Interim Guidance 10-01
5 March 2010

US Army Corps of Engineers®

ENVIRONMENTAL QUALITY

DECISION FRAMEWORK FOR INCORPORATION OF GREEN AND SUSTAINABLE PRACTICES INTO ENVIRONMENTAL REMEDIATION PROJECTS

Groundwater recirculation well powered by a wind turbine at the Former Nebraska Ordance Plant Superfund Site, Mead, NE. Photo by Ernie Guitierrez and used with permission of Curt Elmore, Missouri University of Science and Technology

Environmental and Munitions Center of Expertise
Interim Guidance

AVAILABILITY

Electronic copies of this and other U.S. Army Corps of Engineers Environmental and Munitions Interim Guidance Documents are available on the Internet at http://www.environmental.usace.army.mil/corpguide.htm. Publications are provided in portable document format (PDF).

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REPLY TO
ATTENTION OF

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MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects, Environmental and Munitions Center of Expertise Interim Guidance Document (IGD) 10-01

1. PURPOSE: Interim Guidance Document 10-01 (enclosed) describes the general principles, concepts, and considerations that can be used to incorporate green and sustainable practices into Formerly Used Defense Sites (FUDS) environmental remediation projects. The document describes a decision framework whereby Project Delivery Teams can consider and implement, wherever appropriate, green and sustainable practices throughout the life cycle of a project.

2. APPLICABILITY: This guidance is applicable to FUDS environmental remediation projects executed and managed by the U.S. Army Corps of Engineers (USACE). It may also be applicable to environmental remediation projects managed or implemented by USACE for Army installations and the Environmental Protection Agency, subject to the needs and desires of the customer.

3. EFFECTIVE DATES: The information presented in this interim guidance can be used immediately. The interim guidance will remain in effect indefinitely, unless superseded by other guidance or policy.

4. DISTRIBUTION: This guidance is approved for public release and unlimited distribution.

5. POINT OF CONTACT: For additional information or to submit suggestions for improvements to this guidance, please contact Dr. Carol Dona at (402)-697-2582 or carol.l.dona@usace.army.mil.

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1. Introduction

Consistent with Executive Order 13423 — Strengthening Federal Environmental, Energy, and Transportation Management (EO 2007), the Department of Defense (DoD) has directed DoD Components to "…consider and implement green and sustainable remediation opportunities when and where they make sense" (DoD 2009). Green and sustainable environmental remediation practices are ones 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 (DoD 2009).

This decision framework outlines the process through which these and other green and sustainable practices can be undertaken across the life cycle of Formerly Used Defense Site (FUDS) program projects executed by the US Army Corps of Engineers (USACE).

1.1. Purpose and Scope

The purpose of this document is to provide a process for incorporating green and sustainable practices into environmental remediation consistent with DoD policy (DoD 2009) and the Army Environmental Cleanup Strategic Plan (US Army 2009) during USACE execution of the FUDS program. The scope of the document is to provide these processes for the entire environmental remediation lifecycle, from project inception through site closeout. The framework is readily adaptable to the FUDS Installation Restoration Program (IRP), the Military Munitions Response Program (MMRP), and the Building Demolition and Debris Removal (BD/DR) Program.

1.2. Authorities and Relevant Policies

The FUDS program was established under authority of the Defense Environmental Restoration Program (10 USC §2701) to address those locations described under 10 USC §2701(c) as: "Each facility or site which was under the jurisdiction of the Secretary and owned by, leased to, or otherwise possessed by the United States…." The FUDS program is managed and executed by the USACE, under authority delegated to the Secretary of the Army by Department of Defense Instruction (DoDI 4715.7). Due to the relationship of authorities between DERP and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), USACE preference is to conduct all FUDS environmental response actions in accordance with CERCLA and the National Oil and Substances Pollution Contingency Plan (NCP) (CFR Title 40 Part 300) when appropriate. Consequently, consideration and implementation of green and sustainable practices will typically take place within the existing CERCLA response framework but should not be limited to CERCLA response actions.

Incorporation of sustainable practices in US Federal agencies has been directed by a series of Executive Orders [EO 13101 (EO 1998), EO 13123 (EO 1999b), EO 13134 (EO 1999a), and EO 13148 (EO 2000)], which were consolidated in and superseded by EO 13423 "Strengthening Federal Environmental, Energy, and Transportation Management" (EO 2007). The EO states that to be sustainable "…means to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations of Americans." It further calls on federal agencies to "…conduct their environmental...and energy-related activities...in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner." DoD's policy memorandum, Consideration of Green and Sustainable Remediation Practices in the Defense Environmental Restoration Program, lays out the requirements for DoD Components to carry out their environmental restoration activities consistent with EO 13423 (DoD 2009). Recently, EO 13514 (EO 2009) was also issued, laying out additional requirements and expanding upon the goals established in EO 13423.

In compliance with EO 13423, the Army has also outlined its approach to green and sustainable remediation in the FY 2010-2011 Army Environmental Cleanup Strategic Plan (Army 2009). The Plan states, "the Army's approach to "green remediation" seeks to preserve our natural resources, minimize energy use, minimize carbon dioxide emissions, maximize recycling and reuse of materials, and minimize the Army's environmental footprint." The approach encourages "project managers to seek opportunities to incorporate options for minimizing the impact on the environment of cleanup actions undertaken at Army installations." The Plan also contains the specific objective for the FUDS program to consider "green remediation approaches to existing and future remedies." In addition, the Plan outlines a SMART (Sustainable Management of Available Resources and Technologies) cleanup approach that promotes sustainability through greater flexibility in the reuse of contaminated land, recommending consideration of future reuse of a contaminated site early during development of the site remediation strategy.

In addition to the 2009 DoD policy and the Army Environmental Cleanup Strategic Plan, other policies or positions taken by DoD or its Components with respect to incorporation of green and/or sustainable practices include:

- Use of best management practices for achievement of environmental protection through the establishment of Environmental Management Systems (EMSs) on Army facilities as outlined in the ISO 14001 EMS standard (ISO 2004) and EMS policy and guidance (US Army 2006c);
- Incorporation of sustainable design and development into vertical construction, policy and associated guidance (US Army 2006a, and US Army 2007);

- Minimization/diversion of deconstruction/demolition waste (US Army, 2006a),
- DoD being a signatory to the Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (EPA 2006b);
- The Army Strategy for the Environment (the Army Strategy) in 2004 (US Army 2004), which outlines a vision as the Army "simultaneously meets current as well as future mission requirements world-wide, safeguards human health, improves quality of life, and enhances the natural environment"; and
- The Department of Navy, Naval Facilities Engineering Command, Sustainable Environmental Remediation (SER) Fact Sheet (Navy 2009), which outlines a general approach to applying green and sustainable environmental remediation to a site, including the choice of green and sustainable elements and metrics, methodologies to quantify the metrics, and use of the results to reduce the environmental footprint of the site remediation.

Existing Federal laws and regulations also contain elements that encourage green and sustainable practices. The Energy Independence and Security Act (EISA) of 2007 (EISA 2007), Section 438, includes storm water runoff requirements for development or redevelopment projects involving Federal facilities with footprints exceeding 5000 square feet. In addition, the Federal Acquisition Regulation (FAR), 48 Code of Federal Regulations (CFR) "Environment, Energy and Water Efficiency, Renewable Energy, Occupational Safety, and Drug-Free Workplace," includes the Government's policy to "acquire supplies and services that promote energy and water efficiency, advance the use of renewable energy products, and help foster markets for emerging technologies" [23.202 Policy] (FAR 2009).

The US Environmental Protection Agency (EPA) has provided several information documents on incorporation of green and sustainable practices into environmental remediation. These include the Green Remediation Technology Primer (EPA 2008d), which provides topical information on how to incorporate green and sustainable environmental practices into remediation of contaminated sites, and "Principles for Greener Cleanups," (EPA 2009b), which updates the elements from the Primer to be considered within an environmental remediation project to potentially make the cleanup more green and sustainable. In addition, EPA has issued a ruling that determined six greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) "endanger the public health and welfare of current and future generations" (EPA 2009a). However, no regulatory emission requirements on the greenhouse gases have been established.

Several EPA regions have also issued policies, including:

- Region 2 (http://www.epa.gov/region02/superfund/green_remediation/);
- Region 9 (http://www.clu-in.org/greenremediation/); and
- Region 10 (http://yosemite.epa.gov/R10/extaff.nsf/programs/greencleanups).

These policies are Region-specific but generally include recommendations for use of renewable energy sources, greener materials, cleaner (lower emission) fuels, water conservation, reduced greenhouse gas emissions, and waste and material recycling and reuse.

Despite the existing authorities and policies discussed above, the incorporation of green and sustainable practices into environmental remediation is presently limited by the following:

- No DoD/Department of Army indicator or measure of success;
- The current lack of regulatory requirements mandating incorporation of green and sustainable practices at federal facility sites;
- Concerns within the regulatory community that the CERCLA statutory criteria will be overshadowed by incorporation of green and sustainable practices;
- The difficulty in quantifying the impact of some green and sustainable practices, such as preservation of green space and other ecologically friendly practices, which have aesthetic benefits but do not necessarily lead to site-related risk reduction or result in cost savings; and
- Lack of a current framework to consistently consider site-related impacts that extend beyond the boundaries of the site, affecting, for example, air quality or regional water supplies, which can lead to underestimating the benefits of green and sustainable practices.

Because of these limitations and the fact that green and sustainable remediation has only recently emerged, there is no "industry-standard" structure for incorporating green and sustainable practices into environmental remediation. Section 2 describes the structure used in this decision framework.

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2. Structure to Incorporate Green and Sustainable Practices into Environmental Remediation

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The impetus behind this decision framework is the need to provide a process whereby USACE project teams can consider, implement, and document incorporation of green and sustainable practices into environmental remediation consistent with the existing FUDS regulatory framework, DoD policy, and the Army Environmental Cleanup Strategic Plan. Given the preference of the USACE to use the CERCLA framework for the FUDS program, this decision framework uses the sequential CERCLA site cleanup process as the basic structure with which to frame incorporation of green and sustainable practices.

Certain methodologies are conducive to the incorporation of green and sustainable practices. Use of these methodologies in the different activities associated with CERCLA remediation can achieve significant green and sustainable benefits. Table 1 summarizes the methodologies that are recommended for use in each activity, along with specific applications and examples of incorporation of green and sustainable practices within each methodology. Table 1 also includes locations in Appendix A where instruction in using the methodologies is included.

Table 1. Methodologies for Incorporating Green and Sustainable Practices into Activities in the CERCLA Cleanup Life Cycle

Activity	Methodology	Specific Applications of Methodologies	Potential Green and Sustainable Practices Incorporation	Additional Information Location in Appendix A
Planning (all phases)	Systematic planning (included in all phases)	USACE Technical Project Planning (USACE, 1998) Data Quality Objectives (DQOs) (EPA, 2006a)	Early involvement of stakeholders and concerns, efficient, long-range (to site close-out) project planning	Steps 1-3
Investigative	Dynamic work strategies, real-time measurement, field-based investigation	Performance-Based Management (AFCEE, 2004) TRIAD (ITRC 2003)	Less waste generation, efficient use of resources	Step 5
Remedy development and evaluation	Standard, systematic development and comparison of remedial options on the basis of multiple decision-making criteria	CERCLA Feasibility Study (EPA, 1988)	Balanced decision-making over range of different criteria; same structure serves as a template for considering green and sustainable practices	Steps 7-8
Remedy selection	Stakeholder involvement	Record of Decision (EPA, 1999)	Inclusion of public and support agency concerns	Step 9
Remedy implementation	Independent design review and construction best management practices	Independent Design Review Checklists and Value Engineering Studies (EPA, 2008b) State of Illinois: Green Remediation Best Management Practices (State of Illinois EPA, 2008)	Waste minimization and efficient use of resources; recycling/reuse of equipment/materials	Steps 10-11

Activity	Methodology	Specific Applications of Methodologies	Potential Green and Sustainable Practices Incorporation	Additional Information Location in Appendix A
Operations and maintenance	Optimization of remedial system operations and maintenance	Remediation System Evaluation (USACE, 2009) Long Term Monitoring Optimization (EPA and USACE, 2005b)	Reduced resources through shorter remediation times and through optimization of O&M activities and/or monitoring networks	Steps 13-17
Closeout	Maximization of site reuse, materials, and resources	Principles in waste minimization policy (US Army, 2006a) Low Impact Development Storm Water Practices (EPA 2007a) Planning and Promoting Ecological Land Reuse of Remediated Sites (ITRC, 2006) Carbon Sequestration in Agriculture and Forestry (EPA, http://www.epa.gov/sequestration/practices.html)	Recycling/reuse of equipment/materials, beneficial public or ecological site reuse, carbon sequestration	Step 18

In addition to general methodologies, it is necessary to establish a secondary structure through which green and sustainable principles and practices specific to environmental remediation can be identified, considered, implemented, and documented. The first step in developing this structure is selection of green and sustainable remediation elements. Consistent with EO 13423 (EO 2007), EPA proposed in the Green Remediation Primer (EPA 2008d) that the core elements of green and sustainable remediation be 1) air, 2) water, 3) land and ecosystems, 4) materials and waste, 5) energy, and 6) stewardship. These elements have been further refined in the EPA Greener Cleanup Principles (EPA 2009b) to 1) total energy use (and renewable energy use), 2) air pollutants and greenhouse gas emissions, 3) water use and impact to water resources, 4) materials management and waste reduction, and 5) land management and ecosystem protection. In addition to the elements identified by EPA, the Navy (Navy 2009) and the Air Force (AFCEE 2009) have also identified worker safety as a green and sustainable remediation element. The USACE and Army have not established recommendations for elements. However, the goals in the Army Environmental Cleanup Strategic Plan (Army 2009) can be encompassed by the elements defined by the Navy (Navy 2009), so it is recommended that project teams adopt the Navy recommendations as initial elements on USACE environmental remediation projects. It is expected that the final choice of elements will be project-specific and made by the project team.

