</u>

- Baseline Information
  - Remedial Action Operations Cost and Duration
    - Total remedial action operations cost ($) – [Enter if desired]
    - Duration of remedial action operations (unit time) – [Enter if desired – note that as of SiteWise Version 2, this duration is only used for cost calculation purposes. For all other inputs, the user will need to multiply annual values by the number of years of remedy operation prior to SiteWise input.]

- Material Production
  - Well Materials
    - Well Type 1 – [One-line description of item. Record input values and selections here, as well as any associated calculations. Do the same for each item entered.]
  - Treatment Chemicals & Materials
  - Treatment Media
  - Construction Materials
  - Well Decommissioning
  - Bulk Material Quantities

- Transportation
  - Personnel Transportation – Road
  - Personnel Transportation – Air
  - Personnel Transportation – Rail
  - Equipment Transportation – Road
  - Equipment Transportation – Air
  - Equipment Transportation – Rail
  - Equipment Transportation – Water

- Equipment Use
  - Earthwork
  - Drilling
  - Trenching
  - Pump Operation [Be sure to indicate which Method was used and to select the Electricity Region on the Site Info tab]
  - Diesel and Gasoline Pumps
  - Blower, Compressor, Mixer, and Other Equipment
  - Generators
  - Agricultural Equipment
  - Capping Equipment
  - Mixing Equipment
  - Internal Combustion Engines
  - Other Fueled Equipment
  - Operator Labor
  - Laboratory Analysis
  - Other Known Onsite Activities

- Residual Handling
  - Residue Disposal/Recycling
  - Landfill Operations

  - Thermal/Catalytic Oxidizers

- Resource Consumption
  - Water Consumption
  - Onsite Land and Water Resource Consumption

Once SiteWise input is complete, go to "SiteWise_Input Sheet" for overall project and enter information (including Alternative File Name "Baseline"). Then go to "Generate Alternative" tab and click button labeled "Click to generate alternative using previously entered alternative name". Copies of the input and output summary sheets for this alternative are now located in the directory titled "RA_Baseline _NoFR_1". To store the "[Name of SiteWise Tab].xls" calculation sheet showing detailed calculations, open it in the overall SiteWise project directory when the appropriate input sheet is open, then do a "save as" to put it in the directory for this alternative using a name that indicates "will not update". Then open that file and do "data->edit links" and break the links. If the input sheet for this alternative ever changes, then this calculation sheet needs to be re-saved.

To edit input parameters for this alternative, you must go back to the ORIGINAL SiteWise input sheet and import this alternative using the "Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?" field on the "Site Info" tab. After making necessary changes to the input sheet, re-export the alternative by going to the "Generate Alternative" tab and clicking the button labeled "Click to replace an existing alternative with the same name". Update saved calculation sheets as described above.

Baseline Scenario – (Name of Remedy Component)

Repeat "Scope of Work" and SiteWise input sections for each remedy component/SiteWise tab.

Other Supporting Calculations: Baseline Scenario

Hazardous Air Pollutants

- Present calculations performed outside of SiteWise

Refined Materials Use

- Present calculations performed outside of SiteWise (this information was likely already compiled for SiteWise inputs, but some information on material weights may come from detailed SiteWise output files)

Unrefined Materials Use

- Present calculations performed outside of SiteWise (this information was likely already compiled for SiteWise inputs, but some information on material weights may come from detailed SiteWise output files)

Tons of Non-Hazardous Waste

- Present calculations performed outside of SiteWise (this information was likely already compiled for SiteWise inputs)

Tons of Hazardous Waste

- Present calculations performed outside of SiteWise (this information was likely already compiled for SiteWise inputs)

Heavy Truck Trips through Residential Areas

- Present calculations performed outside of SiteWise

Add any other calculations as appropriate.

Appendix C

Supporting Information and/or Calculations for Footprinting of Other Alternatives

Include

- **Text Description of SiteWise Input**
- **Other Supporting Calculations and/or Information**
- **Cost Spreadsheets**

Appendix C1
Assumptions for SiteWise Input and Other Calculations
[Project Name] GSR Evaluation:

Alternative 1

[Name of SiteWise directory in which related input and output files are located]

For each alternative being footprinted in SiteWise, repeat the process used for Appendix B (Baseline Scenario). In many cases, each alternative will have its own SiteWise directory with input and output files. However, for alternatives that involve relatively simple modifications to the baseline scenario (such as installation of VFDs on motors), calculations for footprint reductions performed outside of SiteWise may be presented here in lieu of SiteWise inputs and results. Regardless of the method used, include as much detailed information as possible about the basis for the calculations performed.

ATTACHMENT A-4

Example GSR Evaluation Report
(Filled in version of Template)

Also Includes the Following Electronic Attachments:

- *MS-Word File for Report Text including GSR BMP Tracking Tables*
- *MS-Excel Table for Presenting Costs*
- *MS-Excel Table for Comparing GSR Metrics/Considerations*
- *SiteWise™ Files for the Example*

Note:

This example report is available in MS-Word format, and can be modified by the user. Check-boxes in forms can be checked and un-checked by right-clicking on the checkbox, selecting "properties", and then selecting "checked" or "not checked".

EXAMPLE REPORT

GREEN AND SUSTAINABLE REMEDIATION (GSR) EVALUATION:

Acme Site at the Made-Up Depot
Town-Name, State-Name

Prepared for:

Mr. John Doe
Made-Up Depot

[Contract No. ABC123]
[Delivery Order No. 1234]

Prepared by:

ABC Consulting
Anywhere, USA

27 August 2012

CONTENTS

List of Appendices

Attachments (Electronic)

- Report File (MS-Word)
- Cost spreadsheet (MS-Excel)
- SiteWise Files

PREFACE

This report summarizes a GSR evaluation for a hypothetical project. The GSR evaluation was performed by ABC Consulting, under Contract #ABC123, Delivery Order No. 1234. The table below summarizes the personnel involved in the GSR evaluation.

Project Representatives		
Name	**Organization**	**Email**
John Doe	Made-Up Depot (Environmental Manager)	John.Doe@xyz.com
Jane Smith	ABC Consulting (Consultant)	Jane.Smith@abc.com
Joe Johnson	ABC Consulting (Consultant)	Joe.Johnson@abc.com

ACRONYMS AND ABBREVIATIONS

Add an acronym list as appropriate, not done for this example report.

1.0 INTRODUCTION

1.1 PURPOSE OF THIS GSR EVALUATION

This Green and Sustainable Remediation (GSR) evaluation pertains to the Acme Site at the Made-Up Depot in Town-Name, State-Name. The Acme Site includes a pump-and-treat (P&T) system in the Operations and Maintenance (O&M) phase. This GSR evaluation was performed by ABC Consultants as part of their ongoing contract to operate and manage the remediation activities.

According to the Department of Defense (DoD) Defense Environmental Restoration Program Manual 4715.20 (DERP Manual) dated March 2012, GSR expands on DoD's current environmental practices and employs strategies for environmental restoration that:

- Use natural resources and energy efficiently;
- Reduce negative impacts on the environment;
- Minimize or eliminate pollution at its source; and
- Reduce waste to the greatest extent possible.

The DERP manual also explains that GSR uses strategies that consider all environmental effects of remedy implementation and operation and incorporates options to maximize the overall environmental benefit of environmental response actions. The DERP Manual further states that "the DoD Component should consider and implement green and sustainable remediation opportunities in current and future remedial activities when feasible."

The objectives of this GSR evaluation include the following:

- Highlight GSR practices previously considered and implemented for the operating P&T Remedy

- Evaluate the footprint for the current P&T system (i.e., the "baseline"), consisting of quantitative GSR metrics and other qualitative GSR considerations

- Determine how key GSR metrics and/or other qualitative GSR considerations would improve or worsen for Alternative 1, which would eliminate the catalytic oxidizer (CATOX) from the treatment train for the existing P&T system and replace it with vapor phase carbon

Alternative 1 was identified as a potential cost-saving option in a recently completed Remediation System Evaluation (RSE) for Made-Up Depot.

1.2 TECHNICAL OVERVIEW: ACME SITE

1.2.1 <u>Overview of Project Location, Setting, and Contamination</u>

The Acme Site is a 500-acre government owned, contractor operated facility located in Town-Name, State-Name. The Acme Site is mostly bordered by woodlands or agricultural land. The site was originally used as farmland prior to establishment, and the major use of the adjacent land continues to be agriculture-related. Northern River is located north of the Acme Site. The Site location and surrounding features are depicted on Figure 1-1 {not included in this example}.

The Site was established in the 1930s to manufacture ammunition. Industrial operations have generated large quantities of potentially hazardous wastes and hazardous substances. Contaminants of concern at the Site include volatile (VOCs). The primary constituents of concern (COCs) are Tetrachloroethene (PCE), Trichloroethene (TCE), and/or daughter products of those compounds such as 1,2-Dichloroethene (1,2-DCE) and vinyl chloride (VC). A concentration map for VOCs is presented on Figure 1-2 {not included in this example}.

1.2.2 <u>Remedial Phase and Status</u>

The operating groundwater remedy at the Acme Site includes pump-and-treat (P&T) with air stripping and long term monitoring (LTM). Off-gas from the air stripper is treated with a catalytic oxidizer (CATOX). In addition to existing remedy components, two additional extraction wells will be installed in the near future to replace two of the older extraction wells (which will be decommissioned). The P&T system is expected to operate for another 30 years. A recently conducted RSE identified an alternative to the current P&T system that would include replacement of the CATOX used to treat air stripper off-gas with vapor phase carbon.

Active remediation components for the current remedy include the following:

- Four groundwater extraction wells, each with a 15 HP pump and a typical extraction rate of 100 gpm.

- Decommissioning and replacement of two of the groundwater extraction wells and associated piping.

- Treatment of all extracted water in the Site treatment plant via air stripping, with a combined influent flow rate of 400 gpm.

    - Water enters an equalization (EQ) tank from the extraction wells. There are no chemical additions to the water that goes to the air stripper.

    - A 25 HP pump (there are two pumps, but only one operates at a time) moves the water from the EQ tank to the packed tower air stripper, which uses a 15 HP fan.

    - From the air stripper water goes to a sump where it is transferred to the Publically Owned Treatment Works (POTW) for disposal (there are two 25 HP pumps, only one used at a time).

    - Air from the air stripper goes through a knockout tank to remove moisture, and then to a catalytic oxidizer (CATOX) unit with a 25 HP fan to draw air through. The CATOX is powered by natural gas (since the influent vapor concentrations are far too low to power the CATOX).

- Annual groundwater sampling for a projected 30 years of remedy operation.

1.3 DOCUMENTS REVIEWED AND MEETINGS CONDUCTED

The following project documents were reviewed for this evaluation:

- 2011 Annual Report
- Remediation System Evaluation (June 2012)

No special conference calls or meetings were performed for this GSR evaluation.

1.4 STRUCTURE OF THIS REPORT

This GSR evaluation report is structured as follows:

- Section 1: Introduction
- Section 2: Key GSR Findings
    - Review of GSR BMPs
    - Quantitative Footprint Analysis for Current P&T System (Baseline)
    - Quantitative Footprint Analysis for Potential Alternative to Current P&T System
    - Other Qualitative Considerations
- Section 3: GSR Recommendations

Supporting information and calculations for quantitative aspects of the evaluation are provided in appendices, and spreadsheet files for the cost discounting calculations and the SiteWise tool are attached electronically.

2.0 KEY GSR FINDINGS

2.1 REVIEW OF BEST MANAGEMENT PRACTICES (BMPs)

2.1.1 GSR BMP Tables Completed for the GSR Evaluation

The GSR BMP tables in Appendix A were used as an outline to consider and summarize previous implementation of GSR principles for the existing remedy, and to identify potential GSR opportunities not previously implemented. Table 2-1 summarizes information entered on the BMP tables in Appendix A, specifically with respect to the number of BMPs that appear to be applicable for this project, the number of BMPs that appear to be practical for this project, the number of BMPs that have been implemented prior to this GSR evaluation, and the number of BMPs that may be associated with potential cost savings for this project.

Table 2-1
Summary of BMP Applicability and Implementation from BMP Tables in Appendix A

	BMP Category								
	A. Planning	B. Characterization and/or Remedy Approach	C. Energy/Emissions Transportation	D. Energy/Emissions Equipment Use	E. Materials & Off-site Services	F. Water Resource Use	G. Waste Generation, Disposal, and Recycling	H. Land Use, Ecosystems, and Cultural Resources	I. Safety and Community
Total Number of BMPs	11	9	4	11	5	5	6	7	8
Number of Applicable BMPs	11	7	4	9	5	3	2	3	4
Number of Practical BMPs	9	6	3	3	1	0	1	0	3
Number of BMPs Implemented Prior to GSR Evaluation									
- Fully	5	4	3	1	0	0	1	0	3
- Partially	2	0	0	2	0	0	0	0	0
- Not Yet	2	2	0	0	1	0	0	0	0
Number of Practical BMPs Likely to Result in Significant Cost Savings	3	4	2	3	1	0	1	0	1

2.1.2 Key Findings Regarding GSR BMPs

An overview of key findings regarding application of the GSR BMPs to this pilot project is provided below.

- Many GSR BMPs have already considered or incorporated, and examples include (but are not limited to) the following:
  - Prepare, store, and distribute electronic documents. A digital data repository is used to store and provide access to reports.
  - Utilize teleconferences rather than meetings when feasible. Calls are conducted in place of meetings whenever possible, usually resulting in meetings only once per year.
  - Consider leaving structures no longer necessary in place. Extraction wells that are being replaced will be filled with cement and left in place.
  - Reduce the number of trips. Minor amounts of waste generated from the P&T system is consolidated with other Installation wastes so that the number of disposal trips is reduced.
  - Reduce trip lengths. Local sources for labor, materials, and waste disposal are already utilized to the extent possible.
  - Minimize drill cuttings and investigation derived waste. Drill cuttings from planned well installation will likely be spread on the surface, and low-flow sampling with dedicated bladder pumps is used (reduces purge water).
- The GSR BMP tables in Appendix A suggest several items that the overall Project Team could consider moving forward. Some examples include the following:
  - Develop a culture of GSR, which could include:
    - Incorporating a section on GSR in meetings, work plans, and reports
    - Identifying stakeholder issues and concerns regarding GSR
  - Incorporate green specifications into solicitations and contracts. Green specifications should be considered for inclusion in future O&M contracts.
  - Use appropriate remedy approach based on site conditions. It is not clear that treatment of air stripper off gas with the CATOX unit is cost-effective. A recommendation to switch from the CATOX to vapor phase carbon is included in the GSR evaluation, based on a quantitative footprint analysis conducted as part of the GSR evaluation.
  - Promote groundwater recharge and reduce demand on POTW (two separate BMPs). Treated water is currently discharged to the POTW, at a cost of approximately $100,000 per year. If this water could be feasibly recharged to groundwater, that would be beneficial with respect to promoting recharge of groundwater regionally. It would also reduce long-term load on the POTW (i.e., increase future capacity). A detailed analysis has yet to be performed, but for cost purposes assume that capital costs of up to $200,000

might be required and net savings on the order of $75,000 per year might result. This is a simple conceptual analysis at this point, and these costs would be refined during an engineering analysis regarding the feasibility of recharging the treated water. A recommendation to consider this approach is included in this GSR evaluation.

  - Consider use variable frequency drives on motors. VFDs could be installed on the pumps for the extraction wells. A cost-benefit analysis of installing VFDs would be an appropriate step moving forward (not addressed in this example report).

- The GSR BMP tables in Appendix A suggest several items that may not be practical at this time because of other project-specific constraints. Examples include the following:

  - Optimize extraction to reduce flow rates. Groundwater modeling has been used to model flow rates and optimize capture. At this point, there does not appear to be an option to further reduce pumping.

2.2 QUANTITATIVE FOOTPRINT ANALYSIS FOR CURRENT P&T SYSTEM (BASELINE SCENARIO)

2.2.1 Overview of Baseline Scenario

The P&T system as currently operated, along with the planned replacement of two extraction wells, serves as a baseline in this GSR evaluation, and involves the following components:

- Assumes 30 years of remedy operation for all components (3% discount rate)
- Installation of two replacement extraction wells in new locations and associated piping
- Decommissioning of two extraction wells being replaced
- 4 pumps (groundwater extraction wells), 15 HP each, typical extraction rate of 100 gpm
- 1 pump (transfer pump from EQ tank to air stripper; there are two pumps, but only one operates at a time), 25 HP
- 1 blower (treatment plant air stripper), 15 HP
- 1 pump (discharge pump to POTW; there are two pumps, but only one operates at a time), 25 HP
- Water usage (water extracted from the aquifer removed as a potential resource) = 400 gpm
- Water discharged to a POTW = 400 gpm
  - *SiteWise Version 2.0 allows for input of water sent to a wastewater treatment facility. The emissions calculated by SiteWise for "wastewater treatment" are likely appropriate if the water discharged to the POTW is similar to sewage. However, if the water has already been treated on-site, and does not have characteristics similar to sewage, then the emissions calculated by SiteWise for "wastewater treatment" are likely much higher than appropriate. In those cases it is likely best to not include discharge to the POTW in the SiteWise™ input. Therefore, since water at this site is treated prior to discharge and does not have characteristics of sewage, discharge to the POTW is not included in the footprint analysis.*

- 1 blower (CATOX), 25 HP
- Catalytic oxidizer with natural gas usage per year of 900 m (thousand) cubic feet per month
- Waste from treatment plant (including plastic rings from air stripper, iron oxide sludge from the bottom of that air stripper, and other waste) disposed of in an off-site landfill 50 miles from site, 1000 lbs per year
- Treatment plant operator, on-site 3 days per week from 20 miles away one-way
- Field personnel for annual sampling plus other non-routine O&M, 2 workers on-site 4 days per year
- Laboratory analysis of groundwater samples, approximate cost of $1,000 per year

Input to the SiteWise tool and other supporting calculations are described in Appendix B.

2.2.2 Summary of Quantitative Footprint Results, Baseline Scenario

Table 2-2 summarizes the quantitative footprint results for the current system over a 30 year period. Input to the SiteWise tool and other supporting calculations are described in Appendix B. The SiteWise files utilized for this portion of the analysis are supplied electronically (SiteWise directory "RA_Baseline_NoFR_1").

Table 2-2
Summary of Quantitative Footprint for Current P&T System (Baseline)

GSR Parameter	Unit	Value (30 year total)
Environmental		
Energy use	MMBtu	631,089
Global warming potential	Metric tons CO2e	54,544
Criteria air pollutant emissions	Metric tons (NOx+SOx+PM)	532
Hazardous air pollutant emissions	Lbs	0
Potable water use	1,000s of gallons	0
Other water use	1,000s of gallons	6,322,192
Refined materials use	Lbs	23,218
% of refined materials from recycled material	%	0
Unrefined materials use	Ton	26
% of unrefined materials from recycled material	%	0
Non-hazardous waste disposal	Ton	15
Hazardous waste disposal	Ton	None
% of potential waste that is recycled or re-used	%	0
Economic		
Life-cycle cost, discounted (3%)	$	10,300,221
Life-cycle cost, undiscounted	$	15,500,000
Up-front cost	$	0*
Societal		
Predicted number of project-related injuries or fatalities	Number of injuries or fatalities	0.344
One-way heavy vehicle trips through residential area	Trips	None

GSR Parameter	Unit	Value (30 year total)
Other Qualitative Considerations		
Land Transferred or Made Available for Potential Beneficial Use	See Section 2.5	
Existing Ecosystem Destruction	**	
Time Frame for Land Reuse	**	
Flexibility and Breadth of Options for Site Reuse	**	
Aesthetics	**	
Use of Renewable Energy	See Section 2.5	

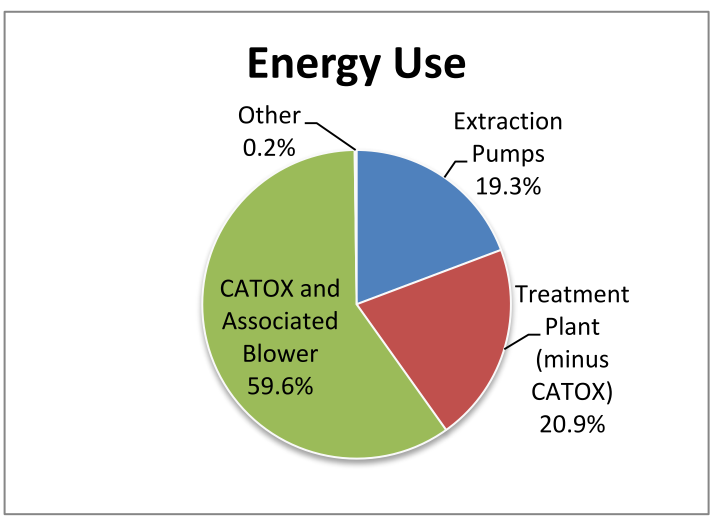
**This GSR evaluation assumes all remedy components for the current system are already in place. Therefore, there is no up-front cost.*

***No qualitative considerations regarding these items were identified.*

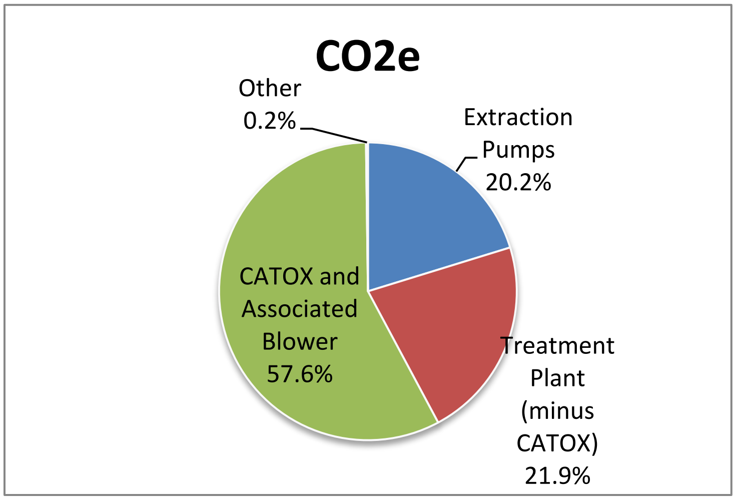
2.2.3 Key Findings from Quantitative Footprint Analysis, Baseline Scenario

Observations and finding based on the quantitative footprinting results from SiteWise include the following:

- The primary contributors to total energy use for the current P&T systems are illustrated on the graphic below and are summarized as follows:
  - The CATOX unit and associated blower, used for treatment of air after the air stripper, use 59.6% of the total energy (376,324 MMBtu). Most of that (325,667 MMBtus) is for natural gas to run the CATOX, and the remainder (50,657 MMBtus) is for the blower electricity.
  - The rest of the treatment equipment other than the CATOX equipment (i.e., blowers and transfer pumps) uses 20.9% of the total energy (131,709 MMBtu). Most of that (101,315 MMBtus) is for the transfer pumps within the treatment building, while the rest is for the air stripper blower (30,394).
  - The extraction pumps for the wells use 19.3% of the total energy (121,578MMBtu).
  - The remaining energy use is relatively minor (0.2%, or 1,478 MMBtu) and is comprised of personnel and equipment transportation, materials use, fueled equipment use, waste disposal, and laboratory analysis.



- The contributors to GHG emissions (measured in CO2e) are distributed in a similar manner as the energy use, as illustrated below:



- Most of the NOx emissions (~88%) are associated with the burning of the natural gas associated with the CATOX. Nearly all of the remainder (~12%) is associated with extraction and transfer pumps and blowers, with a very minor amount associated with other remedial activities.

- Most of the SOx emissions (~73%) are associated with extraction and transfer pumps. Nearly all of the remainder (~27%) is associated with blowers, with a very minor amount associated with other remedial activities.

- Nearly all of the PM emissions (over 99%) are associated with the burning of the natural gas associated with the CATOX, with a very minor amount associated with other remedial activities.

- The total number of injuries/fatalities calculated by SiteWise is 0.344 over the course of the remedy, and approximately 95% of this risk (~0.33 injuries or fatalities) is associated with the system operator's transport to and from the site and time spent on-site.

- With respect to materials, the RSE identified minor use of air stripper media, CATOX calibration gases, and maintenance parts and supplies for pumps, pipes, etc., but quantities were not identified.

- Water usage (non-potable water extracted from the aquifer that no longer is available for use as a resource) is primarily extracted groundwater at the site of 400 gpm (6,307,200,000 gallons over 30 years). A relatively small additional amount of water (14,991,700 gallons over 30 years, or just under 1 gpm) is consumed off-site for the generation of electricity for the P&T operations.

2.3 QUANTITATIVE FOOTPRINT ANALYSIS FOR ALTERNATIVE 1 (REPLACE CATOX WITH VAPOR PHASE CARBON)

2.3.1 Overview of Alternative 1

In this alternative, treatment of air emissions via CATOX is replaced by treatment via vapor phase carbon. To operate this CATOX requires a 25 HP blower and the use of approximately 900 mcf/month of natural gas, which negatively impacts the environment. The air stripper has influent VOC concentration of approximately 350 ug/l and a flow rate of approximately 400 gpm. This translates to an influent VOC mass of approximately 613 pounds per year (i.e., without treatment via CATOX), which would require approximately 10,000 lbs/yr of activated carbon. Quantitative footprinting was performed for this alternative to determine whether this replacement would improve key footprints for the remedy.

System modifications for this alternative include:

- Elimination of the natural gas usage for the CATOX
- Elimination of the blower associated with the CATOX
- Use of 10,000 lbs of vapor phase carbon per year for 30 years (includes footprint of the carbon and footprint of the transportation associated with the carbon)

There should be minimal capital cost to implement this change (besides purchase of a vapor phase carbon vessel estimated at $10,000) and potential net cost savings of approximately $65,800/yr based on the following:

- Annual savings of approximately $64,800 for natural gas
    - 900 mcf/month * 12 months/yr * ~$6/mcf = ~ $64,800/yr
- Annual savings of approximately $13,000 for elimination of the 25 HP blower assuming 0.85 load and 0.85 efficiency, a conversion factor of 0.746 kW/HP, and an estimated electricity rate of $0.07/kWh
    - 25 HP * 0.85/0.85 * 0.746 * 24hrs/day * 365 days/yr * $0.08/kWh = ~$13,000/yr
- Annual savings of approximately $8,000 for O&M of the CATOX
- Annual cost of approximately $20,000 for GAC
    - 10,000 lbs GAC per year * $2/lb = ~$20,000/yr

Input to the SiteWise tool and other supporting calculations are described in Appendix C1.

2.3.2 Summary of Quantitative Footprint Results for Alternative 1 versus Baseline

Table 2-3 compares key quantitative footprint results for this proposed alternative versus the current P&T system that serves as the baseline over a 30 year period. Input to the SiteWise tool and other supporting calculations are described in Appendix C1. The SiteWise files utilized for this portion of the analysis are supplied electronically ("RA_Alternative 1_NoFR_1").

Table 2-3
Summary of Key Quantitative Footprint for Baseline versus Alternative 1
(Replace CATOX with Vapor Phase Carbon)

Legend:

Green	Alternative 1 improved over Baseline
Yellow	Alternative 1 generally Similar to Baseline
Red	Alternative 1 worse than Baseline

GSR Parameter	Unit	Baseline (30 year total)	Alternative 1 (30 year total)
Environmental			
Energy use	MMBtu	631,089	257,785
Global warming potential	Metric tons CO2e	54,544	23,406
Criteria air pollutant emissions	Metric tons (NOx+SOx+PM)	532	117
Hazardous air pollutant emissions	Lbs	0	0
Other water use	1,000s of gallons	6,322,192	6,319,693
Refined materials use	Lbs	23,218	328,718
% of refined materials from recycled material	%	0%	82%
Non-hazardous waste disposal	Ton	15	15
% of potential waste that is recycled or re-used	%	0%	91%
Economic			
Life-cycle cost, discounted (3%)	$	10,300,221	8,954,712
Life-cycle cost, undiscounted	$	15,500,000	13,470,200
Up-front cost	$	0	10,000
Annual cost change (negative for savings)	$/yr	0	-65,800
Societal			
Predicted number of project-related injuries or fatalities	Number of injuries or fatalities	0.344	0.346

2.3.3 Primary Footprints That Would Improve for Alternative 1

The following key footprints would improve in this alternative versus the baseline:

- Total energy use would decline by approximately 373,304 MMBtu (59%) primarily due to reduction of the natural gas usage for the CATOX

- GHG emissions would decline by approximately 31,138 metric tons of CO2e (57%) primarily due to reduction of the natural gas usage for the CATOX

- Criteria air pollutant emissions would decline by approximately 415 metric tons (78%) primarily due to reduction of the natural gas usage for the CATOX

- Water use would decline slightly by approximately 2,499 thousand gallons (0.04%) primarily due to reduction of electricity usage for the blower associated with the CATOX

- The percentages of refined materials from recycled material and potential waste that is recycled improve significantly, but this is only a result of the increased materials use resulting from the addition of regenerated GAC

- Annual cost would decrease by approximately $65,800 per year, and life-cycle costs (discount rate of 3%) over 30 years would decrease by approximately $1.35 million.

2.3.4 Primary Footprints That Would Worsen for Alternative 1

The following key footprints worsen in this alternative versus the baseline:

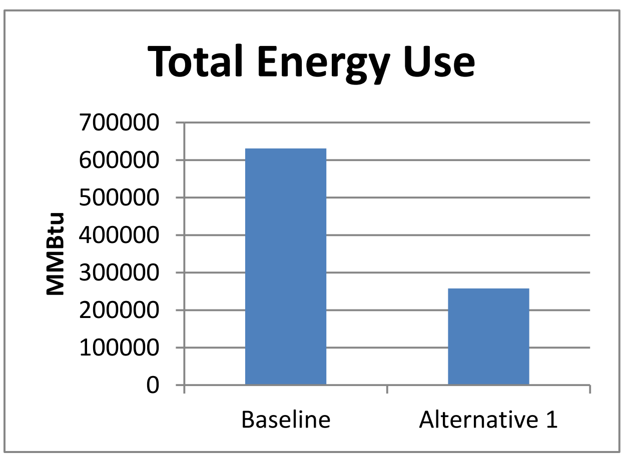
- Refined materials use would increase by 305,500 lbs (1316%) primarily due to the addition of activated carbon.

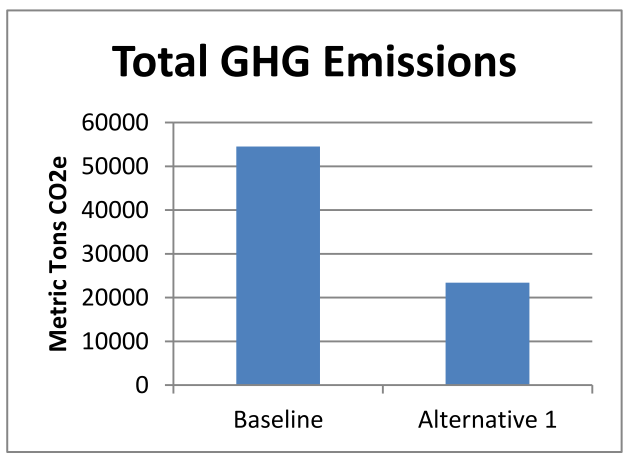
- Up-front capital cost of $10,000 (very minor) would be required for the vapor carbon vessel

- There is a very slight increase in accident risk due to increased transport associated with the vapor carbon.

2.4 COMPARISON OF ENERGY USE AND CO2E BY ALTERNATIVE

The charts below compare energy use and CO2e by alternative.





2.5 OTHER QUALITATIVE CONSIDERATIONS

Although there are clear benefits that could result from the implementation of the above alternative (in terms of cost as well as other GSR metrics), there may be constraints to implementing alternatives to the current P&T systems. These constraints may be associated with contracting or regulatory issues associated with changes to the remedy. This GSR evaluation provides valuable information regarding potential benefits (e.g., GSR metrics including cost) that may be realized if such constraints can be addressed.

Very little renewable energy is used for this remedy. No on-site renewable energy generation was noted, and eGRID (http://cfpub.epa.gov/egridweb/) indicates that for this region of the country only 0.76% of the electricity is from renewable sources. Since not all of the energy use on this site is from electricity, the percentage would be even smaller. Thus, if renewable energy was a possibility for a portion of this remedy, emissions footprints would improve accordingly.

3.0 GSR RECOMMENDATIONS

GSR recommendations are summarized in the form of tracking tables, as follows:

Table Number	Recommendation
3-1	3.1 - Replace CATOX with vapor phase carbon
3-2	3.2 - Consider potential to recharge treated water to groundwater
3-3	3.3 - Evaluate VFDs for pump and blower motors
3-4	3.4 - Other general recommendations o Develop a culture of GSR, which could include: ▪ Incorporating a section on GSR in meetings, work plans, and reports ▪ Identifying stakeholder issues and concerns regarding GSR o Incorporate green specifications into solicitations and contracts. Green specifications should be considered for inclusion in future O&M contracts.

The tracking table format allows the implementation status of the recommendation to be updated as the project progresses.

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Table 3-1
Tracking Table for Recommendation 3.1

<table>
<tr><td colspan="2">Recommendation:

3.1 - Replace CATOX with vapor phase carbon</td><td>Current Date:
8/27/12

Date of Original Recommendation:
8/27/12</td></tr>
<tr><td colspan="3">Basis for Recommendation (Include discussion of cost impacts and value if appropriate):

No information was identified stating that treatment of emissions via CTOX is required. To operate this CATOX requires a 25 HP blower and the use of approximately 900 mcf/month of natural gas, which negatively impacts the environment. To switch to vapor phase carbon should only require $10,000 in capital costs, with potential cost savings of approximately $65,800/yr.

• *Total energy use would decline by approximately 373,304 MMBtu (59%)*
• *GHG emissions would decline by approximately 31,138 metric tons of CO2e (57%)*
• *Criteria pollutants would decline by approximately 415 metric tons (78%)*

These improvements are likely more important to stakeholders than the increase in materials (primarily for vapor carbon) associated with this change.</td></tr>
<tr><td colspan="3">Resources Conserved:
☐ Hazardous air pollutants ☒ GHG emissions (CO2e) ☒ Energy ☒ Water ☐ Waste
☒ Criteria pollutants ☐ Safety/Community ☐ Materials ☐ Land-use</td></tr>
<tr><td>Qualitative Net Cost Impact Over 5 Years, No Discounting

☐ Cost Increase ☒ Cost Savings
☐ Cost Neutral ☐ N/A</td><td colspan="2">☐ Recommended action otherwise required?
If checked, required by:</td></tr>
<tr><td colspan="3">Level of Up-Front Investment Included in 5 Year Cost Impact:
☐ Negligible ☒ < $10,000 ☐ $10,001 - $50,000
☐ $50,001 - $100,000 ☐ $100,001 - $500,000 ☐ > $500,000</td></tr>
<tr><td colspan="3">Attachment(s) to report with footprint assumptions and calculations:

See Section 2.3 and Appendix C-1</td></tr>
<tr><td>Implementation Status:

☐ Fully
☐ Partially
☒ Not Yet
☐ Not Planned</td><td colspan="2">Explanation of Status:

This is a new recommendation for the Project Team to consider moving forward.</td></tr>
</table>

Table 3-2
Tracking Table for Recommendation 3.2

<table>
<tr><td colspan="2" rowspan="2">Recommendation:

3.2 - Consider potential to recharge treated water to groundwater</td><td>Current Date:
8/27/12</td></tr>
<tr><td>Date of Original Recommendation:
8/27/12</td></tr>
<tr><td colspan="3">Basis for Recommendation (Include discussion of cost impacts and value if appropriate):

Treated water is currently discharged to the POTW, at a cost of approximately $100,000 per year. If this water could be feasibly recharged to groundwater, that would be beneficial with respect to promoting recharge of groundwater regionally. It would also reduce long-term load on the POTW (i.e., increase future capacity). A detailed analysis has yet to be performed, but for cost purposes assume that capital costs of up to $200,000 might be required and net savings on the order of $75,000 per year might result. This is a simple conceptual analysis at this point, and these costs would be refined during an engineering analysis regarding the feasibility of recharging the treated water.</td></tr>
<tr><td colspan="3">Resources Conserved:
☐ Hazardous air pollutants ☐ GHG emissions (CO2e) ☐ Energy ☒ Water ☐ Waste
☐ Criteria pollutants ☐ Safety/Community ☐ Materials ☐ Land-use</td></tr>
<tr><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting

☐ Cost Increase ☒ Cost Savings
☐ Cost Neutral ☐ N/A</td><td>☐ Recommended action otherwise required?
If checked, required by:</td></tr>
<tr><td colspan="3">Level of Up-Front Investment Included in 5 Year Cost Impact:
☐ Negligible ☐ < $10,000 ☐ $10,001 - $50,000
☐ $50,001 - $100,000 ☒ $100,001 - $500,000 ☐ > $500,000</td></tr>
<tr><td colspan="3">Attachment(s) to report with footprint assumptions and calculations:

Qualitative at this point, not yet quantified.</td></tr>
<tr><td>Implementation Status:

☐ Fully
☐ Partially
☒ Not Yet
☐ Not Planned</td><td colspan="2">Explanation of Status:

This is a new recommendation for the Project Team to consider moving forward.</td></tr>
</table>

Table 3-3
Tracking Table for Recommendation 3.3

<table>
<tr><td colspan="2" rowspan="2">Recommendation:

3.3 - Evaluate VFDs for pump and blower motors</td><td>Current Date:
8/27/12</td></tr>
<tr><td>Date of Original Recommendation:
8/27/12</td></tr>
<tr><td colspan="3">Basis for Recommendation (Include discussion of cost impacts and value if appropriate):

Some of the motors currently utilized for pumps and/or blowers could potentially be switched to variable frequency drive (VFD) motors. This is beneficial for motors that are oversized and/or throttled back by valves. This would involve a capital cost, which would be made up over time from reduced energy usage. A cost-benefit analysis of installing VFDs would be an appropriate step moving forward, after which cost savings and level of up-front investment can be more accurately determined. For now, assume an approximate 5-year payback period. Total of-up-front investment not yet estimated.</td></tr>
<tr><td colspan="3">Resources Conserved:
☐ Hazardous air pollutants ☒ GHG emissions (CO2e) ☒ Energy ☒ Water ☐ Waste
☒ Criteria pollutants ☐ Safety/Community ☐ Materials ☐ Land-use</td></tr>
<tr><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
☐ Cost Increase ☐ Cost Savings
☒ Cost Neutral ☐ N/A</td><td>☐ Recommended action otherwise required?
If checked, required by:</td></tr>
<tr><td colspan="3">Level of Up-Front Investment Included in 5 Year Cost Impact:
☐ Negligible ☐ < $10,000 ☐ $10,001 - $50,000
☐ $50,001 - $100,000 ☐ $100,001 - $500,000 ☐ > $500,000</td></tr>
<tr><td colspan="3">Attachment(s) to report with footprint assumptions and calculations:

Qualitative at this point, not yet quantified.</td></tr>
<tr><td>Implementation Status:

☐ Fully
☐ Partially
☒ Not Yet
☐ Not Planned</td><td colspan="2">Explanation of Status:

This is a new recommendation for the Project Team to consider moving forward. It was not evaluated quantitatively as part of this example.</td></tr>
</table>

Table 3-4
Tracking Table for Recommendation 3.4

<table>
<tr><td colspan="2">Recommendation:

3.4 - Other general recommendations

• Develop a culture of GSR, which could include:
   o Incorporating a section on GSR in meetings, work plans, and reports
   o Identifying stakeholder issues and concerns regarding GSR
• Incorporate green specifications into solicitations and contracts. Green specifications should be considered for inclusion in future O&M contracts.</td><td>Current Date:
8/27/12

Date of Original Recommendation:
8/27/12</td></tr>
<tr><td colspan="3">Basis for Recommendation (Include discussion of cost impacts and value if appropriate):

Noted as potential areas of improvement during evaluation of GSR BMPs. No specific cost or cost savings is identified, but implementation costs are likely negligible and generally incorporating GSR consideration leads to conservation of resources and related cost savings.</td></tr>
<tr><td colspan="3">Resources Conserved:
☒ Hazardous air pollutants ☒ GHG emissions (CO2e) ☒ Energy ☒ Water ☒ Waste
☒ Criteria pollutants ☒ Safety/Community ☒ Materials ☐ Land-use</td></tr>
<tr><td>Qualitative Net Cost Impact Over 5 Years, No Discounting

☐ Cost Increase ☐ Cost Savings
☐ Cost Neutral ☐ N/A</td><td colspan="2">☐ Recommended action otherwise required?
If checked, required by:</td></tr>
<tr><td colspan="3">Level of Up-Front Investment Included in 5 Year Cost Impact:
☒ Negligible ☐ < $10,000 ☐ $10,001 - $50,000
☐ $50,001 - $100,000 ☐ $100,001 - $500,000 ☐ > $500,000</td></tr>
<tr><td colspan="3">Attachment(s) to report with footprint assumptions and calculations:

Qualitative at this point, not yet quantified.</td></tr>
<tr><td>Implementation Status:

☐ Fully
☒ Partially
☐ Not Yet
☐ Not Planned</td><td colspan="2">Explanation of Status:

This is a new recommendation for the Project Team to consider moving forward. Some of these items have partially been implemented since the initiation of the GSR evaluation (e.g., plan to include GSR section in next year’s annual report).</td></tr>
</table>

FIGURES

{Insert Figures from separate Word or PDF File}

none included for this example report

APPENDIX A

GSR Best Management Practice (BMP) Tables

Check-boxes in forms can be checked and un-checked by right-clicking on the checkbox, selecting “properties”, and then selecting “checked” or “not checked”.

BMP Category A: Planning

BMP A-1: Develop a culture of GSR within the Project Team and encourage GSR ideas from project staff and review similar projects from other sites for possible transfer/adoption of GSR ideas		**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☒ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *There has been informal consideration of GSR-related concepts by the Project Team, but increased visibility of GSR awareness and concepts could be achieved in site reports, meetings with stakeholders, etc.*		

BMP A-2: Incorporate a section on GSR in project meetings, work plans, and reports		**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☒ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☒ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *There is a plan to include a GSR Section in annual reports moving foward*		

BMP Category A: Planning

BMP A-3: Identify and periodically update a list of key stakeholders and their concerns with respect to GSR considerations	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☒ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Regulators are interested in GSR, but they have not yet been engaged in a discussion on GSR, so their specific concerns and interests regarding GSR are not clearly established. The Project Team should document specific concerns of various stakeholders regarding GSR, so that they can be considered and addressed (when feasible) in each phase of the remedial process.*	

BMP A-4: Schedule activities for appropriate seasons and/or time of day to reduce delays caused by weather conditions and fuel needed for heating or cooling Examples: - Work at night in summer to avoid heat stress - Perform field activities in summer to take advantage of longer daylight	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Well and piping installation is planned for late spring or early summer, since that time of year is generally preferable for outdoor work (fewer issues with heating or cooling needs).*	

BMP A-5: Prepare, store, and distribute documents electronically		**Date: 8/27/12**
		☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☒ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *A digital data repository is used to store and provide access to reports.*		

BMP A-6: Utilize teleconferences rather than meetings when feasible		**Date: 8/27/12**
		☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Calls are conducted in place of meetings whenever possible, usually resulting in meetings only once per year (or more as needed).*		

BMP Category A: Planning

BMP A-7: Incorporate green specifications into solicitations and contracts Examples: - Follow pertinent green procurement policies - Select hotel chains with "green" policies - Select laboratories that utilize renewable energy	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☒ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *This has not yet been implemented, but will be considered. Green specifications could be incorporated into future O&M contracts.*	

BMP A-8: Integrate schedules to allow for resource sharing and fewer days of field mobilization	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *The staff at the treatment building also work on other parts of the site.*	

BMP Category A: Planning

BMP A-9: Tailor the remedy cleanup goals such that they are appropriate for anticipated end-use of the property, rather than assuming a more conservative exposure scenario with more stringent cleanup goals		**Date: 8/27/12** ☒ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Current remedy has little or no impact on land use. However, if groundwater recharge of treated water is considered in the future, recharge basins could impact future land use.*		

BMP A-10: Conduct thorough review of project documents and historical records to minimize required scope of investigation Examples: - IRP projects: determine if there are previous aquifer tests that can be used for groundwater modeling rather than conducting new aquifer tests - MMRP projects: perform careful review of historic documents, aerial photographs, and other existing information to reduce the footprint of land that needs to be disturbed for thorough investigation and remediation - MMRP projects: use IRP sampling data to supplement and enhance the MMRP field program (if available)		**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Historical information going back decades has been incorporated into the CSM.*		

BMP Category A: Planning

<table>
<tr><td colspan="2">BMP A-11: Use language in work plans, proposed plans, and decision documents that maximizes flexibility to allow GSR recommendations to be implemented
Examples:
- Designation of a “suitable growth media” for a landfill cap cover material rather than “top soil”
- Allow for “treatment technologies that achieve adequate levels of treatment” rather than specifying only one treatment technology</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

This type of language was not included in the original documents, but could be considered in future site-related documents.</td></tr>
</table>

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td colspan="2">BMP B-1: Develop and routinely update a conceptual site model (CSM) to use as a basis for making remedial process decisions</td><td>Date: 8/27/12
☒ Applicable
☒ Evaluated
☒ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☒ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

A great deal of effort has already been made in updating the CSM as a basis for remedy decisions.</td></tr>
</table>

<table>
<tr><td colspan="2">BMP B-2: Perform regular optimization evaluations to improve efficiency of current or planned actions and/or develop alternative remedial approaches that might shorten remedy duration or otherwise improve the net environmental benefit of the remedy, including use of any methodologies, such as TRIAD (www.triadcentral.org), systematic planning (technical project planning), value engineering studies, and remedial system evaluations, expected to optimize the planning and/or execution of the project</td><td>Date: 8/27/12
☒ Applicable
☒ Evaluated
☒ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☒ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☒ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

RSE recently performed, gives recommendations for system optimization and remedial approaches. Recommendations are currently being considered by the Project Team, including the potential switch from the CATOX to vapor phase carbon for treating air stripper off-gas.</td></tr>
</table>

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td>BMP B-3: Use appropriate characterization or remedy approach based on site conditions
Examples:
- Consider in-situ and passive remedy options that offer adequate protectiveness
- Consider in-situ bioremediation if conditions are already anaerobic and constituents are conducive to reductive dechlorination
- Compare source removal versus in-situ and ex-situ remedial options
- Consider different technologies for impacted areas with higher and lower concentrations
- Use realistic times to remedy closeout (i.e., estimations through modeling) rather than assumed remedy timeframes (e.g., 30 years, which is often used for evaluation of FS alternatives)
- MMRP projects: evaluate man-portable DGM instruments versus vehicle-towed array (VTA) instruments and inclusion of detector-aided reconnaissance (DAR)
- MMRP projects: evaluate best alternative for destruction of munitions (e.g., blow in place versus consolidated shot versus controlled detonation chambers</td><td colspan="2">Date: 8/27/12

☒ Applicable
☒ Evaluated
☒ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☒ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
☐ Significant Cost Increase ☒ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Not clear that CATOX is needed at treatment building. Replacing the CATOX with activated carbon treatment may be beneficial.</td></tr>
</table>

<table>
<tr><td>BMP B-4: Establish decision points to trigger a change from one technology to another or from one remedy alternative to another
Examples:
- Change vapor treatment from thermal oxidation to granular activated carbon (GAC) media based on flow rates and concentrations
- Remove a treatment polishing step if influent to that step already meets discharge criteria
- Move to Monitored Natural Attenuation (MNA) if specific concentration thresholds in groundwater are met</td><td colspan="2">Date: 8/27/12

☒ Applicable
☒ Evaluated
☒ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☒ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting
(discuss in notes if necessary):
☐ Significant Cost Increase ☒ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Currently, there is no clear decision framework for terminating treatment components (such as CATOX).</td></tr>
</table>

BMP Category B: Characterization and/or Remedy Approach

BMP B-5: Focus sampling efforts to meet objectives of the specific remedial phase (e.g., sampling during O&M should be focused on evaluating remedy performance and not on thorough plume characterization) Examples: - Eliminate sampling parameters as appropriate - Reduce sampling frequency as appropriate - Reduce sample locations as appropriate - Enhance monitoring program as appropriate - MMRP projects: consider Incremental Sampling Methodology (ISM) versus discrete sampling for MC characterization	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Sampling frequency for VOC monitoring at treatment building has recently been reduced due to match reporting requirements.*	

BMP B-6: Consider real-time measurements and dynamic work plans to reduce mobilizations and improve effectiveness of investigation efforts Examples: - Field test kits (e.g., test kits for sulfate) - Field screening instruments (e.g., x-ray fluorescence for lead or photoionization detectors for volatile organics) - Drive point sensor technologies (e.g., membrane interface probe or "MIP") - Visual staining or odor - Establish excavation extent based on real-time data collected as excavation proceeds and use GPS to accurately delineate excavation areas - MMRP projects: use GPS and/or the same equipment that was used for detection to confirm anomaly signatures prior to excavating - MMRP projects: consider incorporating field screening methods (e.g., X-ray fluorescence, EXPRAY and explosives test kits, as appropriate or applicable) into the field program to refine sampling locations and reduce the quantities of samples submitted for off-site laboratory analysis - MMRP projects: consider use of advanced electromagnetic sensors (e.g., MetalMapper) for better subsurface item identification to reduce digging requirements	**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *This BMP is generally not applicable for this project.*	

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td colspan="2">BMP B-7: Consider use of existing site structures/infrastructure or mobilization of temporary structures versus new construction
Examples:
- Buildings (e.g., for treatment building or field office)
- Concrete slabs or foundations
- Wells
- Existing excavations for storm water control</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

The needed structures for this remedy are already in place, and no additional needs are anticipated at present.</td></tr>
</table>

<table>
<tr><td colspan="2">BMP B-8: Establish project-specific decision points to limit extent of remediation
Examples:
- Project-specific cleanup levels based on a site-specific risk assessment (coordinated with risk assessment experts) rather than generic cleanup levels, if it results in lower footprints for key parameters and is acceptable to all stakeholders
- MMRP projects: dig stopping rules and anomaly prioritization/detection criteria to minimize false positives</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Groundwater is being remediated to MCLs. There is currently no plan to establish higher risk-based cleanup levels.</td></tr>
</table>

BMP Category B: Characterization and/or Remedy Approach

<table>
<tr><td colspan="2">BMP B-9: Consider leaving in place structures whose removal is not necessary (i.e., foundations, underground pillars, etc.)</td><td>Date: 8/27/12
☒ Applicable
☒ Evaluated
☒ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☒ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☒ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Extraction wells that are being replaced will be filled with cement and left in place.</td></tr>
</table>

BMP Category C: Energy/Emissions – Transportation

BMP C-1: Reduce the number of trips for personnel	Date: 8/27/12
Examples: - Encourage carpooling - Use telemetry systems and webcams to remotely transmit data directly to project offices to avoid trips	☒ Applicable ☒ Evaluated ☒ Practical

Implemented?	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

Carpooling is encouraged. Efforts are made to reduce the number of trips for field work and to couple jobs when possible.

BMP C-2: Reduce the number of trips and/or volume for transported materials, equipment, or waste	Date: 8/27/12
Examples: - Transfer full loads by consolidating shipments from vendors and/or shipments to disposal sites (also share shipments with neighbors if feasible) - Purchase more concentrated chemicals to reduce transportation weight and/or volume	☒ Applicable ☒ Evaluated ☒ Practical

Implemented?	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

Waste from P&T system is consolidated with other Installation wastes. Well construction materials are being delivered in one shipment.

BMP Category C: Energy/Emissions – Transportation

BMP C-3: Reduce trip lengths

Examples:

- Dispose of waste at closest appropriate facility
- Purchase materials, equipment, and services from local vendors
- Use locally produced supplies
- Select most efficient transportation route

Date: 8/27/12

☒ Applicable

☒ Evaluated

☒ Practical

Implemented?
("N/A" if "Practical" not checked)
☒ Fully ☐ Partially ☐ Not Yet ☐ N/A

Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☒ Generally Cost Neutral ☐ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

Local sources for labor, materials, and waste disposal are already utilized to the extent possible.

BMP C-4: Use alternate fuels or other options for transportation when possible

Examples:

- Compressed natural gas
- Biodiesel blends
- Ethanol blends
- Hybrid and/or electric
- Rail lines versus trucks
- Use a fuel efficient passenger car rather than a pickup truck if task allows

Date: 8/27/12

☒ Applicable

☐ Evaluated

☐ Practical

Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A

Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is potentially applicable, but has not yet been fully evaluated.

BMP Category D: Energy/Emissions – Equipment Use

BMP D-1: Consider and implement approaches to minimize engine idle times	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *During well drilling, split spoon samples will only be taken in the screen interval, which reduces drilling idle time.*	

BMP D-2: Ensure peak operating efficiency of equipment to reduce energy use and emissions Examples: - Perform preventative maintenance and operate equipment per manufacturer instructions - Perform retrofits involving low-maintenance multi-stage filters for cleaner engine exhaust - Use synthetic oil to extend operating life (and reduce waste oil) - Purchase newer equipment with reduced emissions	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☒ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *The RSE identified the stripper blower is operating efficiently. However, there are possible efficiencies that can be achieved by putting VFDs on pumps and eliminating the CATOX in favor of vapor phase carbon. In particular, the CATOX is inefficient due to low influent concentrations of groundwater.*	

BMP Category D: Energy/Emissions – Equipment Use

BMP D-3: Use alternate fuel options for equipment when possible Examples: - Compressed natural gas - Biodiesel - Ethanol blends - Ultra-low sulfur diesel, wherever available (and as required by engines with PM traps) - Recycled oil (ensure compliance with operating requirements/warranties)	**Date: 8/27/12** ☒ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *This BMP is potentially applicable, but has not yet been fully evaluated.*	

BMP D-4: Select appropriate equipment and/or power source for the job Examples: - Avoid using large excavators for small earthmoving projects - Use direct push methods when possible to reduce drilling duration - Compare potential use of electricity versus battery versus generator	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☒ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *The CATOX unit is not the right equipment for the job, and this GSR evaluation represents a step towards implementing a solution (switch to vapor carbon).*	

BMP Category D: Energy/Emissions – Equipment Use

BMP D-5: Use variable frequency drives on motors (e.g., pumps, blowers), or replace oversized motors with properly sized motors	**Date: 8/27/12** ☒ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

Some of the motors currently utilized for pumps and/or blowers could potentially be switched to variable frequency drive (VFD) motors. This is beneficial for motors that are oversized and/or throttled back by valves. This would involve a capital cost, which would be made up over time from reduced energy usage. A cost-benefit analysis of installing VFDs would be an appropriate step moving forward, after which cost savings and level of up-front investment can be more accurately determined. For now, assume an approximate 5-year payback period. Total of-up-front investment not yet estimated.

BMP D-6: Identify options for generating renewable energy for direct use in the remedy and/or for alternate use at or near the project site Examples: - Solar, wind, landfill gas (microturbines), combined heat and power, geothermal heat exchange - Applications for remote areas such as solar pumps or solar flares (if demand is not continuous, the need for a battery backup may be avoided) - Generate power or heat exchange from water to be discharged	**Date: 8/27/12** ☒ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☒ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP has not yet been evaluated, but some of the land on this installation could be used for growing biomass.

If renewable energy was a possibility for a portion of this remedy, emissions footprints would improve accordingly. However, it would likely result in increased costs.

BMP Category D: Energy/Emissions – Equipment Use

<table>
<tr><td colspan="2">BMP D-7: Consider purchase of renewable energy certificates (RECs) to offset emissions from the remedial activities (note that a Memorandum titled Department of the Army Policy for Renewable Energy Credits, dated 24 May 2012, states that “the Army shall not purchase RECs solely to meet Federal renewable energy goals,” but it is possible that Project Teams might in some cases consider the purchase of RECs to address concerns of one or more stakeholders at a specific site)</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☒ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

The purchase of RECs could offset footprints resulting from electricity used for the project, but this would not be done under the current contract due to increased cost (i.e., not considered practical).</td></tr>
</table>

<table>
<tr><td colspan="2">BMP D-8: Design/modify housing required for above-ground treatment components for energy-efficiency
Examples:
- Passive lighting
- Compact fluorescent lighting (CFL) or light-emitting diode (LED) lighting
- Timers and/or motion control sensors for lighting
- Shading
- Minimize heating and cooling needs (building size, insulation, etc.)</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

While the building is insulated, no other known modifications for energy efficiency have been performed to date. Such modifications should be evaluated with regards to potential reductions in energy requirements and cost savings (taking into account the payback period required to cover any capital costs).</td></tr>
</table>

BMP Category D: Energy/Emissions – Equipment Use

BMP D-9: For remedies that involve groundwater or air extraction, optimize extraction to reduce flow rates (potentially beneficial with respect to energy use, materials usage, water resources, waste disposal, etc.)	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Groundwater modeling has been used to model flow rates and optimize capture. At this point, there does not appear to be an option to reduce pumping.*	

BMP D-10: Consider pulsing for extraction and/or injection of water or air to maximize mass removal per unit of time or energy, by extracting higher concentrations	**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *This BMP is not applicable for this project, since the focus of the remedy is containment rather than mass removal.*	

BMP Category D: Energy/Emissions – Equipment Use

<table>
<tr><td colspan="2">BMP D-11: Run electrical equipment during times of lower electric demand if possible (this does not reduce energy use but could lower cost and also can lower stress on the energy grid during periods of peak demand)</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is not applicable for this project, since the system must be kept running continuously.</td></tr>
</table>

BMP Category E: Materials & Off-Site Services

BMP E-1: Use materials that are made from recycled materials Examples: - Steel - Asphalt - Plastics - Concrete	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? (“N/A” if “Practical” not checked) ☐ Fully ☐ Partially ☒ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Very few materials are used for the P&T system; as a result, this BMP has not been evaluated extensively.* *If Alternative 1 is implemented, regenerated VGAC could be used, which is considered 90% recycled material. Use of regenerated VGAC likely saves money over virgin VGAC.*	

BMP E-2: Optimize the amount of materials used Examples: - Experiment with different material amounts/doses - Consider alternate materials - Use timers or feedback loops and process controls for dosing - MMRP projects: minimize quantities of donor explosives for MEC destruction	**Date: 8/27/12** ☒ Applicable ☐ Evaluated ☐ Practical
Implemented? (“N/A” if “Practical” not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Very few materials are used for the P&T system; as a result, this BMP has not been evaluated extensively.*	

BMP Category E: Materials & Off-Site Services

<table>
<tr><td colspan="2">BMP E-3: Utilize less refined materials when feasible
Examples:
- Limestone instead of sodium hydroxide for pH adjustment
- Native fill instead of select fill</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):
Very few materials are used for the P&T system; as a result, this BMP has not been evaluated extensively.</td></tr>
</table>

<table>
<tr><td colspan="2">BMP E-4: Identify opportunities for using by-products or “waste” materials from local sources in place of refined chemicals or materials
Examples:
- Cheese whey, molasses, compost, or off-spec food products for inducing anaerobic conditions
- Crushed concrete for use as fill
- Concrete from coal combustion byproducts</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):
Very few materials are used for the P&T system; as a result, this BMP has not been evaluated extensively.</td></tr>
</table>

BMP Category E: Materials & Off-Site Services

<table>
<tr><td colspan="2">BMP E-5: Reduce demand on Publicly Owned Treatment Works (POTWs)
Examples:
- Discharge treated water to groundwater or to surface water rather than POTW
- Minimize amount of water requiring treatment</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☒ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Treated water is currently discharged to the POTW, at a cost of approximately $100,000 per year. If this water could be feasibly recharged to groundwater, that would be beneficial with respect to promoting recharge of groundwater regionally. It would also reduce long-term load on the POTW (i.e., increase future capacity). A detailed analysis has yet to be performed, but for cost purposes assume that capital costs of up to $200,000 might be required and net savings on the order of $75,000 per year might result. This is a simple conceptual analysis at this point, and these costs would be refined during an engineering analysis regarding the feasibility of recharging the treated water.</td></tr>
</table>

BMP Category F: Water Resource Use

BMP F-1: Minimize water consumption Examples: - Sensors to turn off water when not needed - Low flow fittings - Minimize water needs for irrigation (landscape choices, use of mats and mulch)	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

At this point, there does not appear to be an option to reduce pumping, and the remedy consumes very little additional water.

BMP F-2: Preferentially use less refined water resources when feasible Examples: - Use extracted groundwater instead of potable water for chemical blending - Capture and store rain/storm water for future use - Employ rumble grates with a closed-loop gray-water washing system	**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

The remedy consumes very little water beyond what is extracted from the aquifer for treatment.

BMP Category F: Water Resource Use

BMP F-3: Use extracted and treated water for beneficial purposes Examples: - Irrigation - Potable water - Industrial process water	**Date: 8/27/12** ☒ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *There is no obvious user for the treated water.*	

BMP F-4: Promote groundwater recharge Examples: - Recharge extracted and treated water when beneficial uses of the water are not identified and reinjection is practical - Minimize site area covered by impervious surfaces to reduce runoff and maximize infiltration (unless such capping is a specific component of the remedial action)	**Date: 8/27/12** ☒ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Treated water is currently discharged to the POTW, at a cost of approximately $100,000 per year. If this water could be feasibly recharged to groundwater, that would be beneficial with respect to promoting recharge of groundwater regionally. It would also reduce long-term load on the POTW (i.e., increase future capacity). A detailed analysis has yet to be performed, but for cost purposes assume that capital costs of up to $200,000 might be required and net savings on the order of $75,000 per year might result. This is a simple conceptual analysis at this point, and these costs would be refined during an engineering analysis regarding the feasibility of recharging the treated water.*	

BMP Category F: Water Resource Use

<table>
<tr><td colspan="2">BMP F-5: Maintain water quality by preventing nutrient loading to surface water or groundwater
Examples:
- Use phosphate-free detergents instead of organic solvents or acids to decontaminate sampling equipment (if not required for some contaminants)</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is not applicable for this project.</td></tr>
</table>

BMP Category G: Waste Generation, Disposal, and Recycling

<table>
<tr><td colspan="2">BMP G-1: Minimize drill cuttings and all other investigation derived waste (including personal protection equipment)
Examples:
- Direct push or sonic drilling to reduce drill cuttings
- Low-flow sampling or passive diffusion bags (if applicable) to reduce purge water
- When possible place drill cuttings on-site rather than off-site disposal</td><td>Date: 8/27/12
☒ Applicable
☒ Evaluated
☒ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☒ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☒ Significant Cost Savings
☐ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

The depth to water at this site is too great to use direct push for well installation. Drill cuttings from planned well installation will likely be spread on the surface.

Low-flow sampling with dedicated bladder pumps is used (reduces purge water).</td></tr>
</table>

<table>
<tr><td colspan="2">BMP G-2: Segregate excavated soil in pre-planned staging areas so that “clean” material can be deposited on-site and/or reused rather than transported for off-site disposal</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is not applicable for this project.</td></tr>
</table>

BMP Category G: Waste Generation, Disposal, and Recycling

BMP G-3: Consider on-site treatment and re-use of soil instead of off-site disposal Examples: - Land farming - Above ground soil vapor extraction (SVE)	**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is not applicable for this project.

BMP G-4: Minimize need to transport and dispose hazardous waste Examples: - Consider delisting listed hazardous waste if waste is not characteristically hazardous waste - Segregate hazardous waste and non-hazardous waste - Maintaining the non-hazardous land fill classification instead of reclassifying to a hazardous landfill so that OSHA's HAZWOPER standard for cleanup operations does not need to be implemented	**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

Sludge from the air stripper is not considered hazardous waste, so this BMP is not applicable.

BMP Category G: Waste Generation, Disposal, and Recycling

<table>
<tr><td colspan="2">BMP G-5: When possible avoid/minimize use of hazardous/toxic materials that may require special handling or disposal
Examples:
- Cleaning solutions
- Pesticides
- Disposable batteries (use rechargeable batteries)
- MMRP projects: minimize Chemical Agent Contaminated Media (CACM) at RCWM sites.</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is not applicable for this project.</td></tr>
</table>

<table>
<tr><td colspan="2">BMP G-6: Recycle or reuse materials rather than disposing of them
Examples:
- Cardboard
- Plastics
- Concrete
- Asphalt
- Steel and other metals
- Recovered oil/product
- Mulch/compost
- MMRP projects - recycle recovered Material Documented as Safe (MDAS) after inspection and certification that the remnants are free of explosive hazards</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Few materials and wastes are associated with the P&T system.

If Alternative 1 is implemented, spent carbon can be sent off-site for regeneration rather than disposed of in a landfill.</td></tr>
</table>

BMP Category H: Land Use, Ecosystems, and Cultural Resources

BMP H-1: Minimize erosion and soil transport to surface water bodies Examples: - Quickly restore any vegetated areas disrupted by equipment or vehicles - Institute appropriate erosion controls during excavation such as silt fencing	**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is not applicable for this project.

BMP H-2: Minimize disturbances to land Examples: - Establish well-defined traffic patterns for onsite activities to minimize disturbed areas - Consider non-intrusive investigation techniques (e.g., geophysical methods) to identify items like USTs and buried drums	**Date: 8/27/12** ☒ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate

Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is not applicable for this project at this time (unless recharge basins are proposed to promote groundwater recharge).

BMP Category H: Land Use, Ecosystems, and Cultural Resources

<table>
<tr><td>BMP H-3: Preserve/restore ecosystems to the extent possible
Examples:
- Limit the removal of trees and vegetation
- Attempt to transplant disturbed shrubs and small trees to other locations
- Use native species for re-vegetation
- Retrieve dead trees during excavation and later reposition them as habitat snags
- Select and place suitably sized and typed stones into water beds and banks
- Undercut surface water banks in ways that mirror natural conditions
- Cut back rather than remove trees, bushes, vegetation</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td>Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="2">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Remedy operation does not impact ecosystems in a significant way.</td></tr>
</table>

<table>
<tr><td>BMP H-4: Minimize drawdown of the water table in sensitive areas such as wetlands or areas subject to subsidence</td><td>Date: 8/27/12
☒ Applicable
☒ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td>Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="2">Notes (including discussion of pertinent details and possible value of implementing the BMP):

The current pumping is not affecting any nearby wetlands.</td></tr>
</table>

BMP Category H: Land Use, Ecosystems, and Cultural Resources

<table>
<tr><td colspan="2">BMP H-5: Construct wells and other remedial process infrastructure (piping, buildings, etc.) to minimize restrictions to anticipated future use of the site</td><td>Date: 8/27/12
☒ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Remedial activity is not expected to limit future land use beyond those limits already imposed. This could apply in the future if recharge basins for treated water are proposed.</td></tr>
</table>

<table>
<tr><td colspan="2">BMP H-6: Preserve/restore cultural resources to the extent possible
Examples:
- Protected lands such as wildlife refuges, national parks, and wilderness areas
- Culturally sensitive sites such as cemeteries, native burials, and archaeological finds
- Buildings or land parcels with historical significance</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

There are no identified cultural resources in the area that would potentially be impacted by remediation activities.</td></tr>
</table>

BMP Category H: Land Use, Ecosystems, and Cultural Resources

<table>
<tr><td colspan="2">BMP H-7: Document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources
Examples:
- Photodocument conditions prior to clearing brush
- MMRP projects: photodocument conditions prior to BIP</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

There are no identified ecological or cultural resources in the area that would potentially be impacted by remediation activities.</td></tr>
</table>

BMP Category I: Safety and Community

<table>
<tr><td colspan="2">BMP I-1: Minimize and mitigate noise, light and odor disturbance during all phases of the remedial process, to the extent practicable</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

There are no major concerns over these types of disturbances for this project.</td></tr>
</table>

<table>
<tr><td colspan="2">BMP I-2: Minimize dust during construction activities by spraying water or techniques such as laying biodegradable mats, tarps, or materials (already in EM385-1-1)</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
(“N/A” if “Practical” not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

No major construction activities are anticipated.</td></tr>
</table>

BMP Category I: Safety and Community

BMP I-3: Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *The site is accessible from major highways, so trips through residential areas should not be necessary.*	

BMP I-4: Minimize drawdown of the water table in areas that could impact production rates at supply wells and/or irrigation wells	**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Several supply wells are located in the area, and production rates have not been affected.*	

BMP Category I: Safety and Community

BMP I-5: Minimize amount of time that heavy machinery is needed to enhance safety		**Date: 8/27/12** ☒ Applicable ☒ Evaluated ☒ Practical
Implemented? ("N/A" if "Practical" not checked) ☒ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☒ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Heavy machinery will be used for well and piping installation, and these activities will be completed as efficiently as possible to minimize field work.*		

BMP I-6: Minimize handling of dangerous chemicals by selecting alternate chemicals and/or engineering to minimize contact with chemicals (for MMRP projects, there is enhanced risk related to explosion potential and exposure to chemical agents (CA) and agent breakdown products (ABP) associated with RCWM responses)		**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☒ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☒ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP): *Few chemicals used for this project.*		

BMP Category I: Safety and Community

<table>
<tr><td colspan="2">BMP I-7: Contribute to local economy when possible
Examples:
- Consider leasing local office space
- Purchase or lease equipment from local vendors
- Hire workers from local community</td><td>Date: 8/27/12
☒ Applicable
☒ Evaluated
☒ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☒ Fully ☐ Partially ☐ Not Yet ☐ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☒ Generally Cost Neutral ☐ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

Local vendors and materials are used to the extent possible.</td></tr>
</table>

<table>
<tr><td colspan="2">BMP I-8: Utilize on-site construction practices and PPE requirements for anticipated exposure scenarios rather than an overly conservative level of protectiveness that is more resource intensive
Examples:
- Utilize general construction PPE protectiveness, which is less personnel and equipment resource intensive, rather than HTRW PPE protectiveness, when applying a non-hazardous soil cover for a HTRW landfill</td><td>Date: 8/27/12
☐ Applicable
☐ Evaluated
☐ Practical</td></tr>
<tr><td>Implemented?
("N/A" if "Practical" not checked)
☐ Fully ☐ Partially ☐ Not Yet ☒ N/A</td><td colspan="2">Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary):
☐ Significant Cost Increase ☐ Significant Cost Savings
☐ Generally Cost Neutral ☒ N/A or Hard to Estimate</td></tr>
<tr><td colspan="3">Notes (including discussion of pertinent details and possible value of implementing the BMP):

This BMP is not applicable for this project.</td></tr>
</table>

BMP Category J: Other Site-Specific BMPs

BMP J-1:		**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

BMP J-2:		**Date: 8/27/12** ☐ Applicable ☐ Evaluated ☐ Practical
Implemented? ("N/A" if "Practical" not checked) ☐ Fully ☐ Partially ☐ Not Yet ☐ N/A	Qualitative Net Cost Impact Over 5 Years, No Discounting (discuss in notes if necessary): ☐ Significant Cost Increase ☐ Significant Cost Savings ☐ Generally Cost Neutral ☐ N/A or Hard to Estimate	
Notes (including discussion of pertinent details and possible value of implementing the BMP):		

Appendix B
Assumptions for SiteWise Input and Other Calculations
ACME Site GSR Evaluation:

Current P&T System (Baseline)

SiteWise "RA_Baseline_NoFR_1" Directory

All calculations assume a 30-year total for remedy operation. This remedy includes the following:

- Four groundwater extraction wells, each with a 15 HP pump and a typical extraction rate of 100 gpm.

- Treatment of all extracted water in the Site treatment plant via air stripper, with a combined influent flow rate of 400 gpm.

    - Water enters an equalization (EQ) tank from the extraction wells (except for some water that is periodically diverted for ERD injections). There are no chemical additions to the water that goes to the air stripper.

    - A 25HP pump (there are two pumps, but only one operates at a time) moves the water from the EQ tank to the packed tower air stripper, which uses a 15HP fan.

    - From the air stripper water goes to a sump where it is transferred (two 25HP pumps, only one used at a time) to the POTW.

    - Air from the air stripper goes through a knockout tank to remove moisture, and then to a catalytic oxidizer (CATOX) unit with a 25 HP fan to draw air through. The CATOX is powered by natural gas (since the influent vapor concentrations are far too low to power the CATOX). The CATOX has a continuous gas analyzer.

- Installation of two replacement extraction wells in new locations and associated piping

- Decommissioning of two extraction wells being replaced

- Annual groundwater sampling for a projected 30 years of remedy operation.

The notes pertaining to SiteWise input are organized by the following tabs of the SiteWise input sheet:

- New Well Installation – Uses "Remedial Action Construction" tab of the SiteWise input sheet
- P&T System Operation – Uses "Remedial Action Operations" tab of the SiteWise input sheet
- LTM Sampling – Uses "Longterm Monitoring" tab of the SiteWise input sheet

For each section of SiteWise, all the sections are listed, with pertinent information added only for those sections of the input sheet where data were added.

Current P&T System (Baseline) – Overview

Other calculations done outside of SiteWise are then presented. These include the following:

- Hazardous air pollutants
- Potable and non-potable water use
- Refined material use
- Unrefined material use
- Tons of non-hazardous waste
- Tons of hazardous waste
- Project-related risks
- Heavy truck trips through residential areas

A summary cost is included in this Appendix. Information regarding the cost calculations is as follows:

- Since the remedy is already in place, there is no up-front cost.

- The annual cost for the treatment system is $500,000 per year for 30 years.

- The sum of capital and annual costs, non-discounted, is $15,500,000.

- To determine net present value (NPV), a 3 percent discount rate is applied to future costs. NPV is calculated by discounting future costs to present-day dollars using the following equation:

$$PV = \frac{FV}{(1+i)^n} = C \times FV$$

PV is the present value
FV is the value in year "n" (i.e., future value)
i is the discount rate
C is the discount factor, which equals $1/(1+i)^n$

- The NPV calculated is $10,300,221 (see sheet below).