Once the elements are identified, it is necessary to define metrics that allow quantitative and/or qualitative representation of the elements. The Navy used the core EPA elements from the Green Remediation Primer to develop the following metrics: 1) energy consumption, 2) green house gas and criteria pollutant emissions, 3) water impacts, 4) ecological impacts, 5) resource consumption, and 6) community impacts (Navy 2009). The Navy has also included worker accident and fatality risk as a metric for the additional element of worker safety (Navy 2009). As with elements, the USACE and Army do not currently have core metric recommendations; however, the goals in the Army Environmental Cleanup Strategic Plan (Army 2009) can be encompassed by the metrics defined by the Navy. Therefore, it is recommended that the Navy recommendations for metrics also be used as initial metrics for USACE projects, with the final choice of metrics made by the project team based on project-specific needs.

Once the elements and metrics have been selected, green and sustainable practices can be identified that can reduce the overall environmental footprint. Tools to help in this process generally fall into two general categories: 1) tools that identify green and sustainable best management practices (BMPs) and 2) tools that quantify the green and sustainable aspects of different remedial options based on a defined set of metrics.

In using tools that identify BMPs, the BMP is often selected based on applicability to the project conditions, and the elements and metrics through which the BMP achieves green and sustainable benefits are then documented. For example, passive sampling devices may be chosen, with reduction of the environmental footprint attributed to the reduction in waste generated (no investigation-derived waste), and reduced energy use (no need to pump water from wells to collect samples). The tools that quantify green and sustainable aspects through use of metrics are useful when comparing different remedial options, to both determine and document the impact on environmental footprint. One advantage of these latter tools is that they can quantify the overall sustainability of the life cycle of a process. For example, for a particular project, pursuing the BMP of grey water use might require an expanded conveyance system to deliver the water. The overall environmental footprint resulting from conservation of water and pipeline construction and installation (with associated energy use and greenhouse gas emissions) could be evaluated. In some instances, simply following a BMP may not be the most green and sustainable approach.

Examples of some of the tools currently being used are provided in Table 2 below (from SURF 2009) and the EPA Green Remediation Toolbox: Decision Tools (http://www.clu-in.org/greenremediation/subtab_b3.cfm). An example of a tool that identifies green and sustainable BMPs is the State of Illinois Greener Cleanup Matrix (State of Illinois 2007). An example of a tool that quantifies green and sustainable aspects through metrics is the Air Force Sustainable Remediation Tool (SRT) (AFCEE 2009).

It is expected that the decision as to tool use again will be made by the individual project teams based on the specific project requirements and the resources available. However, the USACE is evaluating two tools, the Air Force SRT (AFCEE 2009) and the Battelle SiteWise™ SER tool (Battelle 2009), which are or will be available to the public. An initial version of the Air Force SRT with four remedial technologies (excavation, soil vapor extraction, pump and treat, and in-situ bioremediation) is currently publicly available (http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/srt/index.asp), with an expanded technology suite (reactive walls, in-situ thermal, in-situ chemical oxidation, and long-term monitoring/monitored natural attenuation) expected in early 2010. The SiteWise™ SER tool, which is based on configuring remedial options through a series of activity modules, has been applied to several USACE/Army and Navy sites. The USACE and Navy have contracted with Battelle for further development and purchase of their SiteWise™ SER tool, with expected public availability of the tool in spring 2010. Application of these tools is described in more detail in Appendix A, with examples of application of the SiteWise™ tool to remedy selection and remedy optimization in Steps 8 and 15, respectively, in Appendix A. Detailed instructions on use of these tools is not included in this decision framework; rather, training is being planned on use of the tools and the process by which the tools can be used in an overall green and sustainable remediation evaluation, when the tools are complete and publicly available. Details on training will be communicated separately from this decision framework (see also Section 4).

One additional tool within the systematic planning methodology is sample language specifically for incorporating green and sustainable practices into remediation contracts. Sample language for USACE contracts is provided in Appendix A Step 1 and Attachment A-1. The EPA "Green Response and Remedial Action Contracting and Administrative Tool Kit" also provides sample contracting language. http://www.clu-in.org/greenremediation/docs/Green_RR_Action_Contract__Admn_Toolkit_July%202009.pdf

Section 3 provides a decision flowchart using the above general structure to incorporate green and sustainable practices into the different remediation phases.

Table 2 [from SURF (2009) Exhibit 3-2: Output of Quantitative Sustainability Tools -- Metrics]

Name	Approach	Environmental Outputs	Social Outputs	Economic Outputs
Life Cycle Assessment (general)	Quantitative	Impacts of resource consumption, energy use, transportation emmissions, fuel production	Impact of emissions on regional health and globally	
AFCEE Restoration Sustainability Tool (GSI Environmental)	Quantitative	Carbon dioxide (CO2) emissions, total energy consumed, change in resource service	Safety /accident Risk	Technology cost
Net Environmental Benefit Analysis	Quantify and compare ecosystem service impacts	Evaluates existence and aesthetic value of ecosystems, preservation of biodiversity, habitat for threatened/endangered species and human recreational use	Risk reduction	Cost and natural resource service benefits and losses
URS/Dupont Spreadsheet	Quantitative	Assessment of greenhouse gas production, energy usage, resource usage, and utilization of consumable products to determine carbon footprint/tons of CO_2 equivalents	90 social outputs	
GolderSET-SR-CN Sustainability Tool	Hybrid: Semi-quantitative and Qualitative	Assessment of soil, sediment, groundwater, and surface water quality; product removal; water consumption, wildlife and flora conservation; off-site migration prevention, greenhouse gas emissions, energy conservation; solid residual matter management; site contaminant management; and hazardous waste management.	Assessment of impact of local resident safety and quality of life; worker safety; limited duration of work; benefits for contractor staff; beneficial use for local community; employee skill development; local job creation and diversity; competitive advantage through innovation; response to social sensitivity; and standards, laws, and regulations.	Assessment of initial capital cost moderation; low annual O&M cost; prevention of potential litigation; potential grants or subsidies; environmental liabilities reduction; train service reliability and performance; donations to the community; economic advantages fro the local community; reliability (moderate maintenance and repair); economic advantage of more effective techology; and technological uncertainty management.
Minnesota ToolKit	Qualitative	Assessment of reasonableness of remediation/restoration options through decision tree evaluation and case studies	Assessment of community acceptability	Technology cost
The REC Decision Support System for Comparing Soil Remediation Alternatives (Dutch Research Programme for In-Situ Bioremediation)	Comparison of soil remediation technologies	Environmental merit	Risk reduction	Cost
Shell Cost-Benefit Analysis (United Kingdom)	Quantitative	Impacts of groundwater remediation (monetization of impacts)	Monetization of risk/benefits	Technology cost
Swedish Hållbar Sanering cost-benefit anlaysis/life-cycle analysis model	Quantitative	Primary, secondary, and tertiary effects of contamination/remediation as in resource use, climate change, acidification, eutrophication, ozone formation, human toxicity, and ecotoxicity	Risk/socio-economic cost of secondary emissions (NOx, SO2, VOC, particles and CO2)	Cost of clean-up
British Electric National Grid (developing a tool kit that will be available to public)	Hybrid	Carbon dioxide emissions, waste reuse, levels of noise, dust, vibration, and odor	Deaths/injuries	Cost
Danish National Railway Agency's Model to Calculate Environmental Costs and Benefits	Quantitative evaluation of cost/benefit	Consumption of crude oil, hard coal, natural gas, brown coal, aluminum, iron, copper, manganese, nickel, sand/gravel, and water; Potential effects of global warming, ozone depletion, acidification, photochemical ozone formation, nutrient enrichment, persistent toxicity, human toxicity, ecotoxicity, bulk waste, hazardous waste, nuclear waste, slag and ashes Potential environmental benefits: reduction in persistent toxicity, reduction in ecotoxicity	Reduction in human toxicity from air and groundwater	
California DTSC Green Remediation Matrix	Qualitative matrix	17 items within categories of sustance and thermal releases, resource depletion, and physical disturbances		
Ontario Life Cycle Framework	Qualititative matrix and LCA	Matrix includes 22 items within pollution, disturbance and depletion categories. Life cycle analysis (LCA) includes GWP, solid waste burden, contaminant fate and toxicity, land use, and residual toxicity		
Cadotte LCA study	LCA	Groundwater protection, ozone depletion, acidification, eutrophication, photochemical smog, ecotoxicity,	Human health	
Volkwein LCA study	LCA	16 impact categories		
Godin LCA study	LCA	12 impact categories		
Toffoletto LCA study	LCA	12 impact categories		
Lesage LCA model	LCA	Four combined categories of human health, ecosystem quality, climate change and resources.	Human health	
Illinois EPA/AECOM	Qualitative	Identification of benefits of remediation projects in terms of air, water, land and energy; assessment of clean-up options forminimizing pollution	Identifies potential regulatory, administrative, and operational barriers to remediation	Assessment of maximum efficiency of clean up options
Sustainable Development Principles Worksheet (Chevron Superfund Site)	Quantitative	Waste minimization, recycling		Assessment of use of land and quality of business environment to enhance economic opportunities

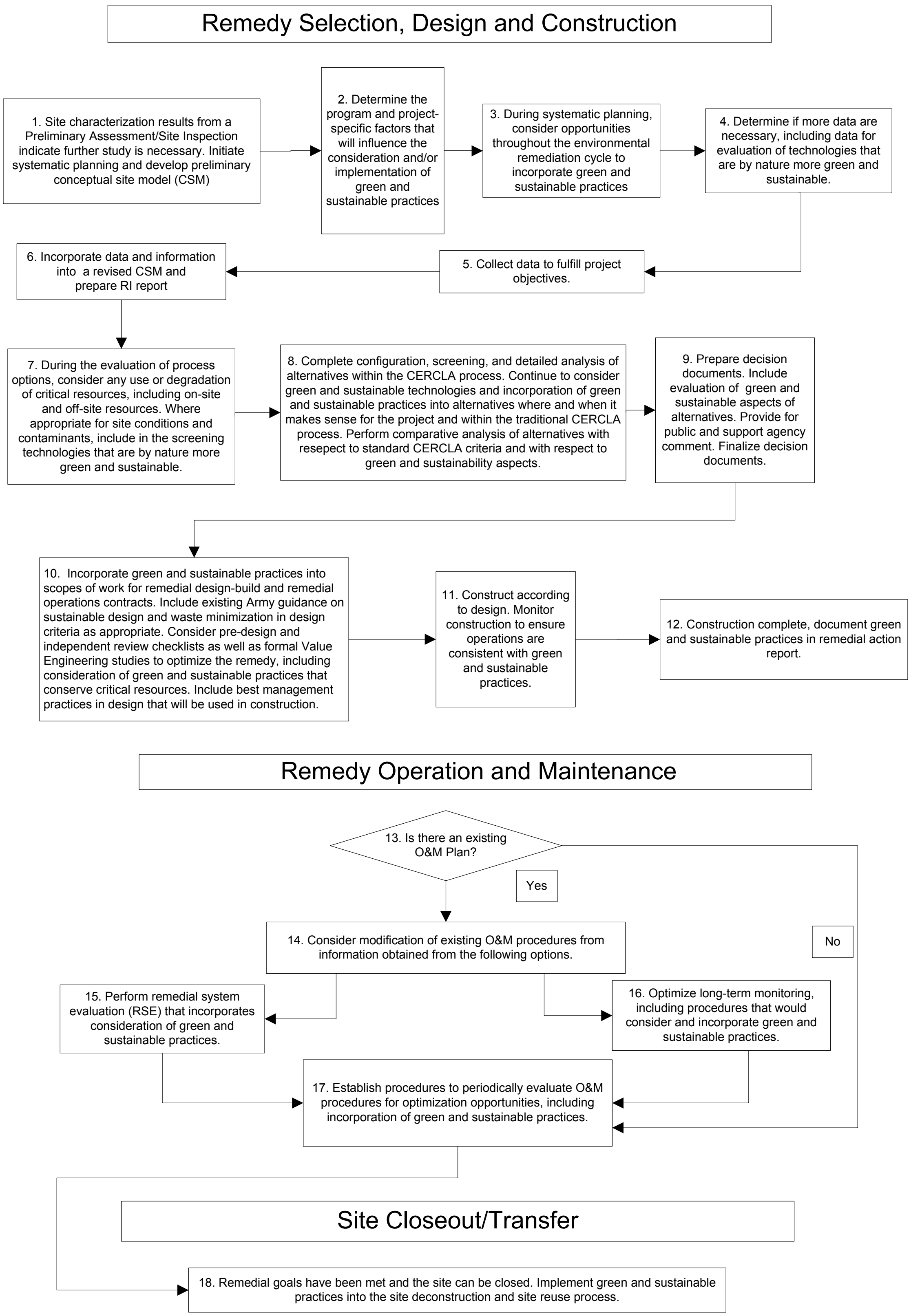
3. Decision Framework to Incorporate Green and Sustainable Practices into the Environmental Project Lifecycle

Decision Flow Chart

The following decision flow chart (Figure 1) maps out the process for considering the incorporation of green and sustainable practices in the overall project lifecycle based on the CERCLA process, from planning through site closeout. Although the lifecycle is specific to the CERCLA process, it is expected that the procedures provided can be applied to other cleanup programs, such as RCRA, underground storage tanks, state-led sites, BD/DR and Brownfields sites.