Current P&T System (Baseline) – Overview

Project:	Acme Site
Option or Alternative:	Current P&T System (Baseline)
Current Date:	8/16/2012

year	capital cost*	annual cost		present value of cost each year		cumulative cash flow	
	(enter in present-day dollars)	*(enter in present-day dollars)*		3%		no discounting	discounted
0	$0	$500,000		$500,000		$500,000	$500,000
1	$0	$500,000		$485,437		$1,000,000	$985,437
2	$0	$500,000		$471,298		$1,500,000	$1,456,735
3	$0	$500,000		$457,571		$2,000,000	$1,914,306
4	$0	$500,000		$444,244		$2,500,000	$2,358,549
5	$0	$500,000		$431,304		$3,000,000	$2,789,854
6	$0	$500,000		$418,742		$3,500,000	$3,208,596
7	$0	$500,000		$406,546		$4,000,000	$3,615,141
8	$0	$500,000		$394,705		$4,500,000	$4,009,846
9	$0	$500,000		$383,208		$5,000,000	$4,393,054
10	$0	$500,000		$372,047		$5,500,000	$4,765,101
11	$0	$500,000		$361,211		$6,000,000	$5,126,312
12	$0	$500,000		$350,690		$6,500,000	$5,477,002
13	$0	$500,000		$340,476		$7,000,000	$5,817,478
14	$0	$500,000		$330,559		$7,500,000	$6,148,037
15	$0	$500,000		$320,931		$8,000,000	$6,468,968
16	$0	$500,000		$311,583		$8,500,000	$6,780,551
17	$0	$500,000		$302,508		$9,000,000	$7,083,059
18	$0	$500,000		$293,697		$9,500,000	$7,376,757
19	$0	$500,000		$285,143		$10,000,000	$7,661,900
20	$0	$500,000		$276,838		$10,500,000	$7,938,737
21	$0	$500,000		$268,775		$11,000,000	$8,207,512
22	$0	$500,000		$260,946		$11,500,000	$8,468,458
23	$0	$500,000		$253,346		$12,000,000	$8,721,804
24	$0	$500,000		$245,967		$12,500,000	$8,967,771
25	$0	$500,000		$238,803		$13,000,000	$9,206,574
26	$0	$500,000		$231,847		$13,500,000	$9,438,421
27	$0	$500,000		$225,095		$14,000,000	$9,663,516
28	$0	$500,000		$218,538		$14,500,000	$9,882,054
29	$0	$500,000		$212,173		$15,000,000	$10,094,227
30	$0	$500,000		$205,993		$15,500,000	$10,300,221

positive dollar value is a "cost", negative dollar value is a "savings"

Life-Cycle Cost, Net Present Value (NPV)->	$10,300,221
Up-front costs (undiscounted) ->	$0
Total of capital costs* (undiscounted) ->	$0
Total of annual costs (undiscounted) ->	$15,500,000
Life-Cycle Cost (undiscounted) ->	$15,500,000

Current P&T System (Baseline) – Well Installation

<u>Scope of Work</u>

- 2 new extraction wells, each 200 ft deep, 6” diameter, schedule 40 PVC, 10” borehole, annular space filled with cement
- Well installation via hollow-stem auger, approximately 8 hours of drilling per well location (drill cuttings spread on-site)
- Drill rig and additional light-duty truck for drillers (2 people) traveling from 50 miles away (one-way)
- Decommissioning of extraction wells being replaced (filled in with cement, assume this is done on the same days as well installation, creating no additional trips or labor hours)
- All construction materials (well casing and screens, pipe, gravel, and cement) delivered together from 50 miles away (one-way)
- One field technician traveling from 20 miles away (one-way) present for drilling oversight
- 500 ft of piping, 6” diameter, schedule 40 HDPE
- 500 ft of trenching for piping installation, 4’ deep by 2’ wide, with 6” gravel bed and the remainder backfilled with excavated soil (trenching an backfilling will take approximately 3 days; left over excavated soil will be spread on-site)
- 1 20-ton excavator transported to and from site, 50 miles-one way
- 1 equipment operator traveling from 50 miles away (one-way) for 3 days of trenching
- One field technician for oversight traveling from 20 miles away (one-way) present for 3 days of trenching

Current P&T System (Baseline) – Well Installation

Input into "Remedial Action Construction" tab of SiteWise Input Sheet.xls

- Baseline Information
    - Remedial Action Operations Cost and Duration
        - Total remedial action construction cost ($) – leave blank

- Material Production
    - Well Materials
        - Well Type 1 – Replacement extraction wells. 2 wells, 200 ft each, Sch 40 PVC, 6" diameter.
        - Well Type 2 – Used to represent HDPE piping associated with new wells. 1 well, 500 ft, Sch 40 HDPE, 6" diameter.
    - Treatment Chemicals & Materials
    - Treatment Media
    - Construction Materials
        - Material 1 – Cement for replacement extraction wells. Select typical cement, area of $\pi(5/12)^2 - \pi(3/12)^2 = 0.35$ ft2, depth of 200 ft per well * 2 wells = 400 ft.
    - Well Decommissioning
        - Well Type 1 – Decommissioning of 2 extraction wells being replaced. 2 wells, 200 ft each, 6" diameter, select typical cement.
    - Bulk Material Quantities
        - Material 1 – Gravel for trenching. Select gravel, cubic feet, 500 ft long * 2 ft wide * 0.5 ft thick = 500 cubic ft.

- Transportation
    - Personnel Transportation – Road
        - Trip 1 – Used to represent drill rig transport to and from site. Assume rig left on-site overnight. Select heavy duty, diesel, 100 miles round-trip, 1 trip taken, 1 traveler.
        - Trip 2 – Light truck for drillers' travel to and from site. Select light truck, gasoline, 100 miles round-trip, 2 trips taken, 1 trip with 1 traveler and 1 trip with 2 travelers = 1.5 travelers average.
        - Trip 3 – Field technician travel to and from site for well installation. Select light truck, gasoline, 40 miles round-trip, 2 trips taken, 1 traveler.
        - Trip 4 – Equipment operator for trenching. Select light truck, gasoline, 100 miles round-trip, 3 trips taken, 1 traveler.
        - Trip 5 – Field technician travel to and from site for trenching. Select light truck, gasoline, 40 miles round-trip, 3 trips taken, 1 traveler.
    - Personnel Transportation – Air
    - Personnel Transportation – Rail

- Equipment Transportation – Road
  - Trip 1 – Transport of construction materials to site. All weights obtained from SiteWise output file "Remedial Action Construction.xls":

	1,493 lbs	(PVC for wells)
	1,222 lbs	(HDPE pipe)
	13,135 lbs	(cement for new wells, 5970.3 kg * 2.2 kg per lb)
	7,368 lbs	(cement for well decommissioning, 3349.3 kg * 2.2 kg per lb)
+	52,392 lbs	(gravel for trench fill, 23814.5 kg * 2.2 kg per lb)
=	75,610 lbs	
=	**37.8 tons**	(2,000 lbs per ton)

    For SiteWise input, select diesel, 50 miles transported (one-way), 37.8 tons transported.
  - Trip 2 – Empty return trip for truck transporting construction materials to site. Select diesel, 50 miles, 0 tons.
  - Trip 3 – Transportation of excavator to and from site. Select diesel, 100 miles transported (round-trip), 20 tons transported.
  - Trip 4 – Empty trips for truck transporting excavator to and from site. Select diesel, 100 miles, 0 tons.
- Equipment Transportation – Air
- Equipment Transportation – Rail
- Equipment Transportation – Water

- Equipment Use
  - Earthwork
  - Drilling
    - Event 1 – Installation of 2 replacement extraction wells. 2 drilling locations, hollow stem auger, 8 hours per location, diesel.
  - Trenching
    - Trencher 1 – Represents all equipment use for trenching (would likely be an excavator, but the trencher input was used so that the equipment horsepower and operating hours could be easily entered into SiteWise). Select diesel, 175 to 300 HP, 24 hours of operating time (three 8 hour days).
  - Pump Operation
  - Diesel and Gasoline Pumps
  - Blower, Compressor, Mixer, and Other Equipment
  - Generators
  - Agricultural Equipment
  - Capping Equipment
  - Mixing Equipment
  - Internal Combustion Engines
  - Other Fueled Equipment
  - Operator Labor
    - Trip 1 – One of the drillers (drill operator risk accounted for in equipment use above). Select construction laborers, 16 hours (two 8-hour days).
    - Trip 2 – Field technician for well installation. Select scientific and technical services, 16 hours (two 8-hour days).
    - Trip 3 – Field technician for trenching (equipment operator risk accounted for in equipment use above). Select scientific and technical services, 24 hours (three 8-hour days).
  - Laboratory Analysis
  - Other Known Onsite Activities

- Residual Handling
  - Residue Disposal/Recycling
  - Landfill Operations
  - Thermal/Catalytic Oxidizers

- Resource Consumption
  - Water Consumption
  - Onsite Land and Water Resource Consumption

Once SiteWise input is complete, go to "SiteWise_Input Sheet " for overall project and enter information (including Alternative File Name "Baseline"). Then go to "Generate Alternative" tab and click button labeled "Click to generate alternative using previously entered alternative name". Copies of the input and output summary sheets for this alternative are now located in the directory titled "RA_Baseline _NoFR_1". To store the "Remedial Action Construction.xls" calculation sheet showing detailed calculations, open it in the overall SiteWise project directory when the appropriate input sheet is open, then do a "save as" to put it in the directory for this alternative using a name that indicates "will not update". Then open that file and do "data->edit links" and break the links. If the input sheet for this alternative ever changes, then this calculation sheet needs to be re-saved.

To edit input parameters for this alternative, you must go back to the ORIGINAL SiteWise input sheet and import this alternative using the "Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?" field on the "Site Info" tab. After making necessary changes to the input sheet, re-export the alternative by going to the "Generate Alternative" tab and clicking the button labeled "Click to replace an existing alternative with the same name". Update saved calculation sheets as described above.

Current P&T System (Baseline) - Operation

Scope of Work

- 4 pumps (groundwater extraction wells), 15 HP each, typical extraction rate of 100 gpm
- 1 pump (transfer pump from EQ tank to air stripper; there are two pumps, but only one operates at a time), 25 HP
- 1 blower (treatment plant air stripper), 15 HP
- 1 pump (discharge pump to POTW; there are two pumps, but only one operates at a time), 25 HP
- Water usage (water extracted from the aquifer removed for other use as a resource) = 400 gpm
- Water discharged to a POTW = 400 gpm
    - SiteWise Version 2.0 allows for input of water sent to a wastewater treatment facility, but this component of the remedy was purposely omitted from SiteWise input due to the GHG emissions factor and other conversion factors used by this version of SiteWise. The lookup table for SiteWise Version 2.0 indicates that it calculates 0.11 kg CO2E emitted per gallon of wastewater treated, but this quantity is likely greater than what would be expected for treatment of water that has already been treated on-site (as is the case at the Acme Site). Later versions of SiteWise may include different conversion factors that would be more appropriate for this type of treatment.
- Waste from treatment plant (including plastic rings from air stripper, iron oxide sludge from the bottom of that air stripper, and other waste) disposed of in an off-site landfill 50 miles from site, 1000 lbs per year
- 1 blower (CATOX), 25 HP
- Catalytic oxidizer with natural gas usage per year of 900 m(thousand)CF/mo
- Treatment plant operator, on-site 3 days per week, traveling from a distance of 20 miles one-way
- Field personnel for annual sampling plus other non-routine O&M, 2 workers on-site 4 days per year
- Laboratory analysis of groundwater samples, approximate cost of $1,000 per year

Current P&T System (Baseline) - Operation

<u>Input into "Remedial Action Operations" tab of SiteWise Input Sheet.xls</u>

- Baseline Information
    - Remedial Action Operations Cost and Duration
        - Total remedial action operations cost ($) – leave blank
        - Duration of remedial action operations (unit time) – 1 yr for this GSR evaluation

- Material Production
    - Well Materials
    - Treatment Chemicals & Materials
    - Treatment Media
    - Construction Materials
    - Well Decommissioning
    - Bulk Material Quantities

- Transportation
    - Personnel Transportation – Road
        - Trip 1 – Treatment plant operator travel to and from site. Select car, gasoline, 40 miles round-trip, 3 trips per week * 52 weeks per year * 30 years = 4680 trips taken, 1 traveler.
    - Personnel Transportation – Air
    - Personnel Transportation – Rail
    - Equipment Transportation – Road
    - Equipment Transportation – Air
    - Equipment Transportation – Rail
    - Equipment Transportation – Water

- Equipment Use
    - Earthwork
    - Drilling
    - Trenching
    - Pump Operation
        - Pump 1 – Extraction well pumps. Select Method 3. Grid region "SPNO" should be pre-selected; if not, go to Site Info tab and select. 4 pumps at 15 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).
        - Pump 2 – Transfer pump from EQ tank to air stripper. Select Method 3. 1 pump at 25 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).
        - Pump 3 – Pump for discharge to POTW. Select Method 3. 1 pump at 25 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).

    - Diesel and Gasoline Pumps
    - Blower, Compressor, Mixer, and Other Equipment
        - Equipment 1 – Blower for treatment plant air stripper. Select Method 1. 1 blower at 15 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).

        - Equipment 2 – 1 blower for CATOX. Select Method 1. 1 blower at 25 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).
    - Generators
    - Agricultural Equipment
    - Capping Equipment
    - Mixing Equipment
    - Internal Combustion Engines
    - Other Fueled Equipment
    - Operator Labor
        - Occupation 1 – Treatment plant operator. Select Scientific and technical services, 8 hours per day * 3 days per week * 52 weeks per year * 30 years = 37440 hours worked on-site
    - Laboratory Analysis
    - Other Known Onsite Activities

- Residual Handling
    - Residue Disposal/Recycling
        - Soil Residue – Transport of waste from treatment plant to landfill. 1000 lbs / 2000 lbs per ton = 0.5 tons per trip. Select diesel, 1 trip per year * 30 years = 30 trips, 50 miles per one-way trip.
        - Residual Water – Included to account for empty trips from landfill to site. 0 tons per trip. Select diesel, 1 trip per year * 30 years = 30 trips, 50 miles per one-way trip.
    - Landfill Operations
        - Operation 1 – Disposal of waste from treatment plant. Select non-hazardous, 0.5 tons per year * 30 years = 15 tons.
    - Thermal/Catalytic Oxidizers
        - Oxidizer 1 – Catalytic oxidizer for air stripper off gas. Input parameters started with 750 F temp and 6000 SCF/min and were iterated until the energy use for a year was obtained. The energy use for a year was 900 m(thousand)CF/mo X 12 mo X 1.028 MMBtu/mCF = 1.08 E04 MMBtu. The input parameters that yielded this electrical usage were 750F operating temp, continuous operation (8760 hrs/year – final input was 262,800 hours to account for 30 years of operation), 6 ppmV contaminant concentration, and 1350 SCF/min flow.

- Resource Consumption
    - Water Consumption
        - Not included (see note on water sent to a POTW in Scope of Work above)
    - Onsite Land and Water Resource Consumption
        - Volume of groundwater or surface water lost (gal): Entire Site 1 – Water extracted from the aquifer removed for other use as a resource. 400 gpm * 1440 min per day * 365 days per yr * 30 years = 6,307,200,000 gallons.

Once SiteWise input is complete, go to "SiteWise_Input Sheet " for overall project and enter information (including Alternative File Name "Baseline"). Then go to "Generate Alternative" tab and click button labeled "Click to generate alternative using previously entered alternative name". Copies of the input and output summary sheets for this alternative are now located in the directory titled "RA_Baseline _NoFR_1". To store the "Remedial Action Opeartions.xls" calculation sheet showing detailed calculations, open it in the overall SiteWise project directory when the

appropriate input sheet is open, then do a "save as" to put it in the directory for this alternative using a name that indicates "will not update". Then open that file and do "data->edit links" and break the links. If the input sheet for this alternative ever changes, then this calculation sheet needs to be re-saved.

To edit input parameters for this alternative, you must go back to the ORIGINAL SiteWise input sheet and import this alternative using the "Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?" field on the "Site Info" tab. After making necessary changes to the input sheet, re-export the alternative by going to the "Generate Alternative" tab and clicking the button labeled "Click to replace an existing alternative with the same name". Update saved calculation sheets as described above.

Current P&T System (Baseline) - LTM

<u>Scope of Work</u>

- Field personnel for annual sampling and other non-routine O&M, 2 workers on-site 4 days per year, each traveling 20 miles one-way
- Laboratory analysis of groundwater samples, approximate cost of $1,000 per year (this cost includes transportation to the lab and analyses performed)

Current P&T System (Baseline) - LTM

<u>Input into "Longterm Monitoring" tab of SiteWise Input Sheet.xls</u>

- Baseline Information
    - Longterm Monitoring Cost and Duration
        - Total longterm monitoring cost ($) – leave blank
        - Duration of longterm monitoring (unit time) – 1 yr for this GSR evaluation

- Material Production
    - Well Materials
    - Treatment Chemicals & Materials
    - Treatment Media
    - Construction Materials
    - Well Decommissioning
    - Bulk Material Quantities

- Transportation
    - Personnel Transportation – Road
        - Trip 1 – Sampling personnel travel to and from site. Select light truck, gasoline, 40 miles round-trip * 2 vehicles (assuming no carpooling) = 80 miles, 4 trips per year * 30 years = 120 trips taken, 1 traveler per vehicle.
    - Personnel Transportation – Air
    - Personnel Transportation – Rail
    - Equipment Transportation – Road
    - Equipment Transportation – Air
    - Equipment Transportation – Rail
    - Equipment Transportation – Water

- Equipment Use
    - Earthwork
    - Drilling
    - Trenching
    - Pump Operation
    - Diesel and Gasoline Pumps
    - Blower, Compressor, Mixer, and Other Equipment
    - Generators
    - Agricultural Equipment
    - Capping Equipment
    - Mixing Equipment
    - Internal Combustion Engines
    - Other Fueled Equipment
    - Operator Labor
        - Occupation 1 – Sampling personnel. Select Scientific and technical services, 2 people * 8 hours per day * 4 days per event * 1 event per year * 30 years = 1920 hours.
    - Laboratory Analysis
        - Analysis 1 – Lab analysis for annual sampling. $1,000 per year for 30 years = $30,000 spent
    - Other Known Onsite Activities

- Residual Handling

  - Residue Disposal/Recycling
  - Landfill Operations
  - Thermal/Catalytic Oxidizers

- Resource Consumption
  - Water Consumption
  - Onsite Land and Water Resource Consumption

Once SiteWise input is complete, go to "SiteWise_Input Sheet " for overall project and enter information (including Alternative File Name "Baseline"). Then go to "Generate Alternative" tab and click button labeled "Click to generate alternative using previously entered alternative name". Copies of the input and output summary sheets for this alternative are now located in the directory titled "RA_Baseline _NoFR_1". To store the "Longterm Monitoring.xls" calculation sheet showing detailed calculations, open it in the overall SiteWise project directory when the appropriate input sheet is open, then do a "save as" to put it in the directory for this alternative using a name that indicates "will not update". Then open that file and do "data->edit links" and break the links. If the input sheet for this alternative ever changes, then this calculation sheet needs to be re-saved.

To edit input parameters for this alternative, you must go back to the ORIGINAL SiteWise input sheet and import this alternative using the "Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?" field on the "Site Info" tab. After making necessary changes to the input sheet, re-export the alternative by going to the "Generate Alternative" tab and clicking the button labeled "Click to replace an existing alternative with the same name". Update saved calculation sheets as described above.

Other Supporting Calculations: Current P&T System (Baseline)

Hazardous Air Pollutants

- None identified

Potable and Non-Potable Water Use

- 6,307,200,000 gallons of non-potable water extracted from the aquifer and not replaced
- SiteWise calculates an additional 14,992,00 gallons of non-potable water used for off-site electricity generation

Refined Materials Use

Some of these are from SiteWise output:

	1,493 lbs	(PVC for wells)
	1,222 lbs	(HDPE pipe)
	13,135 lbs	(cement for new wells, 5970.3 kg * 2.2 kg per lb)
+	7,368 lbs	(cement for well decommissioning, 3349.3 kg * 2.2 kg per lb)
=	**23,218 lbs**	

- Remedial activities also include the use of air stripper media, CATOX calibration gases, and maintenance parts and supplies for pumps, pipes, etc., but quantities for those materials were not identified for this evaluation.

Unrefined Materials Use

- 26 tons gravel from SiteWise output (52,392 lbs)

Tons of Non-Hazardous Waste

- 15 tons (specified as SiteWise input for treatment plant waste)

Tons of Hazardous Waste

- None identified

Project-Related Risks

- 0.344 injuries or fatalities (from SiteWise output)

Heavy Truck Trips through Residential Areas

- None identified

Appendix C1
Assumptions for SiteWise Input and Other Calculations
ACME Site GSR Evaluation:

Alternative 1 – Replace CATOX with Vapor Phase Carbon

SiteWise "RA_Alternative1_NoFR_1" Directory

All calculations assume a 30-year total for remedy operation. In this alternative, treatment of air emissions via CATOX is replaced by treatment via vapor phase carbon. This remedy alternative includes all the components of the Baseline remedy, except for the following changes:

- Elimination of the CATOX unit and associated blower.
- Use of 10,000 lbs vapor phase carbon per year for 30 years (300,000 lbs over remedy lifetime), based on the following calculation (using and extraction rate of 400 gpm and an influent concentration of 350 µg/L):
    - 400 gpm x 3.785 L/gal x 1440 min/day x 365 days/yr x 350 µg/L / 1,000,000,000 µg per kg = 279 kg x 2.2 lbs per kg = 613 lbs of contaminant per year
    - The minimum amount of activated carbon needed to treat contaminants is 10 lbs of activated carbon to 1 lb of contaminant
    - Conservative estimate of 10,000 lbs of activated carbon per year used

The notes pertaining to SiteWise input are organized by the following tabs of the SiteWise input sheet:

- New Well Installation – Uses "Remedial Action Construction" tab of the SiteWise input sheet
- P&T System Operation – Uses "Remedial Action Operations" tab of the SiteWise input sheet
- LTM Sampling – Uses "Longterm Monitoring" tab of the SiteWise input sheet

For each section of SiteWise, all the sections are listed, with pertinent information added only for those sections of the input sheet where data were added.

Other calculations done outside of SiteWise are then presented. These include the following:

- Hazardous air pollutants
- Potable and non-potable water use
- Refined material use
- Unrefined material use
- Tons of non-hazardous waste
- Tons of hazardous waste
- Risks to on-site works and from transportation
- Heavy truck trips through residential areas

A summary cost sheet is included in this Appendix. Information regarding the cost calculations is as follows:

- Up-front cost of ~$10,000 for vapor carbon vessel

Alternative 1 – Overview

- The annual cost for the treatment system is \$434,200 per year for 30 years, based on potential net cost savings of approximately \$65,800/yr, including the following:
    - Annual savings of approximately \$64,800 for natural gas
        - 900 mcf/mnth * 12 months/yr * ~\$6/mcf = ~ \$64,800/yr
    - Annual savings of approximately \$13,000 for elimination of the 25 HP blower assuming 0.85 load and 0.85 efficiency, a conversion factor of 0.746 kW/HP, 95% uptime, and an estimated electricity rate of \$0.07/kWh
        - 25 HP * 0.85/0.85 * 0.746 * 24hrs/day * 365 days/yr * \$0.08/kWh = ~\$13,000/yr
    - Annual savings of approximately \$8,000 per year for O&M of the CATOX
    - Annual cost of approximately \$20,000 for GAC
        - 10,000 lbs GAC per year * \$2/lb = ~\$20,000/yr
- The sum of capital and annual costs, non-discounted, is \$13,470,200.
- To determine net present value (NPV), a 3 percent discount rate is applied to future costs. NPV is calculated by discounting future costs to present-day dollars using the following equation:

$$PV = \frac{FV}{(1+i)^n} = C \times FV$$

PV is the present value
FV is the value in year "n" (i.e., future value)
i is the discount rate
C is the discount factor, which equals $1/(1+i)^n$

- The NPV calculated is \$8,954,712 (see sheet below)

Alternative 1 – Overview

Project: Acme Site

Option or Alternative: Alternative 1 (No CATOX)

Current Date: 8/16/2012

year	capital cost*	annual cost		present value of cost each year		cumulative cash flow	
	(enter in present-day dollars)	*(enter in present-day dollars)*		3%		no discounting	discounted
0	$10,000	$434,200		$444,200		$444,200	$444,200
1	$0	$434,200		$421,553		$878,400	$865,753
2	$0	$434,200		$409,275		$1,312,600	$1,275,029
3	$0	$434,200		$397,355		$1,746,800	$1,672,383
4	$0	$434,200		$385,781		$2,181,000	$2,058,164
5	$0	$434,200		$374,545		$2,615,200	$2,432,709
6	$0	$434,200		$363,636		$3,049,400	$2,796,345
7	$0	$434,200		$353,044		$3,483,600	$3,149,389
8	$0	$434,200		$342,761		$3,917,800	$3,492,150
9	$0	$434,200		$332,778		$4,352,000	$3,824,928
10	$0	$434,200		$323,086		$4,786,200	$4,148,014
11	$0	$434,200		$313,675		$5,220,400	$4,461,689
12	$0	$434,200		$304,539		$5,654,600	$4,766,229
13	$0	$434,200		$295,669		$6,088,800	$5,061,898
14	$0	$434,200		$287,057		$6,523,000	$5,348,955
15	$0	$434,200		$278,696		$6,957,200	$5,627,651
16	$0	$434,200		$270,579		$7,391,400	$5,898,230
17	$0	$434,200		$262,698		$7,825,600	$6,160,929
18	$0	$434,200		$255,047		$8,259,800	$6,415,975
19	$0	$434,200		$247,618		$8,694,000	$6,663,594
20	$0	$434,200		$240,406		$9,128,200	$6,904,000
21	$0	$434,200		$233,404		$9,562,400	$7,137,403
22	$0	$434,200		$226,606		$9,996,600	$7,364,009
23	$0	$434,200		$220,006		$10,430,800	$7,584,015
24	$0	$434,200		$213,598		$10,865,000	$7,797,612
25	$0	$434,200		$207,376		$11,299,200	$8,004,989
26	$0	$434,200		$201,336		$11,733,400	$8,206,325
27	$0	$434,200		$195,472		$12,167,600	$8,401,797
28	$0	$434,200		$189,779		$12,601,800	$8,591,576
29	$0	$434,200		$184,251		$13,036,000	$8,775,827
30	$0	$434,200		$178,885		$13,470,200	$8,954,712

positive dollar value is a "cost", negative dollar value is a "savings"

Life-Cycle Cost, Net Present Value (NPV)->	$8,954,712
Up-front costs (undiscounted) ->	$10,000
Total of capital costs* (undiscounted) ->	$10,000
Total of annual costs (undiscounted) ->	$13,460,200
Life-Cycle Cost (undiscounted) ->	$13,470,200

Alternative 1 – New Wells

<u>*Scope of Work*</u>

- 2 new extraction wells, each 200 ft deep, 6” diameter, schedule 40 PVC, 10” borehole, annular space filled with cement
- Well installation via hollow-stem auger, approximately 8 hours of drilling per well location (drill cuttings spread on-site)
- Drill rig and additional light-duty truck for drillers (2 people) traveling from 50 miles away (one-way)
- Decommissioning of extraction wells being replaced (filled in with cement, assume this is done on the same days as well installation, creating no additional trips or labor hours)
- All construction materials (well casing and screens, pipe, gravel, and cement) delivered together from 50 miles away (one-way)
- One field technician traveling from 20 miles away (one-way) present for drilling oversight
- 500 ft of piping, 6” diameter, schedule 40 HDPE
- 500 ft of trenching for piping installation, 4’ deep by 2’ wide, with 6” gravel bed and the remainder backfilled with excavated soil (trenching an backfilling will take approximately 3 days; left over excavated soil will be spread on-site)
- 1 20-ton excavator transported to and from site, 50 miles-one way
- 1 equipment operator traveling from 50 miles away (one-way) for 3 days of trenching
- One field technician for oversight traveling from 20 miles away (one-way) present for 3 days of trenching

Alternative 1 – New Wells

Input into "Remedial Action Construction" tab of SiteWise Input Sheet.xls

- Baseline Information
    - Remedial Action Operations Cost and Duration
        - Total remedial action construction cost ($) – leave blank

- Material Production
    - Well Materials
        - Well Type 1 – Replacement extraction wells. 2 wells, 200 ft each, Sch 40 PVC, 6" diameter.
        - Well Type 2 – Used to represent HDPE piping associated with new wells. 1 well, 500 ft, Sch 40 HDPE, 6" diameter.
    - Treatment Chemicals & Materials
    - Treatment Media
    - Construction Materials
        - Material 1 – Cement for replacement extraction wells. Select typical cement, area of $\pi(5/12)^2 - \pi(3/12)^2 = 0.35$ ft2, depth of 200 ft per well * 2 wells = 400 ft.
    - Well Decommissioning
        - Well Type 1 – Decommissioning of 2 extraction wells being replaced. 2 wells, 200 ft each, 6" diameter, select typical cement.
    - Bulk Material Quantities
        - Material 1 – Gravel for trenching. Select gravel, cubic feet, 500 ft long * 2 ft wide * 0.5 ft thick = 500 cubic ft.

- Transportation
    - Personnel Transportation – Road
        - Trip 1 – Used to represent drill rig transport to and from site. Assume rig left on-site overnight. Select heavy duty, diesel, 100 miles round-trip, 1 trip taken, 1 traveler.
        - Trip 2 – Light truck for drillers' travel to and from site. Select light truck, gasoline, 100 miles round-trip, 2 trips taken, 1 trip with 1 traveler and 1 trip with 2 travelers = 1.5 travelers average.
        - Trip 3 – Field technician travel to and from site for well installation. Select light truck, gasoline, 40 miles round-trip, 2 trips taken, 1 traveler.
        - Trip 4 – Equipment operator for trenching. Select light truck, gasoline, 100 miles round-trip, 3 trips taken, 1 traveler.
        - Trip 5 – Field technician travel to and from site for trenching. Select light truck, gasoline, 40 miles round-trip, 3 trips taken, 1 traveler.
    - Personnel Transportation – Air
    - Personnel Transportation – Rail

- Equipment Transportation – Road
  - Trip 1 – Transport of construction materials to site. All weights obtained from SiteWise output file “Remedial Action Construction.xls”:

	1,493 lbs	(PVC for wells)
	1,222 lbs	(HDPE pipe)
	13,135 lbs	(cement for new wells, 5970.3 kg * 2.2 kg per lb)
	7,368 lbs	(cement for well decommissioning, 3349.3 kg * 2.2 kg per lb)
+	52,392 lbs	(gravel for trench fill, 23814.5 kg * 2.2 kg per lb)
=	75,610 lbs	
=	**37.8 tons**	(2,000 lbs per ton)

    For SiteWise input, select diesel, 50 miles transported (one-way), 37.8 tons transported.
  - Trip 2 – Empty return trip for truck transporting construction materials to site. Select diesel, 50 miles, 0 tons.
  - Trip 3 – Transportation of excavator to and from site. Select diesel, 100 miles transported (round-trip), 20 tons transported.
  - Trip 4 – Empty trips for truck transporting excavator to and from site. Select diesel, 100 miles, 0 tons.
- Equipment Transportation – Air
- Equipment Transportation – Rail
- Equipment Transportation – Water

- Equipment Use
  - Earthwork
  - Drilling
    - Event 1 – Installation of 2 replacement extraction wells. 2 drilling locations, hollow stem auger, 8 hours per location, diesel.
  - Trenching
    - Trencher 1 – Represents all equipment use for trenching (would likely be an excavator, but the trencher input was used so that the equipment horsepower and operating hours could be easily entered into SiteWise). Select diesel, 175 to 300 HP, 24 hours of operating time (three 8 hour days).
  - Pump Operation
  - Diesel and Gasoline Pumps
  - Blower, Compressor, Mixer, and Other Equipment
  - Generators
  - Agricultural Equipment
  - Capping Equipment
  - Mixing Equipment
  - Internal Combustion Engines
  - Other Fueled Equipment
  - Operator Labor
    - Trip 1 – One of the drillers (drill operator risk accounted for in equipment use above). Select construction laborers, 16 hours (two 8-hour days).
    - Trip 2 – Field technician for well installation. Select scientific and technical services, 16 hours (two 8-hour days).
    - Trip 3 – Field technician for trenching (equipment operator risk accounted for in equipment use above). Select scientific and technical services, 24 hours (three 8-hour days).
  - Laboratory Analysis
  - Other Known Onsite Activities

- Residual Handling
    - Residue Disposal/Recycling
    - Landfill Operations
    - Thermal/Catalytic Oxidizers

- Resource Consumption
    - Water Consumption
    - Onsite Land and Water Resource Consumption

Once SiteWise input is complete, go to "SiteWise_Input Sheet " for overall project and enter information (including Alternative File Name "Baseline"). Then go to "Generate Alternative" tab and click button labeled "Click to generate alternative using previously entered alternative name". Copies of the input and output summary sheets for this alternative are now located in the directory titled "RA_Baseline _NoFR_1". To store the "Remedial Action Construction.xls" calculation sheet showing detailed calculations, open it in the overall SiteWise project directory when the appropriate input sheet is open, then do a "save as" to put it in the directory for this alternative using a name that indicates "will not update". Then open that file and do "data->edit links" and break the links. If the input sheet for this alternative ever changes, then this calculation sheet needs to be re-saved.

To edit input parameters for this alternative, you must go back to the ORIGINAL SiteWise input sheet and import this alternative using the "Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?" field on the "Site Info" tab. After making necessary changes to the input sheet, re-export the alternative by going to the "Generate Alternative" tab and clicking the button labeled "Click to replace an existing alternative with the same name". Update saved calculation sheets as described above.

Alternative 1 – Operation

<u>*Scope of Work*</u>

- 4 pumps (groundwater extraction wells), 15 HP each, typical extraction rate of 100 gpm
- 1 pump (transfer pump from EQ tank to air stripper; there are two pumps, but only one operates at a time), 25 HP
- 1 blower (treatment plant air stripper), 15 HP
- 1 pump (discharge pump to POTW; there are two pumps, but only one operates at a time), 25 HP
- Delivery (from 100 miles away) and installation of 5,500 lb steel vessel for carbon
- 300,000 lbs of activated carbon (regenerated) over remedy lifetime
- Delivery of 10,000 lbs of activated carbon from 50 miles away (one way) once per year for 30 yrs
- Delivery of 10,000 lbs of activated carbon to be regenerated 50 miles away (one way) once per year for 30 yrs
- Water usage (water extracted from the aquifer removed for other use as a resource) = 400 gpm
- Water discharged to a POTW = 400 gpm
    - SiteWise Version 2.0 allows for input of water sent to a wastewater treatment facility, but this component of the remedy was purposely omitted from SiteWise input due to the GHG emissions factor and other conversion factors used by this version of SiteWise. The lookup table for SiteWise Version 2.0 indicates that it calculates 0.11 kg CO2E emitted per gallon of wastewater treated, but this quantity is likely greater than what would be expected for treatment of water that has already been treated on-site (as is the case at the Acme Site). Later versions of SiteWise may include different conversion factors that would be more appropriate for this type of treatment.
- Waste from treatment plant (including plastic rings from air stripper, iron oxide sludge from the bottom of that air stripper, and other waste) disposed of in an off-site landfill 50 miles from site, 1000 lbs per year
- Treatment plant operator, on-site 3 days per week, traveling from a distance of 20 miles one-way

Alternative 1 – Operation

<u>Input into "Remedial Action Operations" tab of SiteWise Input Sheet.xls</u>

- Baseline Information
    - Remedial Action Operations Cost and Duration
        - Total remedial action operations cost ($) – leave blank
        - Duration of remedial action operations (unit time) – 1 yr for this GSR evaluation

- Material Production
    - Well Materials
    - Treatment Chemicals & Materials
    - Treatment Media
    - Construction Materials
    - Well Decommissioning
    - Bulk Material Quantities
        - Material 1 – Carbon vessel. Select steel, pounds, 5,500 lbs.
        - Material 2 – Activated carbon. Select Regenerated GAC, pounds, 300,000 lbs.