A summary of the process is included here; Appendix A provides a step-by-step walk-through of the steps in Figure 1, with details of implementation, examples, and references.

Figure 1 Decision Flow Chart for Incorporating Green and Sustainable Principles into the Life Cycle of USACE Environmental Remediation Projects



The decision process begins when initial site characterization indicates additional investigation is necessary (Step 1). A systematic planning process is recommended to form the project team, consisting of technical staff, customer, regulators, and stakeholders. A preliminary conceptual site model (CSM) is developed, which seeks to identify any constraints on implementation of green and sustainable practices. These constraints could be imposed by site conditions (presence of a sole source aquifer, for example) or community input. Step 2 examines program- and project-specific factors that may influence how and to the degree to which green and sustainable practices are incorporated. Such factors include contractual mechanisms, project scope, schedule and funding, and availability of experienced personnel to perform or oversee incorporation of green and sustainable practices. Included in Appendix A are examples of template contract language that can be used to incorporate green and sustainable practices into different types of environmental remediation contracts. Step 3 identifies the information that needs to be collected in order to implement green and sustainable practices across the complete remediation process, and Step 4 identifies the process through which data can be collected for evaluation of remedial technologies that are inherently green and sustainable. Generally, these technologies are ones that mimic a natural process, such as phytoremediation. Ideally, the life cycle of the project will be considered when information and data gaps and needs are identified.

The investigation process is covered in Steps 5 and 6. Implementation of Step 5 involves consideration of investigation and data collection techniques that are green and sustainable. One approach that lends itself to greater efficiencies during investigation is the use of dynamic work strategies and real-time measurement technologies, including field-generated data. Many green and sustainable BMPs are also listed in Step 5 that can be adopted in an *a la carte* manner. Updating of the CSM and preparation of the investigation report (Step 6) should clearly lay out conditions that favor implementation of green and sustainable practices and should identify site-specific cleanup levels.

Steps 7-9 examine ways of considering green and sustainable practices through the remedy formulation, evaluation, and selection process. Step 7 takes into consideration any on- or off-site critical resources, such as a regional aquifer or energy supply, in development of the process options and identifies technologies that are inherently more green and sustainable. Step 8 addresses how to incorporate consideration of green and sustainable practices in the existing regulatory framework for configuration, screening, evaluation and comparison of remedial alternatives, both through incorporation of BMPs and through use of stand-alone sustainability evaluation tools. These tools are summarized in Section 2, with more information in Appendix A. The remedy evaluation process culminates in selection of the preferred remedy in a decision document (Step 9), which provides an opportunity for regulatory and community preference for green and sustainable practices to be offered and considered.

Remedial design (Step 10) and construction (Step 11) present many opportunities to encourage a more green and sustainable remedy, whether through independent design review, BMPs, or adoption of LEED-like building standards as guidelines. Benefits of incorporation of green and sustainable practices are documented in the remedial action report (Step 12).

Steps 13 through 17 address ways of including green and sustainable practices during the operation and maintenance (O&M) phase of a project, through optimization studies or remedial system evaluations. The tools that can be used are summarized in Section 2, with more detail in Appendix A. These tools include ones that quantify different environmental metrics for optimization options, such as greenhouse gas emissions and energy use, and qualitative ones that identify BMPs. Regardless of the structure and tools through which the operations are evaluated for more green and sustainable practices, it is recommended that a schedule for such evaluations be developed and followed. This process is consistent with guidance for identifying opportunities for optimization during periodic reviews of operating remedies.

The final step in the life cycle of a project is achieved when remedial goals have been met and the site can be closed (Step 18). This step emphasizes practices that involve responsible deconstruction and minimization of waste, low impact development approaches, reuse of equipment, beneficial site reuse, and conservation of resources during site restoration.

4. Path Forward

This decision framework captures a snapshot in time of the current practice of incorporating green and sustainable practices into environmental remediation. Considerable incorporation has already occurred (see case study summary from SURF (2009) in Appendix C); it is expected that the number of examples of incorporation of green and sustainable practices into environmental remediation, as well as the tools used for selection of the best green and sustainable practices for any specific project, will continue to grow rapidly. As a follow-up to this framework, the USACE is planning to distribute reports on assessment of the use of the Battelle SiteWise™ and AFCEE SRT tools from the tools' application on numerous sites. A training session on both the AFCEE SRT and the Battelle SiteWise™ tools is currently planned for the May 2010 Battelle Remediation of Chlorinated Solvents and Recalcitrant Compound Conference in Monterey, CA. The USACE is also planning training on this decision framework and the Battelle SiteWise™ tool. This training will be offered to USACE districts once the tool development is complete.

We invite you to be part of this process. We welcome your feedback on the decision framework, any examples of incorporation of green and sustainable practices on your sites, your interest in training on the decision framework and/or tools, and your participation in the training that is planned for the future. Please contact Carol Lee Dona of the US Army Corps of Engineers Environmental and Munitions Center of Expertise (EMCX) at carol.l.dona@usace.army.mil with comments, examples, interest, and questions. We will use this information to make any revisions in future versions of this decision framework.

5. References

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Appendix A

Step-by-Step Walk-Through of Green and Sustainable Practices Flow Chart

For each remedial phase, this section supplies details as to how to perform each step in the flow chart, as well as supplying references. It is noted that the decision to incorporate green and sustainable practices, and the degree to which these practices are incorporated, may vary depending on the phase, funding, scheduling, and resources.

Step 1: Site characterization results from a Preliminary Assessment/Site Inspection indicate further study is necessary. Initiate systematic planning and develop preliminary CSM.

Technical Project Planning (TPP) (USACE, 1998) is the systematic planning process that USACE has developed for identifying project objectives and designing data collection programs at hazardous, toxic, and radioactive waste (HTRW) sites. TPP has also been adopted by the Military Munitions Response Program. TPP is one within a larger group of systematic planning processes that have been designed for environmental remediation project planning. These include the EPA Data Quality Objectives (DQO) process (EPA, 2006), the systematic project planning process within the EPA Triad program (ITRC 2006), and the Air Force Performance Based Management process (AFCEE, 2004). Although this document generally presents discussion in terms of TPP, the same principles apply to the other systematic planning processes.

TPP helps ensure that the requisite type, quality, and quantity of data are obtained to satisfy project objectives that lead to informed decisions and site closeout. TPP can be used from investigation through closeout at simple sites as well as complex sites. It is recommended that this process be the basis for planning the incorporation of green and sustainable practices into USACE environmental remediation projects.

Within this process, it is important to initially select a project team that includes the relevant technical disciplines, as well as the customer, regulators, and stakeholders. After identifying the team, a preliminary CSM (USACE, 2003; EPA, 2009e) should be developed using the information available to summarize the current understanding of geological and hydrologic conditions, suspected contaminant sources, potential migration pathways, and receptors. This preliminary CSM, in addition to identifying any traditional data gaps, should also identify potential constraints on resources that would be important to subsequent consideration of green and sustainable practices. These can include constraints from aspects other than environmental; for example, constraints imposed by the mission and community aspects of the Army triple bottom line. In keeping with DoD policy (DoD 2009), these constraints contribute to the evaluation of incorporating green and sustainable practices "when and where they make sense."

Because TPP encompasses the entire life cycle of a project, the process affords multiple opportunities to consider incorporation of green and sustainable practices from project initiation through site reuse. Inclusion of all stakeholders throughout project planning and execution allows for more efficient project execution and closeout.

Proceed to Step 2.

Step 2: Determine the program- and project-specific factors that will influence the consideration and/or implementation of green and sustainable practices.

Program- and project-specific factors may influence how and the degree to which green and sustainable practices are incorporated. The project should consider contractual impacts to projects incorporating green and sustainable practices as specified in FAR Part 23, paragraph 23.202, Environment, Energy and Water Efficiency, Energy Technologies, Occupational Safety, and Drug-Free Workplace, where it is the Government's policy "to acquire supplies and services that promote energy and water efficiency, advance the use of renewable energy products, and help foster markets for emerging technologies."

The customer and project team should also consider the following:

1) Contractual mechanism;
2) Scope;
3) Schedule and funding; and
4) Availability/knowledge of personnel to perform/oversee the sustainability evaluation and implement sustainability recommendations.

Each of these considerations is discussed below. It is generally assumed in the discussion that a contractor will perform the work. If the work is to be performed by an in-house team, in-house scopes of work and work plans can also be developed based on the information included below.

Contractual Mechanism

Generally, the types of contracts used for USACE contracts are fixed price and cost reimbursement (with or without incentives), with performance-based service contracts used to the maximum extent possible (FAR Parts 16 and 37, FAR 2009). Table A-1 summarizes the potential for incorporation of green and sustainable practices into each of these types of contracts, both existing and future. Depending upon the specific language of existing contracts, green and sustainable practice evaluation and implementation language may be incorporated into specific Indefinite Delivery Indefinite Quantity (ID/IQ) task orders at the development stage. Proposed template language is included in Attachment A-1. An additional resource for sample language is the EPA "Green Response and Remedial Action Contracting and Administrative Tool Kit").http://www.clu-in.org/greenremediation/docs/Green_RR_Action_Contract__Admn_Toolkit_July%202009.pdf

Table A-1. Potential Green and Sustainable Practices Incorporation into USACE Contracts

Contract type	Existing	Future
Fixed Price	Existing Contracts and existing task orders against ID/IQ contracts – Generally, no	New Contracts – Yes New task orders against existing ID/IQ Contracts – Yes, provided base contract language supports such changes
Cost Reimbursement	Generally, yes provided the base contract language supports such changes	New Contracts – Yes New task orders against existing ID/IQ Contracts – Yes, provided base contract language supports such changes

For existing fixed price contracts and task orders, incorporation of green and sustainable practices may be limited to suggestions that the contractor would voluntarily perform to reduce costs and maximize profit. One example of green and sustainable practice incorporation possible in an existing fixed price contract or task order would be energy conservation; another example would be cost-effective waste minimization.

For future fixed price contracts and task orders, the following is one process that can be used in green and sustainable practice incorporation:

1) Include minimum standards of practice for incorporating green and sustainable practices. For example, "The contractor will use native vegetation when replanting vegetation in order to reduce watering/irrigation needs." Or "The contractor will use biodiesel or blended fuels, for example, 20% biodiesel and 80% petrodiesel for all contractor-owned diesel equipment used at the project site."
2) Request the offeror provide its proposed, optional green and sustainable practices approach based upon guidance provided by the government. The various approaches provided by each offeror are evaluated as part of the "best value" tradeoff process.
3) Upon selection of the "best value" to the government, using price and technical factors, the offeror's green and sustainable practices approach is incorporated into the resulting contract award.

For future performance-based service contracts using incentives, the following is one process that can be used for establishment of performance goals and measurements standards for incorporation of green and sustainable practices:

1) Include a performance incentive in the contract for incorporation of green and sustainable practices – this can be a certain percentage of the overall contract.

2) In the Performance Work Statement, provide guidance on green and sustainable practices that could be applied to the project and the weighting of each resource savings within the overall incentive. In response, the offeror would explain how the resource savings would be achieved using green and sustainable practices.
3) Technical merit of the proposed green and sustainable practices, along with other technical consideration and price, would be considered in the "best value" tradeoff selection decision.
4) After award at appropriate milestone intervals, the achievement of the performance metrics incorporated into the contract would be measured.

An example of this process is illustrated in Example A-1.

Example A-1: Incorporating green and sustainable practices into incentive awards
Note: the percentages in Steps 1 and 3 and the weighting factors in Step 2 are for illustrative purposes only. It is expected that the contractor (or the government) will establish percentages and weighting factors as appropriate to the specific project.

1. Identification of resources and goals for incorporation of green and sustainable practices (g_i)
    Water – 30% use of non-potable water
    Energy – 30% renewable energy
    Waste minimization – 65% diversion

2. Weighting Factors (w_i) for Goal ($\Sigma w_i = 1$)
    Water – 0.25
    Energy – 0.5
    Waste minimization – 0.25

3. Contractor's Actual Performance (c_i)
    Water – 20% non-potable water use
    Energy – 25% total energy renewable
    Waste minimization – 50% waste diversion

4. Calculation of the Percent of the Incentive Award
    $100 \text{ x } \Sigma w_i (c_i/g_i)$ = Percent of Incentive Award
    $100 \text{ x } [0.25 \times (20/30) + 0.5 \times (25/30) + 0.25 \times (50/65)]$ = 78% of award

5. Contract Price
    $1,000,000.00

6. Incentive Award (2% of contract price)
    ($1,000,000.00 x 2%) x 78% = $15,600.00

For future cost reimbursement contracts and task orders, the following is one process that can be used in sustainability incorporation:

1) Include minimum standards of practice for incorporating green and sustainable practices. For example, "The contractor will use native vegetation when replanting vegetation in order to reduce watering/irrigation needs." Or "The contractor will use

biodiesel or blended fuels, for example, 20% biodiesel and 80% petrodiesel, for all contractor-operated diesel equipment used at the project site."

2) Request the offeror provide its proposed, optional green and sustainable practices approach based upon guidance provided by the government along with the net cost or net savings to the project. For example, the offeror would provide the net cost or net savings of implementing a wind energy system to reduce overall energy consumption.
3) The various approaches provided by each offeror are evaluated as part of the "best value" tradeoff process. Upon selection of the "best value" to the government, using price and technical factors, the offeror's green and sustainable practices approach is incorporated into the resulting contract award.

Using the methods described above, incorporation of green and sustainable practices into new fixed-price and cost reimbursement contracts should be relatively unlimited by the contractual mechanism. Also, as indicated in Table A-1, most existing cost reimbursable contracts can be modified directly for consideration/implementation of green and sustainable practices provided it is within the scope of the contract. However, incorporation of green and sustainable practices into existing performance-based service, fixed price contracts may be limited to cost-effective incorporation of practices that are voluntarily accepted by the contractors.

Scope

For projects with a relatively simple scope of work with little environmental impact, a comprehensive evaluation of green and sustainable practices may not be resource-effective in terms of cost or manpower. However, rules of thumb (ROT) or green and sustainable best management practices (BMPs)—such as energy conservation, use of native plants that require less water, and diversion of waste–may still be possible and should be considered. The reader is referred to subsequent specific sections on each remedial phase for reference to BMPs and ROT that are easily incorporated.

Schedule and Funding

Schedule and funding constraints influence the incorporation of green and sustainable practices throughout the life cycle of a project. They are considered together because of 1) the general need in the USACE for funds to be requested before receipt and 2) designation of the funds for specific purposes when requested and received.

The optimum time for consideration of incorporation of green and sustainable practices is at the beginning of each project phase or prior to initiation of a new contract action. However, for existing work within a phase or for a phase that is already funded without sustainability identification or incorporation, green and sustainable practices may still be incorporated through conservation of resources, such as energy or waste minimization, that result in cost savings. Also, projects that are planned through multiple phases where future funding is uncertain can include implementation of green and sustainable practices as an option dependent on available funding.

Availability and Knowledge of Project Team

Availability of an experienced and knowledgeable staff, which is able to evaluate and incorporate green and sustainable practices, is an important consideration because of the potential complexity of balancing resource conservation/protection with other decision-making variables. The time commitment and knowledge necessary for USACE personnel on a project team to incorporate green and sustainable practices will partially depend on whether the project is completed in-house or through a contractor. If performed by a contractor, staff knowledge would need to be sufficient to identify feasible performance criteria and evaluate and oversee the execution of the procedures implemented by the contractor. If performed by an in-house team, staff would not only need to be able to identify feasible practices, but also implement them, which could require considerable expertise, depending on the complexity of the project. However, use of the methodologies and tools in Table 1, such as TPP, TRIAD, and the design/RSE checklists, can result in significant incorporation of green and sustainable practices. As these existing processes and methods are standard or commonly used practices by USACE, it is expected that the project team and/or the contractor will have, or be able to obtain, sufficient knowledge to execute them. Use of pre-existing green and sustainable BMPs and ROT, listed or referenced in subsequent sections in this decision framework, simplifies incorporation of green and sustainable practices without requiring extensive knowledge on the part of the project team.

From the discussion above, incorporation of green and sustainable practices into environmental remediation projects will generally not be prevented by contract mechanism, funds and schedule, scope or project team availability/knowledge, although the degree to which they can reasonably be incorporated will vary.

Proceed to Step 3.

Step 3: During systematic planning, consider opportunities throughout the environmental remediation cycle to incorporate green and sustainable practices.

The following are recommended for consideration when identifying information and data needs and data gaps for the project during the TPP process:

- Information necessary to evaluate recycling options for waste and debris (NIBS, 2009; EPA, 2008c, US Army 2006a);
- Opportunities for use of existing equipment/buildings and use/reuse of equipment/buildings during remediation and after site closure;
- Feasibility of the use of renewable energy at the project site (DOE/NREL 2008d and 2008b, AWEA 2009);

- Constraints on resources (for example, presence of a sole source aquifer; a remote location off of the power grid that limits availability of electricity); and
- Future use and ownership/transfer of the site and any related institutional controls.

The reader is referred to the later sections in this decision framework on each remedial phase for references and more detail.

In addition to the above information, the following planning questions can be addressed as part of the TPP process to further encourage use of green and sustainable practices:

- Should a life-cycle analysis of the cleanup plan be performed (USDC, 2003)?
- Should the remedy design be optimized, both with respect to traditional aspects such as cost, but also resource consumption (energy, water, etc), waste minimization, and air emissions (see Step 10 for more detail)?
- Will the system performance (operation and maintenance and any monitoring) be optimized, both with respect to traditional aspects such as operating costs but also energy and water use, waste minimization, and air emissions (see Steps 15 and 16 for more detail)?
- Are periodic reviews of the remedy planned that include opportunities to update or optimize the remedy, considering resource consumption (energy, water, etc.), waste minimization, and air emissions (see Step 17 for more detail)?

Proceed to Step 4.

Step 4: Determine if more data are necessary, including data for evaluation of technologies that are by nature more green and sustainable.

During TPP or other systematic planning activities, the types and quality of data necessary to move the site towards close-out are determined and documented. Data needs required for evaluation and possible implementation of remedial technologies that are green and sustainable should be identified and considered during TPP as appropriate for site conditions and contaminants. These technologies are generally those that mimic a natural process, for example phytoremediation.

The following technologies have particular potential as green and sustainable practices (EPA, 2008d):

- Enhanced bioremediation;
- Biowalls or permeable reactive barriers;
- Soil amendments, including landfarming and composting;
- Monitored natural attenuation;
- Phytoremediation;
- Constructed wetlands; and

- Evapotranspiration covers.

The latter three technologies also provide for carbon dioxide sequestration (uptake of atmospheric carbon dioxide by plants), as well as contaminant treatment or containment (EPA, 2008d). The first three technologies provide for increase in soil quality as well as contaminant treatment or containment (EPA, 2008d).

If data are sufficient, then proceed to Step 6; otherwise proceed to Step 5.

Step 5: Collect data to fulfill project objectives.

During field investigations, it is recommended that sample or data collection methods that are green and sustainable be considered. The methodologies of dynamic work strategies and use of real-time measurement technologies, including field-generated data, are green and sustainable methodologies because of the general conservation of resources, i.e. energy savings because of reduction of fuel from on-site analysis, and minimization of waste, i.e. reduction of investigation-derived waste from field-generated data. The Air Force Performance-Based Management approach (AFCEE 2009) and the EPA TRIAD [(ITRC 2003) and the Triad Resource Center at http://www.triadcentral.org/] utilize these methodologies.

In addition to consideration of dynamic work strategies and real-time measurement technologies, the following BMPs, as suggested by EPA (EPA 2008d), can also be considered during planning of site investigations:

- Investigation derived waste (IDW) plan with the best approach for minimizing waste generation, handling, and disposal costs;
- Use of steam and non-phosphate detergent instead of toxic cleaning fluids, where appropriate for site contaminants;
- Use of direct push drilling rigs rather than conventional rotary rigs for collection of subsurface soil and ground water samples where technical and sample requirements are met, resulting in IDW, energy, and drilling minimization;
- Consideration of larger push rods to enable a direct push rig to be used also for installation of monitoring wells with pre-packed screen sizes, with potential energy savings, minimization of waste, and reduction of the extent of site disturbance;
- Use of biodiesel fuel rather than fossil fuel diesel;
- Minimization of engine idling to maximize fuel conservation;
- Use of geophysical techniques such as ground penetrating radar as appropriate for identification of stratigraphic units;
- Passive sampling techniques for monitoring quality of ground or surface water over time to reduce the disposal of water that requires management as hazardous waste;
- Remote data collection where possible to reduce onsite field work and associated labor cost, fuel consumption, and vehicular emissions; and

- Renewable energy powered systems to operate meteorological stations, air emission sensors, and/or mobile laboratory equipment.

Table A-2 from the Sustainability Remediation Forum (SURF) (SURF 2009) also gives examples of green and sustainable practices that can be incorporated into the site investigative phase.

It is noted that stand-alone sustainability evaluation tools can be used to compare the green and sustainable aspects of the life cycle of any sampling process; however, generally the site investigation process is relatively simple and short in duration so use of BMPs is most common.

Once data are collected, proceed to Step 6.

Table A-2 Examples of Sustainable Practices for Site Assessment that Incorporate Innovative Technologies [Note: from Sustainable Remediation Forum (SURF 2009)]

Technology	Sustainable Practices	Applications	Advantages	Limitations	Technical References
Direct Push tools for installation of monitoring wells	Installation of monitoring wells using Direct Push (direct-push) tool (e.g., GeoProbe©).	For use in unconsolidated materials to average depths up to 100 ft. Direct-push wells can be installed with a single screened interval or specialized multi-level monitoring systems.	1) Requires less materials, energy, and time for installation than conventional monitoring wells. Therefore, direct-push rigs minimize investigative-derived waste (IDW), and energy consumption. 2) Minimizes rig mobilization/demobilization energy requirements and air emissions, as direct-push rigs are generally smaller than conventional hollow-stem auger rigs.	1) Many U.S.state regulations do not permit direct-push monitoring wells for long-term site monitoring because two-inch annular spaces cannot easily be achieved.	Einarson, 2006 Nielsen et al., 2006 EPA, 1993 EPA, 1997 EPA, 2005a
Direct-push tools for groundwater and soil sampling	Use of direct-push tools to collect depth-discrete soil and groundwater samples as a substitute for installation of conventional monitoring wells when only one sampling event is needed (e.g., piston and dual tube samplers for soil sampling, and protected screen samplers and vertical profilers for groundwater sampling).	For use in unconsolidated materials to depths of up to 50 ft to 100 ft, depending on site lithology.	1) Requires less materials, energy and time for collection than conventional monitoring well installation and sample collection. Therefore, direct-push rigs minimize IDW and energy consumption. 2) Minimizes rig mobilization/demobilization energy requirements and air emissions, as direct-push rigs are generally smaller than conventional hollow-stem auger rigs.	1) One-time collection of samples. 2) Not well suited for coarse-grained soil types	Pitkin et al., 1994 EPA, 1997 EPA, 2004 EPA, 2005a
Nonpumping groundwater-sampling devices	Use of passive-diffusion or grab-type samplers for collection of groundwater.	Deployed in existing monitoring wells.	1) Minimizes IDW and energy consumption associated with purge sampling. 2) Often correlates well with data collected using conventional sampling techniques. 3) Can be used to collect samples for any laboratory analytical tests.	1) Some devices may be limited to specific contaminant type (e.g. VOCs). 2) Some devices cannot be reused. 3) Regulatory barriers exist for some devices.	ITRC, 2006b
Screening tools	Use of field screening qualitative methods for a preliminary assessment of contamination (e.g., handheld organic vapor analyzers such as flame ionization detector or photoionization detector, ultraviolet fluorescence, dye tests and the Gore-Sorber© interface probe).	Ideal for screening soil and groundwater samples to generate depth profiles of relative contaminant concentrations or detection of Non-Aqueous Phase Liquid (NAPL). Some devices are useful for air monitoring and pre-screening confirmation samples during excavation.	1) Minimizes both IDW and the number of samples analyzed by a laboratory. 2) Minimizes soil sample transportation energy requirements and air emissions. 3) Inexpensive to rent and easy to use. 4) A relative quick method for assessing the presence of contaminants.	1) Some devices cannot be reused. 2) Regulatory barriers exist for some devices. 3) Results in qualitative, not quantitative data	EPA, 1997
Geophysical methods	Tools for screening sites for metallic objects, subsurface features, or changes in soil bulk density (e.g., magnetometer surveys, frequency domain electromagnetics, time domain electromagnetics, ground penetrating radar, surface resistivity, shallow seismic reflection, refraction).	1) Alluvial and glacial environments are ideal. 2) Some technologies (e.g.. GPR) do not work well in fine-grained soils.	1) Use of non-intrusive and portable tools that can be rapidly deployed. 2) Can be partially used in lieu of conventional tools (e.g. hollow stem auger rig) that are more energy intensive, and generate IDW and air emissions.	Background magnetic field or above-ground metallic features can interfere with data interpretation.	EPA, 2000
Direct push sensor technologies	Tools for characterizing lithology, contaminant distribution and subsurface hydraulic properties (e.g., cone penetrometer test, soil-conductivity probe, membrane interface probe, laser-induced fluorescence, and hydraulic profiling tools).	For use in unconsolidated soils to depths up to 150 ft depending on conditions and advancement method.	1) Proven technologies that can be deployed rapidly and efficiently to characterize the subsurface. 2) Minimizes IDW, air emissions, and energy consumption. 3) Minimizes rig mobilization/demobilization energy requirements and air emissions, as some rigs are smaller than conventional hollow-stem auger rigs.	Some sensors can be influenced by field conditions that may bias the interpretation of the data.	Griffin and Watson, 2002 Wilson, 2005
'Beyond the Fence' Technologies for Site Assessment					
Recycled materials	Use of recycled materials	Materials for monitoring-well installation, soil and groundwater sampling, as well as screening tools.	Minimize investigative derived waste and energy consumption associated with fabrication of new materials.	May compromise sample integrity if used for soil and groundwater sampling without proper decontamination procedures and practices.	EPA, 2008d
Biofuels	Use of biofuels for transportation.	Personnel, materials and equipment can be transported by trucks and other vehicles that use biofuels.	Minimize transportation energy requirements and air emissions of trucks and other vehicles.	Limited availability of zero-emission biofuel vehicles and of biofuel fueling stations.	EPA, 2008d