- Transportation
    - Personnel Transportation – Road
        - Trip 1 – Treatment plant operator travel to and from site. Select car, gasoline, 40 miles round-trip, 3 trips per week * 52 weeks per year * 30 years = 4680 trips taken, 1 traveler.
    - Personnel Transportation – Air
    - Personnel Transportation – Rail
    - Equipment Transportation – Road
        - Trip 1 – Trips for transportation of regenerated carbon to the site and transportation of spent carbon to be regenerated off-site. Select diesel, 100 miles per round trip * 1 trip per year * 30 yrs = 3,000 miles, 10,000 lbs transported per trip / 2,000 lbs per ton = 5 tons.
        - Trip 2 – Delivery of carbon vessel. Select diesel, 100 miles one-way, 5,500 lbs / 2,000 lbs per ton = 2.75 tons transported.
        - Trip 3 – Empty return trip for carbon vessel delivery. Select diesel, 100 miles one-way, 0 tons.
    - Equipment Transportation – Air
    - Equipment Transportation – Rail
    - Equipment Transportation – Water

- Equipment Use
    - Earthwork
    - Drilling
    - Trenching
    - Pump Operation
        - Pump 1 – Extraction well pumps. Select Method 3. Grid region "SPNO" should be pre-selected; if not, go to Site Info tab and select. 4 pumps at 15 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).
        - Pump 2 – Transfer pump from EQ tank to air stripper. Select Method 3. 1 pump at 25 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).

        - Pump 3 – Pump for discharge to POTW. Select Method 3. 1 pump at 25 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).

    - Diesel and Gasoline Pumps
    - Blower, Compressor, Mixer, and Other Equipment
        - Equipment 1 – Blower for treatment plant air stripper. Select Method 1. 1 blower at 15 HP operating continuously (24 hours per day * 365 days per year * 30 years = 262,800 hours).
    - Generators
    - Agricultural Equipment
    - Capping Equipment
    - Mixing Equipment
    - Internal Combustion Engines
    - Other Fueled Equipment
    - Operator Labor
        - Occupation 1 – Treatment plant operator. Select Scientific and technical services, 8 hours per day * 3 days per week * 52 weeks per year * 30 years = 37440 hours worked on-site
    - Laboratory Analysis
    - Other Known Onsite Activities

- Residual Handling
    - Residue Disposal/Recycling
        - Soil Residue – Transport of waste from treatment plant to landfill. 1000 lbs / 2000 lbs per ton = 0.5 tons per trip. Select diesel, 1 trip per year * 30 years = 30 trips, 50 miles per one-way trip.
        - Residual Water – Included to account for empty trips from landfill to site. 0 tons per trip. Select diesel, 1 trip per year * 30 years = 30 trips, 50 miles per one-way trip.
    - Landfill Operations
        - Operation 1 – Disposal of waste from treatment plant. Select non-hazardous, 0.5 tons per year * 30 years = 15 tons.
    - Thermal/Catalytic Oxidizers

- Resource Consumption
    - Water Consumption
        - Not included (see note on water sent to a POTW in Scope of Work above)
    - Onsite Land and Water Resource Consumption
        - Volume of groundwater or surface water lost (gal): Entire Site 1 – Water extracted from the aquifer removed for other use as a resource. 400 gpm * 1440 min per day * 365 days per yr * 30 years = 6,307,200,000 gallons.

Once SiteWise input is complete, go to “SiteWise_Input Sheet ” for overall project and enter information (including Alternative File Name “Alternative1”). Then go to “Generate Alternative” tab and click button labeled “Click to generate alternative using previously entered alternative name”. Copies of the input and output summary sheets for this alternative are now located in the directory titled “RA_Alternative1 _NoFR_1”. To store the “Remedial Action Opeartions.xls” calculation sheet showing detailed calculations, open it in the overall SiteWise project directory when the appropriate input sheet is open, then do a “save as” to put it in the directory for this

alternative using a name that indicates "will not update". Then open that file and do "data->edit links" and break the links. If the input sheet for this alternative ever changes, then this calculation sheet needs to be re-saved.

To edit input parameters for this alternative, you must go back to the ORIGINAL SiteWise input sheet and import this alternative using the "Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?" field on the "Site Info" tab. After making necessary changes to the input sheet, re-export the alternative by going to the "Generate Alternative" tab and clicking the button labeled "Click to replace an existing alternative with the same name". Update saved calculation sheets as described above.

Alternative 1 – LTM

<u>*Scope of Work*</u>

- Field personnel for annual sampling, 2 workers on-site 4 days per year, each traveling 20 miles one-way
- Laboratory analysis of groundwater samples, approximate cost of $1,000 per year (this cost includes transportation to the lab and analyses performed)

Alternative 1 – LTM

<u>Input into "Longterm Monitoring" tab of SiteWise Input Sheet.xls</u>

- Baseline Information
    - Longterm Monitoring Cost and Duration
        - Total longterm monitoring cost ($) – leave blank
        - Duration of longterm monitoring (unit time) – 1 yr for this GSR evaluation

- Material Production
    - Well Materials
    - Treatment Chemicals & Materials
    - Treatment Media
    - Construction Materials
    - Well Decommissioning
    - Bulk Material Quantities

- Transportation
    - Personnel Transportation – Road
        - Trip 1 – Sampling personnel travel to and from site. Select light truck, gasoline, 40 miles round-trip * 2 vehicles (assuming no carpooling) = 80 miles, 4 trips per year * 30 years = 120 trips taken, 1 traveler per vehicle.
    - Personnel Transportation – Air
    - Personnel Transportation – Rail
    - Equipment Transportation – Road
    - Equipment Transportation – Air
    - Equipment Transportation – Rail
    - Equipment Transportation – Water

- Equipment Use
    - Earthwork
    - Drilling
    - Trenching
    - Pump Operation
    - Diesel and Gasoline Pumps
    - Blower, Compressor, Mixer, and Other Equipment
    - Generators
    - Agricultural Equipment
    - Capping Equipment
    - Mixing Equipment
    - Internal Combustion Engines
    - Other Fueled Equipment
    - Operator Labor
        - Occupation 1 – Sampling personnel. Select Scientific and technical services, 2 people * 8 hours per day * 4 days per event * 1 event per year * 30 years = 1920 hours.
    - Laboratory Analysis
        - Analysis 1 – Lab analysis for annual sampling. $1,000 per year for 30 years = $30,000 spent
    - Other Known Onsite Activities

- Residual Handling

    - Residue Disposal/Recycling
    - Landfill Operations
    - Thermal/Catalytic Oxidizers

- Resource Consumption
    - Water Consumption
    - Onsite Land and Water Resource Consumption

Once SiteWise input is complete, go to "SiteWise_Input Sheet" for overall project and enter information (including Alternative File Name "Baseline"). Then go to "Generate Alternative" tab and click button labeled "Click to generate alternative using previously entered alternative name". Copies of the input and output summary sheets for this alternative are now located in the directory titled "RA_Baseline _NoFR_1". To store the "Longterm Monitoring.xls" calculation sheet showing detailed calculations, open it in the overall SiteWise project directory when the appropriate input sheet is open, then do a "save as" to put it in the directory for this alternative using a name that indicates "will not update". Then open that file and do "data->edit links" and break the links. If the input sheet for this alternative ever changes, then this calculation sheet needs to be re-saved.

To edit input parameters for this alternative, you must go back to the ORIGINAL SiteWise input sheet and import this alternative using the "Do you want to reload a previously saved remedial alternative in the SiteWise input sheet?" field on the "Site Info" tab. After making necessary changes to the input sheet, re-export the alternative by going to the "Generate Alternative" tab and clicking the button labeled "Click to replace an existing alternative with the same name". Update saved calculation sheets as described above.

Other Supporting Calculations
Alternative 1 - Replace CATOX with Vapor Phase Carbon

Hazardous Air Pollutants

- None identified

Potable and Non-Potable Water Use

- 6,307,200,000 gallons of non-potable water extracted from the aquifer and not replaced.
- SiteWise calculates an additional 12,493,000 gallons of non-potable water used for off-site electricity generation.

Refined Materials Use

Some of these items are from SiteWise output.

	1,493 lbs	(PVC for wells)
	1,222 lbs	(HDPE pipe)
	13,135 lbs	(cement for new wells, 5970.3 kg * 2.2 kg per lb)
	7,368 lbs	(cement for well decommissioning, 3349.3 kg * 2.2 kg per lb)
	5,500 lbs	(steel carbon vessel)
+	300,000 lbs	(regenerated GAC 10000 lb/yr * 30 yr)
=	**328,718 lbs**	

- Remedial activities include the use of air stripper media and maintenance parts and supplies for pumps, pipes, etc., but quantities were not identified for this evaluation.
- Since the activated carbon is regenerated, assume approximately 90% is from recycled material and 10% is virgin material. 90% * 300,000 lbs = 270,000 lbs of recycled material. 270,000 lbs / 328,718 lbs = 82% of refined materials from recycled material.

Unrefined Materials Use

- 26 tons gravel for trenching from SiteWise output (52,392 lbs)

Tons of Non-Hazardous Waste

- 15 tons (specified as SiteWise input for treatment plant waste)
- Since spent carbon is sent off-site for regeneration rather than being sent to a landfill for disposal, it is considered “potential waste that is recycled” but is not included as “non-hazardous waste”. 10,000 lbs/yr * 30 yrs = 300,000 lbs / 2,000 lbs per ton = 150 tons of carbon recycled.
- Total “potential waste recycled” is 15 tons + 150 tons = 165 tons. 150 tons / 165 tons = 91% of potential waste that is recycled.

Alternative 1 – Other Supporting Calculations

Tons of Hazardous Waste

- None identified

Project-Related Risks

- 0.346 injuries or fatalities (from SiteWise output)

Heavy Truck Trips through Residential Areas

- None identified

ATTACHMENT A-5

Suggested GSR Evaluation Checklist to Complement other RSE Checklists for Remedy Optimization within the Remedial Operation Phase of a Remedy

U. S. Army Corps of Engineers
Remediation System Evaluation
Green and Sustainable Remediation

Installation Name	________________________________
Site Name / I.D.	________________________________
Evaluation Team	________________________________
Site Visit Date	________________________________

This checklist is meant to assist the evaluation of Green and Sustainable Remediation (GSR) as a component of Remedy Optimization within the Remedial Operation phase of a remedy. This checklist has the following sections:

1) Typical GSR Evaluation Components
2) References
3) Data Collection, Evaluation of Alternatives, and Potential Cost Savings
4) Documenting Results
5) Supplemental notes and data

The checklist provides suggestions for information gathering, and space has been provided to record observations and notes from data review and the site visit. Supplementary notes, if required, should be numbered to correspond to the appropriate checklist sections.

1) Typical GSR Evaluation Components

A GSR evaluation typically involves the following components:

- Planning for a GSR evaluation
- Considering GSR Best Management Practices (BMPs)
- Evaluating specific GSR "metrics" (i.e., "quantitative GSR footprints") and assessing qualitative GSR considerations (e.g., land use, aesthetics, renewable energy)
- Documenting the GSR evaluation and the consideration/implementation of GSR opportunities

2) References

The following references are suggested:

- DoD, "*Department of Defense Manual, Defense Environmental Restoration Program (DERP) Management,*" Publication Number 4715.20 (9 March 2012), Section 6.d.
  http://www.dtic.mil/whs/directives/corres/pdf/471520m.pdf

- *Detailed Approach for Evaluating Green and Sustainable Remediation (GSR) on Army Environmental Projects*, which is which is Appendix A of the following report: *Final Study Report: Evaluation of Consideration and Incorporation of Green and Sustainable Remediation (GSR) Practices in Army Environmental Remediation,* August 27, 2012
  https://casi.erdc.usace.army.mil/focusareas/green_remediation/ - "publications")

3) Data Collection, Evaluation of GSR Opportunities, and Potential Cost Savings

Refer to the GSR Approach outlined in *Detailed Approach for Evaluating Green and Sustainable Remediation (GSR) on Army Environmental Projects* (referenced above) for details. Planning for the GSR evaluation includes a suggested screening evaluation regarding the applicability of quantitative footprint calculations as part of a project-specific GSR evaluation across the entire environmental life cycle. The subsequent identification and analysis of GSR opportunities includes the following:

- Review Information and Fill Data Gaps
- Fill Out GSR BMP Checklist Tables
- Evaluate Quantitative Footprints (When Applicable) plus Qualitative Considerations
- Document GSR Evaluation Findings and Recommendations

The BMP checklists include GSR BMPs in the following general categories:

A. Planning
B. Characterization and/or Remedy Approach
C. Energy/Emissions - Transportation
D. Energy/Emissions - Equipment Use
E. Materials & Off-Site Services
F. Water Resource Use
G. Waste Generation, Disposal, and Recycling
H. Land Use, Ecosystems, and Cultural Resources
I. Safety and Community
J. Other Site-Specific BMPs

As mentioned above, the GSR evaluation typically includes quantification of GSR metrics, plus qualitative considerations, that include the following:

- Quantitative Environmental Metrics:
  - Energy Use
  - Global Warming Potential
  - Criteria Air Pollutants (NOx + SOx + PM)
  - Hazardous or Toxic Air Pollutants
  - Potable Water Use
  - Other Water Use
  - Refined Materials
  - Percent of Refined Materials from Recycled or Reused Sources
  - Unrefined Materials
  - Percent of Unrefined Materials from Recycled or Reused Sources
  - Non-Hazardous Waste Disposal
  - Hazardous Waste Disposal
  - Percent of Total Potential Waste Recycled or Reused

- Quantitative Economic Metrics:
  - Life-Cycle Cost, Discounted
  - Life-Cycle Cost, Undiscounted
  - Up-Front Cost

- Quantitative Societal Metrics:
  - Risk for Injuries/Fatalities
  - One-Way Heavy Vehicle Trips through Residential Areas

- Qualitative Considerations:
    - Land Transferred or Made Available for Potential Beneficial Use
    - Existing Ecosystem Destruction
    - Time Frame for Land Reuse
    - Flexibility and Breadth of Options for Site Reuse
    - Aesthetics
    - Use of Renewable Energy

These items are typically assessed for a "baseline case" and one or more alternatives to the baseline. Calculations for many GSR metrics are typically performed using the SiteWise™ spreadsheet tool (or equivalent), but some GSR metrics must be calculated outside of such tools. Implementation of a GSR opportunity may have an impact on the life-cycle cost of the remedial process, with respect to the following items that may increase, decrease, or stay the same as a result of the GSR opportunity:

- Up-front costs and/or large non-routine expenses (i.e., capital costs)
- Annual costs
- Remedial process duration

In some cases, implementation of a GSR opportunity may increase life-cycle costs, and presumably this type of GSR opportunity will be implemented only if the perceived environmental benefits of the GSR opportunity are determined by project stakeholders to justify the additional costs. For cases where implementation of a GSR opportunity decreases life-cycle cost, but capital costs are high, the alternative might still not be preferred. When there is a capital cost coupled with a lower annual cost, a "payback period" and "return on investment" can be calculated. Potential constraints that may limit implementation of GSR opportunities include the following:

- Cost, including lack of sufficient capital to meet up-front costs
- Schedule
- Contracting
- Program policy
- Regulatory and public reviews/input
- GSR evaluation timing within the remedial phase
- Other project-specific variables and logistics

GSR opportunities are potentially "practical" if they are feasible from a technical standpoint and provide net benefits as shown from the economic, social, and environmental metrics and other qualitative considerations. However, issues such as those listed above impact the potential implementability of GSR opportunities.

a) Has the GSR Approach in *Detailed Approach for Evaluating Green and Sustainable Remediation (GSR) on Army Environmental Projects* (referenced above) been reviewed?

____

____

____

b) Has the screening evaluation described in Section 2.1.4 of the GSR Approach been performed regarding the applicability of quantitative footprint calculation?

____

____

____

c) Are there significant data gaps that need to be filled before GSR evaluation can be completed?

____

____

____

d) Have GSR BMP checklists from the GSR Approach been evaluated (to serve as an outline for identifying potential GSR opportunities as well as identifying GSR items already considered and implemented)?

e) Have GSR considerations been considered when developing potential alternatives to the current operating (i.e., baseline) remedy?

f) Have GSR metrics (including costs) and qualitative considerations been evaluated for a baseline and alternatives to the baseline?

4) Documenting Results

The results of the GSR evaluation may be incorporated as a section and/or appendix of a Project report (e.g., as part of a Remediation System Evaluation report). In some cases, the entire GSR Evaluation Report will be included as a stand-alone report or Appendix, and in other cases the GSR evaluation results may simply be summarized in a formal Project document or provided as a memorandum. The goal is to document that GSR items were considered and GSR recommendations were implemented when feasible. The use of tracking tables for each GSR recommendation (a template of which is included in the GSR Approach referenced earlier) allows the team to document and explain the basis of each GSR recommendation and the implementation status. Such tracking tables for GSR recommendations can be updated throughout the project with reasons provided for implementation or rejection of each recommendation.

a) Will the GSR evaluation results be part of another report (e.g., a section of an RSE Report) or will the GSR evaluation findings and recommendations be documented in a standalone report or memorandum?

b) Have GSR opportunities previously implemented for this remediation project been documented?

c) Have completed GSR BMP checklists from the GSR Approach been included, and/or have significant findings from the evaluation of GSR BMPs been summarized?

d) Have results of calculation of GSR metrics (if calculated) been presented, and have the methods and assumptions for those calculations been documented?

e) Have tracking tables from the GSR Approach been included for each GSR recommendation to document the basis of each GSR recommendation, the implementation status, and an explanation of the implementation status?

____

____

____

f) Is there a plan to document progress towards implementing GSR opportunities in future project reports?

____

____

____

5) Supplemental Notes and Data

There are _______ pages of supplemental notes and data attached to this checklist.

APPENDIX B

Case Study Summary Sheets

- *Beneficial Use of Treated Water: Joint Base Lewis-McChord*
- *Controlled Detonation Chamber (CDC): Multiple MMRP Sites, California*
- *Comparison of Low Flow vs. Passive Diffusion Bag Sampling: Joint Base Lewis-McChord*
- *Comparison of Different Well Drilling Techniques: Schilling Air Force Base Atlas Missile Facility S-1*

U.S. Army
Green and Sustainable Remediation (GSR)
Case Study

Beneficial Use of Treated Water

Joint Base Lewis-McChord WASHINGTON

This case study briefly summarizes an application of green and sustainable remediation (GSR) that has already been implemented in the course of the remedial process. GSR practices employed in this example include, but are not limited to, the following categories:

- Planning for sustainability
- Optimizing characterization and remedy approach
- Energy/emission reductions
- Water resource conservation
- Improvements to land use and reduction of impact on ecosystems and cultural resources
- Improvements related to safety and community

Over 1,500 gallons per minute of treated water from the operating SLA P&T system are pumped 1,500 feet to the Madigan Army Medical Center (MAMC) where it flows through the heat exchanger for the facility air conditioning system and allows more efficient facility cooling. The treated water is subsequently discharged to a water feature (a creek) in the atrium of the hospital, then to a lined pond on the northeast side of the hospital, and finally to an infiltration pond where it percolates into the shallow aquifer. Even during periods when cooling at the hospital is not needed, the discharge of treated water to the water feature/pond is maintained and is seen as a beneficial use (i.e., maintains flow in the creek).

Annual footprint reductions for the remedy associated with this GSR application include the following:

- **7,600 MMBtu of energy used (69% reduction)**
- **280 metric tons of CO_2e (67% reduction)**
- **0.5 metric tons of NO_x (68% reduction)**
- **0.4 metric tons SO_x (69% reduction)**

The “reductions” noted above represent the percentage of the offset relative to the energy use and emissions for operation of the remedy. In addition to these energy and emission offsets, the water reuse also conserves local water resources and benefits creek ecosystem. Although this practice did not directly reduce costs for the remedy, it offsets the costs for MAMC to obtain water.

For more information, contact
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June 2011

Controlled Detonation Chamber (CDC):

Multiple MMRP Sites CALIFORNIA

This case study briefly summarizes the calculation of GSR footprints for transportation and operation of a Controlled Detonation Chamber (CDC) to destroy unexploded ordnance (UXO). Inputs were based on a study where a CDC was sequentially used at four locations in California.

- Illustrates the types of inputs required to calculate footprints
- Footprints for energy use and emissions are minor (though likely larger than for UXO destruction using OB/OD or BIP)
- Footprints include hazardous solid waste and non-hazardous solid waste that would not be expected from OD/OD or BIP
- Decisions to use a CDC versus OB/OD or BIP for UXO destruction will likely be made based on considerations of site-specific cost, safety, and/or community concerns.

A Controlled Detonation Chamber (CDC) destroys Munitions and Explosives of Concern (MEC) while protecting humans and the environment from the detonation. Where appropriate, this technology provides an alternative to the traditional practices of open burn/open detonation (OB/OD) and blow-in-place (BIP) for destruction of unexploded ordnance (UXO). In cases where it is unsafe to move the UXO items, a CDC cannot be used.

This case study summarizes findings from a quantitative footprint analysis based on parameters for deploying a CDC sequentially at four locations in California, based on information provided in the report "*CDC Optimization Demonstration – Draft Final*" by DeMil International, Inc. (August 2005) which evaluated the logistical, regulatory, and economic requirements of deploying a transportable CDC to multiple sites within a limited geographic area. A transportable Model T-10 CDC was used to destroy munitions that were safe to move at the following four locations in California: Fort Hunter Liggett; Mare Island; Camp Roberts; and Seal Beach Naval Weapons Station.

For this case study, GSR footprints for the CDC use referenced above were calculated by Tetra Tech, as part of a larger GSR Study that included GSR evaluations for 12 Pilot Projects (three of which were for MMRP projects). Relatively low footprints (e.g., energy use, greenhouse gas emissions) were determined for the three MMRP Pilot Projects in the GSR Study, likely because of the short-term nature of the MMRP activities for those Pilot Projects (compared to long-term active remedies for MMRP and/or non-MMRP projects such as pump and treat for groundwater). The three MMRP Pilot Projects included BIP for destruction of UXO rather than use of a CDC. It is expected that the environmental footprints for a CDC will be generally higher than for BIP (or OB/OD) due to the transportation requirements for the CDC unit. This case study was performed to see if the relatively higher GSR footprints for use of a CDC would be sufficiently large to approach or exceed an energy use screening threshold of 10,000 MMBtus identified in the overall GSR Study to differentiate projects where quantitative GSR footprinting is most beneficial for identifying potential footprint reductions.

For more information, contact
Name: Nick Stolte, GSR Study MMRP Coordinator
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The SiteWise™ tool was used for the case study GSR footprint calculations. No attempt was made to calculate comparative GSR footprints for OB/OD or BIP activities (which would be expected to be lower), since parameters for those approaches to UXO destruction were not documented in the report provided. The following total footprint results were calculated for transportation and use of the CDC at the four locations:

- 609 MMBtu of energy used
- 44 metric tons of CO_2e (equivalent global warming potential of carbon dioxide)
- 0.0823 metric tons of NO_x+SO_x+PM (nitrogen oxides, sulfur oxides, and particulate matter)
- 1,060 lbs of refined materials use (for donor explosive)
- 7.1 tons of waste generation

These footprints were calculated based on the following inputs:

- The weight of the CDC alone was 65,000 lbs and the gross weight for transport was 97,000 lbs.
- Mobilization of the CDC from Crescent City, Illinois to Fort Hunter Liggett, California (2,594 miles, based on overweight permit route), and two weeks of use.
- 192 miles one-way transport to Mare Island (near Vallejo, CA), and one week of use.
- 216 miles one-way transport to Camp Roberts, CA, and one week of use.
- 252 miles one-way transport to Seal Beach Naval Weapons Station, CA, and one week of use, followed by demobilization of the CDC from Seal Beach NWS to Crescent City, IL (2,349 miles).
- 3-person UXO/CDC crew during field work (8 weeks total, including mobilization/demobilization), with one additional person during mobilization and demobilization (two weeks total).
- 3 UXO Technicians/CDC personnel travel approximately 3,000 miles total (round-trip) and one additional person for mobilization/demobilization travels approximately 1,000 miles total (round-trip).
- One work week assumed to consist of five 8-hour labor days and only 4 explosive operations days (with no explosive operations during mobilization/demobilization).
- Use of 400 lbs of donor explosives at Fort Hunter Liggett, 200 lbs at Mare Island, 400 lbs at Camp Roberts, and 60 lbs at Seal Beach NWS (the UXO destroyed is not included in the GSR footprint evaluation).
- Waste samples collected and shipped to a laboratory in Sacramento, CA (SiteWise calculates laboratory footprint based on cost of analytic services, and for this case study approximately $20,000 for laboratory costs was assumed).
- Munitions debris turned over to the facility for appropriate disposition and disposal (no quantities provided, so no scrap metal disposal footprint was calculated).
- Six 55-gallon drums of solid hazardous waste cleaned out of the CDC at Fort Hunter Liggett, four at Mare Island, four at Camp Roberts, and five at Seal Beach NWS, with each drum estimated to weigh approximately 600 lbs.

For more information, contact
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- Seven 55-gallon drums of non-hazardous decontamination water generated at Seal Beach NWS, with each drum estimated to weigh approximately 400 lbs.
- Drum contents disposed of in Inglewood, CA, which is 256 miles from Fort Hunter Liggett, 388 miles from Mare Island, 225 miles from Camp Roberts, and 26 Miles from Seal Beach.

The calculated footprints for energy use and emissions are minor (though likely larger than for UXO destruction using OB/OD or BIP). For instance, the energy footprint of 609 MMBtus is well below the threshold of 10,000 MMBtus developed in the GSR Study to identify projects mostly likely to benefit from calculating quantitative footprints. This is consistent with the observations from the GSR Study that short-term active remedies have minor footprints, and therefore are likely to benefit less from quantitative footprinting efforts than long-term active remedies. It is also noted that the CDC use in the case study generated hazardous solid waste and non-hazardous liquid waste, and those types of wastes would generally not be generated by OB/OD or BIP.

Decisions to use a CDC versus OB/OD or BIP for UXO destruction will likely be made based on considerations of site-specific cost, safety, and/or community concerns. However, the case study illustrates that environmental footprints can be calculated if stakeholders determine that footprints for one or more parameters are a potential concern, and also illustrates the type of input information that is required to perform the footprint evaluation.

U.S. Army
Green and Sustainable Remediation (GSR)
Case Study

Comparison of Low Flow vs. Passive Diffusion Bag Sampling

Joint Base Lewis-McChord WASHINGTON

This case study briefly summarizes a Green and Sustainable Remediation (GSR) practice that has been applied at this site and can be implemented at many sites that currently use low flow sampling. GSR practices which are implemented in this case study include:

- Planning for sustainability
- Energy/emission reductions
- Water resource conservation
- Reduction of materials use and waste generation
- Improvements related to safety and community

The monitoring program for pump and treat (P&T) systems at Joint Base Lewis-McChord (JBLM) was used as a case study to compare the relative impact of using passive diffusion bag (PDB) sampling as opposed to low flow sampling. Currently, 61 wells are sampled for volatile organic compounds (with 56 of them using PDBs for sample collection). The case study compared two scenarios in which sampling was performed either completely by PDBs or completely by low flow sampling.

Footprint reduction from using PDBs is driven by the reduced time spent in the field. A two person team can sample 12 wells per day using PDBs while only being able to sample 5 wells per day using low flow methods. More days in the field translates to more vehicle miles, higher accident risk, and more energy and equipment use. Annual impact reductions are summarized as follows:

- **A 54% reduction in GHG emissions using PDBs**
- **A 55% reduction of energy used using PDBs**
- **A 63% reduction in Criteria Air Pollutant Emissions using PDBs**
- **A 59% reduction in accident injury or fatality risk using PDBs**

For more information, contact
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September 2011

Case Study of Comparative Impacts of Low-Flow Sampling vs. Passive Diffusion Bag Sampling

Joint Base Lewis-McChord

This case study was performed to compare the environmental footprint of low flow sampling (LFS) versus passive diffusion bag (PDB) sampling at Joint Base Lewis-McChord (JBLM). JBLM is located in northwest Washington approximately 30 miles south of Seattle. Contamination is due to a 23 acre industrial landfill that had been actively used in the past. The primary contaminants of concern (COCs) are volatile organic compounds such as trichloroethene (TCE). Treatment consists of three separate pump and treat systems. Monitoring of the treatment systems is accomplished by sampling for COCs and water levels from 61 wells, 56 of which are sampled by PDBs and 5 by low flow sampling. An operations and maintenance staff located on the site performs all of the sample collection.

The case study was performed by developing two unique scenarios in which well samples were assumed to be collected either by PDBs only or LFS only. Quantitative analysis of environmental footprint was performed using SiteWise™ version 2 (SiteWise™ (available at http://www.ert2.org/t2gsrportal/SiteWise.aspx). Detailed assumptions and calculations are addressed in the tables included in this report. Information that is not formally referenced was obtained from the installation as part of a larger body of information collected for performance of a Remediation System Evaluation (RSE) on the installation. See USACE and Tetratech Geo (2011) for more details.

Some general assumptions used during the analysis are:

- No attempt was made to calculate the impact of the material used for packing, storing, and shipping the samples (such as coolers, bubble wrap, ice packs etc.) since SiteWise does not include materials such as these in its calculations. Furthermore, samples would be packed and shipped by the same methods for either low-flow or passive diffusion bag sampling so inclusion of these materials in the comparison of the two scenarios would not show any comparative difference.
- All investigation derived waste (IDW) generated from decontamination of equipment and well purging is disposed of at an on-site water treatment system which consists of an air stripper that sends treated water to infiltration galleries. Since the on-site treatment system operates continuously, using it to treat a small amount of IDW would not create any impact to the environment in terms of air stripper operation. However, the effect to the environment of the higher water use with low-flow sampling, including decontamination of the pumps, is included in the footprint comparison.

SAMPLE COLLECTION[1]	Event 1	Event 2	Event 3
Short Description of Event	Quarterly Sampling Only	Quarterly + Semi-Annual Sampling	Quarterly + Semi-Annual + Annual
Vehicle type (car, truck, suv, hybrid)	Light Truck	Light Truck	Light Truck
Fuel (gasoline, diesel)	Gasoline	Gasoline	Gasoline
Number of wells sampled	44	83 wells + 45 water levels	144 wells + 45 water levels
Distance traveled per day (miles)	10	10	10
Number of days sampling[2]	4	8	13
Number of travelers	2	2	2

[1] Wells are sampled on one of three schedules: quarterly, semi-annual, or annual. In order to input the sampling events into SiteWise™ V2, it is assumed that the sampling teams will mobilize four times per year with two of the mobilizations devoted solely to quarterly sampling (Event 1), one devoted to quarterly + semi-annual sampling (Event 2), and one devoted to quarterly + semi-annual + annual sampling (Event 3).
[2] The number of days sampling for each event is based on the number of wells sampled and the rate at which wells are sampled. A USGS study (Huffman, R. M., 2002) concluded that for a two person team, 12 wells could be sampled per day via PDB's. Water levels readings are assumed to be taken all in one day.
[3] An Interstate Technology Regulatory Council (ITRC 2002) brochure states that PDB's may be hung in a well for as long as one year between sampling events. Based on this finding, it is assumed that the team would hang a new PDB in each well following the recovery of a sample. No trips have to be made solely to hang a new PDB prior to collecting a sample.

SAMPLE SHIPMENT[1]	Event 1	Event 2	Event 3
Short Description of Event	Quarterly Sampling Only	Quarterly + Semi-Annual Sampling	Quarterly + Semi-Annual + Annual
Vehicle type (car, truck, suv, hybrid)	SUV	SUV	SUV
Fuel (gasoline, diesel)	Gasoline	Gasoline	Gasoline
Distance traveled per trip (miles)[2]	40	40	40
Number of trips	2	2	3
Number of travelers	1	1	1

[1]Samples are delivered from JBLM to Test America Labs in Seattle via an express courier, travelling in an SUV.
[2]Test America labs are located 20 miles away from JBLM. Since an express courier would most likely be making a dedicated trip with the samples, the round-trip mileage is used for each sample shipment. A report from Fort Lewis (USACE and Tetratech GEO) states that samples will be shipped via overnight courier once every week, so the number of trips to deliver samples is calculated based off of this information.

OPERATOR LABOR	Occupation 1
Choose occupation from drop-down menu	Operating engineers
Input total time worked onsite (hours)	400
The time worked is calculated based on an assumed 8 hour work day, with 25 total days worked for each laborer.	

SAMPLE COLLECTION	**Event 1**	**Event 2**	**Event 3**
Short Description of Event	Quarterly Sampling Only	Quarterly + Semi-Annual Sampling	Quarterly + Semi-Annual + Annual
Vehicle type (car, truck, suv, hybrid)	Light Truck	Light Truck	Light Truck
Fuel (gasoline, diesel)	Gasoline	Gasoline	Gasoline
Number of wells sampled	44	83 wells + 45 water levels	144 wells + 45 water levels
Distance traveled per day (miles)	10	10	10
Number of days sampling[2]	9	18	30
Number of travelers	2	2	2

Wells are sampled on one of three schedules: quarterly, semi-annual, or annual. In order to input the sampling events into SiteWise™ V2, it is assumed that the sampling teams will mobilize four times per year with two of the mobilizations devoted solely to quarterly sampling (Event 1), one devoted to quarterly + semi-annual sampling (Event 2), and one devoted to quarterly + semi-annual + annual sampling (Event 3).

[2] The number of days sampling for each event is based on the number of wells sampled and the rate at which wells are sampled. A USGS study (Huffman, R. M., 2002) concluded that for a two person team, 5 wells could be sampled per day using low flow sampling. Water levels readings are assumed to be taken all in one day.

SAMPLE SHIPMENT	**Event 1**	**Event 2**	**Event 3**
Short Description of Event	Quarterly Sampling Only	Quarterly + Semi-Annual Sampling	Quarterly + Semi-Annual + Annual
Vehicle type (car, truck, suv, hybrid)	SUV	SUV	SUV
Fuel (gasoline, diesel)	Gasoline	Gasoline	Gasoline
Distance traveled per trip (miles)[1]	40	40	40
Number of trips	2	4	6
Number of travelers	1	1	1

[1]Samples are delivered from JBLM to Test America Labs in Seattle via an express courier, travelling in an SUV.

[2]Test America labs are located 20 miles away from JBLM. Since an express courier would most likely be making a dedicated trip with the samples, the round-trip mileage is used for each sample shipment. A report from Fort Lewis (USACE and Tetratech GEO 2011) states that samples will be shipped via overnight courier once every week, so the number of trips to deliver samples is calculated based off of this information.

PUMP OPERATION	**Event 1**	**Event 2**	**Event 3**
Short Description of Event	Quarterly Sampling Only	Quarterly + Semi-Annual Sampling	Quarterly + Semi-Annual + Annual
Pump type (discharge, extraction, etc.)	Low Flow Sampling Pump	Low Flow Sampling Pump	Low Flow Sampling Pump
Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN			
Pump horsepower (hp)[1]	0.5	0.5	0.5
Number of pumps operating	1	1	1
Operating time for each pump (hrs)[2]	22	41.5	72
Pump load[3]	1.0	1.0	1.0
Pump motor efficiency	0.85	0.85	0.85

[1]For the purposes of modeling low flow sampling in the low flow sampling scenario, it was assumed that a Grundfos Redi-Flo 2 electrical powered pump would be used

[2]Operating time is based on the assumption that 30 minutes of pumping would be required in order for monitoring parameters of the purge water to stabilize at each well. Total time is calculated as (30 min/well) X (number of wells per sampling event). The volume of water purged is calculated by assuming a purge rate of 200 ml/min or 6000 ml or 1.6 gallons total per well. Further, it was assumed that the pump was decontaminated after use at each well with a 5 gal wash, followed by a 5 gal rinse, or 10 gallons of water per well for decontamination. Although in some circumstances, reuse of the decontamination solution may be permissible, it was assumed here that fresh solutions were used for each well

[3] Pump load is entered as 1.0 since entering a value less than one is only done when system downtime is included in the calculations.

OPERATOR LABOR	**Occupation 1**
Choose occupation from drop-down menu	Operating engineers
Input total time worked onsite (hours)	912

The time worked is calculated based on an assumed 8 hour work day, with 57 total days worked for each laborer.

Well Sampling Case Study Comparison of Low Flow Sampling and Passive Diffusion Bags

Summary of Results

The assumptions detailed in the tables above were entered into SiteWise™, and the footprint calculations were then generated. The results from the calculations are presented in two methods.

- Method One: This method presents the results calculated for an entire year of sampling using either PDBs or low-flow sampling. The inputs and assumptions for this method are exactly the same as the ones in the tables preceding this page.
- Method Two: For this method, the impact of sampling a single well by either PDBs or low-flow sampling was calculated. To do this, the impact of performing one day of sampling using either method was calculated. Those results were then divided by the number of wells sampled in one day for each method (12 wells via PDBs and 5 via low-flow sampling). This method allows use of the case study results to determine qualitatively the impact difference between the two sampling methods for any number of wells. As noted below, since the assumptions are different for each site, application of the results from this case study should only be used qualitatively if applied to other sites.

General Discussion of Results

The results show that in general, PDB sampling has more GSR benefits than low flow sampling. This can be attributed to the fact that PDB sampling can complete more wells per day, meaning fewer days of field mobilization. Also, no equipment is needed for PDB sampling whereas low-flow sampling requires submersible pumps that must be powered and decontaminated after each well.