Step 6: Incorporate data and information into a revised CSM and prepare RI report.

After data collection, the resulting revised CSM should give an adequate representation of the site from which the RI report and baseline risk assessment can be prepared. As noted in Step 1, the CSM should identify resource limitations that would encourage implementation of green and sustainable practices. It can also incorporate any climatic/meteorological/ geological characteristics of the site that would be useful in evaluating the potential use of renewable resources (DOE/NREL 2008a and 2008b, AWEA online).

Green and sustainable practices can be incorporated in the RI process in several ways. The first is with the determination of cleanup levels based on a site-specific risk assessment, as opposed to relying on generic contaminant cleanup levels. Site-specific cleanup levels will support a more appropriate choice and design of the remedy, which should minimize waste generation and resource consumption (Illinois EPA, 2008). In addition, by ensuring that necessary data are collected and evaluated, the incorporation of green and sustainable practices in the remedy selection process will be more straightforward. Furthermore, the presentation of the CSM in the RI report offers an opportunity to identify characteristics of the site that would facilitate consideration of green and sustainable practices. For example, the scarcity or importance of a natural resource (like a sole source aquifer) would encourage greater emphasis on practices that conserve that resource. Similarly, the potential of renewable energy (wind or solar, for example) at a site may encourage less reliance on fossil fuels (DOE/NREL 2008a and 2008b, AWEA online, EPA 2008d).

Proceed to Steps 7 through 9, which detail the Feasibility Study process.

Step 7: During the development of general response actions, consider any use or degradation of critical resources, including on-site and off-site resources. Where appropriate for site conditions and contaminants, include in the screening technologies that are by nature more green and sustainable.

In the CERCLA remedial alternative development process (EPA 1988), the first step is development of remedial action objectives (RAOs). As these are defined in the CERCLA process as "medium-specific or operable unit-specific goals" for "protecting human health and the environment," it is recommended that the RAOs continue to adhere to the CERCLA definition based on protecting human health and the environment without green and sustainable considerations. However, in the development of general response actions, it is recommended that use or degradation of any critical resources, both on-site and off-site, be identified and considered.

Once the general response actions are determined, the following treatment technologies that are by nature more green and sustainable (EPA 2008d; State of Illinois EPA 2008) should be included in the screening if appropriate for the site:

- Enhanced bioremediation;
- Biowalls;
- Soil amendments;
- Phytoremediation;
- Constructed wetlands;
- Evapotranspiration covers; and
- Monitored natural attenuation [consideration required by Army policy dated 12 Sept 1995 (US Army 1995)].

Data collection for these same technologies was also outlined in Step 4.

In addition to these treatment technologies, disposal technologies that allow reuse of either treated or untreated extracted soil or groundwater should be included in the screening. These include sprinkler irrigation of either treated or untreated groundwater and reuse of treated, composted waste (EPA 2008d, State of Illinois EPA 2008).

Within the screening of technologies, it is expected that potential treatment and disposal technologies will continue to be evaluated on technical implementability, effectiveness, and cost. During the process option screening evaluations, conservation, protection, and improvement of critical natural resources can be reflected in these three criteria. For example, technologies relying on 1) resources that are limited in supply could affect technology implementability and/or cost and 2) resources with high economic value could affect technology cost. On-site resources, for example, energy, and off-site resources, for example regional water supply, can also be considered.

Proceed to Step 8.

Step 8: Complete configuration, screening, and detailed analysis of alternatives within the CERCLA process. Continue to consider green and sustainable technologies and incorporation of green and sustainable practices into alternatives where and when it makes sense for the project and within the traditional CERCLA process. Perform comparative analysis of alternatives with respect to standard CERCLA criteria and with respect to green and sustainability aspects.

After general process option development and technology screening, the technologies that pass screening are assembled into alternatives. The resulting alternatives are then screened based on the same effectiveness, implementability, and cost criteria prescribed by the CERCLA process for technologies (EPA 1988). Any inherently green and sustainable technologies that passed screening are included in the assembling of alternatives. Green and sustainable best management practices are also included in the alternative development where and when they make sense for the project. These potentially include the following:

- Practices that conserve, protect, and/or improve critical natural resources;

- Use of existing equipment or buildings;
- Plans to reuse or recycle materials or equipment after remediation;
- Minimization of hazardous and/or non-hazardous waste;
- Feasibility of the use of renewable energy sources ((DOE/NREL 2008a and 2008b, AWEA 2009, EPA 2008e); the latter resource includes procedures for determining the feasibility of different renewable energy types as well as examples of application); and
- Beneficial reuse of the site.

The alternatives that pass screening are then brought into detailed analysis. In the traditional CERCLA process, the alternatives are evaluated and compared against each other on the following criteria (EPA 1998):

- Threshold Criteria
    a. Overall Protection of Human Health and the Environment.
    b. Compliance with ARARs.
- Balancing Criteria
    a. Long-term Effectiveness and Permanence.
    b. Reduction of Toxicity, Mobility, and Volume Through Treatment.
    c. Short-Term Effectiveness.
    d. Implementability.
    e. Cost.
- Modifying Criteria
    a. Support Agency Acceptance.
    b. Community Acceptance.

As the green and sustainable aspects of the remedy currently have no required regulatory status, 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 green and sustainable considerations. This separation makes clear the differentiation between the non-statutory regulatory status of green and sustainable aspects compared to the statutory status of the CERCLA criteria. However, as some of the green and sustainable aspects may be directly related on any individual project to the CERCLA criteria, these aspects can also be discussed within the standard CERCLA comparative analysis. Some examples of green and sustainability considerations and their potential inclusion within the statutory CERCLA criteria are given in Table A-3.

Table A-3 Connection Between Sustainability Factors and CERCLA Evaluation Criteria

Sustainability factor	Evaluation criteria	Comments
On-site and off-site human work and exposure risk during remedy implementation	Short term effectiveness	As part of the short term effectiveness criterion, accident and fatality risk for on-site workers can be included. Also risks both to the workers and the public from off-site worker activities related to the remediation could be included. Example off-site activities potentially affecting both workers and the community are travel to and from work, transport of equipment to the site, and transport of waste material away from the site.
Natural resource use (water, energy, land)	Implementability, cost, community and support agency acceptance	If limited in amount or highly valued, green and sustainable use of the resource may be reflected in higher cost or supply may limit implementability. Also, community supported site resources such as green spaces can contribute towards remedy public acceptance. In addition, either regulatory or public incentives for use of remedies with green and sustainable elements may be available, which may be reflected in decreased cost or increased implementability (see NCSC 2009 for a compilation of incentives at all levels of government).
Off-site impact of remediation	Short-term effectiveness and/or community acceptance	The remediation may involve off-site noise, dust, and/or odor effects that adversely affect neighboring communities. Consideration and/or mitigation of these effects can be considered as part of the short-term effectiveness and/or public acceptance CERCLA criteria.

The basic goal of the comparative analysis of alternatives based on green and sustainable considerations is to compare the alternatives based on relative reductions in environmental footprint of each alternative. It is recommended that the set of elements and metrics described in Section 2 be used to define and measure environmental footprint. These include the elements from the EPA Green Remediation Primer (EPA 2008d) [1) air, 2) water, 3) land and ecosystems, 4) materials and waste, 5) energy, and 6) stewardship, with the additional element of worker safety as suggested by the Navy (Navy 2009)] and the metrics currently used by the Navy (Navy 2009) [1) energy consumption, 2) greenhouse gas and criteria pollutant emissions, 3) water impacts, 4) ecological impacts, 5) resource consumption, 6) community impacts and 7) worker accident and fatality risk]. It is expected that other elements and/or metrics may be important and selected depending on the individual project needs and resources. Also, the specific considerations within the metrics will be different and vary in importance for different projects. For example, on one site, community impact could take into account noise, dust, or odor from the remediation. On another project, community impact may address the loss or gain of jobs related to the remediation.

Once the elements and metrics have been determined, a decision should be made as to the basis on which the environmental footprint of the different alternatives will be compared. This comparison can depend solely on green and sustainable best management practices or on quantitative or qualitative estimates of the reductions of environmental footprint from the green and sustainable practices that have been incorporated. For the latter, quantitative or qualitative measures of the environmental elements used in the environmental footprint analysis are necessary.

A number of the tools designed to measure green and sustainable elements through defined metrics are included in the table in Section 2 (SURF 2009). EPA has also compiled a summary of the available tools, which is available on the EPA CLU-IN site at Tools (http://www.clu-in.org/greenremediation/subtab_b3.cfm).

The USACE is evaluating specifically the use of two tools to which the USACE has or will soon have public access. These tools are the Sustainable Remediation Tool, developed by the Air Force Center for Engineering and the Environment (AFCEE) (AFCEE 2009), and the SiteWise™ Sustainable Environmental Remediation (SER) tool initially developed by Battelle Inc, and presently under further development by the Navy and the USACE (Battelle 2009).

The current SRT version (http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/srt/index.asp) calculates and compares greenhouse gas emissions, energy use, natural resource use, cost, and worker accident risk for four different environmental technologies, excavation, soil vapor extraction, pump and treat, and in-situ bioremediation. The Air Force is targeting a completion date of early 2010 for four more modules: biowalls, monitored natural attenuation/long term monitoring, thermal desorption, and chemical oxidation. The tool contains a “Tier 1” level evaluation, which uses rules of thumb commonly used in the environmental remediation industry, and a “Tier 2” evaluation, which is more detailed and uses site-specific information. In addition, the tool contains a Stakeholder Roundtable feature where various parties involved can weight the importance of each metric.

The SiteWise™ tool calculates greenhouse gas emissions, energy use, criteria air pollutant emissions, worker accident/fatality risk, and water usage for five different activity areas: material production, personnel transportation, equipment and material transportation, equipment usage, and residual (waste) management. The results allow identification of the activity areas and specific components within the activity areas where the greatest impact to decreasing the overall environmental footprint can be achieved.

It is expected that each tool will be used for different applications and the two tools could be used in combination. Metrics common to the tools are greenhouse gases, energy use, water use, residual waste, and worker accident risk. Both tools allow quantitative calculation of these metrics. In addition, the SiteWise™ tool calculates criteria air pollutant emissions and worker fatality risk and the SRT calculates cost and natural resource change. The structures of the tools also differ. The SRT allows direct calculation of metrics based on the technology(s) involved in each alternative. The SiteWise™ tool first configures the alternatives through a combination of different activity modules, and then measures the metrics of the configured alternatives. Both tools require some user input but have a number of tool-supplied default values, many of which can be overwritten by the user. An example application of the SiteWise™ tool in its current development is shown in Example A-2, which profiles a Navy site where the SiteWise™ tool was used to evaluate the sustainability of different alternatives in a feasibility study.

The project team may also want to include some metrics that are evaluated qualitatively, either within or outside of the tool that is used. For example, the Navy includes community impacts as a core metric and defines this as any impacts to the community not already measured, including "local disturbances and health and safety issues caused by remedy, such as noise; traffic issues, including accidents during transportation; odor, dust, and emissions of VOCs and other contaminants" (Navy 2009).

Detail on tool use is limited in this decision framework since the tools are not fully developed and available. More detailed instructions using the SRT and SiteWise™ tools are planned through training offered at the May 2010 Battelle Remediation of Chlorinated Solvents and Recalcitrant Compounds Conference. In addition, web-based training on the SiteWise™ tool to USACE districts is being planned for 2010 by the EM-CX once the SiteWise™ tool is fully developed and available. Those interested in the training should contact Carol Lee Dona at the EM-CX (carol.l.dona@usace.army.mil) to receive updated information on this training.

The results from use of tool(s) and/or identification of BMPs incorporated into the alternatives are then documented in the FS report for potential use in selection of the preferred remedy in the proposed plan and formal support agency and community input.

Example A-2

Profile: Operable Unit 2C, Former Naval Air Station Alameda, Alameda, CA

Cleanup Objectives: Remove volatile organic compounds from soil and two water-bearing zones.

Sustainability Approach: Perform evaluation using the Battelle SiteWise™ SER tool of remedial alternatives and incorporate results into screening of alternatives in the feasibility study.

Remedial Alternatives Evaluated: Soil remedies involved various combinations of excavation, engineered cap, off-site disposal, institutional controls, soil vapor extraction, and monitoring. Groundwater remedies consisted of variations on *in situ* chemical oxidation/reduction, enhanced bioremediation, electrical resistive heating, institutional controls, and monitoring.

Results: For metrics, SER analysis examined greenhouse gas emissions, energy usage, air emissions, collateral risk, and resource consumption. Simple graphical outputs permitted ranking of alternatives based on the five SER metrics and facilitated identification of the activities (for example, transportation of equipment and excavated soil) that had the largest environmental footprint for each of the metrics.

Recognition of activities that were least green and sustainable [consuming the most resources or releasing the most greenhouse gasses, for example] allowed identification of practices that could mitigate the environmental impact. These practices could be adopted during remedial design, construction, and/or operations.

Proceed to Step 9.

Step 9: Prepare decision documents. Include evaluation and documentation of green and sustainable aspects of alternatives. Provide for public and support agency comment. Finalize decision documents.

It is recommended that the proposed plan and ROD include both the standard CERCLA comparative analysis of alternatives (EPA 1988) and the comparison of alternatives based on green and sustainable remediation aspects prepared in Step 8. Green and sustainability considerations may be factored directly in the CERCLA balancing criteria of support agency and public acceptance if there is significant favorable (or unfavorable) public and/or support agency opinion toward alternatives incorporating green and sustainable practices. This is particularly the case if support agency and/or public incentives exist for green and sustainable remediation practices (see NCSC 2009 for a state-by-state listing of incentives). However, similar to the approach recommended in preparation of the FS in Step 8, it is recommended that the standard CERCLA approach be used for preparation of, and support agency and public participation in, the decision document process (USEPA 1999). After support agency and public participation has been incorporated and documented, finalize decision documents, documenting the decision process and any consideration and/or implementation of incorporation of green and sustainable practices into the decision process and documents.

Proceed to Step 10.

Step 10: Incorporate green and sustainable practices into scopes of work for remedial design-build and remedial operations contracts. Include existing Army guidance on green and sustainable design and waste minimization as design criteria as appropriate. Consider pre-design and independent review checklists as well as formal Value Engineering studies to optimize the remedy, including consideration of green and sustainable practices that conserve critical resources. Include best management practices in design that will be used in construction.

Green and sustainable practices to be incorporated may be those designated as part of the decision documents or best management practices incorporated into the design process for remedy construction. One general way of incorporating green and sustainable practices is through optimization of the design since design optimization identifies ways to best use resources. The design optimization processes recommended in this decision framework are facilitated by completion of independent review checklists, both in the pre-design and design review phases. The design checklists developed jointly by EPA and the USACE are included in Attachment A-2 (EPA 2008c). A formal independent design review through a value engineering (VE) study, typically performed at the 30% design complete stage can also be performed (OMB 1993, USACE 2005). The Army requires VE studies on all federally funded HTRW projects managed by the US Army Corps of Engineers with construction costs over $1,000,000 (USACE 2005)[1].

The checklists in Appendix A-2 are in the process of being augmented to include evaluation of the generation of greenhouse gases, the consideration of renewable energy sources, and BMPs for incorporating green and sustainable practices during construction. Until the augmented checklists are completed, it is recommended that the existing checklists be used, which will incorporate a significant number of green and sustainable practices. It is also recommended that the examples of BMPs as identified by the State of Illinois EPA (State of Illinois EPA 2008) and the US EPA (EPA 2008d) and listed below be considered in the development and review of the design.

1. Protection of air quality
    a. Impose idling restrictions on construction equipment.
    b. Use low-sulfur diesel.
    c. Use construction equipment with enhanced emission controls.
    d. Sequence work to minimize double-handling of materials.
    e. Cover stockpiles with tarps, apply alternative dust-control measure, or vegetate stockpiles.

[1] For USACE projects funded by other federal agencies, the requirement to use VE may be waived by the customer.

2. Reduction of potable water use
   a. Collect rain water for on-site use, such as dust control.
   b. Implement a water conservation plan.
   c. Capture and treat greywater for reuse.
3. Reduction of waste
   a. Abandon rather than remove subsurface structures.
   b. Crush existing structures to optimize scrap recovery and produce fill material as needed for on-site operations.
   c. Grind uncontaminated waste wood and other organics for reuse.
   d. Identify salvage options for materials from existing structures.
   e. Use recycled materials for fill.
4. Conservation of energy/use of renewable energy sources
   a. Capture free product or emissions for on-site energy recovery.
   b. Incorporate renewable energy sources, such as wind or solar, into treatment systems.
   c. Optimize performance of treatment processes with respect to pumps and piping.

In addition to the BMPs listed above, EPA is developing fact sheets on incorporation of green and sustainable BMPs with respect to general remediation implementation as well as implementation of individual technologies. Fact sheets on general implementation of green and sustainable practices into remedies and for soil excavation technology are available at http://yosemite.epa.gov/r10/extaff.nsf/9ec68d774a97483688256567006c1843/69bfdf59b4e1702788256567006a8bf5?OpenDocument.

Army vertical building standards can also be evaluated for potential green and sustainable practices that can be incorporated into construction. Since building requirements for environmental remediation sites are relatively modest, the effort would not generally justify full use of LEED building standards as prescribed in Army vertical building policy (US Army 2006a, 2007). However, the LEED standards can be used as guidelines for practices, for example, storm water handling, energy conservation, and creation of green spaces, through which green and sustainable practices can be incorporated.

Once the design is complete and approved, proceed to Step 11.

Step 11: Construct according to design. Monitor construction to ensure activities are consistent with green and sustainable practices.

Because many of the green and sustainable practices outlined in Step 11 are relatively recent, it is recommended that construction activities be monitored periodically for proper execution.

Proceed to Step 12.

Step 12: Construction complete, document green and sustainable practices in remedial action report.

Where possible, the net benefits of adopting green and sustainable practices during design and construction should be noted in the remedial action report. These could include cost savings and/or reduction of environmental footprint due to use of renewable energy, reductions in air emissions or waste generation, or conservation of critical resources (through reuse of water, for example, or energy conservation).

Proceed to Step 13.

Step 13: Is there an existing O&M plan?

If there is an existing operations and maintenance (O&M) plan, go to Step 16. Otherwise, go to Step 14.

Step 14: Consider modification of existing O&M procedures from information obtained from the following options.

Depending on the type and phase of the remedial system, the programs in Steps 15 and 16 can be considered and implemented. If the remediation includes an operating treatment system without long-term monitoring, go to Step 15. If the site is in long-term monitoring with no treatment system, go to Step 16. If a site contains both an active treatment system and long-term monitoring, consider the procedures in both Steps 15 and 16.

Proceed to Step 15 or Step 16, as appropriate.

Step 15: Perform remediation system evaluation (RSE) that incorporates consideration of green and sustainable practices.

The purpose of the RSE program developed by the US Army Corps of Engineers is to optimize an operating environmental remediation system (USACE 2009). The RSE already incorporates a number of green and sustainable factors. In addition to optimizing for cost and risk reduction, the remedial system is evaluated with respect to following that have the potential for incorporation of green and sustainable practices:

- Reduction of site close-out time;
- Optimization of equipment operation and maintenance; and
- Reduction of resource (energy, water) consumption.

The RSE thus promotes a more green and sustainable remedy in the short-term by reducing resource consumption and optimizing O&M and in the long-term by shortening time to site close-out. For more information on the RSE program, the reader is referred to http://www.environmental.usace.army.mil/rse.htm (USACE 2009).

The RSE checklists (USACE 2009) are in the process of being augmented to include evaluation of the generation of greenhouse gases, the consideration of renewable energy sources, and BMPs for incorporating green and sustainable practices. Until the augmented checklists are completed, it is recommended that the existing checklists be used, which will incorporate a significant number of green and sustainable practices.

In addition to the optimization processes in RSEs that already incorporate green and sustainable factors, an impact analysis of the activities within the remedial system is helpful in identifying which activities are contributing the most to the environmental footprint. This information can then be used to identify changes in the operating systems that could most significantly reduce the environmental footprint. The USACE is evaluating the Battelle SiteWise™ tool (Battelle 2009) on a number of sites for this purpose. As discussed in Step 8, the SiteWise™ tool calculates greenhouse gas emissions, energy use, criteria air pollutant emissions, worker accident/fatality risk, and water usage for five different activity areas: material production, personnel transportation, equipment and material transportation, equipment usage, and residual (waste) management. The results allow identification of the activity areas and specific components within the activity areas where the greatest impact to decreasing the overall environmental footprint can be achieved.

Example A-3 includes an example of the use of the SiteWise™ tool in a remediation system evaluation (RSE) at a pump & treat facility where enhanced bioremediation has been used to speed up restoration. The results indicate that significant reductions in environmental footprint could be obtained from switchout of equipment. The results also indicate the potential environmental footprint reduction in continuing biostimulant injections, the design of which is to reduce the operating time of the pump and treat system.

Tools such as the SiteWise™ tool can also be used to evaluate the overall environmental footprint reduction with incorporation of any BMPs. An example is the potential use of non-potable water that would require a conveyance system to bring the water to the site. The tool would assess the overall reduction (or increase) in environmental footprint from the savings in potable water as balanced against the potential increased greenhouse gas emissions and energy use from producing and installing the conveyance system. The tool can also assess the green and sustainable benefits associated with replacement of fossil-fuel driven energy supplies with renewable energy sources.

In the overall RSE process, the results from a tool such as SiteWise™ are then considered along with other project considerations, such as cost, risk reduction, and close-out time, to make final decisions about incorporation of green and sustainable practices. While the RSE process identifies opportunities for optimization, it is at the discretion of the project team directing the remediation to decide which recommendations to implement, consistent with DoD policy to implement green and sustainable practices "when and where they make sense."

Example A-3

Profile: Cornhusker Army Ammunition Plant, near Grand Island, NE

Cleanup Objectives: Remove TNT and RDX from groundwater.

Sustainability Approach: Perform evaluation of operations involving pump & treat and enhanced bioremediation using the Battelle SiteWise™ SER tool (Battelle 2009).

Site Operations: P&T has been operating at the site since 1994, with 210M gallons of water extracted and treated annually and 20K lbs of carbon changed out every 8 months. To speed up restoration, biostimulant injections have been performed.

Results: For metrics, SER analysis examined greenhouse gas emissions, energy usage, air emissions, collateral risk, and resource consumption. Most of the environmental footprint—over 70% of greenhouse gas and criteria air pollutant emissions, as well as energy usage—is caused by equipment use (air compressors, transfer pumps, building heaters). Consumables (like biostimulant) account for roughly 25% or less. When it comes to collateral risk, though, transportation of personnel to and from the site accounted for nearly 80% of the risk due to fatality and 40% due to injury.

Tool outputs readily facilitated identification of activities responsible for greatest environmental impact and, therefore, permitted focusing on changes in those activities that would minimize impacts. For example, swapping out a 10 hp pump for a 15 hp variable frequency drive pump significantly reduced the environmental footprint. The analysis also identified that continued judicious use of biostimulant was advantageous since this had the potential to decrease site closure time, thus decreasing equipment use, which was the largest contributor to the environmental footprint with respect to energy use and greenhouse gases and criteria air pollutant emissions.

Proceed to either Step 16 (long-term monitoring included in remedy O&M) or Step 17 (no long-term monitoring).

Step 16: Optimize long-term monitoring, including procedures that would consider and incorporate green and sustainable practices.