Note that these results do not represent an endorsement of one sampling method versus the other. GSR considerations are one of many factors in selecting a sampling method. Also, the limitations of using the results of this case study for other sites should be considered. Since assumptions will be different for each site, the results from this case study should only be used qualitatively when considering applying the results to other sites.

Tables summarizing the data generated by SiteWise™ V2, as well as selected charts generated in SiteWise™ V2, are displayed below:

Well Sampling Case Study Comparison of Low Flow Sampling and Passive Diffusion Bags

Table 1 Footprint of Both Sampling Methods

GSR Parameter	Low Flow Sampling	PDB Sampling
Environmental		
Energy (MMBtu)	7.356810484	3.35953835
Global warming potential (Metric tons CO2e)	0.560912676	0.266416238
Criteria air pollutant emissions (Metric tons NOx+SOx+PM10)	0.000313755	0.000116394
Water Use (gallons)	3132	0
Non-hazardous waste generation (tons)	0	0
Hazardous waste generation (tons)	0	0
Economic		
Up-front Cost		
Societal		
Injury or fatality risk	0.022054443	0.009717158
Predicted number of hours lost to injury	0.175944123	0.077517393

Table 2 Footprint of Sampling One Well with Both Sampling Methods

GSR Parameter	Low Flow Sampling *1 Well*	PDB Sampling *1 Well*
Environmental		
Energy (MMBtu)	6.25E-02	2.51E-02
Global warming potential (Metric tons CO2e)	4.88E-03	1.99E-03
Criteria air pollutant emissions (Metric tons NOx+SOx+PM10)	2.22E-06	8.09E-07
Water Use (gallons)	11.6	0.00E+00
Non-hazardous waste generation (tons)	0.00E+00	0.00E+00
Hazardous waste generation (tons)	0.00E+00	0.00E+00
Economic		
Up-front Cost		
Societal		
Injury or fatality risk	8.14E-05	3.39E-05
Predicted number of hours lost to injury	6.49E-04	2.70E-04

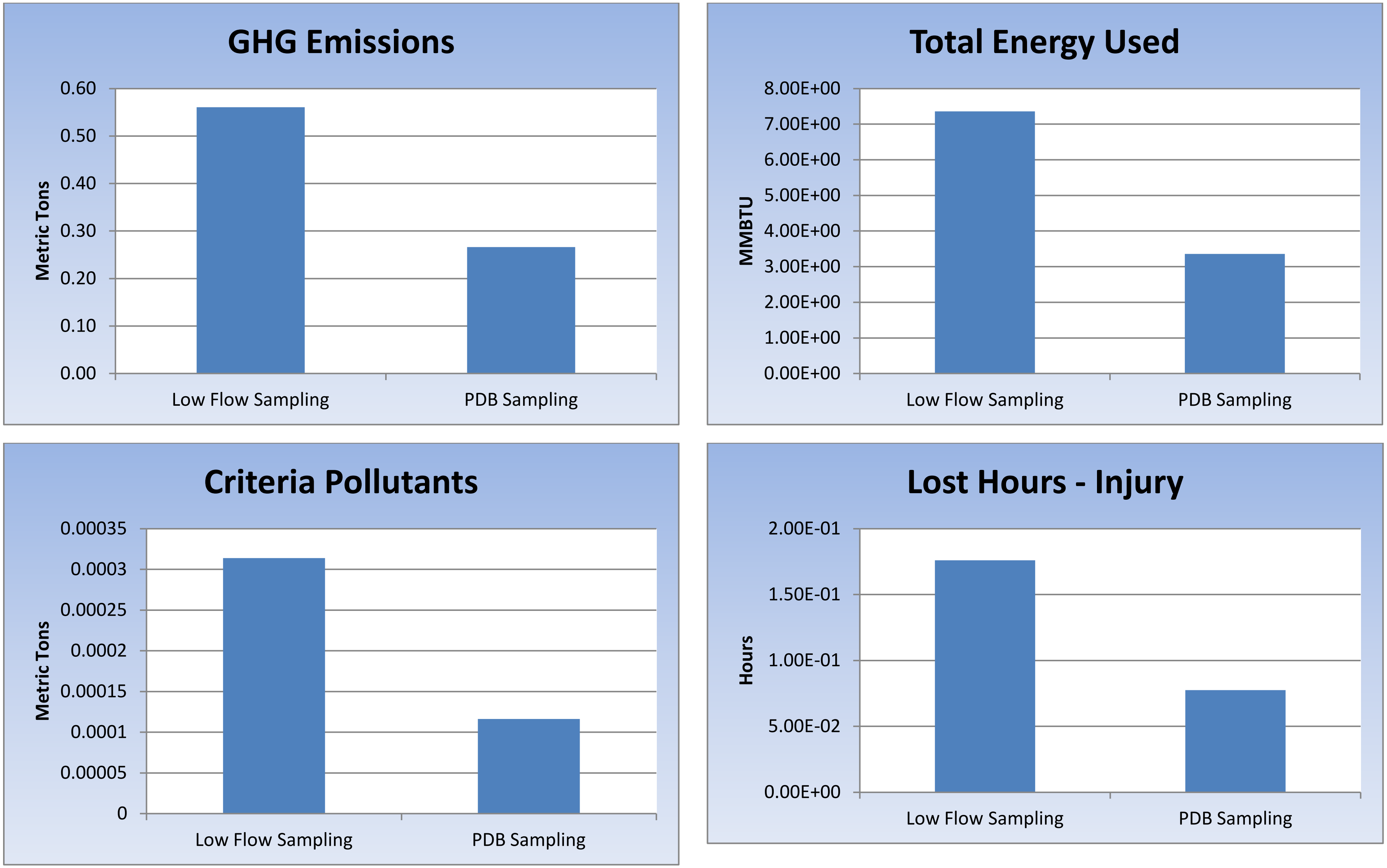

Figure 1 Graphic Display of Footprint Data from Table 1

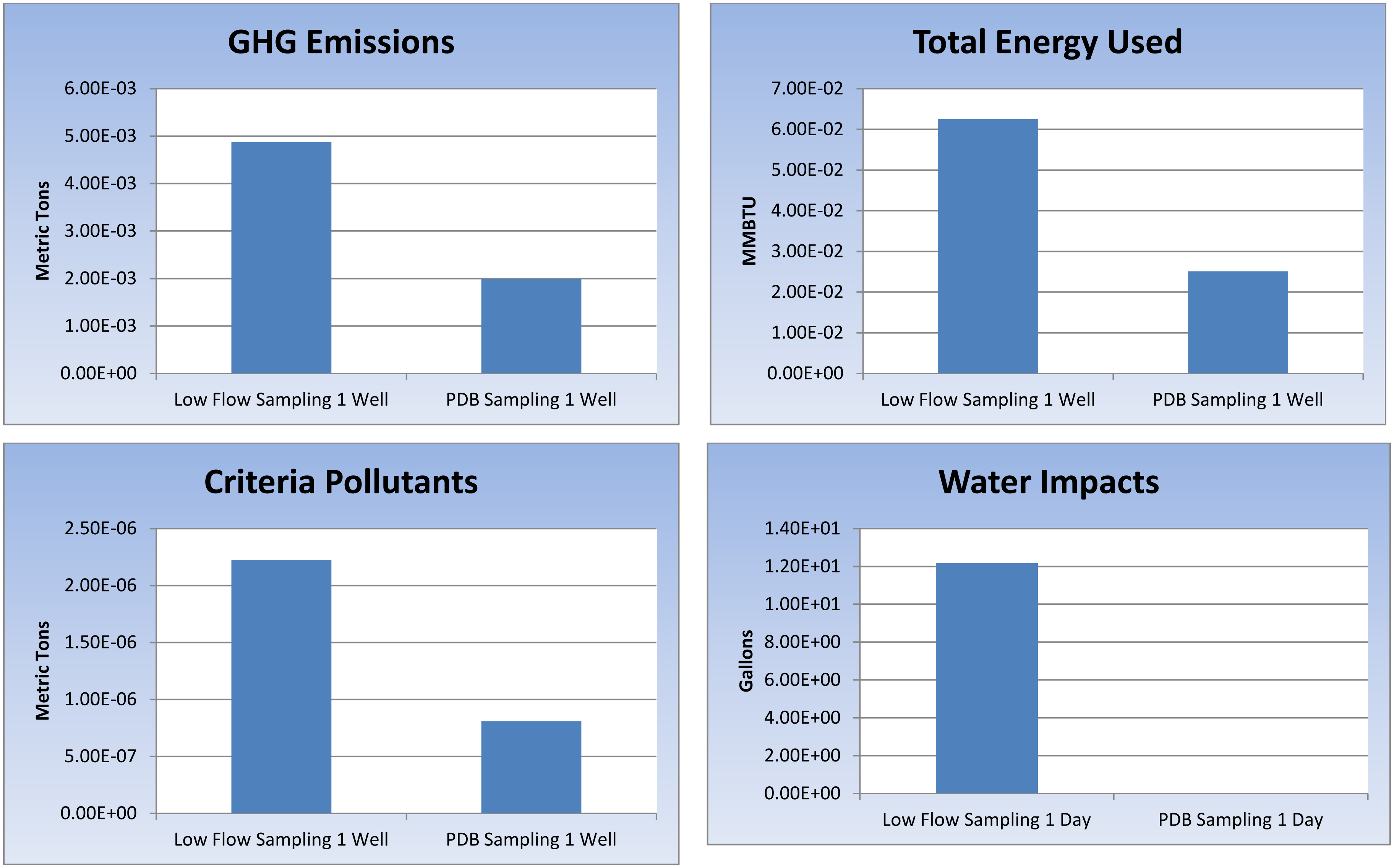

Figure 2 Graphic Display of Footprint Data from Table 2

References:

US Army Corps of Engineers Environmental and Munitions Center of Expertise and Tetratech GEO (USACE and Tetratech GEO 2011), Remedial System Evaluation, Joint Base Lewis-McChord, Washington (Former Fort Lewis Portion), Final Report, prepared by the US Army Corps of Engineers Environmental and Munitions Center of Expertise and Tetratech GEO, May 2011.

Geosyntec Consultants. (Geosyntec 2006,). *Standard Operating Procedures for Groundwater Sampling, January 2006.* Retrieved July 17, 2011, from http://ndep.nv.gov/bmi/docs/appendix_c07.pdfHuffman, R. L. (Huffman, 2002). *Comparison of Passive Diffusion Bag Samplersand Submersible Pump Sampling Methods forMonitoring Volatile Organic Compounds in GroundWater at Area 6, Naval Air StationWhidbey Island, Washington.* Retrieved July 13, 2011, from USGS Webpage: http://pubs.usgs.gov/wri/wri024203/pdf/wri024203.pdf

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Puls, R. J., & Barcelona, M. J. (Puls and Barcelona, 1996). *LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES, April 1996.* Retrieved July 13, 2011, from Environmental Protection Agency Website: http://www.epa.gov/tio/tsp/download/lwflw2a.pdf

U.S. Army
Green and Sustainable Remediation (GSR) Case Study

Comparison of the Different Well Installation Techniques

Schilling Air Force Base Atlas Missile Facility S-1, Kansas

This case study summarizes a GSR consideration that can be made for nearly any site which requires the installation of wells. Specific GSR practices which could be implemented based on the information in this case study include:

- Planning for sustainability
- Energy/emission reductions
- Water resource conservation
- Reduction of materials use and waste generation
- Improvements related to safety and community

The installation of five monitoring wells at a Formerly Used Defense Site (FUDS) was used as a scenario to model a case study comparing five different methods for monitoring well installation. Drilling methods were included based on frequency of use (cable tool, hollow stem auger, and mud rotary) and potential GSR benefits (direct push and sonic drilling).

Results of the case study showed that mud rotary drilling has the largest environmental impact followed by hollow stem auger, sonic drilling, cable tool, and direct push. Several other insights were also discovered including:

- **Handling of Investigation Derived Waste (IDW) has a relatively small impact compared to the other well installation activities**
- **Not surprisingly, transportation of equipment and personnel was responsible for the majority of the environmental impact of the drilling rigs that utilize the least amount of fuel (cable tool and direct push)**
- **At locations where direct push well installation is feasible, it creates only 36% of the GHG emissions and 4% of the NO_x and SO_x emissions that other common technologies such as hollow stem auger.**

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April 2012

Case Study Comparing the Impacts of Different Boring Methods Used for Well Installation

Schilling Air Force Base Atlas Missile Facility S-1; Bennington, Kansas

This case study was done to compare the relative impacts of different well installation techniques. Five installation techniques were chosen for evaluation based on either their frequency of use (cable tool, hollow stem auger and mud rotary) or their potential Green and Sustainable Remediation (GSR) benefit (sonic drilling and direct push). The case study uses the installation of 5 monitoring wells at the Schilling S-1 Atlas Missile Site to demonstrate the comparative impacts of the different drilling methods. Whenever possible, actual data from the project were used to build this scenario, but in some cases assumptions had to be made. Most of those assumptions are fairly simple and are addressed as they come up in the tables on the following pages. However, a few assumptions and decisions are of more importance and are addressed as follows:

- While site geology often determines which drilling technology is applicable, for the purpose of comparing the different drilling technologies it was assumed that the site geology would allow for all 5 well installation technologies to be used. In reality not all of the technologies would be usable at this site as there are lenses of cemented material which stop the less-robust methods (direct push and hollow stem auger). Direct push and hollow stem rigs can also be subject to depth limitations even in geologic formations that otherwise are suitable.
- It was assumed that all of the drilling technologies included in this study would be available for use. This is another assumption that will usually not be the case since some rigs are more commonly used (cable tool, mud rotary, and hollow stem auger) and others are not as common (direct push and sonic). For the less common drill rigs, there may be greater mobilization distances which would increase the environmental impact of using these drill rigs.
- The rate of well completion is used frequently to calculate the amount of time that equipment and personnel spend on-site. It includes the time to drill, install, and develop the well.
- Another concept of note is IDW generation. For each well installation method, the amount of IDW generated is expressed as number of barrels per foot. This includes drill cuttings, development water, and in the case of mud rotary drilling, drilling mud.
- Three-man crews were used for all drilling methods modeled, including direct push.

To complete the study, the inputs that are described in the tables below were entered into SiteWise™ version 2 as five different alternatives. Once all of the alternatives were entered, comparisons of the different alternatives were generated in SiteWise™. At the end of this report, tables and graphs are included showing the impacts of each method. Also included is a qualitative comparison of the different methods that further explains the results.

DRILLING	**Event 1**
Number of Drilling Locations	5
Drilling Method	Sonic
Days Spent at Site	8
Time spent drilling at each location (hr)[1]	15.4
Depth of wells (ft)[2]	80
Fuel type	Diesel
[1]The rate for well completion using sonic drilling is 52 ft/day (Masten and Davis). In that study 10 hour work days were used, which is also the case for the drilling that is being performed at the Site. [2]The depth of the wells is an assumed value based on the specification that wells would be drilled ten feet below the top of the water table, which is at 70 feet bgs.	

PERSONNEL TRANSPORTATION - ROAD	**Vehicle 1**	**Vehicle 2**	**Vehicle 3**
Trip Description	Rig Mob/Demob	Truck Mob/Demob	Mob/Demob + Daily Trips
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No
Vehicle type	Heavy Duty	Heavy Duty	Light Truck
Fuel	Diesel	Diesel	Gasoline
Distance traveled per trip (miles)[1]	340	340	340 (mob/demob), 10 (daily trips)
Number of trips taken	1	1	2 (mob/demob)[2], 16 (daily trips)
Number of travelers	1	1	1 (mob/demob), 3 (daily trips)
For equipment/personnel mobilization, it is assumed that three vehicles mobilize to the site. Included are the drill rig and support truck (both modeled as heavy duty trucks) and a light truck carrying other miscellaneous equipment. The drill rig and support truck stay at the Site for the duration of the drilling while the light truck is used to transport personnel between the site and hotels/restaurants. [1]Vehicles mobilize from Kansas City which is 170 miles from the Site. Daily trips in Vehicle 3 are between the Site and a town approximately five miles away. All mileage is round trip. [2] Since drilling would take longer than one week (crews only drill four days per week because of site resident restrictions and eight days of drilling are required), a second trip between the Site and Kansas City would occur to allow personnel to return to Kansas City over the weekend.			

EQUIPMENT TRANSPORTATION – ROAD[1]	Trip 1	Trip 2	Trip 3	Trip 4
Short Description of Trip	IDW Barrel Delivery	IDW Barrel Delivery (empty return)	IDW Barrel Pickup (empty departing)	IDW Barrel Pickup
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No
Fuel	Diesel	Diesel	Diesel	Diesel
Distance traveled (miles)	170	170	170	170
Weight of equipment transported (tons)	0.24	0.00	0.00	4.32

[1]In SiteWise V2, the disposal of IDW could be input in the "Residue Disposal" table. In actuality, either the "Residue Disposal" table or the "Equipment Transportation-Road" table can be used since both tables require the same input information and calculate environmental impact using the same algorithm; therefore, the choice of which table to use is arbitrary.
All IDW generated on site is assumed to be transported to a landfill in Kansas City for disposal.
The assumption is made that an on-road truck (semi-trailer) would bring all of the IDW barrels to the Site. Weights of IDW barrels are 40 lbs when empty and 920 lbs when filled with drill cuttings or 500 lbs when filled with equipment decontamination waste. The weight of equipment transported is based on the volume of IDW generated by the sonic drilling. The Masten and Davis study reported an IDW generation of 1 barrel for every 60 feet of drilling plus 1 barrel of decontamination waste per well.

LANDFILL OPERATIONS	Operation 1
Choose landfill type for waste disposal	Non-Hazardous
Input amount of waste disposed in landfill (tons)	4.32

OPERATOR LABOR	Occupation 1
Occupation	Construction Laborers
Input total time worked onsite (hours)	230

Time spent working is calculated based on the time that it takes to complete all of the wells. It is assumed that there are three workers on a sonic drill crew, and they each work ten hour days. The days worked are not rounded up to the next whole day since SiteWise calculates accident and injury risk based on operator labor. Hence if it takes 2.5 days to install all wells, that means that while the crews may be at the site for 3 days, they will only be working with equipment for 2.5 of those days.

Materials calculations are based on an assumed well that has a boring depth of 80 feet (this is similar to the existing monitoring well located on-site). A six inch inside diameter boring is drilled using the specific drilling method for this section. A 2” inner PVC pipe runs the length of the boring and a 6” steel casing protects the upper 4 feet. Sand fills the annular space in the lower 15 feet of the boring and a bentonite grout fills the rest of the annular space. The well is completed with a cement flush mount.

WELL MATERIALS	**Inner PVC Casing**	**Outer Steel Casing**
Input number of wells	5	5
Input length of casing (ft)	80	4
Material Schedule	Sch 40 PVC	Sch 40 Steel
Well diameter (inches)	2	6
SiteWise calculates material usage based on pounds of piping per linear foot. The PVC casing is assumed to run the entire length of the boring from the top of casing to the bottom of the screen (this is slightly simplified since the screened interval would have slotted PVC instead of solid PVC). Steel casings are assumed to go four feet below ground surface, which is approximately the frost line distance.		

BULK MATERIAL QUANTITIES	**Material 1**	**Material 2**	**Material 3**
Choose material from drop down menu	Sand	Bentonite Grout	Cement
Choose units of material quantity from drop down menu	pounds	pounds	Pounds
Input material quantity	157	654.5	416
Weight of sand is based on an assumed unit weight of 120 lbs per cubic foot. Bentonite is assumed to be 100 lbs per cubic foot and cement is 150 lbs per cubic foot.			

DRILLING	**Event 1**
Number of Drilling Locations	5
Drilling Method	Direct Push
Days Spent at Site	2
Time spent drilling at each location (hr)[1]	3.2
Depth of wells (ft)[2]	80
Fuel type	Diesel

[1]The rate for well completion using direct push well installation is 250 ft/day (ESTCP 2009). No information was given concerning whether the work days were 8 or 10 hours, so 10 hour work days were assumed.
[2]The depth of the wells is an assumed value based on the specification that wells would be drilled ten feet below the top of the water table, which is at 70 feet bgs.

PERSONNEL TRANSPORTATION - ROAD	**Vehicle 1**	**Vehicle 2**	**Vehicle 3**
Short Trip Description	Rig Mob/Demob	Truck Mob/Demob	Mob/Demob + Daily Trips
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No
Vehicle type	Light Truck	Light Truck	Light Truck
Fuel	Gasoline	Gasoline	Gasoline
Distance traveled per trip (miles)[1]	340	340	340 (mob/demob), 10 (daily trips)
Number of trips taken	1	1	1 (mob/demob), 4 (daily trips)
Number of travelers	1	1	1 (mob/demob), 3 (daily trips)

For equipment/personnel mobilization it is assumed the three vehicles mobilize to the site. Included are the vehicle carrying the direct push probe, a supporting vehicle carrying drill rods and other drilling equipment, and a light truck carrying other items and personal supplies for the drillers (all modeled as light trucks). The truck carrying the direct push probe as well as the support truck both stay on Site for the duration of the drilling while the light truck is used to transport personnel between the site and hotels/restaurants.
[1]Vehicles mobilize from Kansas City which is 170 miles from the Site. Daily trips in Vehicle 3 are between the Site and a town approximately five miles away. All mileage is round trip.

EQUIPMENT TRANSPORTATION – ROAD[1]	Trip 1	Trip 2	Trip 3	Trip 4
Short Description of Trip	IDW Barrel Delivery	IDW Barrel Delivery (empty return)	IDW Barrel Pickup (empty departing)	IDW Barrel Pickup
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No
Fuel	Diesel	Diesel	Diesel	Diesel
Distance traveled (miles)	170	170	170	170
Weight of equipment transported (tons)	0.12	0.00	0.00	1.52

[1]In SiteWise V2, the disposal of IDW could be input in the “Residue Disposal” table. In actuality, either the “Residue Disposal” table or the “Equipment Transportation-Road” table can be used since both tables require the same input information and calculate environmental impact using the same algorithm; therefore, the choice of which table to use is arbitrary.
All IDW generated on site is assumed to be transported to a landfill in Kansas City for disposal.
The assumption is made that an on-road truck (semi-trailer) would bring all of the IDW barrels to the Site. Weights of IDW barrels are 40 lbs when empty and 920 lbs when filled with drill cuttings or 500 lbs when filled with equipment decontamination waste. The weight of equipment transported is based on the volume of IDW generated by the direct push well installation. The ESTCP study (ESTCP 2009) reported an IDW generation of 1 barrel for every 66 feet of drilling.

LANDFILL OPERATIONS	Operation 1
Choose landfill type for waste disposal	Non-Hazardous
Input amount of waste disposed in landfill (tons)	1.52

OPERATOR LABOR	Occupation 1
Occupation	Construction Laborers
Input total time worked onsite (hours)	48

Time spent working is calculated based on the time that it takes to complete all of the wells. It is assumed that there are three workers on a direct push well installation crew, and they each work ten hour days. The days worked are not rounded up to the next whole day since SiteWise calculates accident and injury risk based on operator labor. Hence if it takes 2.5 days to install all wells, that means that while the crews may be at the site for 3 days, they will only be working with equipment for 2.5 of those days.

Materials calculations are based on an assumed well that has a boring depth of 80 feet (this is similar to the existing monitoring well located on-site). A 4.25" drive rod is used to clear the boring, and a 2" PVC pipe runs from the screen to the surface. Similar to the "conventional" well installation methods, a 6" steel casing protects the PVC pipe above the frost line. Sand fills the annular space (which is smaller for direct push wells) for the lower 15' of the boring and bentonite grout fills the remaining annular space. The well is completed with a cement flush mount. It is again worth noting that the assumption of using direct push to install a 4.25" diameter 80' deep well would not be feasible in all subsurface conditions.

WELL MATERIALS	**Inner PVC Casing**	**Outer Steel Casing**
Input number of wells	5	5
Input length of casing (ft)	80	4
Material Schedule	Sch 40 PVC	Sch 40 Steel
Well diameter (inches)	2	6
SiteWise calculates material usage based on pounds of piping per linear foot. The PVC casing is assumed to run the entire length of the boring from the top of casing to the bottom of the screen (this is slightly simplified since the screened interval would have slotted PVC instead of solid PVC). Steel casings are assumed to go four feet below ground surface, which is approximately the frost line distance.		

BULK MATERIAL QUANTITIES	**Material 1**	**Material 2**	**Material 3**
Choose material from drop down menu	Sand	Bentonite Grout	Cement
Choose units of material quantity from drop down menu	Pounds	pounds	pounds
Input material quantity	49.7	207	416
Weight of sand is based on an assumed unit weight of 120 lbs per cubic foot. Bentonite is assumed to be 100 lbs per cubic foot and cement is 150 lbs per cubic foot.			

DRILLING	Event 1
Number of Drilling Locations	5
Drilling Method	Cable Tool[1]
Days Spent at Site	21
Time spent drilling at each location (hr)[2]	41
Depth of wells (ft)[3]	80
Fuel type	Diesel

[1] Since SiteWise does not include cable tool rigs as one of the available drilling technologies, external research was done to determine a fuel consumption rate of 0.7 gallons per hour (http://scribd.com/doc/29443476/Cable-Tool-Drilling)

[2]The rate for well completion using cable tool drilling is 19.5 ft/day (Masten and Davis). In that study 10 hour work days were used, which is also the case for the drilling that is being performed at the Site.

[3]The depth of the wells is an assumed value based on the specification that wells would be drilled ten feet below the top of the water table, which is at 70 feet bgs.

PERSONNEL TRANSPORTATION - ROAD	Vehicle 1	Vehicle 2	Vehicle 2
Short Trip Description	Rig Mob/Demob	Truck Mob/Demob	Mob/Demob +Truck Daily Trips
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No
Vehicle type	Heavy Duty	Heavy Duty	Light Truck
Fuel	Diesel	Diesel	Gasoline
Distance traveled per trip (miles)[1]	340	340	340 (mob/demob), 10 (daily trips)
Number of trips taken	1	1	5 (mob/demob)[2], 42 (daily trips)
Number of travelers	1	1	1 (mob/demob), 3 (daily trips)

For equipment/personnel mobilization, it is assumed that three vehicles mobilize to the site. Included are the drill rig and support truck (both modeled as heavy duty trucks) and a light truck carrying other miscellaneous equipment. The drill rig and support truck stay at the Site for the duration of the drilling while the light truck is used to transport personnel between the site and hotels/restaurants.

[1]Vehicles mobilize from Kansas City which is 170 miles from the Site. Daily trips in the pickup are between the Site and a town approximately five miles away. All mileage is round trip.

[2] Since drilling would take longer than one week (crews only drill four days per week because of site resident restrictions, and twenty one days are required for drilling), five total trips between the Site and Kansas City would occur to allow personnel to return to Kansas City over the weekends.

EQUIPMENT TRANSPORTATION – ROAD[1]	Trip 1	Trip 2	Trip 3	Trip 4
Short Description of Trip	IDW Barrel Delivery	IDW Barrel Delivery (empty return)	IDW Barrel Pickup (empty departing)	IDW Barrel Pickup
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No
Fuel	Diesel	Diesel	Diesel	Diesel
Distance traveled (miles)	170	170	170	170
Weight of equipment transported (tons)	0.24	0.00	0.00	4.32
[1]In SiteWise V2, the disposal of IDW could be input in the "Residue Disposal" table. In actuality, either the "Residue Disposal" table or the "Equipment Transportation-Road" table can be used since both tables require the same input information and calculate environmental impact using the same algorithm; therefore, the choice of which table to use is arbitrary. All IDW generated on site is assumed to be transported to a landfill in Kansas City for disposal. The assumption is made that an on-road truck (semi-trailer) would bring all of the IDW barrels to the Site. Weights of IDW barrels are 40 lbs when empty and 920 lbs when filled with drill cuttings or 500 lbs when filled with equipment decontamination waste. The weight of equipment transported is based on the volume of IDW generated by the sonic drilling. The Masten and Davis study reported an IDW generation of 1 barrel for every 60 feet of drilling plus 1 barrel of decontamination waste per well.				

LANDFILL OPERATIONS	Operation 1
Choose landfill type for waste disposal	Non-Hazardous
Input amount of waste disposed in landfill (tons)	4.32

OPERATOR LABOR	Occupation 1
Occupation	Construction Laborers
Input total time worked onsite (hours)	615
Time spent working is calculated based on the time that it takes to complete all of the wells. It is assumed that there are three workers on a cable tool drill crew, and they each work ten hour days. The days worked are not rounded up to the next whole day since SiteWise calculates accident and injury risk based on operator labor. Hence if it takes 2.5 days to install all wells, that means that while the crews may be at the site for 3 days, they will only be working with equipment for 2.5 of those days.	

Materials calculations are based on an assumed well that has a boring depth of 80 feet (this is similar to the existing monitoring well located on-site). A six inch inside diameter boring is drilled using the specific drilling method for this section. A 2" inner PVC pipe runs the length of the boring and a 6" steel casing protects the upper 4 feet. Sand fills the annular space in the lower 15 feet of the boring and a bentonite grout fills the rest of the annular space. The well is completed with a cement flush mount.

WELL MATERIALS	**Inner PVC Casing**	**Outer Steel Casing**
Input number of wells	5	5
Input length of casing (ft)	80	4
Material Schedule	Sch 40 PVC	Sch 40 Steel
Well diameter (inches)	2	6
SiteWise calculates material usage based on pounds of piping per linear foot. The PVC casing is assumed to run the entire length of the boring from the top of casing to the bottom of the screen (this is slightly simplified since the screened interval would have slotted PVC instead of solid PVC). Steel casings are assumed to go four feet below ground surface, which is approximately the frost line distance.		

BULK MATERIAL QUANTITIES	**Material 1**	**Material 2**	**Material 3**
Choose material from drop down menu	Sand	Bentonite Grout	Cement
Choose units of material quantity from drop down menu	pounds	pounds	pounds
Input material quantity	157	654.5	416
Weight of sand is based on an assumed unit weight of 120 lbs per cubic foot. Bentonite is assumed to be 100 lbs per cubic foot and cement is 150 lbs per cubic foot.			

DRILLING	**Event 1**
Number of Drilling Locations	5
Drilling Method	Mud Rotary
Days Spent at Site	8
Time spent drilling at each location (hr)[1]	14.5
Depth of wells (ft)[2]	80
Fuel type	Diesel
[1]The rate for well completion using mud rotary drilling is 55 ft/day (Masten and Davis). In that study 10 hour work days were used, which is also the case for the drilling that is being performed at the Site. [2]The depth of the wells is an assumed value based on the specification that wells would be drilled ten feet below the top of the water table, which is at 70 feet bgs.	

PERSONNEL TRANSPORTATION - ROAD	**Vehicle 1**	**Vehicle 2**	**Vehicle 3**
Short Trip Description	Rig Mob/Demob	Truck Mob/Demob	Mob/Demob + Daily Trips
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No
Vehicle type	Heavy Duty	Heavy Duty	Light Truck
Fuel	Diesel	Diesel	Gasoline
Distance traveled per trip (miles)[1]	340	340	340 (mob/demob), 10 (daily trips)
Number of trips taken	1	1	2 (mob/demob)[2], 16 (daily trips)
Number of travelers	1	1	1 (mob/demob), 3 (daily trips)
For equipment/personnel mobilization, it is assumed that three vehicles mobilize to the site. Included are the drill rig and water/support truck (both modeled as heavy duty trucks) and a light truck carrying other miscellaneous equipment. The drill rig and support truck stay at the Site for the duration of the drilling while the light truck is used to transport personnel between the site and hotels/restaurants. [1]Vehicles mobilize from Kansas City which is 170 miles from the Site. Daily trips in the pickup are between the Site and a town approximately five miles away. All mileage is round trip. [2] Since drilling would take longer than one week (crews only drill four days per week due to site resident restrictions and eight days of drilling are needed), a second trip between the Site and Kansas City would occur to allow personnel to return to Kansas City over the weekend.			

LANDFILL OPERATIONS	**Operation 1**
Choose landfill type for waste disposal	Non-Hazardous
Input amount of waste disposed in landfill (tons)	43

EQUIPMENT TRANSPORTATION – ROAD[1]	Trip 1	Trip 2	Trip 3	Trip 4
Short Description of Trip	IDW Barrel Delivery	IDW Barrel Delivery (empty return)	IDW Barrel Pickup (empty departing)	IDW Barrel Pickup[2]
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No
Fuel (gasoline, diesel)	Diesel	Diesel	Diesel	Diesel
Distance traveled (miles)	170	170	170	170
Weight of equipment transported (tons)	3.72	0.00	0.00	43

[1]In SiteWise V2, the disposal of IDW could be input in the "Residue Disposal" table. In actuality, either the "Residue Disposal" table or the "Equipment Transportation-Road" table can be used since both tables require the same input information and calculate environmental impact using the same algorithm; therefore, the choice of which table to use is arbitrary.
All IDW generated on site is assumed to be transported to a landfill in Kansas City for disposal.
The assumption is made that an on-road truck (semi-trailer) would bring all of the IDW barrels to the Site. Weights of IDW barrels are 40 lbs when empty and 920 lbs when filled with drill cuttings. The weight of equipment transported is based on the volume of IDW generated by the mud rotary drilling. The Masten and Davis study reported an IDW generation of 1 barrel for every 2.15 feet of drilling. Assuming that this includes all of the recovered drilling fluids and all of the water extracted for well development, for 400 feet of drilling this would calculate to 186 barrels. Since the barrels are primarily filled water, the weight of the barrels is calculated assuming they are filled with water only.
[2]The total amount of IDW generated would be 43 tons. However, the method that SiteWise uses to calculate fuel economy of an on-road truck does not accept equipment weights greater than 40 tons, so the load has to be distributed between two trips, each with weight of 21.5 tons.

OPERATOR LABOR	Occupation 1
Occupation	Construction Laborers
Input total time worked onsite (hours)	218

Time spent working is calculated based on the time that it takes to complete all of the wells. It is assumed that there are three workers on a mud rotary drill crew, and they each work ten hour days. The days worked are not rounded up to the next whole day since SiteWise calculates accident and injury risk based on operator labor. Hence if it takes 2.5 days to install all wells, that means that while the crews may be at the site for 3 days, they will only be working with equipment for 2.5 of those days.

WATER CONSUMPTION	Drilling Mud Make-up Water
Input total water consumed from potable water treatment facility (gal)	10000

Water consumption is based on the amount of water needed to make up the drilling mud used during drilling. The Masten and Davis study states

that "several thousand" gallons of drilling mud may be needed. It was assumed that each boring would require 2000 gallons of drilling mud

Materials calculations are based on an assumed well that has a boring depth of 80 feet (this is similar to the existing monitoring well located on-site). A six inch inside diameter boring is drilled using the specific drilling method for this section. A 2" inner PVC pipe runs the length of the boring and a 6" steel casing protects the upper 4 feet. Sand fills the annular space in the lower 15 feet of the boring and a bentonite grout fills the rest of the annular space. The well is completed with a cement flush mount.

WELL MATERIALS	**Inner PVC Casing**	**Outer Steel Casing**
Input number of wells	5	5
Input length of casing (ft)	80	4
Material Schedule	Sch 40 PVC	Sch 40 Steel
Well diameter (inches)	2	6
SiteWise calculates material usage based on pounds of piping per linear foot. The PVC casing is assumed to run the entire length of the boring from the top of casing to the bottom of the screen (this is slightly simplified since the screened interval would have slotted PVC instead of solid PVC). Steel casings are assumed to go four feet below ground surface, which is approximately the frost line distance.		

BULK MATERIAL QUANTITIES	**Material 1**	**Material 2**	**Material 3**
Choose material from drop down menu	Sand	Bentonite Grout	Cement
Choose units of material quantity from drop down menu	pounds	pounds	pounds
Input material quantity	157	654.5	416
Weight of sand is based on an assumed unit weight of 120 lbs per cubic foot. Bentonite is assumed to be 100 lbs per cubic foot and cement is 150 lbs per cubic foot.			

DRILLING	**Event 1**
Number of Drilling Locations	5
Drilling Method	Hollow Stem Auger
Days Spent at Site	7
Time spent drilling at each location (hr)[1]	13.33
Depth of wells (ft)[2]	80
Fuel type	Diesel

[1]The rate for well completion using hollow stem auger drilling is 60 ft/day (ESTCP 2009). No information was given concerning whether the work days were 8 or 10 hours, so 10 hour work days were assumed.
[2]The depth of the wells is an assumed value based on the specification that wells would be drilled ten feet below the top of the water table, which is at 70 feet bgs.