If the site is in long-term monitoring, significant conservation of resources can be realized by optimizing the location, frequencies, and methods of monitoring. The process recommended in this decision framework is the "Roadmap to Long-Term Monitoring Optimization" process jointly developed by the USACE and EPA (EPA, 2005b). The Roadmap describes five tools for performing optimization evaluations: Cost Effective Sampling (CES), Geostatistical Temporal/Spatial Optimization Algorithm (GTS), Monitoring and Remediation Optimization System (MAROS), Parsons 3-Tiered LTMO, and Adaptive Environmental Monitoring System (AEMS). Data requirements and evaluation outputs vary between tools, and it is up to the project team to determine which tool is most appropriate for a particular project.

In addition, consideration should be given to long-term monitoring BMPs, which include (EPA 2008d):

- Use of passive sampling devices for monitoring of air, sediment, and ground or surface water;
- Remote data collection; and
- Renewable energy powered systems to operate any passive or active data collection systems.

As with the RSE process, recommendations are made to the organization overseeing the remediation. The decision as to which green and sustainable practices are incorporated, as well as other optimization measures, is at the discretion of the project team directing the monitoring, consistent with DoD policy to implement green and sustainable practices "when and where they make sense."

Proceed to Step 17.

Step 17: Establish procedures to periodically evaluate O&M procedures for optimization opportunities, including incorporation of green and sustainable practices.

If there is no existing O&M plan, it is recommended that the O&M plan be written to include periodic reviews, potentially including the RSEs and/or long-term monitoring optimization outlined in Steps 15 and 16. It is also important as the remedy proceeds to realize that further optimization can occur, which can lead to reductions in resource consumption and more rapid site closure. Therefore, it is recommended that a schedule be established so the system can be reassessed for any further opportunities for optimization and incorporation of green and sustainable practices. The schedule will vary with the system but a convenient maximum timeframe for CERCLA sites is five years, to coincide with the five-year review (EPA 2001). The five-year review guidance (EPA 2001) encourages identification of opportunities to improve the performance and/or reduce the costs; this identification could also include opportunities to include green and sustainable practices into O&M. Although not typically performed during a five-year review, optimization studies can be recommended. Again, as part of the recommendation for a remedy optimization study, inclusion of an evaluation of opportunities to incorporate green and sustainable practices can be explicitly identified. Identification of optimization opportunities, including incorporation of green and sustainable practices, can also be included as part of periodic monitoring reports. It is recommended that this periodic monitoring and additional system optimizations continue until remedial goals have been met and the site can be closed.

Proceed to Step 18.

Step 18: Remedial goals have been met and the site can be closed. Implement green and sustainable practices into the site deconstruction and site reuse process.

It is assumed that the criteria for closing the site have been reached and regulatory approval has been obtained. The treatment system can now be dismantled and the site can be used for other purposes.

There are numerous opportunities to incorporate green and sustainable practices during site close-out and site reuse/development. Although these practices may have already been introduced into the TPP process or other systematic planning process earlier in the remediation process, the following should be considered:

Deconstruction/Minimization of Waste

The Army policy for military deconstruction waste (US Army 2006a) was developed based on data indicating that 50% diversion of deconstruction (non-hazardous) waste was cost effective. It is suggested that waste diversion principles from the Army policy be examined to determine the amount of waste, both hazardous and non-hazardous, that can cost-effectively be diverted. An additional web resource on diversion of waste is the EPA "Wastes - Non-Hazardous - Municipal Solid Waste" website (http://www.epa.gov/epawaste/nonhaz/municipal/index.htm).
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Sustainable Stormwater Management Approaches and Other Low Impact Development (LID) Approaches

It is recommended that the principles from the Energy Independence and Security Act of 2007 – Section 438, which requires the maintenance or restoration "to the maximum extent technically feasible" of "the predevelopment hydrology of the property" for "any development or redevelopment project involving a Federal Facility with a footprint that exceeds 5,000 square feet" (EISA 2007), be applied in determining low impact development (LID) practices that can be used in site redevelopment. The EPA document "Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices" (EPA 2007a) describes LID practices that can be used, including the following:

- Conservation designs for minimizing runoff generation;
- Engineered structures or landscape features to help capture and infiltrate runoff;
- Storage of captured runoff, with later reuse of the captured water, and
- Conveyance systems to route excess runoff through and off the site.

Expansion of the Options for Site Reuse and Enhancement of the End Use of the Site

Green and sustainable practices can expand or enhance end use of the site. One method is including ecological enhancements, which modify "a site to increase/improve habitat for plants and animals while protecting human health and the environment" (ITRC 2006). The

ITRC guidance further describes the environmental, economic, and public benefits, as well as the process to implement ecological enhancements (ITRC 2006).

Another method of expansion of the options for site reuse after closure is to continue use of equipment used in the remediation. For example, renewable energy sources used to power the treatment system could continue to supply energy to municipal or facility power grids.

An additional method to expand site reuse options is the use of agricultural and/or forest practices that increase carbon sequestration. Carbon sequestration here is defined as the use of plants and/or trees for long-term storage of carbon dioxide, the purpose of which is mitigation of global warming. Examples of practices that can be applied to FUDS remedial sites are grass conservation or riparian buffers and planting or replanting trees. For more information, the reader is referred to the EPA web site: "Carbon Sequestration in Agriculture and Forestry: Agricultural and Forest Practices that Sequester Carbon and Reduce Other Greenhouse Gas Emissions", http://www.epa.gov/sequestration/practices.html.

Site Restoration Practices That Conserve Resources

Site restoration practices that are green and sustainable through conservation of resources include the following (SSI et al. 2007, EPA 2007b):

- Use of native plants that require little or no irrigation and no maintenance, such as mowing or fertilizing;
- Use of water-efficient irrigation system, for example drip irrigation, where or if irrigation is necessary; and
- Use of compost or other carbon-rich soil for fill requirements if structural requirements are met – the carbon-rich soil improves water retention, thereby requiring less applied water.

Attachment A-1
Possible Sustainability Contract Language Tailored to Federal Acquisition Regulations (FAR) Section 15.204-1 Uniform Contract Format (FAR 2009)

Base Contract - Section C - Statement of Work:

"The contractor will be required to incorporate sustainability into its execution of the specific project(s) as identified in the individual Task Order Statements of Work. Potential green and sustainable enhancements that may be included, but is not limited to, the following list identified below. Specific green and sustainable enhancements will be identified in each task order statement of work:

Water Impacts
- Minimize use of potable water and maximize use of non-potable water during daily operations and treatment processes.
- Use of native vegetation to reduce watering/irrigation needs.

Energy Usage
- Use of alternative energy sources such as solar energy, wind energy, and landfill gas energy.
- Use of alternative fuels to operate machinery and equipment.
- Reducing energy consumption through optimization of treatment systems.

Waste minimization
- Recycling, reusing and reclaiming materials in order to reduce resulting debris disposal.

Other
- Minimize dust export of contaminants.
- Use of minimally invasive remediation technologies, where possible and effective."

Base Contract - Section H – Special Contract Requirements:

"The proposed sustainability solutions provided by the offeror, at the proposed price, will be incorporated into each resulting task order of this contract upon Government acceptance and award of the task order."

Base Contract - Section H – Special Contract Requirements:

"Any changes to the sustainability technical solutions of each resulting task order executed under this contract will be approved in writing by the Contracting Officer based upon appropriate justification(s) from the Contractor."

Base Contract - Section H – Special Contract Requirements:

"**Reporting:** The contractor will provide a "green" section on reuse, recycling, waste streams reduction, and resource conservation as part of the periodic progress report for each task order. The intent is to show what is being done to keep wastes out of landfills or disposal facilities and to conserve energy or other natural resources, thereby reducing negative impacts of a removal action. The report should also document estimated cost savings from implementing the action, if applicable, and the estimated environmental benefit from implementing the action. Alternatives considered but not executed due to cost, time, or other factors also may be reported. A comment section of the monthly report may describe factors interfering with these efforts, such as unavailability of a local recycling process/facility, prohibitive cost, or inability to ensure items are "clean" enough to be re-used by others."

Base Contract - Section H – Special Contract Requirements:

"All proposed sustainability enhancements in each individual task order must be supported with a life-cycle analysis 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. For example, the net cost or savings of implementing a wind energy system to reduce energy consumption versus the overall energy cost savings for the life of the project."

Base Contract - Section H – Special Contract Requirements:

"All proposed sustainability solutions will be separately priced in each individual task order although the overall price for the entire remediation effort will be evaluated using a "best value" tradeoff selection process, using both technical evaluation factors along with price."

Task Order Statement of Work:

"Clean Air: The contractor will use cleaner technology and engines, cleaner fuel and cleaner diesel control technology on all diesel equipment used the site during the execution of the cleanup remedy to the maximum extent practicable. Clean diesel technologies are preferred, and alternative fuels such as biodiesel or natural gas-powered vehicles should also be considered. The contractor will use alternative fuels, of at least a B20 blend or higher, on all on-site diesel equipment where these fuels are available within a reasonable distance from the site. The contractor will employ the most efficient emission control technology for reducing particulate matter (PM) emissions on non-road and on-road diesel powered equipment used at a site.

Task Order Statement of Work:

"**Renewable Energy:** The contractor will evaluate all reasonably feasible renewable energy sources when conducting work related to selecting a cleanup remedy and/or executing a cleanup remedy and/or when optimizing an existing cleanup remedy. Sources of renewable energy generally include solar, wind, and biomass and biogas. Examples of renewable energy technologies include photovoltaic panels, wind turbines, digesters, gasifiers, and micro turbines. Part of evaluating renewable energy sources and technologies will involve a cost analysis, comparing the energy costs from renewable sources versus traditional electricity sources provided by local utilities, over the expected life of the cleanup remedy. Similarly, an evaluation of the avoided emissions as a result of using renewable energy sources versus traditional energy sources provided by local utilities will be performed. The contractor will also evaluate the cost of purchasing green power from organizations that offer green power within the general vicinity of the project site."

Task Order Statement of Work:

"**Green Landscaping:** The contractor will use cost effective and environmental friendly landscaping solutions to minimize environmental impacts at the site. Green landscaping practices include protecting and preserving natural resources by reducing or eliminating the amount of waste materials involved in groundskeeping and by reducing or eliminating the amount of water, pesticides, fuels, oils, and other materials used in landscaping. The contactor will incorporate green landscaping practices to the maximum extent practicable by using native vegetation whenever feasible; by reducing the production of waste to promote more efficient use of materials; by reusing materials in order to prolong their useful life and delay their recycling and/or final disposal; by recycling to minimize waste generation by recovering and reprocessing usable products that might otherwise be disposed of ; and by making purchases that meet project needs but have a better overall effect on the environment, such as biobased, recycled content, and other environmentally preferable elements."

Task Order Statement of Work:

"**Industrial Materials Reuse (IMR)**: The contractor will incorporate IMR, i.e., reusing or recycling byproduct materials generated from industrial processes that can be used as substitutions for raw materials in the manufacture of consumer products, roads, bridges, buildings, and other construction projects, whenever practicable.

Task Order Statement of Work:

"**Reporting:** The contractor will provide a "green report" on reuse, recycling, waste streams reduction, and resource conservation as part of the periodic progress report for this task order. The intent is to show what is being done to keep wastes out of landfills or disposal facilities and to conserve energy or other natural resources, thereby reducing negative impacts of a removal action. Alternatives considered but not executed due to cost, time, or other factors also may be reported. A comment section of the monthly report may describe factors interfering with these efforts, such as unavailability of a local recycling process/facility, prohibitive cost, or inability to ensure items are "clean" enough to be re-used by others."

Task Order Statement of Work:

"The proposed sustainability solutions provided by the offeror, at the proposed price, will be incorporated into this task order upon Government acceptance and award of the task order."

Task Order Statement of Work:

"Any changes to the sustainability technical solutions in this task order will be approved in writing by the Contracting Officer based upon appropriate justification(s) from the Contractor."

Task Order Statement of Work:

"All proposed sustainability enhancements in this task order must be supported with a life-cycle analysis 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."

Task Order Statement of Work:

"All proposed sustainability solutions in this task order should be separately priced although the overall price for the entire remediation effort will be evaluated using a "best value" tradeoff selection process, using both technical evaluation factors along with price."

Task Order Statement of Work:

"In addition to the task order price, the Government intends to offer a financial incentive to incorporate green and sustainable practices into this task order. The incentive will be separately identified in a contract line item (CLIN) and will be funded at _% of the offeror's total price.