PERSONNEL TRANSPORTATION - ROAD	**Vehicle 1**	**Vehicle 2**	**Vehicle 3**
Short Trip Description	Rig Mob/Demob	Truck Mob/Demob	Mob/Demob + Daily Trips
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No
Vehicle type	Heavy Duty	Heavy Duty	Light Truck
Fuel	Diesel	Diesel	Gasoline
Distance traveled per trip (miles)[1]	340	340	340 (mob/demob), 10 (daily trips)
Number of trips taken	1	1	2 (mob/demob)[2], 14 (daily trips)
Number of travelers	1	1	1 (mob/demob), 3 (daily trips)

For equipment/personnel mobilization, it is assumed that three vehicles mobilize to the site. Included are the drill rig and support truck (both modeled as heavy duty trucks) and a light truck carrying other miscellaneous equipment. The drill rig and support truck stay at the Site for the duration of the drilling while the light truck is used to transport personnel between the site and hotels/restaurants.
[1]Vehicles mobilize from Kansas City which is 170 miles from the Site. Daily trips in the pickup are between the Site and a nearby town approximately five miles away. All mileage is round trip.
[2] Since drilling would take longer than one week (crews only drill four days per week due to site resident restrictions, and seven days of drilling are needed), a second trip between the Site and Kansas City would occur to allow personnel to return home over the weekend.

EQUIPMENT TRANSPORTATION – ROAD[1]	Trip 1	Trip 2	Trip 3	Trip 4
Short Description of Trip	IDW Barrel Delivery	IDW Barrel Delivery (empty return)	IDW Barrel Pickup (empty departing)	IDW Barrel Pickup
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No
Fuel (gasoline, diesel)	diesel	diesel	diesel	diesel
Distance traveled (miles)	170	170	170	170
Weight of equipment transported (tons)	0.4	0.00	0.00	8.06

[1]In SiteWise V2, the disposal of IDW could be input in the "Residue Disposal" table. In actuality, either the "Residue Disposal" table or the "Equipment Transportation-Road" table can be used since both tables require the same input information and calculate environmental impact using the same algorithm; therefore, the choice of which table to use is arbitrary.
All IDW generated on site is assumed to be transported to a landfill in Kansas City for disposal.
The assumption is made that an on-road truck (semi-trailer) would bring all of the IDW barrels to the Site. Weights of IDW barrels are 40 lbs when empty and 920 lbs when filled with drill cuttings or 500 lbs when filled with equipment decontamination waste. The weight of equipment transported is based on the volume of IDW generated by the hollow stem auger drilling. The Masten and Davis study reported an IDW generation of 1 barrel for every 27 feet of drilling plus 1 barrel of decontamination waste per well.

LANDFILL OPERATIONS	Operation 1
Choose landfill type for waste disposal	Non-Hazardous
Input amount of waste disposed in landfill (tons)	8.06

OPERATOR LABOR	Occupation 1
Occupation	Construction Laborers
Input total time worked onsite (hours)	200

Time spent working is calculated based on the time that it takes to complete all of the wells. It is assumed that there are three workers on a hollow stem auger drill crew, and they each work ten hour days. The days worked are not rounded up to the next whole day since SiteWise calculates accident and injury risk based on operator labor. Hence if it takes 2.5 days to install all wells, that means that while the crews may be at the site for 3 days, they will only be working with equipment for 2.5 of those days.

Materials calculations are based on an assumed well that has a boring depth of 80 feet (this is similar to the existing monitoring well located on-site). A six inch inside diameter boring is drilled using the specific drilling method for this section. A 2” inner PVC pipe runs the length of the boring and a 6” steel casing protects the upper 4 feet. Sand fills the annular space in the lower 15 feet of the boring and a bentonite grout fills the rest of the annular space. The well is completed with a cement flush mount.

WELL MATERIALS	**Inner PVC Casing**	**Outer Steel Casing**
Input number of wells	5	5
Input length of casing (ft)	80	4
Material Schedule	Sch 40 PVC	Sch 40 Steel
Well diameter (inches)	2	6
SiteWise calculates material usage based on pounds of piping per linear foot. The PVC casing is assumed to run the entire length of the boring from the top of casing to the bottom of the screen (this is slightly simplified since the screened interval would have slotted PVC instead of solid PVC). Steel casings are assumed to go four feet below ground surface, which is approximately the frost line distance.		

BULK MATERIAL QUANTITIES	**Material 1**	**Material 2**	**Material 3**
Choose material from drop down menu	Sand	Bentonite Grout	Cement
Choose units of material quantity from drop down menu	pounds	pounds	pounds
Input material quantity	157	654.5	416
Weight of sand is based on an assumed unit weight of 120 lbs per cubic foot. Bentonite is assumed to be 100 lbs per cubic foot and cement is 150 lbs per cubic foot.			

Summary of Results

Once all of the different scenarios described in the tables above were entered into SiteWise V2, the Final Summary spreadsheet could be created. Results are presented in two forms.

- Method One: The first method shows the results generated in SiteWise by entering the inputs for each drilling technique exactly as they are documented in the tables above. This form of results represents a traditional footprint calculation which includes all of the activities related with installing the 5 wells.
- Method Two: The second method of reporting the results is to display them on a “per well basis”. By presenting the results in this fashion, readers can apply the results from the case study to other sites where the number of wells being installed is different from that of the case study. It should be noted that the impact of installing one well was determined by creating scenarios in which a single well was installed using each different drilling method. This means that the results from Method Two are not simply equal to one fifth of the results from Method One (since 5 wells were installed). Multiplying Method Two values by the number of wells in Method One would produce answers that are higher than the results from Method One. This factors in economy of scale (impact per well goes down as the number of wells installed increases). Another important note is that mobilization and demobilization were stripped from the individual well footprint calculations. A single mob/demob event was calculated so the reader can choose at their discretion how many mobilization trips would be required to install any number of wells.

General Discussion of Results

The results indicate that mud rotary drilling has the greatest environmental impact followed by hollow stem, sonic, cable tool, and direct push. What this indicates is that the fuel consumed by the drill rig represents the largest driver of environmental impact. Drill rigs such as mud rotary, hollow stem, and sonic had significantly better drilling rates than cable tool, but their fuel consumption was disproportionately greater.

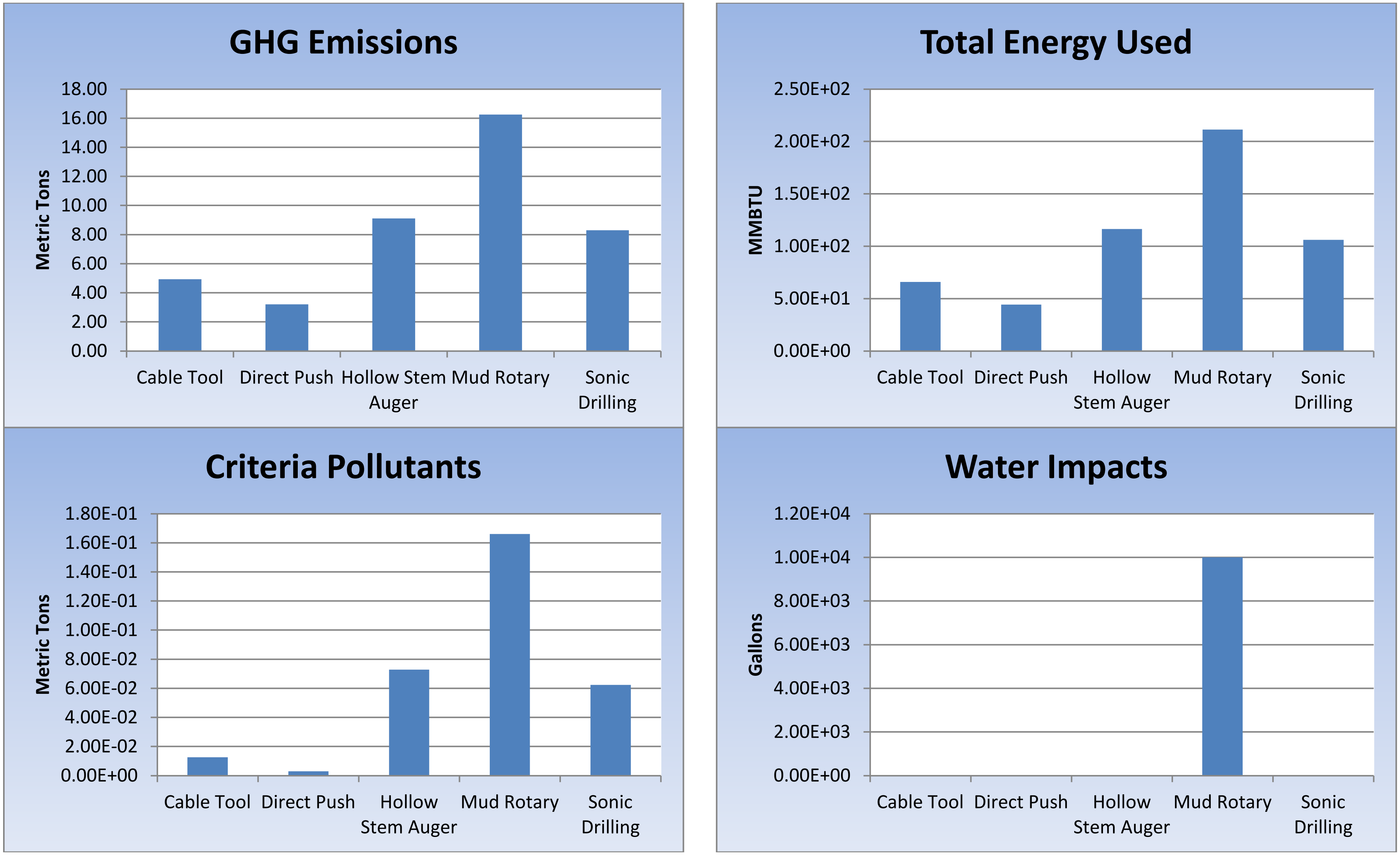
The results from this case study should only be accepted in a qualitative manner when considering well installation at other sites. The amount of variance between the assumptions in the case study and real world values will almost always be different.

Also, this case study does not represent an endorsement of one drilling technology versus another. While the results do indicate that certain drilling techniques have GSR advantages, GSR represents only one of the considerations that should be made when selecting a drilling method. Other limiting factors can include cost, site geology, equipment availability, etc.

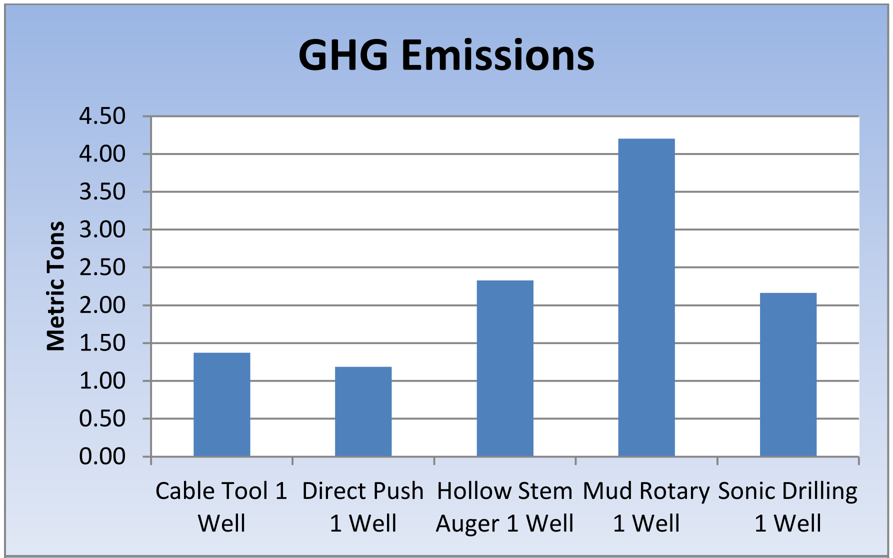
	Method One (includes Mob/Demob)				
GSR Parameter	**Cable Tool**	**Direct Push**	**Hollow Stem**	**Mud Rotary**	**Sonic**
Environmental					
Energy (MMBtu)	65.93	44.20	116.36	217.84	106.15
Global warming potential (Metric tons CO2e)	4.937	3.208	9.114	16.753	8.300
Criteria air pollutant emissions (Metric tons NOx+SOx+PM10)	0.013	0.003	0.073	0.166	0.062
Water Use (gallons)	0.000	0.000	0.000	10000.000	0.000
Non-hazardous waste generation (tons)	4.320	1.520	8.060	85.600	4.320
Hazardous waste generation (tons)	0.000	0.000	0.000	0.000	0.000
Economic					
Up-front Cost					
Societal					
Injury or fatality risk	1.97E-02	2.63E-03	7.72E-03	8.53E-03	8.69E-03
Predicted number of hours lost to injury	1.57E-01	2.09E-02	6.14E-02	6.78E-02	6.91E-02

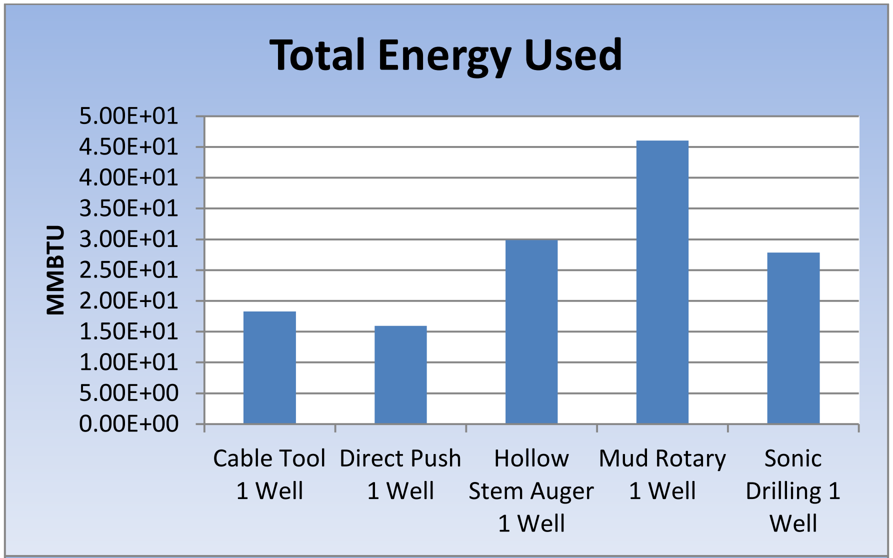
	Method Two (Mob/Demob Separate)					Mob/Demob	
GSR Parameter	**Cable Tool**	**Direct Push**	**Hollow Stem**	**Mud Rotary**	**Sonic**	**Direct Push**	**Other Methods**
Environmental							
Energy (MMBtu)	18.28	15.94	29.89	54.74	27.83	7.09	14.85
Global warming potential (Metric tons CO2e)	1.37	1.18	2.33	4.20	2.16	0.56	1.14
Criteria air pollutant emissions (Metric tons NOx+SOx+PM10)	0.00	0.00	0.01	0.03	0.01	<0.005	<0.005
Water Use (gallons)	0.00	0.00	0.00	2000.00	0.00	0.00	0.00
Non-hazardous waste generation (tons)	0.86	0.30	1.61	17.12	0.86	0.00	0.00
Hazardous waste generation (tons)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Economic							
Up-front Cost							
Societal							
Injury or fatality risk	3.98E-03	7.66E-04	1.74E-03	2.06E-03	1.93E-03	1.94E-03	6.48E-04
Predicted number of hours lost to injury	3.17E-02	6.07E-03	1.38E-02	1.64E-02	1.54E-02	1.54E-02	5.12E-03

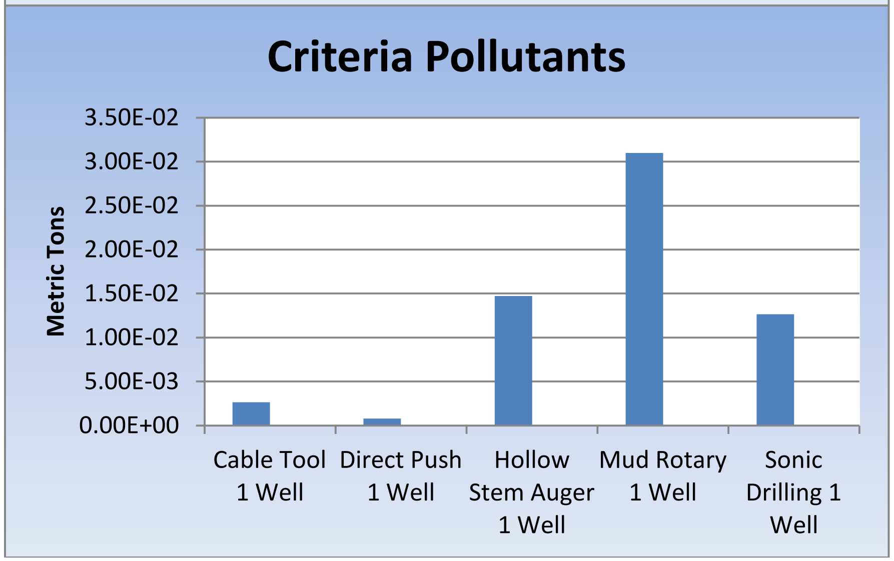
Method One Charts

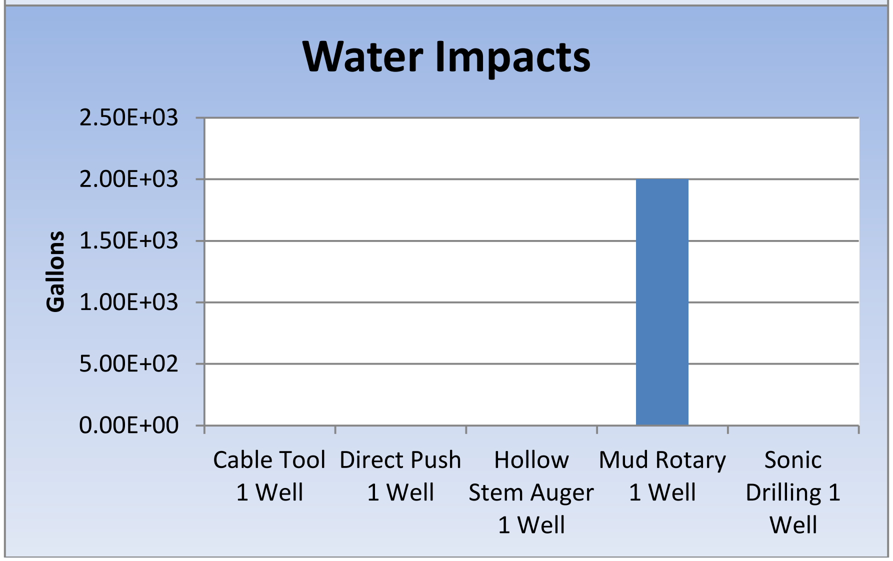


Method Two Charts









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ESTCP. (2009). *Demonstration/Validation of Long-Term Monitoring Using Wells Installed by Direct Push Technologies and Enhanced Low-Flow Groundwater Sampling Methods.*

Masten, D., & Booth, S. (1996). The Cost Effectiveness of Sonic Drilling. *Los Alamos National Laboratory* .

Oothoudt, T., & Davis, R. (1997). Drilling Method May be Gold at End of Rainbow for Difficult Terrains. *Soil & Groundwater Cleanup* , 34-36.

APPENDIX C

Memorandums Regarding Consideration and Implementation of GSR Recommendations for Pilot Projects

- *Akiachak Federal Scout Armory*
- *Former Black Hills Army Depot*
- *Former NAD – Hastings*
- *Iowa Army Ammunition Plant*
- *Lake City Army Ammunition Plant*
- *Lockbourne Landfill*
- *Fort Missoula Blue Mountain Training Area*
- *Shepley's Hill Landfill (Draft FFS Phase)*
- *Shepley's Hill Landfill (Constructability Phase)*
- *Umatilla Chemical Depot*
- *Schilling Air Force Base Atlas Missile Facility S-1*
- *Former Schilling Atlas Missile Site S-5*

MEMORANDUM FOR RECORD

FOR:	Akiachak Federal Scout Armory, Akiachak, AK
PREPARED BY:	Carol Dona, USACE Environmental and Munitions Center of Expertise (EM CX), ACSIM GSR Study Project Manager
DATE:	26 March 2012
REFERENCE:	Final Report Pilot Project GSR Evaluation, Akiachak Federal Scout Armory, Akiachak, AK, 10 January 2012
SUBJECT:	Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

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1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to document the process through which the Project Team agreed to participate in the Study, the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and any follow-on actions of the Project Team.

1.1 Project Overview

The GSR Team (Rob Greenwald, Doug Sutton, and Sarah Farron of Tetra Tech and Carol Dona, Nick Stolte, and Mark Rothas of the USACE EM CX) was provided with the Remedial Action Plan Addendum and other related documents for removal of petroleum-contaminated soil discovered after the original 2010 contaminated soil removal at the Akiachak Federal Scout Armory (Akiachak FSA), which is located near the remote village of Akiachak, Alaska (See GSR Evaluation Report for details). The Akiachak FSA is an inactive Alaska Army National Guard (AANG) facility. Although excavation and off-site removal of the contaminated soil had already been contracted, the Project Team (MAJ Kim Gage and Jennifer Nutt of the Army National Guard Directorate (NGD) were interested in potential application of GSR opportunities identified in the project to other similar sites in the future. The GSR evaluation included comparison of quantitative footprints for the selected remediation alternative (excavation and off-site disposal) with two other potential remedial technologies (in-situ biological treatment, and excavation with ex-situ thermal treatment). Quantitative footprints were also calculated for two storm water treatment options (granulated activated carbon and alder chips).

1.2 Project Contacts

MAJ Kim Gage NGB 703.601.7984 Kim.Gage@us.army.mil

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

MAJ Kim Gage was in attendance as the NGD representative at a Study MMRP brainstorming meeting in Huntsville, AL on 16 November 2010. He suggested several NGD sites with petroleum-contaminated soil as candidates for the Study. On review of these sites with Ms. Nutt, MAJ Gage and Ms. Nutt's recommendation based on schedule and scope was Akiachak FSA. After initial review of project documents, the Study Team agreed that the project would be a good pilot in the Study. MAJ Gage volunteered to facilitate communication between the GSR Study Team and the Project Team.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

Initial provision of project documents to the Study Team for consideration of the project as a pilot in the Study was arranged by Ms. Nutt. The transmittal of additional documents to Tetra Tech was arranged during the Step 3 call (see Section 4.0 below). Also, the GSR Best Management Practices (BMP) List [1] was supplied to MAJ Gage and Ms. Nutt for their review before the Step 5 call, with Ms. Nutt agreeing to supply the BMP list to the remedial contractor, who also joined the Step 5 call.

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

During the Step 3 call (21 January 2011)[2], the schedule for GSR inclusion in the Project was agreed upon. The remedial alternative (excavation and off-site disposal) was already selected, the Work Plan was finalized, and field work was scheduled for early June 2011. Therefore, it was decided that the foci of the GSR evaluation would be on identification of GSR opportunities already included in the Work Plan and potential GSR opportunities for future sites that have similar conditions to the Akiachak FSA One of the potential future alternatives introduced by Tetra Tech on the Step 3 call was an in-situ bioremediation technique (such as using the Micro-Blaze®product). Ms. Nutt stated that there were concerns about in-situ bioremediation being effective with the low temperatures at the Akiachak FSA site. However, Ms. Nutt indicated that it would be valuable to include in the GSR evaluation for potential use in the future at other sites. Ms. Nutt also indicated that an ex-situ thermal treatment facility that could remediate petroleum-contaminated soil had recently opened up near the site but would require barge transport. It was agreed that the in-situ bioremediation and excavation with ex-situ thermal treatment options would be compared with the baseline option (excavation and off-site disposal via barge to the Lower 48 in the GSR evaluation report). It was also agreed that the USACE would initially review the Draft GSR evaluation report prepared by Tetra Tech, followed by review of the GSR evaluation report as revised by Tetra Tech by Ms. Nutt and MAJ Gage. The date of the Step 5 call (11 March 2011) [2] was set to allow the remedial contractor to attend.

The GSR BMP list served as an outline for the Step 5 discussion, which included the GSR Study Team, the EM CX, MAJ Gage, Ms. Nutt, and Jamie Oakley of Ahtna Engineering Services, the remediation contractor. The GSR opportunities already included in the proposed work were identified during the call that lasted 2.5 hours. In addition, it was confirmed that GSR quantitative footprints of the in-situ bioremediation and the excavation/ex-situ thermal treatment option would be prepared for comparison with the footprint of the selected alternative (excavation and off-site disposal). In addition, it was agreed that GSR footprinting of the two treatment options for the collected storm water (granulated activated carbon and alder chips) would also be included. The information collected in the Step 5 call, information from the references provided by the Project Team, and additional cost data as requested by Tetra Tech and provided by Ms. Nutt, were used by Tetra Tech to develop the Draft GSR Evaluation Report, which was supplied to the EM CX Study Team for review on 21 April, 2011. The revised Draft Final GSR Evaluation Report was provided to the Project Team 2 May 2011. The GSR Evaluation Report was revised per comments from Ms. Nutt, finalized, and the Final GSR Evaluation Report (dated 10 January 2012) was provided to the Project Team on 12 January 2012. The GSR practices implemented at the

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[1] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

[2] Final Report Pilot Project GSR Evaluation, Akiachak Federal Scout Armory, Akiachak, AK, 10 January 2012, Section 1

Akiachak FSA site, along with information on the potential in-situ bioremediation and ex-situ treatment options at 21 similar ARNG sites in the future, is being documented in a separate write-up by Ms. Nutt. Consideration and implementation of GSR was not documented in the Remedial Action Report (RAR) for the Akiachak FSA site, as the RAR was largely already written after the initial 2010 soil removal.

5.0 FOLLOW-UP

No further follow-up beyond supply of the GSR write-up being prepared by Ms. Nutt.

MEMORANDUM FOR RECORD

FOR:	Former Black Hills Army Depot – FUDS Property Number B08SD0008, Igloo, South Dakota
PREPARED BY:	Nicholas J. Stolte, P.E., USACE Environmental and Munitions Center of Expertise (EM CX), ACSIM GSR Study MMRP Coordinator
DATE:	2 April 2012
REFERENCE:	Final Report Pilot Project GSR Evaluation: Former Black Hills Army Depot, Igloo, South Dakota, 12 January 2012
SUBJECT:	Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to document the process through which the site was proposed and the Project Team agreed to participate in the Study, the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and any follow-on actions of the Project Team.

1.1 Project Overview

The Former Black Hill Army Depot (BHAD) is a Formerly Used Defense Site (FUDS) near Igloo, South Dakota. There are several Munitions Response Sites (MRSs) on the property that are known or suspected to contain Munitions and Explosives of Concern (MEC), including Chemical Warfare Material (CWM), and Munitions Constituents (MC). The MRSs are being addressed as part of the Military Munitions Response Program (MMRP) and are currently in the Remedial Investigation/Feasibility Study (RI/FS) phase.

The GSR Team (Rob Greenwald, Doug Sutton, Michelle Caruso, and Sarah Farron of Tetra Tech and Carol Dona, Nick Stolte, of the USACE EM CX) was provided with the *Draft Work Plan for the Black Hills Army Depot Remedial Investigation and Feasibility Study* (Parsons, April 2011). The Project Team included Ashley Roeske (Project Manager at the time of the evaluation) and Ken Shott of US Army Engineering and Support Center, Huntsville (USAESCH) and the Project Team Contractor (Parsons).

The RI activities include characterizing the nature and extent of munitions-related contamination at three Munitions Response Sites (MRSs): Chemical Warfare Burning Pit Area (CWBPA), Burning Ground #1 (BG-1) and Burning Ground #2 (BG-2). Field activities include both aerial and ground-based Digital Geophysical Mapping (DGM), excavation, soil sampling, and analysis. The RI field activities were in progress when the GSR evaluation was performed. Some of the RI field activities (geophysics) were completed in 2011 (prior to the GSR evaluation), and the remainder of the RI field investigation (intrusive investigation and MC sampling) will be conducted starting in spring of 2012 (after the GSR evaluation). Thus, this GSR evaluation has been performed during the execution of the RI Work Plan. The GSR evaluation included a review of Best Management Practices (BMP), quantitative footprints analysis for planned RI activities, and other qualitative considerations.

1.2 Project Contacts

Allyn Allison, Project Manager, 256.895.1121, Allyn.T.Allison@usace.army.mil

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

The Former Black Hills Army Depot project was identified by Deborah Walker of the EM CX as a potential Chemical Warfare Materiel MMRP Study pilot at a Study MMRP brainstorming meeting in Huntsville, AL on 16 November 2010. Ms. Walker discussed potential Study participation with Ashley Roeske, Huntsville Center who indicated initial interest but needed to check the project schedule. Ms. Roeske determined that the project schedule was beyond the point where GSR recommendations that would be identified could be considered and incorporated; however, she was interested in the GSR Evaluation findings being potentially used for other future CWM projects. The GSR Team agreed that the pilot could proceed under these conditions. Ms. Roeske also checked to see if the contract with the Project Team Contractor would allow participation. It was determined that the contract did not include GSR, so a contract modification was necessary. Carol Dona of the EM CX arranged for funds for the Project Team Contractor participation as well as funds to Huntsville Center Contracting to process the modification to the contract. Once the contract was modified, the Project Team and Project Team Contractor committed to full participation in the Study.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

Initial provision of project documents to the Study Team for consideration of the project as a pilot in the Study was arranged by Ashley Roeske, the USACE Project Manager at the time of the Study. The transmittal of additional documents to Tetra Tech was arranged during the Step 3 call (see Section 4.0 below). Also, the GSR Best Management Practices (BMP) List [1] was supplied to Ms. Roeske and her team for their review before the Step 5 call. In this instance, the USACE Project Team determined that the Contractor's participation in the study was out of scope. The USACE Project Team made a modification to the existing contract to allow the Contractor to participate.

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

During the Step 3 call[2], the project team discussed the scope and schedule of the project and arranged for document transfer to the GSR team and the GSR team described the evaluation process used for the Study. Subsequent to the Step 3 call, the GSR Team provided the Project Team with the list of BMPs to review and consider prior to the Step 5 call. It was also established that Parsons would not be required to include the results of the evaluation in the RI/FS Report. For this pilot project, the GSR evaluation would serve as more of a "brainstorming" exercise for the benefit of the GSR Study, and since this is the only MMRP Pilot Project in the Study involving CWM, it could be an opportunity to identify which GSR practices are feasible for such a project and which are not.

During the Step 5 call, an extensive review of BMPs was performed by the GSR Team with the Project Team. During this call it became apparent that the Project Team had already considered and implemented many of the GSR BMPs. Although the Project Team did not explicitly consider these BMPs as part of a

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[1] Appendix A, *Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation* https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

[2] Final Report Pilot Project GSR Evaluation: Former Black Hills Army Depot, Igloo, South Dakota, 12 January 2012, Section 1

GSR evaluation, many of the BMPs have been considered and implemented as part of the overall process of conducting an MMRP project and/or using sound principles of science and project management.

While going through the BMP list during the Step 5 call, the GSR Team suggested several items that the Project Team could consider, including: adding a section on GSR in the final RI/FS reports, distribute documents electronically to the greatest extent possible, and recycling of plastic bottles. There were also several BMPs that were identified but not considered practical due to type of work being performed.

The information collected in the Step 5 call and information from the references provided by the Project Team were used by Tetra Tech to develop the Draft GSR Evaluation Report, which was supplied to the EM CX Study Team for review on 20 September 2011. The revised Draft Final GSR Evaluation Report (dated 27 October 2011) was provided to the Project Team on 1 November 2011. No comments were received from the Project Team on the report, and it was finalized on 12 January 2012 and provided to the Project Team.

5.0 FOLLOW-UP

No further follow-up for this project.

MEMORANDUM FOR RECORD

FOR:	Former Naval Ammunition Depot (NAD) – Hastings Sitewide Groundwater Remediation, Operable Unit 14, Former Naval Ammunition Depot, Hastings, Nebraska
PREPARED BY:	Carol Dona, Environmental and Munitions Center of Expertise, ACSIM GSR Study Project Manager
DATE:	15 April 2012
REFERENCE:	Final Report Pilot Project GSR Evaluation: Former NAD – Hastings Sitewide Groundwater Remediation, Operable Unit 14, Former Naval Ammunition Depot, Hastings, Nebraska, March 8, 2012
SUBJECT:	Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to document 1) the process through which the Project Team agreed to participate in the Study, 2) the processes the project team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and 3) any follow-on actions the Project Team took in response to the Draft Report.

1.1 Project Overview

The GSR Team (Tetra Tech plus Carol Dona and Dave Becker of the EM CX) was provided with a 30 Percent Design report and associated drawings ("Pre-Draft Design" dated 3 December 2010) for the treatment system for Operable Unit 14, Sitewide Groundwater at the former Blaine Naval Ammunition Depot (NAD), Hastings, Nebraska. Tetra Tech conducted a GSR evaluation after the 30 Percent Design and prior to the 60 Percent Design, and the Draft GSR Evaluation Report prepared by Tetra Tech was provided to the Project Team on 5 February 2011 so GSR findings and recommendations could potentially be included within the 60 Percent Design. The NAD is a Formerly Used Defense Site (FUDS). The remediation at the NAD is overseen by the USACE, Kansas City District (NWK), and Shaw Environmental, Inc. is the contractor for the remedial design. The NWK NAD Project Team included Julius Calderon and Frank Bales, NAD remedial engineers, and Brian Roberts, NAD Project Manager.

1.2 Project Contacts

Brian Roberts, Project Manager, 816 389-3892, Brian.J.Roberts @usace.army.mil

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

Dave Becker of the EM CX, who has been a primary technical reviewer for the NAD for the past 20 years, initially approached Brian Roberts, the NAD project manager, about participation in the Study. After Mr. Roberts expressed initial interest, Carol Dona of the EM CX followed up with an email describing the Study process and the project team participation. Upon confirmation of a commitment to participate, Dr. Dona arranged for Study funds to be directed to the Project Team for their participation in the Study activities. The GSR Team recognized that maintaining the schedule necessary to meet the target design award date was a necessary condition for Project Team participation in the Study. Dr. Dona and Mr. Becker also assured the Project Team that the Project Team had discretion regarding incorporating the GSR opportunities identified in the Draft GSR Evaluation Report.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

A planning Step 3 call [1]with the GSR team, the Project Team, and the Project Team contractor was held on 7 January 2011. During this call the overall schedule of GSR inclusion in the on-going project was established and pertinent information was exchanged. As a result of the compressed Project Team schedule, the EM CX and Tetra Tech agreed to supply the Draft GSR Evaluation Report to the Project Team and Contractor at the same time it supplied the Draft GSR Evaluation Report to the EM CX (the normal Study schedule would have had the EM CX review the Draft GSR Evaluation Report first). Arrangements were made for transfer of documents pertinent to the Design, including the Record of Decision, groundwater modeling reports, and well placement and monitoring to Tetra Tech (see a detailed listing in the Final GSR Evaluation Report). The GSR Best Management Practices (BMP) List[2] was also supplied to the Project Team including their contractor for review in preparation for the “Step 5” call [1], where there would be a detailed discussion of GSR opportunities. Also, a set of bullet points with major remedy GSR discussion points was developed by Tetra Tech and distributed two days before the Step 5 call (see Section 4.0 below). It was also agreed that GSR consideration and incorporation would be documented within the project by the Contractor including a summary GSR section in the 60% and later versions of the Design, with the GSR Evaluation Report referenced as an Appendix in the Design Analysis Report. Dr. Dona arranged for Study funds to the Project Team for their participation in the Study activities.

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

The Step 5 call was held on 13 January 2011 and lasted just over 2 hours (see Draft GSR Evaluation Report for EM CX, NWK, and Shaw attendees). Using the bullet point list and the GSR BMP list as discussion foci, the potential GSR opportunities as initially identified by Tetra Tech were reviewed for practicality with the Project Team, as well as additional GSR opportunities as identified by the Project Team. The latter included the Project Team endorsement and/or proposal for the beneficial use of treated water for irrigation, the re-use of former building pads for the treatment plant, and the potential use of untreated water for cooling purposes. The information collected in the Step 5 call and the references provided by the Project Team were used by Tetra Tech to develop the Draft GSR Evaluation Report, which was supplied to the EM CX and the Project Team and Shaw on 5 February 2011 for review and consideration of the GSR suggestions contained within. The Project Team and Shaw summarized the GSR suggestions proposed in the Draft GSR Evaluation Report in Section 6.2 of the Design Analysis Report (attached separately), and referenced the Draft GSR Evaluation Report in Appendix E of the Design Analysis Report.

In addition to the documentation of the GSR identification in the 60% Design Analysis Report, the EM CX requested the Project Team provide the rationale for what recommendations had been (or had not been) implemented. Shaw Environmental supplied separately a rationale memo dated 20 December 2011 that explained why they had or had not implemented the GSR options, and that memo is attached.

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[1] Final Report Pilot Project GSR Evaluation: Former NAD – Hastings Sitewide Groundwater Remediation, Operable Unit 14, Former Naval Ammunition Depot, Hastings, Nebraska, March 8, 2012, Section 1.3

[2] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

5.0 FOLLOW-UP

In addition to the EM CX direct participation with the Project Team through the GSR Study, the 30%, 60%, and 90% design packages were reviewed by the EM CX as part of its function of independent review of key FUDS documents. The process for consideration, implementation, and documentation of GSR recommendations was further followed through the 90% design stage by the EM CX. As part of this process, the EM CX highlighted several GSR recommendations for the design that would have had lower GSR footprints and lower estimated costs. These recommendations included the use of two rather than one treatment plant and a treatment process (granulated activated carbon) that would allow central treatment of low concentrations of both RDX and chlorinate volatile organics, instead of the well-head treatment units for RDX as presented in the 90% design. The use of variable-frequency drive motors for well pumps was also recommended.

The recommendation for two treatment plants, rather than one, central treatment facilities was not implemented due to high costs as estimated by the Project Team for two plants and the concern that additional erosion control would be needed for the discharge point for the treated water from the second treatment plant. The use of wellhead treatment specifically for RDX rather than use of a treatment process for both chlorinated organics and RDX at the central treatment plant was incorporated between the 60 and 90% design to satisfy a request from EPA. EPA was concerned that RDX would be below cleanup levels at the central treatment plant due simply to dilution when combined with other extracted groundwater. Treatment of RDX at the point of extraction was required because dilution was not an acceptable method of remediation for EPA. In a follow-up phone call with the NWK, it was explained that NWK thought the wellhead treatment of RDX was expected to only be required for a short time. Therefore, although the wellhead treatment units were expected to require substantial amounts of energy, this requirement was expected to be short-lived. Also, wellhead treatment units had already been employed in a similar situation at another Nebraska FUDS site. Variable-frequency drive motors were not planned for the wells, as it was expected that the wells would be run near close to the optimal rate for the life of the wells.

GSR section from the **DRAFT FINAL DESIGN ANALYSIS REPORT EXTRACTION AND TREATMENT SYSTEM, SITEWIDE GROUNDWATER REMEDIATION, OPERABLE UNIT 14, *Former Naval Ammunition Depot, Hastings, Nebraska, September 11, 2011***

6.2 U.S. Army Corps of Engineers Green and Sustainable Remediation Pilot Project Evaluation

A green and sustainable remediation (GSR) evaluation was performed by the USACE and a third party contractor team for the former NAD as a pilot project and is included in Appendix E, "Green and Sustainable Remediation Pilot Project." The evaluation follows the process of considering, incorporating, documenting, and evaluating the benefits of GSR practices. While performing the evaluation the GSR Team suggested several items that the Shaw Project Team could consider during the groundwater extraction and treatment design. Selected recommendations are evaluated within this Design Analysis Report while other recommendations were evaluated in the design evaluation phase but not selected and not included in the design. The GSR evaluation presented the following recommendations:

- Recommendations based on quantified environmental footprint considerations
- Include VFDs for air stripper blower motors (see Section 4.2.2.7)
- Use of VFDs on extraction pumps (see Section 3.1.2.7)
- Build two treatment plants for the North and South Plume Areas, respectively
- Recommendation to further evaluate specific alternatives
- Consider powering remedy with wind energy (see Section 6.1)
- Qualitative recommendation:
- Potentially generating renewable energy from the discharge of treated water
- Incorporate language in the design to minimize engine idle times for heavy equipment during remedy construction
- Consider including potential purchase of Renewable Energy Certificates as part of the feasibility analysis that is currently planned for wind energy
- Have the architect look into passive lighting, sensors for lighting, and other design elements for the treatment building that might reduce energy consumption (see Sections 3.1.2.7 and 4.2.2.7

Results of Consideration of Recommendations from the GSR Evaluation Report for the Hastings NAD Sitewide Groundwater Remedial Design, Supplied to the EM CX 11 December 2011.

The following are recommendations presented in the Draft GSR Evaluation Report (USACE 2011) followed by Shaw's assessment for consideration in the Hastings NAD Sitewide Groundwater Remediation Design. The Draft Final Design Analysis Report (DAR) includes Renewable Energy and Sustainability Considerations (Section 6). When referencing the Draft Final DAR, please note revisions to Section 6 are being prepared for the Final submittal. Some of the recommendations in the GSR report were already being considered by Shaw in the groundwater remedy design.

1. Consider powering remedy with Wind Energy

   Used: Not as part of GW Design
   Why not: A readily available power grid is much more economical than wind energy. Wind energy is being considered separate from the GW Design and includes an evaluation to connect large wind turbines directly to the grid. This would be much more efficient than numerous, distributed wind generation at the various well control houses.

2. Use of VFDs on air stripper blower motors

   Used: No
   Why not: Reduction in airflow reduces stripper removal efficiencies. Air flow typically does not vary with flow as maximum removal efficiency is always desired.

3. Use of VFDs on extraction pumps

   Used: No
   Why not: Distance from the Well Control Houses to the pumps is too great. This results in great damage from reflected wave problems common to long runs on VFD circuits. Sine wave filters were considered and, while they smooth out the waveform, eliminate the phase-to-phase reflected wave, and greatly reduce the phase-to-ground reflected wave problems, they also introduce a large voltage drop. The large voltage drop of the filter combined with the large voltage drop of the long motor branch circuits would be much more than is economically feasible for the installation.

   Extensive research was performed into evaluating the variable frequency drives. See the DAR for a discussion of the sine wave filter investigation and see the technical letter by Scott Davis and Jimmy Sparkman for further research into the cost-ineffectness of VFDs for this application. This is also discussed in the Draft GW Design responses to comments.

4. Build two treatment plants

   Used: No
   Why not: Excessive costs for two plants and additional erosion control for discharge in South plume.
   Comments: Treatment plant is being built in between the North & South plume in order to reduce all costs, increase functionality & ease of use, and to limit the amount of O&M.

5. Potentially generating renewable energy from the discharge of treated water

   Used: No
   Why not: Excessive capital costs compared to return in savings.
   Not enough change in elevation. See also response to comments on the Draft GW Design - Dr. Checks comment #3870337 & #3876305.

6. Incorporate language in the design to minimize engine idle times for heavy equipment during remedy construction

   Used: Not in design
   Why not: Will address during construction.

7. Consider including potential purchase of Renewable Energy Certificates as part of the feasibility analysis that is currently planned for wind energy.

   Used: Not within the GW Design
   Why not: Wind energy is not currently being considered in the GW Design. See response to recommendation 1.

8. Have the architect look into passive lighting, sensors for lighting, and other design elements for the treatment building that might reduce energy consumption

   Used: No and Yes
   Why/Why not: Passive lighting was not considered because cost and the security of the unoccupied buildings are considered more important. The introduction of windows or skylights also creates a maintenance item for the largely unoccupied spaces. For these reasons, occupancy sensors were used on the interior lighting circuits in the treatment plant and well control houses.

9. Consider use of coal by-products as a re-cycled material that can be used for concrete

   Used: Yes
   Why: Up to 20% fly ash is currently specified in the concrete mix design.

10. In future remedy phases, include green specifications in the O&M contract

    Used: Not in the design
    Why not: Will address at a later date in the preparation of the O&M Plan.

11. In future remedy phases, utilize alternative fuels as part of the construction activities where possible

    Used: No
    Why not: Will address during construction.

MEMORANDUM FOR RECORD

FOR: Iowa Army Ammunition Plant (MMRP), Middletown, Iowa

PREPARED BY: Carol Dona, USACE Environmental and Munitions Center of Expertise (EM CX), ACSIM GSR Study Project Manager

DATE: 16 May 2012

REFERENCE: Final Report Pilot Project GSR Evaluation, Iowa Army Ammunition Plant, Middletown, Iowa, 11 April 2012

SUBJECT: Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

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1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to document 1) the process through which the site was proposed and the Project Team agreed to participate in the Study, 2) the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and 3) any follow-on actions of the Project Team.

1.1 Project Overview

The Iowa Army Ammunition Plant (IAAAP) is a government-owned, contractor-operated facility adjacent to the town of Middletown in Des Moines County, Iowa under the command of the United States Army Joint Munitions Command (JMC), Rock Island, Illinois. The plant is now operated by American Ordnance, LLC, with production activities at IAAAP currently including loading, assembling, and packaging of munitions, including projectiles, mortar rounds, warheads, demolition charges, anti-tank mines, and anti-personnel mines. Other activities at IAAAP include forestry, grazing, agriculture, and outdoor recreation, including hunting and fishing. The IAAAP Project Team included Jim Bard, AEC IAAAP Environmental Remediation Manager (ERM); Linda Wobbe, acting IAAAP Remediation Program Manager (RPM) at the time of the initiation of the pilot; Rodger Allison, IAAAP RPM, on academic sabbatical at initiation of the pilot but resuming his RPM duties later in the pilot; Leon Baxter, IAAAP (Rodger Allison's supervisor); Sara Garland, PIKA International, IAAAP management support; and Laura Percifield, USACE Omaha District (NWO) MMRP Project Manager. Terry Thonen from URS, the Project Team contractor, also participated in the Pilot. The GSR Team that participated in and prepared the GSR evaluation included Rob Greenwald, Sarah Farron, and Michelle Caruso of Tetra Tech, Carol Dona and Nick Stolte of the EM CX, and Kevin Roughgarden of ACSIM. The GSR Evaluation pertained to the proposed Remedial Action (RA) alternatives in the Draft Feasibility Study (Draft FS) associated with munitions and explosives of concern (MEC) and munitions constituents (MC) contamination at four Munitions Response Sites (MRSs) at the IAAAP. The RA alternatives for which quantitative footprints were prepared and compared included Land Use Controls, MEC Subsurface Clearance, and MC Removal with Off-Site Disposal.

1.2 Project Contacts

Rodger Allison, IAAAP RPM, rodger.d.allison.civ@mail.mil, 319.753.7130.

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

Jim Bard, AEC, was in attendance as one of the AEC representatives at a Study MMRP brainstorming meeting in Huntsville, AL on 16 November 2010. Mr. Bard indicated his interest in participation in the Study and suggested several potential MMRP and IRP projects for which he was AEC ERM, including both an IRP and a MMRP project at IAAAP. Through subsequent conversations and evaluation of project scope and schedule with Dr. Dona, it was determined that IAAAP was a good installation for potential Study participation. Mr. Bard then checked with and received approval from his supervisor, Jeff Gschwind, for participation in the Study. He also received interest in IAAAP participation from Linda Wobbe, acting IAAAP RPM. Following Ms. Wobbe's interest, Mr. Bard also received approval for Study participation from Rodger Allison, IAAAP RPM who was on academic sabbatical leave at the time. Following approval from AEC and IAAAP, Dr. Dona discussed project participation with Laura Percifield, NOW Project Manager for the MMRP project. Ms. Percifield discussed participation with her contractor, URS, and indicated their concurrence on participation in the Study. Ms. Wobbe discussed and obtained concurrence from the IRP project contractor, Tetra Tech, for the IRP contractor Study participation. Once concurrence on participation of all those involved in the MMRP and IRP projects was confirmed, a Step 3 call with all parties (except Mr. Allison, who was on sabbatical) was scheduled (See Section 4.0 below).

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

A SharePoint site was set up by Tetra Tech following the Step 3 call to facilitate transfer of Project documents to the GSR Team. The Study schedule did not allow participation of the IRP project in the Study, so only the documents uploaded for the MMRP pilot that was included in the Study are summarized here. The document uploaded to the SharePoint site for the MMRP project was the following:

- *Draft Feasibility Study Report, Military Munitions Response Program, Iowa Army Ammunition Plant, Middletown, Iowa* (November 2011

Tetra Tech also downloaded some additional documents including the RODs, ESDs, and 5-year reviews to their network drive directly from the EPA web site http://cfpub.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.additional&id=0700413. In addition, the GSR Best Management Practices (BMP) List[1] was supplied to the Project Team as an attachment to the Step 3 call minutes (see Section 4.0).

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

The Step 3 call[2] was held on 31 March 2012, with both IRP Project Team members (Linda Wobbe, Jim Bard, Tetra Tech, and Laura Percifield) and MMRP Project Team members (Linda Wobbe, Jim Bard, and URS) attending along with members of the GSR Team (Rob Greenwald, Sarah Farron, Carol Dona, and Nick Stolte). Although not apparent at the time of the Step 3 call, the schedule for the IRP project

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[1] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

[2] Final Report Pilot Project GSR Evaluation, Iowa Army Ammunition Plant, Middletown, Iowa, 11 April 2012, Section 1

was later sufficiently delayed that it was not feasible to complete the GSR inclusion process within the Study time frame. The following information then pertains only to the MMRP project, which was included as one of the Study pilots.

It was initially agreed on the Step 3 call that the Step 5 call[2] would be arranged when the "internal draft" of the FS was available for review. This timing was considered ideal since the GSR could be incorporated into the version of the FS (the Draft FS) that would then be reviewed by the regulators. However, since significant changes in the internal Draft FS occurred during the internal USACE review, it was agreed that the GSR evaluation would be performed after the Draft FS was available. The November 2011 Draft FS was supplied to the GSR team on 17 November 2011 and the Step 5 conference call conducted on 21 November 2011. In attendance were Project Team members Rodger Allison, now back from sabbatical and resuming his RPM duties, Leon Baxter, and Sara Garland from IAAAP, Terry Thonen from URS, Laura Percifield from NWO, Rob Greenwald, Sarah Farron, and Michelle Caruso from Tetra Tech, Carol Dona and Nick Stolte from the EM CX, and Kevin Roughgarden from ACSIM. During this call the GSR Team used the list of GSR BMPs developed for the Study as an outline to ask questions to the Project Team and allow the Project Team to provide pertinent information to the GSR Team. Tetra Tech used the information from the Step 5 call, along with information from the review of the Draft FS and other project documents, to prepare the Draft Final GSR Evaluation Report, dated 10 February 2012. This was provided to the Project Team on 5 March 2012. Comments received from the Project Team were incorporated into the Final GSR Evaluation Report, dated 11 April 2012.

5.0 FOLLOW-UP

A summary of the GSR Evaluation has been included in the internal Draft of the Proposed Plan, with the GSR Evaluation Report referenced as a stand-alone document in the IAAP Administrative Record.

MEMORANDUM FOR RECORD

FOR: Lake City Army Ammunition Plant, Independence, MO

PREPARED BY: Carol Dona, USACE Environmental and Munitions Center of Expertise (EM CX), ACSIM GSR Study Project Manager

DATE: 9 May 2012

REFERENCE: Final Report Pilot Project GSR Evaluation, Lake City Army Ammunition Plant, Independence, MO, 26 January 2012

SUBJECT: Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

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1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to 1) document the process through which the site was proposed and the Project Team agreed to participate in the Study, 2) the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and 3) any follow-on actions of the Project Team.

1.1 Project Overview

The Lake City Army Ammunition Plant (LCAAP) is an Active Army facility. It was established in 1941 for manufacture and testing of small caliber ammunition for the Army and is the only major small arms manufacturing facility for the Army. The Project Team for this pilot included Laurie Haines, Army Environmental Command (AEC) Senior Technical Advisor for Active Army optimization; Jonathan Harrington, LCAAP AEC remedial project manager, and Sara Clark-Kennedy, LCAAP environmental coordinator. The GSR Team included Rob Greenwald, Doug Sutton, and Sarah Farron of Tetra Tech, Carol Dona of the EM CX, and Kevin Roughgarden of ACSIM. This pilot differed from the other Study pilots in that a "pre-draft" GSR evaluation (hereafter referred to as the Pre-Draft) was conducted with information for the GSR evaluation obtained from a Remediation System Evaluation (RSE) report (dated 27 May 2011) that was prepared from an RSE performed prior to and separate from the GSR Study. The Pre-Draft was distributed to and discussed in detail with the Project Team in a call between the Project Team and the GSR Team. Since the GSR opportunities had already been included in the RSE Report, the call allowed the opportunity to follow up on the status of the GSR and related optimization items that had previously been identified; this differed from the other GSR Study pilots where the call with the Project Team involved a detailed identification of potential GSR opportunities. The input from the Project Team from this call was incorporated into a Draft Final GSR Evaluation Report supplied to the Project Team, with the Final GSR Evaluation Report incorporating the Project Team review comments. The GSR Evaluation was performed on the multiple Operable Units at LCAAP where contaminated groundwater is being treated, with emphasis on the pump and treat operations for the dissolved-phase contaminant plumes and some consideration of an in-situ bioremediation substrate.

1.2 Project Contacts

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2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

Carol Dona and Kevin Roughgarden initially contacted Ms. Haines about the potential for participation in the GSR Study of one or more Active Army installations with projects in the remedial operation phase. Ms. Haines conveyed information about the GSR Study to Jim Daniel, chief of the AEC Cleanup and Munitions Response Division and Ms. Haines' supervisor, and asked him if he supported 1) participation in the GSR Study of one or more Active Army installations that had had GSR indentified in RSEs, 2) the GSR Team contacting the installation restoration managers and Environmental Remediation Managers (ERMS) for potential participation, and 3) if he supported Ms. Haines's assistance within the Study. Upon affirmative confirmation of the above from Mr. Daniel, Ms. Haines agreed to assist the GSR Team in facilitating the process of the inclusion of Active Army installations environmental projects, in the remedial operation phase, into the GSR Study.

The Study Team then reviewed with Ms. Haines installations where RSEs (including GSR consideration) had recently been performed. LCAAP and Joint Base Lewis-McChord (Former Fort Lewis) were the installations identified as the best candidates for the Study. LCAAP was chosen as the best candidate for the GSR Study pilot, since it includes multiple pump and treat systems and an extensive in-situ bioremediation source treatment network, and therefore had significant potential for future GSR gains (it was decided that Joint Base Lewis-McChord would be used as a case study in the Study because of the significant number of GSR practices that had already been implemented). To minimize the time commitment of LCAAP staff and the ERM, the GSR Team proposed that a 'pre-draft" GSR Evaluation Report (Pre-Draft) be prepared by Tetra Tech from the GSR analysis in the RSE that could be supplied to LCAAP ahead of a conference call. Ms. Haines agreed to this option. Tetra Tech prepared the Pre-Draft, along with a draft cover email, that was revised and used by Ms. Haines to transmit the Pre-Draft and request for Study participation to LCAAP. Upon receipt of the Pre-Draft and letter from Ms. Haines, Jonathan Harrington, LCAAP AEC ERM, and Sara Clark-Kennedy, LCAAP environmental coordinator, agreed to participate in the Study.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

Tetra Tech and the EM CX had co-performed the LCAAP RSE and had obtained the necessary documents for the preparation of the Pre-Draft through those activities. The Final RSE Report was provided to Mr. Harrington by Ms. Haines. The Pre-Draft, including the Best Management Practices (BMP) list from the Study approach[1], was provided to the Project Team ahead of the conference call. This Pre-Draft included a preliminary identification of BMPs potentially applicable for the pump and treat systems at the facility. Ms. Clark-Kennedy also provided comments on the Pre-Draft, and Dr. Dona provided sample GSR contract language to the Project Team, prior to the conference call.

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

As described in Section 2.0 above, initial agreements were obtained from AEC and the LCAAP to participate in the Study. The Pre-Draft, dated 14 November 2011, was prepared by Tetra Tech and supplied to the Project Team for review ahead of a conference call originally scheduled on 21 November 2011. Ms. Clark-Kennedy was unable to join the 21 November 2011 call because of a plant emergency and the call was rescheduled to 28 November 2011. However, on the 21 November 2011 call Mr.

[1] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

Harrington expressed interest in inclusion of GSR in the contract language of an upcoming LCAAP contract renewal. Dr. Dona subsequently supplied (for discussion on the 28 November 2011 call) example performance work statement (PWS) language for inclusion of GSR from a recent AEC PBA advertisement. Ms. Clark-Kennedy also supplied review comments on the Pre-Draft ahead of the 28 November 2011 call. During the 28 November 2011 call, which lasted approximately 1.5 hours, Mr. Harrington and Ms. Clark-Kennedy gave valuable perspective (Ms. Haines was unable to join the call) on the reasons why or why not implementation of the recommendations in the Pre-Draft were feasible. The two most significant limitations to GSR implementation identified by Ms. Clark-Kennedy were:

- The Project Team would not consider making changes to the remedy that would require a ROD amendment, since re-opening the ROD could lead to negative consequences for other aspects of the remedy.

- The current restoration contractor did not review the RSE Report (and presumably would not review the GSR Report), since such effort is not included in their Scope of Work. However, the restoration contract, which is a performance-based contract, is up for renewal in September 2012 and Mr. Harrington indicated that the contract language supplied by Dr. Dona was already in the language for the upcoming contract renewal. Under the new contract language, the contractor could consider GSR and related recommendations, but they would not be obligated to. Ms. Clark-Kennedy indicated there was another contractor for the building that housed the central on-site remediation treatment system and the associated pump and treat system. The contract for this work was an annual, fixed-price contract, where changes would be fairly easy.

The status of the recommendations made in the RSE Report was also updated in the call, the conclusions of which are summarized below.

- Removal of equipment not required in the ROD is being considered. However, this takes time, effort, new equipment, and/or money. Also, it was noted that funding from the Army for the capital costs associated with additional or replacement equipment may be limited. In addition, some multi-year contracts may be difficult to change, potentially resulting in delays in equipment replacement and/or exchange.

- Regulator approval is necessary for changes in the environmental restoration conditions, i.e. from one enhanced reductive dechlorination (ERD) substrate to another. The approval process can be time consuming and regulator agreement with the change is not guaranteed.

- Changes in the environmental restoration conditions also need to be presented to the public through the Remediation Advisory Board (RAB). The process of preparation and addressing questions can be time consuming.

- The potential benefits to changing the ROD have to be balanced against the other potentially adverse actions, such as imposition of more stringent cleanup levels that could result from opening up the ROD. Also, the time and effort involved in the regulatory process of seeking ROD Amendment approval can be an obstacle.

Following the Project Team and Study Team calls, Tetra Tech revised the Pre-Draft per input from the call as well as Project Team comments. Also, a case study GSR comparison of different ERD substrates was prepared and added to the Draft Final GSR Evaluation Report, dated 22 December 2011, and posted for Project Team review at the AMRDEC Safe Access Site on 27 December 2011. Comments from the

Project Team were incorporated into the Final GSR Evaluation Report, dated 26 January 2012, which was posted to the AMRDEC Safe Access Site on 2 February 2012.

5.0 FOLLOW-UP

LCAAP is considering implementation of the recommendations in the GSR Evaluation Report within the constraints of effort, fund availability, and schedule.

MEMORANDUM FOR RECORD

FOR: Former Lockbourne Air Force Base Landfill, Columbus, OH

PREPARED BY: Carol Dona, USACE Environmental and Munitions Center of Expertise (EM CX), ACSIM GSR Study Project Manager

DATE: 15 May 2012

REFERENCE: Revised Final Report Pilot Project GSR Evaluation, Former Lockbourne Air Force Base Landfill, June 20, 2011

SUBJECT: Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

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1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to document 1) the process through which the Project Team agreed to participate in the Study, 2) the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and 3) any follow-on actions of the Project Team.

1.1 Project Overview

The Former Lockbourne Air Force Base Landfill (the Landfill) is a Formerly Used Defense Site (FUDS) where the remediation is being managed by the US Army Corps of Engineers (USACE) Louisville District. The GSR Team (Rob Greenwald, Doug Sutton, and Sarah Farron of Tetra Tech and Carol Dona and Sam Bass of the USACE EM CX) was initially provided with the Landfill Focused Feasibility Study, from which Tetra Tech identified preliminary GSR opportunities for consideration and inclusion in the Landfill 30% Basis of Design (BoD) Report (30% Design). The 30% Design was then used by Tetra Tech for a more thorough GSR evaluation, which, with information presented at an on-site design meeting, was then presented to the Project Team (Carla Heck, Cindy Ries, Kevin Mieczkowski, and Brooks Evens of USACE Louisville District) and the Project contractor, CH2MHill, for consideration for incorporation in the 60% BoD Report. In addition to the Landfill being one of the pilot projects in the ACSIM GSR Study, the Landfill project was separately but concurrently followed through the FUDS TADDS document review system at the EM CX. GSR inclusion in the Design was followed through both the GSR Study and the TADDS review system. GSR inclusion in the Proposed Plan and the Decision Document were followed through the TADDS document review system.

1.2 Project Contacts

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Carla Heck (Project Manager) USACE Louisville District, 502.315.3829 Carla.M.Heck@usace.army.mil

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

The Landfill was first brought to the attention of Carol Dona of the EM CX as a potential pilot project in the ACSIM GSR Study through her role as one of the reviewers in the EM CX TADDS Document review system for the Landfill Draft Final Focused Feasibility Study. She contacted Cindy Ries of Louisville District, who suggested Dr. Dona brief the Project Team and the Ohio state regulator on a Project Team call on Jan 11, 2011. The State and Project Team concurred with project participation in the Study if the accelerated schedule (completion of the design and decision documents by the end of the 2010-11 fiscal year) would allow participation in the Study. The GSR Study Team reviewed the schedule and determined that participation in the Study would work if the reviews of the GSR documents were performed concurrently by the EM CX and the Project Team instead of sequentially. The Project Team then agreed to participate in the Study. An important consideration of the Project Team was that GSR inclusion was one of the factors for the end of year plus up FUDS funding that the Project Team hoped to receive for the Landfill remediation. The Project Team also indicated there was language in the contract for the remediation contractor, CH2MHill, that included GSR evaluation and consideration in the Design. This indicated that it was in the scope of the contract for CH2MHill to participate in the Study.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

Project documents were supplied to the GSR Study Team by Louisville District following the Project Team agreement to participate in the Study. Also, the GSR Best Management Practices (BMP) List [1] was supplied to Project Team and CH2MHill per the Step 3 call (see Section 4.0) for reference and review for an on-site Project design meeting in which the Step 5 GSR discussion was incorporated. Additional information on the Design was obtained by the GSR Study Team from the discussions at the design meeting (see Section 4.0).

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

In the Step 3 call[2] on Jan 25, 2011, members of the GSR Study Team and Project Team agreed to a schedule that included a preliminary identification of GSR opportunities by Tetra Tech that could be considered for incorporation into the 30% Design, followed by a later, more thorough review by Tetra Tech of the 30% Design for GSR opportunities that were supplied to the Project Team and remediation contractor, CH2MHill, for consideration and incorporation in the 60% Design. The Project Team invited the GSR Study Team to attend an on-site Design meeting where the detailed discussion of GSR opportunities could be presented and discussed with all the stakeholders present at the meeting. This meeting was held in the afternoon of 2 March 2011 following the 30% Design briefing by CH2MHill. Representatives from Ohio EPA and the current site landowner, Columbus Regional Airport Authority (CRAA), were present as well as EM CX and Tetra Tech representatives from the GSR Study Team and representatives from the Project Team. The BMP list was used as an outline for identification of GSR items already incorporated as well as additional GSR items that could potentially be incorporated in the Design. Additional GSR items identified by the meeting participants included on-site reuse of the mulch from the brush removal, partial (i.e., not complete) removal of a concrete channel structure[3], and potential use of the channel water for on-site dust control and potential future wetlands mitigation. The information from the meeting along with information from the review of project documents was presented in the Draft GSR Evaluation Report prepared by Tetra Tech and provided to the EM CX and the Project Team for review on 23 March 2011. The Draft GSR Evaluation Report was revised per comments from the EM CX and the Project Team by Tetra Tech and was finalized 3 May 2011. The Approach for the overall Study

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[1] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056)

[2] Revised Final Report Pilot Project GSR Evaluation, Former Lockbourne Air Force Base Landfill, June 20, 2011, Section 1

was subsequently finalized, and a Revised Final GSR Evaluation Report, including changes consistent with the finalized Approach, was submitted on 20 June 2011. The consideration and incorporation of GSR was summarized in a section of the 60% Design (see attached).

5.0 FOLLOW-UP

The GSR consideration, incorporation, and documentation process was also followed through the EM CX TADDS document review system. The documents reviewed included the 30, 60 and 90% Basis of Design Reports and also the Landfill Proposed Plan and Decision Document. In addition to providing review and comments on the GSR language included in the Basis of Design Reports, the EM CX recommended the following changes in the Proposed Plan language to allow the following GSR opportunities identified in the Study to be incorporated into the Landfill design and construction: 1) use of “groundwater monitoring” instead of “long-term groundwater monitoring” to allow maximum flexibility in reducing or discontinuing groundwater monitoring once performance goals were met; 2) substitution of “cover material, suitable for establishing and supporting the vegetation selected for the cover” for “topsoil” to allow use of the mulch from brush clearing to be used with fertilizer instead of imported top soil, and 3) replacement of the language “Removing the reinforced concrete structure in the West Ditch and consolidating the debris underneath the proposed cap to improve surface water drainage at the landfill” to “Removing the reinforced concrete structure to the extent that is necessary to improve surface water drainage at the landfill while maintaining structural integrity of the landfill slope and future cover” to allow only partial removal of the reinforced concrete structure if otherwise deemed appropriate. The same recommendations were made and incorporated into the Decision Document. The former two items were included in the final design; the third item, partial removal of the concrete structure, was replaced with complete removal in the final design primarily because the CRAA wetlands permit, which designates complete concrete structure removal, would need to be modified and approved for partial structure removal. A secondary concern, stability of the structure if only partially removed, also argued for complete removal. The final design also included a number of GSR construction BMPs (see separately attached file: Lockbourne GSR Sections in Final Design).

Funding for the project was received and the request for proposal (RFP) included GSR. Although it was originally planned that an incentive for GSR implementation would be included in the RFP, because of time restrictions on funding availability, combined with extended time requirements for definition of the incentive measurement criteria in the RFP, the GSR incentive was deleted from the RFP. However, GSR inclusion was retained as one of the contract award technical evaluation factors.

- Balance future land use considerations by allowing for multiple reuse options.
- Balance the dimensions of the cover versus the area to be excavated, thus maximizing reuse of the site for industrial/commercial purposes.
- Complete site restoration activities quickly, such as seeding and other erosion control items.

6.2 Remedial Design Level GSR Elements

The following RD-level GSR elements have been incorporated into the RD package:

- Propose a cut and fill borrow source onsite for cover soil, select fill, and topsoil (plantable soil) materials.
- Use native species for revegetation.
- Quickly and efficiently implement seeding and erosion restoration items at the end of the construction so as to limit erosion impacts.
- Remove the West Ditch reinforced concrete structure, reducing the need for two construction efforts at the same site and thus minimizing the use of equipment and resources.
- Consolidate the reinforced concrete structure debris under the landfill cover, minimizing waste generation requiring offsite disposal.
- Minimize dust during construction activities by spraying water or by laying biodegradable mats, tarps, or materials.
- Select and place rock-lined channel protection at the outlets of swales and pipes.

The following GSR language is included in the technical specifications.

- Employ sustainable practices to the maximum extent practicable during performance of the work. Sustainability practices to be used in performing the work may include the following:
  - Minimize vehicle miles driven including mobilization mileage, crew travel mileage, equipment and materials delivery mileage (bulk shipments), and maintenance/ repair mileage.
  - Limit vehicle idling.
  - Use alternative fuels for equipment and vehicles.
  - Use vehicles meeting new USEPA clean diesel standards, or upgrade to new emissions controls (such as diesel oxidation catalysts, diesel particulate filters, and closed crankcase ventilation filtration systems) to reduce particulate matter, carbon monoxide, and nitrogen oxides in exhaust.
  - Minimize packaging waste.
  - Recycle packaging waste.

- Use recycled or recycled-content material (such as paper towels, trash bags or plastic sheeting, or materials packaging) as applicable.
- Reuse materials where applicable.
- Use local resources and materials, including local sources of water for dust suppression.
- Use reasonable measures to minimize and suppress fugitive emissions of dust, vapors, and other site materials during site work.

- Complete an evaluation of Occupational Safety & Health Administration's Hazardous Waste Operations and Emergency Response Standard (29 CFR 1910.120/29 CFR 1926.65) applicability, to support efficient resource use.

6.3 Green and Sustainable Remediation Report

The following items were included as recommendations in the final GSR report:

1. Evaluate the pros and cons of complete versus partial removal of the West Ditch concrete structure.

   Response—Partial removal was considered in the 60 percent remedial design submittal. However, complete removal is now planned because of potential stability problems with leaving part of the structure behind.

2. Determine if there are technical issues that would preclude leaving stumps in place in the area that will be covered.

   Response—Potential for development of preferential pathways and for additional differential settlement is increased if stumps are left within the footprint of the landfill. Therefore, areas of disturbance will be grubbed in accordance with the technical specifications (Appendix D).

3. Evaluate the idea to dig out an area to allow pooling of surface water for use during construction.

   Response—Temporary ponds (sediment basins) are incorporated into the RD for sediment control, but the ponded water is not proposed for reuse in the RD. The contractor can consider the East or West Ditch as a water source for dust control.

4. Perform a detailed technical and feasibility evaluation to maximize potential use of mulch generated by vegetation clearing for other aspects of the remedial action construction.

   Response—The reuse of onsite soils and mulch as the basis for creation of topsoil (plantable soil) for the cover will be evaluated by the contractor and used if deemed suitable. Importation of topsoil (plantable soil) is proposed if onsite soils are not deemed suitable.

5. Evaluate use of Hydrosleeves for groundwater sampling to eliminate/reduce purge water.

Response—The method of groundwater sampling will be established after groundwater data have been collected as part of LTM. Hydrosleeves will be evaluated as a potential sampling method during development of the final LTM Plan.

6. Evaluate potential alternatives for dust control.

   Response—The contractor will choose means and methods for dust control. Language has been added to the technical specifications encouraging the use of green and sustainable methods for dust control during the remedial action.

MEMORANDUM FOR RECORD

FOR:	Blue Mountain Training Area, Fort Missoula, Missoula, Montana
PREPARED BY:	Nicholas J. Stolte, P.E., USACE Environmental and Munitions Center of Expertise (EM CX), ACSIM GSR Study MMRP Coordinator
DATE:	2 April 2012
REFERENCE:	Final Report Pilot Project Green and Sustainable Remediation Evaluation: Blue Mountain Training Area, Fort Missoula, Missoula, Montana, 21 December 2011
SUBJECT:	Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

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1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to document the process through which the site was proposed and the Project Team agreed to participate in the Study, the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and any follow-on actions of the Project Team.

1.1 Project Overview

Fort Missoula, located outside of Missoula Montana, included areas that were historically used by Montana Army National Guard (MTARNG) personnel for training with small arms, grenades and demolition. Due to the past munition-related activities at the areas, Munitions and Explosives of Concern (MEC) and Munitions Constituents (MC) are suspected to be present. Those areas have been defined as two distinct Munitions Response Sites (MRSs): the Blue Mountain Training Area (BMTA) and the Grenade Training Site (GTS). Currently, the sites are active recreation areas. The property is being address as part of the Military Munitions Response Program (MMRP). Currently, the project is in the Remedial Investigation/Feasibility Study (RI/FS) phase. The Pilot Project GSR evaluation pertained to RIFS activities associated with characterizing the nature and extent of MEC and MC at the BMTA MRS.

The GSR Team (Rob Greenwald, Doug Sutton, Michelle Caruso, and Sarah Farron of Tetra Tech and Carol Dona, Nick Stolte, of the USACE EM CX) was provided with the Draft Work Plan: *Military Munitions Response Program Remedial Investigations and Feasibility Studies; Grenade Training Site and Blue Mountain Training Area, Fort Missoula, Missoula, Montana* (Weston, February 2011). The Project Team included Clif Youmans and Sundi West of MTARNG, Rob Halla of National Guard Bureau (NGB), and the Project Team Contractor (Weston Solutions).

Field activities included in the RIFS for BMTA include analog metal detector-aided surveys, Digital Geophysical Mapping (DGM), excavation, soil sampling, and analysis. The GSR evaluation included a review of Best Management Practices (BMP), quantitative footprints analysis for planned RI activities, and other qualitative considerations.

1.2 Project Contacts

Clif Youmans, MTARNG, 406-324-3085, Clifton.Youmans@us.army.mil

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

MAJ Kim Gage was in attendance as the NGB representative at a Study MMRP brainstorming meeting in Huntsville, AL on 16 November 2010. He suggested Fort Missoula as a potential MMRP project for the Study. Two introductory calls were held to discuss participation of the Project Team. The first call was held on 11 March 2011 and included MAJ Gage. The second was held on 1 April 2011 and included MAJ Gage plus members of the Project Team. The Project Team wanted to know if the GSR evaluation would interfere with the project schedule. Since the work plan for the RI had been accepted by the NGB and would soon be finalized, it was agreed that the GSR Team do an evaluation based on the current version of the work plan. The GSR team would indicate where GSR has already been integrated into the work plan and make recommendations that would not change the work plan or impose significant impacts on the Project Team's consultant. Then in the RI Report, the results of the GSR evaluation could be discussed and those recommendations that were implemented could be documented by the Project Team.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

Initial provision of project documents to the Study Team for consideration of the project as a pilot in the Study was arranged by MAJ Kim Gage of National Guard Bureau. The transmittal of additional documents to Tetra Tech was arranged during the Step 3 call (see Section 4.0 below). Also, the GSR Best Management Practices (BMP) List [1] was supplied to the Project Team for their review before the Step 5 meeting.

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

Pursuant to the GSR approach implemented in the Study, an introductory conference call (referred to as the "Step 3" call[2]) was conducted on 11 March 2011. A second "Step 3" call was conducted on 1 April, 2011. This second call included participants from the MTARNG who are conducting the RI/FS, and was conducted so that the GSR Team and the Project Team could thoroughly discuss integration of the GSR evaluation into the RI/FS project schedule.

Part of the overall study was to include a few on-site meetings in lieu of a Step 5 [2] call. Missoula was selected for an on-site meeting because the GSR Team felt it would be beneficial to have an on-site meeting for one of the MMRP projects included in the Study. The GSR Team traveled to Missoula, MT and attended a public meeting on 17 May 2011. The discussion of GSR considerations was held on 18 May 2011. During the on-site meeting, an extensive review of BMPs was performed by the GSR Team with the Project Team. The Project Team has extensively considered GSR principles in developing the RI/FS Work Plan, and has already included a page entitled "Sustainability Commitment" on the project website (www.BlueMountainRIFS.org). The website included methods of energy and water conservation, and waste minimization.

Most of the BMPs identified as "applicable" were also considered "practical." The quantitative GSR footprints calculated for the planned RI/FS activities were extremely low, so there is little room for

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[1] Appendix A, *Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation* https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

[2] Final Report Pilot Project Green and Sustainable Remediation Evaluation: Blue Mountain Training Area, Fort Missoula, Missoula, Montana, 21 December 2011, Section 1

significant footprint reductions. The Project Team had already made extensive consideration of GSR principals and no additional items regarding GSR were recommended.

The information collected in the on-site meeting and information from the references provided by the Project Team were used by Tetra Tech to develop the Draft GSR Evaluation Report, which was supplied to the EM CX Study Team for review on 20 June 2011. The revised Draft Final GSR Evaluation Report was provided to the Project Team on 15 July 2011. No comments were received from the Project Team on the report and it was finalized on 21 December 2011.

5.0 FOLLOW-UP

The RI Report will include a section on GSR principals and practices that were considered and incorporated as part of this project.

MEMORANDUM FOR RECORD

FOR:	Shepley's Hill Landfill, Former Fort Devens Army Installation (Fort Devens), Devens, MA
PREPARED BY:	Carol Dona, USACE Environmental and Munitions Center of Expertise (EM CX) Project Manager
DATE:	15 May 2012
REFERENCE:	Final Report Pilot Project GSR Evaluation: Shepley's Hill Landfill: Draft FFS Phase, Former Fort Devens Army Installation, Devens, MA, March 2011
SUBJECT:	Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

1.0 INTRODUCTION: The purposes of the Memorandum for Record (MFR) are to document 1) the process through which the site was proposed and the Project Team agreed to participate in the Study, 2) the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and 3) any follow-on actions of the Project Team.

1.1 Project Overview

Remediation of the Shepley's Hill Landfill (the Landfill) is part of the Base Realignment and Closure (BRAC) process at the Former Fort Devens Army Installation (Fort Devens). The remediation of the Landfill is being managed for Army BRAC by the USACE New England District (NAE). A plume of arsenic emanates northward from the vicinity of the landfill toward a stream and has apparently impacted water quality in a nearby pond located northeast of the landfill. Two Study GSR pilot evaluations were performed on two sequential phases in the Landfill remediation process: the Draft Focused Feasibility Study (FFS) phase; and the follow-on Constructability Phase for one component of the remedy . This technical memorandum describes the process used for the GSR evaluation performed for the Draft FFS phase. The purpose of the FFS is to evaluate a number of remedial alternatives for potential replacement and/or augmentation of the current operating remedy, a pump and treat system, for the groundwater arsenic plume. The pump and treat system was installed in 2006 per the 1995 ROD as a contingency remedy to monitored natural attenuation (MNA) when the groundwater arsenic plume continued to expand. The results of the FFS are intended to be integrated into an ESD or ROD amendment. The GSR Team (Rob Greenwald, Doug Sutton, and Sarah Farron of Tetra Tech plus Carol Dona and Dave Becker of the USACE EM CX) performed an initial GSR evaluation in December, 2010. They provided input to the Project Team (Ellen Iorio, NAE, project manager; Ian Osgerby (now retired), NAE Innovative Technology Advocate, Darrell Moore, NAE, technical lead; and Bob Simeone, Army BRAC) and the Project Contractor (Sovereign) in late December 2010 on the Internal Draft FFS. Tetra Tech then followed up with a more comprehensive GSR evaluation based on the Draft FFS, the results of which were formulated into a GSR Evaluation Report dated March 2011 for consideration and incorporation into the Draft Final FFS and subsequent use in the ROD Amendment. Finalization of the Draft Final FFS is waiting resolution with EPA on a Technical Impractibility (TI) Waiver that BRAC is proposing based on the Army position of the impracticability of restoring groundwater quality to unrestricted use in the area of the arsenic plume to the north of the Landfill within a timeframe that is reasonable based on the particular circumstances of the site.

1.2 Project Contact(s)

Maryellen (Ellen) Iorio, USACE NAE project manager, Maryellen.Iorio@usace.army.mil, 978-318-8433

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

Dave Becker of the EM CX, who has been a primary EM CX technical reviewer for work at the Landfill for the last seven years, suggested the project to Carol Dona as a potential pilot for the Study. Dr. Dona initially contacted Ian Osgerby, who was at that time the innovative technology advocate for NAE. Mr Osgerby indicated his interest in participating in the Study and recommended contacting his section chief, David Margolis, and the Landfill project manager, Ellen Iorio. Dr. Dona contacted Mr. Margolis and Ms. Iorio, who showed initial interest in Study participation. Ms. Iorio also queried Bob Simeone, the Fort Devens Army BRAC representative, about Study participation; Mr. Simeone provided concurrence for participation in the potential Study with the caveat that the participation should give measureable additional value. He noted that EPA had sponsored a Remedial System Evaluation (RSE) that also evaluated GSR in 2009. A NAE/EM CX/BRAC teleconference was held on 18 November 2010 where the potential of two projects were discussed, one using the Draft FFS to recommend GSR for consideration within the alternatives considered for selection in the ESD or ROD Amendment, and another on the design of the alternative selected in the ESD or ROD Amendment. The schedule that needed to be met for GSR Study participation was determined. Subsequent confirmation with Tetra Tech indicated this schedule was practical for their performance of the GSR Evaluation(s). Dr. Dona then confirmed with NAE and BRAC participation of the Landfill project in the Study.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

Since Tetra Tech had performed the earlier 2009 RSE, they were already familiar with the site and had many of the Project documents. Also, given its past independent technical review of project submittals the EM CX already had many of the historical Landfill documents. An internal Draft version (17 December 2010 Draft) of the FFS was provided to Tetra Tech and the EM CX on 21 December 2010 for an initial GSR review. EM CX and Tetra Tech comments were incorporated into this revised version of this Draft, dated 29 December 2010, which was distributed to the regulators on 31 December 2010 and provided to the EM CX on 26 January 2011, who then distributed it to Tetra Tech. This latter version was used for the subsequent, more comprehensive GSR Evaluation performed by Tetra Tech.

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

Following confirmation of the Project Team participation in the Study, a quick-turnaround GSR identification was performed on the internal Draft FFS dated 17 December 2010 by the EM CX and Tetra Tech, with initial GSR opportunities identified for consideration in the revision of the FFS before the FFS was supplied for review to the State and Federal regulators. Comments from Tetra Tech and the EM CX were provided to the Project Team on 24 December 2010. The FFS was revised per the review and the revised FFS dated 29 December 2010 was supplied to the regulators on 31 December 2010.

A Step 3 was held with the GSR team, the Project Team, and the Project Team Contractor on 21 January 2010 to further plan the Project Team and Contractor involvement in the Study. During this call the overall schedule for potentially including GSR into the sequential remedial phases, the FFS and then the design of the remedy chosen through the ESD or ROD Amendment, was formulated. Dr. Dona agreed to arrange funding for the involvement in the Study by the Project Team and Project Team Contractor. Dr. Dona also agreed to supply sample GSR contract language so GSR could be included in the upcoming scoping of the contract for the Landfill remediation design. The funds and contract language were provided to NAE following the Step 3 call[1]. The Step 5 call[1] was scheduled and subsequently held on 9 February 2010 and lasted about 2 hours. At the request of the Project Team and Contractor, Tetra Tech had supplied a bullet list of discussion points as well as the GSR Best Management Practices (BMP) List from the Study Approach[2] for review by the Project Team and Contractor prior to the call. Tetra Tech used the information from the Step 5 call along with information obtained from review of the 29 December 2010 FFS and their prior performance of the RSE to prepare the Draft GSR Evaluation Report, dated and supplied to the Project Team on 4 March 2011. The 29 December 2010 FFS, including the GSR section, was also reviewed by the EM CX within the FUDS independent technical review system, with comments supplied to NAE on 6 February 2011.

Disagreement as to the path forward between Army BRAC and the regulators was encountered upon regulator review of the 29 December 2010 FFS. This delayed progression of the project forward through the ROD Amendment and the subsequent design phase. Because of Project Team concerns about the Final GSR Evaluation Report not reflecting these Project changes, the GSR Evaluation Report, when finalized on 14 November 2011, was dated back to the Draft GSR Evaluation Report date of March 2011, with statements included in the Remedial Phase and Status Section (Section 1.2.2) that the GSR evaluation was based on the December 2010 Draft FFS, and did not address FFS modifications that occurred subsequent to the December 2010 Draft FFS.

5.0 FOLLOW-UP

A GSR section in the FFS, which has not been finalized pending resolution of issues under discussion between the regulators and BRAC regarding the remedy, is planned that discusses the environmental footprints of the alternatives, with the footprints being considered in the assessment of the alternatives. The sequential follow-up pilot originally scoped for the design of the remedial alternative selected in the planned ROD amendment was modified to evaluate one component of the remedy, a barrier wall, that was not in dispute between Army BRAC and the regulators. The process used with this Study pilot is described separately in the technical memorandum for the GSR evaluation performed for the Constructability Phase.

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[1] Final Report Pilot Project GSR Evaluation: Shepley's Hill Landfill: Draft FFS Phase, Former Fort Devens Army Installation, Devens, MA, March 2011, Section 1.

[2] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

MEMORANDUM FOR RECORD

FOR: Shepley's Hill Landfill, Former Fort Devens Army Installation (Fort Devens), Devens, MA

PREPARED BY: Carol Dona, USACE Environmental and Munitions Center of Expertise (EM CX), ACSIM GSR Study Project Manager

DATE: 15 May 2012

REFERENCE: Final Report Pilot Project GSR Evaluation: Shepley's Hill Landfill: Constructability Phase, Former Fort Devens Army Installation, Devens, MA, April 2012

SUBJECT: Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

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1.0 INTRODUCTION: The purposes of the Memorandum for Record (MFR) are to document 1) the process through which the site was proposed and the Project Team agreed to participate in the Study, 2) the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and 3) any follow-on actions of the Project Team.

1.1 Project Overview

The Shepley's Hill Landfill remediation is part of the Base Realignment and Closure (BRAC) process that is occurring at the Former Fort Devens Army Installation (Fort Devens). The remediation of the Landfill is being managed for Army BRAC by the USACE New England District (NAE). A plume of arsenic emanates northward from the vicinity of the landfill toward a stream and has apparently impacted water quality in a nearby pond, Plow Shop Pond, located northeast of the landfill. Study pilots were performed on two sequential phases in the Shepley's Hill Landfill remediation process: the Draft Focused Feasibility Study (FFS) phase and the follow-on Constructability Phase for one component of the remedy. This technical memorandum describes the process used for the GSR evaluation performed for the Constructability Phase. The GSR Team for this Study pilot was Rob Greenwald, Doug Sutton, and Sarah Farron of Tetra Tech plus Carol Dona and Dave Becker of the USACE EM CX. The Project Team was Ellen Iorio, NAE, project manager; Ian Osgerby (now retired), NAE Innovative Technology Advocate, Darrell Moore, NAE, technical lead; Bob Simeone, Army BRAC; and the Project Team Contractor (Sovereign). It was originally planned that the second pilot included in the ACSIM GSR Study would evaluate the design phase of the selected alternative. Because of disagreement between the regulators and Army BRAC on the remedial alternative to include in the ESD or ROD Amendment, the second pilot included in the ACSIM GSR Study was modified to evaluate one component of the remedy (a barrier wall) that was not in dispute between Army BRAC and the regulators.

1.2 Project Contact(s)

Maryellen (Ellen) Iorio, USACE NAE project manager, Maryellen.Iorio@usace.army.mil, 978-318-8433

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

The process through which the project team initially agreed to participate in the Study is described in the technical memorandum for the initial pilot in the Draft FFS phase. Following disagreement of the regulators with Army BRAC with respect to the selection of the remedy for the ESD or ROD Amendment, with the resultant delay in the ESD or ROD Amendment and selection of the remedy on which the design was to be based, the Study Team, Project Team, and Project Team Contractor agreed in a conference call on 25 August 2011 to do the second pilot GSR evaluation for a barrier wall expected to be part of the overall remedy. The regulators and BRAC were in agreement on this component of the remedy, and the GSR evaluation was conducted using additional "constructability" information for the wall generated beyond the Draft FFS phase.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

In addition to the documents exchanged between the Study Team and the Project Team for the GSR Evaluation during the Draft FFS Phase, the Project Team supplied the following additional documents for the Constructability Phase pilot:

1) *Shepley's Hill Landfill Pre-Construction Investigation Workplan* (dated November 2011)
2) *Draft Constructability Basis Report, Hydraulic Barrier Wall at Shepley's Hill Landfill* (dated 21 October 2011).

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

Earlier in the Study, a Draft Focused Feasibility Study (Draft FFS), dated December 2010, was provided to the GSR Team for an initial GSR evaluation (Draft FFS Phase) for alternatives to the current P&T system. That Draft FFS also presented two alternatives to minimize contaminated groundwater flux to the nearest part of Plow Shop Pond (Red Cove) – a barrier wall with a permeable reactive portion, or a barrier wall alone. The Draft FFS was subsequently revised, and overall remedy selection has not yet occurred because of disagreement between the regulators and Army BRAC on the remedy to include in the planned ESD or ROD Amendment. This necessitated revision of the original plan to follow the GSR evaluation in the FFS phase with a second GSR evaluation of the design of the remedy selected in the ESD or ROD Amendment. Since a barrier wall between the closed landfill and Plow Shop Pond is expected to be a component of the selected remedy, and the Project Team has initiated constructability investigations for that barrier wall (including plans for a pre-construction field investigation related to that barrier wall), the Project and Study teams agreed on a 25 August 2011 call to perform a GSR evaluation on the options being considered for the barrier wall (which included a soil bentonite slurry wall, a cement bentonite slurry wall, and a sheet pile wall). The Project and Study Teams also agreed to replace the typical Step 3 call [1] with the 25 August 2001 call. In addition, there was agreement that the Study Approach Best Management Practices (BMP) list[2] would be completed by the GSR Team and supplied to the Project Team and Contractor for a red-line review, with a follow-up phone call if the Project Team and Contractor requested such call. The BMP list as completed by the GSR Team was supplied to the Project Team within a "Pre-Draft" GSR Evaluation Report, dated 9 November 2011, which was supplied to the Project Team 9 November 2011. Comments on the "Pre-Draft" GSR Evaluation Report were incorporated into the Draft Final GSR Evaluation Report, dated 1 February 2012 and supplied to the

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[1] Final Report Pilot Project GSR Evaluation: Shepley's Hill Landfill: Constructability Phase, Former Fort Devens Army Installation, Devens, MA, April 2012, Section 1.

[2] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

Project Team 1 February 2012. No further comments were received and the GSR Evaluation Report was finalized on 10 April 2012.

5.0 FOLLOW-UP

Since the results of the GSR Evaluation in the Constructability Phase were completed ahead of the selection of the overall remedy for the Landfill, no follow-up by the Project Team has occurred. It is expected that the information and recommendations from the GSR Evaluation Report will be considered after the ESD or ROD Amendment has been approved and the design of the selected Landfill remedy is performed.

MEMORANDUM FOR RECORD

FOR:	Umatilla Chemical Depot (OU3), Umatilla, Oregon
PREPARED BY:	Carol Dona, USACE EM CX, ACSIM GSR Study Project Manager
DATE:	15 April 2012
REFERENCE:	Final Report Pilot Project Green and Sustainable Remediation Evaluation, Umatilla Chemical Depot (OU3), Umatilla, Oregon 7 February 2012
SUBJECT:	Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

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1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to 1) document the process through which the site was proposed and the Project Team agreed to participate in the Study, 2) the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report), and 3) any follow-on actions of the Project Team.

1.1 Project Overview

Remediation at the Umatilla Chemical Depot (UMCD) is managed by the US Army Corps of Engineers (USACE), Seattle District (NWS), for the Army Base Realignment and Closure Program (BRAC). This GSR Evaluation Pilot pertained specifically to the Explosives Washout Lagoons Groundwater (Operable Unit 3) at the UMCD, hereafter referred to as UMCD OU3. The Project Team included Mandy Michalsen, Jeff Powers, and Leanna Woods Poon of NWS. The GSR Team consisted of Rob Greenwald, Doug Sutton, and Sarah Farron of Tetra Tech and Carol Dona of the EM CX. The GSR evaluation was based on the recommended remedy in the Draft Final Focused Feasibility Study (FFS) (see Section 3.0 below), which was "Alternative 4" (Pump and Treat Expansion and Bioremediation). As well as a qualitative review of the GSR Best Management Practices (BMPs), the GSR Evaluation included a quantitative footprint analysis for the recommended remedy and the following potential variations on the baseline recommended remedy:

- Variation 1 – Initial P&T and In-Situ Bio at Waste Lagoon for 3 Years Instead of 5 Years (the latter the length of In-Situ Bio designated in the Draft Final FFS)

- Variation 2 – Ship Lab Samples to a Closer Lab

1.2 Project Contacts

Mandy Michalsen, Technical Lead, USACE Seattle District, 206-764-3324, mandy.m.michalsen@usace.army.mil

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

Carol Dona first recommended consideration of GSR inclusion in the UMCD OU3 project as an Army project within an Air Force, Navy, and USACE ESTCP Study where results from application of the

SiteWise™ Tool for Green and Sustainable Remediation (SiteWise) would have been compared with a full Life Cycle Assessment conducted using SimaPro. When multiple Army projects were proposed for the ESTCP Study, Rob Greenwald of Tetra Tech, who was on the ESTCP Study Team, suggested that the UMCD OU3 project could instead be a pilot project in the GSR Study. Richard Wilson, project manager, and Mandy Michalsen, project technical lead, indicated their agreement with participation in the Study with the condition that GSR Study funding would be supplied to the Project Team. After agreement of participation, Carol Dona arranged for funds to support the Project Team in GSR Study participation. The Project Team indicated the scope of the GSR evaluation should be limited to the recommended alternative in the Draft Final FFS.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

Provision of project documents to the Study Team was arranged by Ms. Michalsen and Leanna Woods Poon of NWS. The documents included the following:

- Draft Final Focused Feasibility Study (FFS) for Groundwater at the Explosives Washout Lagoon (EWL) Area, Operable Unit 3 (OU3), at the Umatilla Chemical Depot, Umatilla, OR (Draft Final, USACE, 26 August 2011)
- RACER cost-estimation database file associated with the Draft Final FFS
- Pulse Pumping Optimization Evaluation, August, 2009 Pulse Pumping Event (SCS Engineers and EMR Corporation, October 2009) and Pulse Pumping Technical Memorandum (EMR, 5 October 2009)
- Groundwater Treatment Plant Systems Operations and Maintenance Manual (SCS Engineers, January 2008)
- Independent Technical Review: Exit Strategy Development, Washout Lagoons Pump And Treat Site, Umatilla Chemical Depot, Hermiston, OR (Final Draft, USACE HTWR CX, December 2006)

In addition, the GSR Team was provided additional information by the Project Team via email, in response to questions regarding assumptions used in RACER and/or values to assume for the quantitative footprinting. Also, the GSR Best Management Practices (BMP) List[1] was supplied to the Project Team for their review before the Step 5 call (see Section 4.0).

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

The GSR approach being implemented in the Study typically includes an introductory conference call (referred to as the “Step 3” call) to introduce the Project Team to the Study, to arrange for transfer of information to the GSR Team, and to schedule a more detailed “Step 5” call[2]. For this pilot project, Dr. Dona informally addressed those items with the Project Team during the discussions involving first participation in the ESTCP project and then the GSR Study, so a “Step 3” call was not necessary. The

[1] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

[2] Final Report Pilot Project Green and Sustainable Remediation Evaluation, Umatilla Chemical Depot (OU3), Umatilla, Oregon 7 February 2012, Section 1

"Step 5" conference call was conducted on 13 September 2011 and lasted approximately two hours. During this call the GSR Team used the list of GSR Best Management Practices (BMPs) developed for the Study as an outline to ask questions to the Project Team and allow the Project Team to provide pertinent information to the GSR Team. The Draft GSR Evaluation Report dated 29 September 2011, which also served as the Draft Final GSR Evaluation Report, was supplied to the Project Team 29 September 2011. Comments received from NWS 7 December 2011 were incorporated into the Final GSR Evaluation Report, dated 7 February 2012, which was supplied to the Project Team 9 February 2012.

5.0 FOLLOW-UP

The Project Team requested the SiteWise GSR Tool files used for the preparing the GSR quantitative footprints so they could modify the input and recalculate the footprints as necessary with any changes in the remedy through the process of finalization of the FFS and implementation of the selected remedy.

MEMORANDUM FOR RECORD

FOR:	Schilling Air Force Base Atlas Missile Facility S-1, Ottawa County, KS
PREPARED BY:	Carol Dona, USACE Environmental and Munitions Center of Expertise (EM CX), ACSIM GSR Study Project Manager
DATE:	19 April 2012
REFERENCE:	Final Report Pilot Project GSR Evaluation, Schilling Air Force Base Atlas Missile Facility S-1, 14 March 2012
SUBJECT:	Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to document 1) the process through which the Project Team agreed to participate in the Study; 2) the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Evaluation Report (the Draft Report); and 3) any follow-on actions of the Project Team.

1.1 Project Overview

The Schilling Air Force Base Atlas Missile Facility S-1, hereafter referred to as Schilling S-1, was one of twelve missile bases that were constructed within a 35 mile radius around the Schilling Air Force Base located in Salina, Kansas. After decommissioning and sale of the Schilling S-1 property in 1966, the property has had multiple owners, with the current owner using the property as a private residence. Through the Formerly Used Defense Site (FUDS) program, a Preliminary Assessment (PA) was performed by the USACE Kansas City District (NWK) in 2005, with the PA results indicating contamination above screening levels in the groundwater. These findings prompted a follow-on Site Inspection (SI) also performed by NWK. The GSR Evaluation was performed on the SI phase using the SI Work Plan prepared by NWK. As SI field work was on-going when the GSR Evaluation was performed, the GSR Evaluation focused on what GSR was already incorporated in the SI Work Plan, as well as GSR practices that could be considered and potentially incorporated in a potential follow-on remedial investigation (RI) at Schilling S-1 and also in future SIs and RIs at other NWK sites. Consistent with the intention to provide a GSR evaluation that could be used beyond specific application to Schilling S-1, the GSR Evaluation Report included case studies comparing different well drilling techniques and comparing passive sampling bags to low-flow sampling. The GSR Team that completed the GSR Evaluation included Carol Dona, Mike Bailey, Carl Harms, Anita Meyer, Thomas Georgian, Chung-Rei Mao, Ed Bave, Mark Fisher, and Dave Becker of the EM CX, with Sarah Farron and Rob Greenwald of Tetra Tech as reviewers. The NWK Project Team included Saqib Khan, project manager; Chuck Williams, geologist; Jody Gentry, remedial engineer; Jerry Montgomery, chemist; and Dave Daniel, risk assessor. The SI Work Plan was prepared in-house by the NWK Project Team, with the SI field work performed by a NWK drill crew, so no Project Team contractor was involved.

1.2 Project Contacts

Saqib Khan, Project Manager, Saqib.Khan@usace.army.mil, 816-389-3239.

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

Carol Dona initially discussed NWK Study participation with an Installation Restoration Program (IRP) project or projects in the SI and/or RI phase with Dave Nelson, NKW FUDS Program Manager. Mr. Nelson expressed interest both in specific project involvement and also development of material that could be used for broader application to other SIs and RIs. A number of Schilling Atlas sites were considered; it was found that the schedule of the Schilling S-1 project was the best match for participation in the Study. Dr. Dona then interfaced with Saqib Khan, the Schilling S-1 project manager, who indicated his willingness to participate in the Study under the conditions that Study participation would not affect the schedule for completion of field work. Upon Dr. Dona indicating that the GSR Team would adapt the Study participation to the Project schedule, Mr. Khan agreed to Project Team Study participation.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

The Draft Final SI Work Plan (Site Inspection Draft Final Work Plan: Schilling Air Force Base Atlas F Missile Facility S-1 April 2011) was provided to the EM CX initially as part of the EM CX independent review of selected FUDS documents. A limited GSR review was performed concurrent with the EM CX review, with the GSR opportunities identified in this review supplied to the Project Team as part of EM CX comments on the Work Plan to the Project Team. Saqib Khan also supplied the Preliminary Assessment Report (Preliminary Assessment Report: Schilling Air Force Base Atlas F Missile Facility S-1, October 2008*)* to the GSR Team following agreement to Project Team participation in the Study. In addition, the GSR Best Management Practices (BMP) List[1] as initially filled out by the GSR Team was supplied to the Project Team prior to the Step 5 call (see below).

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

The GSR approach being implemented in the Study typically includes an introductory conference call (referred to as the "Step 3" call[2]) to introduce the Project Team to the Study, to arrange for transfer of information to the GSR Team, and to schedule a more detailed "Step 5" call. For this pilot project, Dr. Dona informally addressed the items normally addressed in the Step 3 call with Mr. Khan through her role as EM CX POC for review of the Draft Final SI Work Plan (initial call 17 May 2011) and subsequent email communications. The detailed Step 5 call was held on 21 July 2011 and lasted two hours, with GSR Team EM CX participants Anita Meyer, Dave Becker, Mike Bailey, Carl Harms, and Carol Dona and Project Team NWK members Saqib Khan, Chuck Williams, Jody Gentry, Jerry Montgomery, and Dave Daniel. The list of GSR BMPs was used as the primary outline for identification of GSR opportunities. The GSR Team provided the BMP list with their initial evaluation to the Project Team for review in advance of the Step 5 call. During the Step 5 conference call, the Project Team gave their feedback on the applicability of each BMP, and the GSR Team requested additional information where needed to complete the GSR evaluation. Since the field work was ongoing at the time of the Step 5 call, it was decided that the foci of the GSR Evaluation Report would be on identification of GSR opportunities already included in the Work Plan and potential GSR opportunities for the potential Project follow-on RI phase, as well as more general application to SI and RI phases in other NWK projects. Also, the Project Team was able to give the GSR Team important information about how the procedures in the SI Work

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[1] Appendix A, Final Installation Restoration Program (IRP) and Munitions Response Program (MMRP) Approach: Process for Consideration and Incorporation of GSR Practices in Army Environmental Remediation
https://casi.erdc.usace.army.mil/focusareas/green_remediation/?contentRegion=Item&id=62056

[2] Final Report Pilot Project GSR Evaluation, Schilling Air Force Base Atlas Missile Facility S-1, 14 March 2012, Section 1

Plan were working in the field work. These included the adaptations that were being made per field conditions, e.g. heavy rains, the necessity of changing the drilling technique, and the relatively short drill crew schedules due to restriction of no weekend work at the request of the Site owner. The information collected in the Step 5 call, along with information from the references and additional information obtained by the NWK from the drill crew that was supplied to the EM CX, was used by the EM CX to develop the Draft GSR Evaluation Report, which was supplied to the Project Team 1 November 2011. Comments were received from the Project Team 30 November 2011 and incorporated into the Draft Final GSR Evaluation Report, supplied back to the Project Team for review 6 January 2011. In response to comments by the Project Team, a case study comparing the GSR metrics of passive sampling bags to low-flow sampling was included. The Project Team indicated they had no further comments 5 March 2012 and the GSR Evaluation Report was finalized 14 March 2012. In the Final GSR Evaluation Report, the Report appendices were expanded to include a case study comparing the GSR metrics of the potential different well installation techniques. This case study, along with the case study comparing passive sampling bags and low-flow sampling methodologies, can be used as stand-alone documents for other projects[3].

5.0 FOLLOW-UP

If a RI subsequent to the SI is performed, the Project Team will have available the GSR Evaluation Report that includes GSR opportunities identified for consideration and incorporation in the RI phase. Also, the case studies comparing 1) different well installation techniques and 2) passive sampling bags and low-flow sampling methodologies were provided both in the GSR Evaluation Report and also separately to the NWK FUDS Program Manager for potential use in other NWK SIs and RIs.

[3] The case study comparing the different well installation techniques directly used data from the Schilling S-1 SI, whereas the case study comparing passive sampling bags and low-flow sampling used data from Joint Base Lewis-McChord.

MEMORANDUM FOR RECORD

FOR:	Former Schilling Atlas Missile Site S-5, McPherson County, KS
PREPARED BY:	Carol Dona, ACSIM GSR Study Project Manager
DATE:	15 April 2012
REFERENCE:	Former Schilling Atlas Missile Site S-5 Final Green and Sustainable Remediation (GSR) Analysis Report, September 2010
SUBJECT:	Project Team Consideration, Incorporation, and Documentation of Green and Sustainable Remediation (GSR) Options as identified in ACSIM GSR Study

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1.0 INTRODUCTION: The purpose of the Memorandum for Record (MFR) is to document the process through which the Project Team agreed to participate in the Study; the processes the Project Team used in considering, incorporating, and documenting the GSR options as identified in the Draft GSR Analysis Report (the Draft Report); and any follow-on actions of the Project Team.

1.1 Project Overview

The Former Schilling Atlas Missile Site S-5 (Schilling S-5) is a Formerly Used Defense Site (FUDS) where the remediation is being managed by the US Army Corps of Engineers (USACE) Kansas City District (NWK). This pilot, performed in-house by the EM CX and the first pilot in the ACSIM GSR Study (the Study), was used to follow GSR inclusion in a project in the remedy selection phase and also to establish conditions for Project Teams to participate in the Study. The GSR Team was Mike Bailey, Jeff Lester, and Carol Dona of the EM CX. The Project Team was Julius Calderon and Frank Bales, remedial engineers, and Saqib Khan, project manager. Matt Dolly, section chief of CENWK ED-EG and Mr. Calderon's supervisor, was also instrumental in establishing management approval of the Project Team's participation in the Study, as well as Cathy Sanders, NWK counsel, who reviewed and provided revisions for the GSR summary language in the Proposed Plan. Upon request of the Project Team, the GSR Team performed a quantitative GSR footprint comparison of the remedial alternatives being considered for the preferred alternative in the Proposed Plan. The GSR footprints, along with discounted and non-discounted costs, were calculated both for the standard 30 year time frame used in the Feasibility Study (FS) and the longer remedial time frames estimated by analytical modeling. Results from the GSR Analysis Report were incorporated into the Proposed Plan and the Decision Document.

1.2 Project Contacts

Saqib Khan, project manager, NWK, 816-389-3239, Saqib.Khan@usace.army.mil.
Julius Calderon, remedial engineer, NWK, 816-389-3550, Julius.C.Calderon@usace.army.mil.

2.0 PROJECT TEAM COMMITMENT TO PARTICIPATE

Schilling S-5 was one of the projects suggested by Frank Bales, NWK senior remedial engineer, as a potential project in the Study in a conversation with Carol Dona. Mr. Bales recommended further discussion with Julius Calderon, the primary remedial engineer on the project. Mr. Calderon showed initial interest but referred approval for participating in the project to his supervisor, Matt Dolly. Dr. Dona provided more information on the Study and addressed Mr. Dolly’s concerns about funding (supplemental funding for the Project Team’s participation in the Study would be provided), confidentiality (GSR analysis results would be kept internal to the Project Team until the Project Team determines what GSR items it wanted to include, if any), and cost impact (GSR options would at a minimum be identified as cost savings, cost neutral, and cost increase, with quantitative costs included along with any other GSR footprinting). Mr. Dolly then presented the information to the NWK HTRW Supervisors and received approval for NWK participation in the Study. Upon agreement to participate, Dr. Dona arranged for funds to support the Project Team participation in the Study.

3.0 INFORMATION EXCHANGE FOR GSR EVALUATION

Mr. Calderon provided the Schilling S-5 Feasibility Study, which included RACER cost estimation files; a costing table that extended the calculation of discounted and non-discounted costs past the 30 year time frame used with RACER; the REMCHLOR modeling performed by the NWK from which the remedial timeframes of the preferred alternative remedial options were calculated; and the Draft Final Proposed Plan. This pilot was performed before the Study approach had been prepared by Tetra Tech, and therefore the Best Management Practices Table used in later pilots was not available and therefore not supplied to the Project Team. The importance of confidentiality and cost impact ascertained from the planning of the Schilling S-5 pilot, however, was incorporated into the Study approach. Dr. Dona also presented to the NWK a brown bag that described GSR in the Army and the USACE, with specific reference to the Schilling S-5 participation in the Study.

4.0 GSR CONSIDERATION, IMPLEMENTATION, AND DOCUMENTATION

Quantitative footprints were calculated with SiteWise (the GSR tool used in the Study) for two remedial alternatives being considered for the preferred alternative:

- Long-Term Monitoring/Monitored Natural Attenuation (LTM/MNA)
- In-Situ Treatment/MNA (with the in-situ treatment consisting of either Enhanced Anaerobic Bioremediation or In-Situ Chemical Oxidation)

GSR footprints, along with discounted and non-discounted costs, were quantified for both the 30 year time period used in the FS and the remedial timeframes estimated from the REMCHLOR modeling (208 years for the LTM/MNA alternative and 78 years for the In-Situ Treatment/MNA alternative). The Draft GSR Analysis Report dated September 2010 was provided to the Project Team for review on 9 September 2010. The EM CX also supplied draft Proposed Plan language to NWK for review and inclusion. The NWK counsel revised the text to combine the FS costs that were calculated over the 30 year time period used in the FS with the GSR evaluation results over the longer time frames estimated from modeling. The Draft GSR Analysis Report was revised, finalized, and provided to the Project Team on 4 March 2011 for reference, along with the revised Draft Final Proposed Plan which included the GSR summary language as revised by the NWK counsel. The Proposed Plan GSR summary language indicated that GSR analysis supported the selection of the In-Situ Treatment with MNA alternative as the preferred remedy (see attached Proposed Plan GSR language). The complete GSR Analysis was cited in the Proposed Plan as a stand-alone document in the Project Administrative Record.

5.0 FOLLOW-UP

The Schilling S-5 Proposed Plan drafts and the Decision Document through Draft Final were also reviewed by the EM CX. The EM CX recommended that the same language used in the Proposed Plan be included in the Decision Document. This language is included, with the Decision Document currently circulating for final approval.

GSR Summary Section from the Final Former Schilling Atlas Missile Site S-5 Proposed Plan. This Section follows the evaluation of the remedial alternatives from the FS detailed analysis per the CERCLA nine criteria.

9.4 Consideration of Green and Sustainable Remediation (GSR) Practices

The 2009 DOD Memorandum "*Consideration of Green and Sustainable Remediation Practices in the Defense Environmental Restoration Program*" directs, "when and where it makes sense," the use of GSR strategies for remedial actions that:

- Use natural resources and energy efficiently;
- Reduce negative impacts on the environment;
- Minimize or eliminate pollution at its source;
- Protect and benefit the community at large; and
- Reduce waste to the greatest extent possible.

The 2010 Green and Sustainable Remediation (GSR) Analysis Report, which is included in the Administrative Record File, was performed to compare the In-Situ Treatment with MNA alternative to the LTM/MNA alternative. The results of the GSR evaluation indicate that the LTM alternative is generally less sustainable than the In-Situ Treatment with MNA alternative.

For example, the LTM/MNA alternative is calculated to have approximately 60-100% higher greenhouse gas emissions, energy use, and worker accident/fatality risk as well as 30-55% priority criteria pollutant emissions. The higher emissions, energy usage, and accident/fatality risk are largely due to the more extended monitoring period (206 years vs. 78 years) of the LTM/MNA alternative. Only the water use for the LTM/MNA alternative is calculated to be lower (~70%), which is due to the larger amounts of water necessary with the In-Situ Treatment alternative for dilution and injection of substrate or oxidant.