For illustration purposes, the example below shows how the calculation process would be administered (with a hypothetical contractor performance). In no case should the below calculations be construed as an entitlement by the offeror/contractor on the actual task order incentive calculation:

Example A-2-1: Incorporating green and sustainable practices into incentive awards (Note percentages and weighting factors are examples – these are expected to vary for specific projects)

1. **Identification of resources and goals for incorporation of green and sustainable practices (g_i)**
   Water – 30% use of non-potable water
   Energy – 30% renewable energy
   Waste minimization – 65% diversion
2. **Weighting Factors (w_i) for Goal ($\Sigma w_i = 1$)**
   Water – 0.25
   Energy – 0.5
   Waste minimization – 0.25
3. **Contractor's Actual Performance (c_i)**
   Water – 20% non-potable water use
   Energy – 25% total energy renewable
   Waste minimization – 50% waste diversion
4. **Calculation of the Percent of the Incentive Award**
   $100 \times \Sigma w_i (c_i/g_i)$ = Percent of Incentive Award
   $100 \times [0.25 \times (20/30) + 0.5 \times (25/30) + 0.25 \times (50/65)]$ = 78% of Award
5. **Contract Price**
   $1,000,000.00
6. **Incentive Fee**
   ($1,000,000.00 x 2%) x 78% = $15,600.00

The actual green and sustainable practice goals, the associated weighted factors and the calculation formula for this task order are as follows:

Identification of resources and goals for incorporation of green and sustainable practices (g_i) Note that actual resource usages and weighting factors are expected to vary for projects

Water – 30% use of non-potable water
Energy – 30% renewable energy
Waste minimization – 65% diversion

Weighting Factors (w_i) for Goal ($\Sigma w_i = 1$)

Water – 0.25
Energy – 0.5
Waste minimization – 0.25

Calculation of the Percent of the Incentive Award

$100 \times \Sigma w_i (c_i/g_i)$ = Percent of Incentive Award

ATTACHMENT A-2
INDEPENDENT REVIEW CHECKLIST FOR
EPA FUND LEAD REMEDIAL DESIGN PROJECTS
Draft Final (9-30-2008)

INDEPENDENT DESIGN REVIEW (IDR) CHECKLIST FOR EPA FUND LEAD REMEDIAL DESIGN PROJECTS (DRAFT FINAL) 9-30-08 draft

Outline:

I. Introduction.

A. Purpose. The purpose of the checklist is to help guide the design review team during performance of an independent design review (IDR) of Fund-Lead projects at the preliminary (i.e., 30% RD) design stage. The team will perform the IDR concurrently with or independently of the value engineering (VE) screen and/or study and will make recommendations to EPA on how to proceed with the design. A tyical VE team is comprised of a certified value specialist or value engineer, a construction manager, a construction engineer, a hydrogeologist, and additional engineers or scientists with expertise in design/construction of remedial components under design at a given site. The EPA RPM for the site is encouraged to participate and assist the team during the VE process. The team generally begins its work upon submittal of the preliminary, 30% RD documents, and will try to work within the review schedule that is normally provided for EPA review of draft preliminary (i.e., 30% RD) design documents. If the independent design review is done separately from a VE study, the team make-up will typically include an individual experienced in construction, a hydrogeologist, and other disciplines with expertise in the type of remediation under evaluation.

B. Instructions to Design Review Team.

1. The design review team will focus on the following types of recommendations:

a. recommendations to improve the design (design comments);
b. cost savings measures (with an estimate of savings); and
c. potential VE study items.

2. The design review team will provide points of contact (POCs) and phone numbers for all recommendations if available, particularly regarding the following types of recommendations:

a. TRIAD approach recommendations;
b. Treatment process or remedy recommendations;

c. Contracting recommendations; and
d. Optimization recommendations.

3. The design review team will provide their recommendations to the EPA RPM in a draft report within three weeks from the conclusion of the team meeting that will generally take place near the site. The design review team will try to work within the review schedule provided by the EPA RPM.

II. Part One, Predesign Issues. To be performed by USACE Environmental and Munitions Center of Expertise (EMCX) or Review Team Leader, and results discussed with the RPM prior to the Design Review Team Meeting.

Note: These items need not necessarily be reviewed by the entire team. These items may be addressed by a subset of the larger IDR group or a separate group such as the EMCX. The results of the Part A review will be discussed with the RPM in advance of the scheduled call among the IDR team, designer and RPM. Issues identified during the Part A review and considered within the scope of the VE effort and IDR will be relayed to the IDR team during the scheduled conference call.

A. General Considerations Regarding RD Reviews.

1. Are all ROD remedial components addressed in the RD? (YES) (NO) (NA)

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The design review should include a brief review of the ROD (particularly the selected remedy section of the ROD) or other EPA decision document for the site (e.g., an Explanation of Significant Differences, or ROD Amendment), to ensure that all remedial components of the selected remedy, and any studies, assessments, or design related efforts recommended or required in the ROD or other EPA decision document for the site, are being properly addressed in the RD.

2. Have new or modified ARARs been promulgated since the ROD, or have new or modified components of the selected remedy been identified by EPA or others to meet the ROD's remedial action objectives since the ROD was signed? (YES) (NO) (NA)

____

____

The design reviewers should flag items for discussion with EPA if the design review indicates that any new or modified ARARs have been promulgated since the ROD or other EPA decision document for the site was signed. Items to be identified include:

a. those which potentially call into question the protectiveness of the selected remedy.

b. potentially new or modified components of the selected remedy which have been identified by EPA or others as necessary to meet the remedial action objectives noted in the ROD or other EPA decision document for the site since the ROD or other EPA decision document for the site was signed. EPA may then consider whether such changes in ARARs or remedial components have been appropriately documented pursuant to EPA's ROD guidance. Section 7.2.Types of Post Record of Decision Changes. http://www.epa.gov/superfund/resources/remedy/rods/index.htm

c. does the design comply with applicable state and federal laws?

As noted in EPA's ROD guidance, EPA may need to determine the type of change involved, depending on the extent or scope of modification being considered (i.e., nonsignificant or minor, significant, or fundamental change). Each type of post-ROD change may potentially be associated with one of three documentation procedures: (1) a memo or note to the post-ROD file for an insignificant or minor change; (2) an ESD for a significant change, and (3) a ROD amendment for a fundamental change.

3. Design review recommendations to modify or eliminate a component of the ROD's selected remedy, and/or design/construct a different or modified component:

If the design review identifies a potentially more effective or efficient manner in which to remediate the site than specified, modifying or eliminating a component of the selected remedy, and/or designing a different or modified component to take the place of this component The design reviewers should review the ROD or other EPA decision document for the site to determine if factors other than cost significantly impacted EPA's decision to select such ROD components to be part of the selected remedy and flag such preferences for discussion with EPA. EPA will consider whether the design review's preferences for changes in remedial components would be appropriate to pursue during the RD, and/or whether such preferences need to be appropriately documented pursuant to EPA's ROD guidance (as discussed above).
It is possible that a lower cost remedial component may not be the preferred overall remedial component for a site. The most appropriate remedy at a site is selected among available alternatives upon considering the nine criteria in accordance with the NCP. A cost-effective remedy in the Superfund program is one whose "costs are proportional to its overall effectiveness". (NCP §300.430(f)(1)(ii)(D)).

B. Coordination**.** The independent review team leader will act as the POC with the EPA RPM. The POC is responsible for identifying: the critical issues involved in this review; the members of the team; and coordinating the budget, schedule and eventual assembly of the report.

1. Has an EPA Regional public relations/community coordinator, state public relations/community coordinator, and other primary stakeholder representatives been included in the "team"? (YES) (NO) (NA)

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2. Does the design information reflect active communication between the project manager and managers from other similar sites to identify lessons learned (provide a list of similar sites)? (YES) (NO) (NA)

3. Have the site staffing requirements been coordinated with the RPM? (YES) (NO) (NA)

4. Have lateral boundaries of excavations been defined on the drawings based on contaminant data to ensure delays for additional property access agreements during construction do not occur? (YES) (NO) (NA)

5. Has responsibility for obtaining access agreements with residents or local municipalities been defined (agency)? Similarly, who will handle Public Relations, newsletters to residents and municipalities and how often? Is the contractor required to play a role in keeping residents apprised of progress? (YES) (NO) (NA)

6. Will site security be required for the site? (YES) (NO) (NA)

7. Are permit equivalencies required for the work such as any construction permits, state permits, wetland permits, well drilling permits, etc? Have responsibilities been identified who will coordinate them? Has the designer delineated these permits, coordinated with appropriate agencies and prepared drafts of all the permits or are they addressed in the contract specifications? (YES) (NO) (NA)

8. Are Real Estate concerns such as property acquisition, relocations, rights of way and easements being properly documented and responsibilities addressed? Will all permits and real estate easements be in place prior to award/NTP? (YES) (NO) (NA)

9. Has the ROD and the current design been reviewed to ensure the proposed site remedial actions represent a current, feasible alternative which reflects the latest state of the science? (YES) (NO) (NA)

10. If the site has been overgrown with high vegetation, is it necessary to clear the site and re-survey the site to assure there are no hidden items, debris, utilities, etc. that may have to be removed, or accounted for in the design? (YES) (NO) (NA)

C. Cleanup Criteria.

General Question: Are the cleanup goals, remedial action objectives, and ARAR requirements clearly and consistently identified in the ROD or other EPA decision document for the site? (YES) (NO) (NA)

1. Cleanup Goals.

a. Is it feasible to achieve the cleanup goals identified in the ROD or other EPA decision document for the site during the proposed remedial action, and have the cleanup goals been appropriately applied in the remedial design (engineering, cost, verifiable, analytically achievable, etc.)? (YES) (NO) (NA)

b. Are the cleanup goals consistent with cleanup goals at other sites with similar site-specific characteristics? (YES) (NO) (NA)

c. Were anthropogenic and naturally occurring background concentrations appropriately considered in the design? E.g., were these levels determined and compared to the cleanup goals identified in the ROD or other EPA decision document for the site?
(YES) (NO) (NA)

d. Was the conceptual site model (CSM) updated following completion of the ROD or other EPA decision document for the site? If so have cleanup goals been established in a ROD or other site decision document for all viable routes of exposure identified within the updated CSM? (YES) (NO) (NA)

e. Have the cleanup compliance locations been defined (e.g., extent of contamination above cleanup goals, ARAR-driven locational requirements, physical boundaries)?
(YES) (NO) (NA)

2. Remedial Action Objectives.

a. Will the ROD's remedial action objectives, and potential exposure to levels of contaminants above the ROD's cleanup goals through all media identified as complete exposure pathways in the ROD's conceptual site model (e.g., soil, air, surface water, sediment and groundwater), be satisfactorily addressed by the remedial action?
(YES) (NO) (NA)

b. Have the objectives of the remediation system (e.g., source zone remediation, source zone containment, plume containment, plume restoration) been defined, and are those objectives consistent with the remedial action objectives within the ROD or other EPA decision document for the site? (YES) (NO) (NA)

c. Has an defined exit strategy been defined for each media involved in the remedy?
(YES) (NO) (NA)

d. Has future use of the aquifer been considered in the design of the ground water remedy?
(YES) (NO) (NA)

3. ARARs.

a. General Discussion on ARARs: As noted in the NCP, EPA's policy is to "freeze ARARs" when the ROD is signed rather than freezing ARARs at initiation of remedial action. This is because a process that allows continuous post-ROD changes to remedies to accommodate new or modified requirements could disrupt CERCLA cleanups, adversely affect the operation of the CERCLA program, be inconsistent with Congress' mandate to expeditiously cleanup sites, and adversely affect PRP negotiations. However, the NCP notes that two situations warrant consideration of incorporating new or current ARARs into the design at the time when the preliminary design is being reviewed:

1. If any new or modified ARARs been promulgated since the ROD was signed which calls into question the protectiveness of the selected remedy (the EPA Region should be requested to provide input on whether any new or modified ARAR would affect the protectiveness of the remedy); and

2. If any new or modified components of the selected remedy have been identified as necessary to meet the ROD's remedial action objectives since the ROD was signed.

b. Specific Questions:

1. Will the draft cleanup design comply with applicable or relevant and appropriate requirements (ARARs), and meet cleanup goals noted in the ROD or other EPA decision

document for the site? (YES) (NO) (NA)

2. Are ARARs and/or cleanup goals noted in the ROD or other EPA decision document for the site being exceeded by the proposed design (e.g. are cleanup criteria more stringent than necessary or practicable)? (YES) (NO) (NA)

3. Have any new or modified ARARs been promulgated since the ROD or other EPA decision document for the site was signed and, if not implemented, would call into question the protectiveness of the selected remedy? If so, will the remedial design incorporate these new or modified ARAR requirements?
(YES) (NO) (NA)

4. Have any new or modified remedial components been identified since the ROD or other EPA decision document for the site was signed which are considered necessary to meet the remedial action objectives noted in the ROD or other EPA decision document for the site (e.g., through an ESD, ROD Amendment, other decision making process)? If so, will the remedial design incorporate current ARAR requirements for these new or modified ARAR requirements?
(YES) (NO) (NA)

5. Are there any special ARAR and/or special notification requirements for any contaminants at the site that must be addressed during the remedial action, such as for PCBs or asbestos? (YES) (NO) (NA)

6. Has consideration been given to treating a RCRA characteristic hazardous waste onsite or offsite to render it non-hazardous to reduce disposal costs and allow disposal in a RCRA Subtitle D vs. Subtitle C landfill, assuming the waste is not a 'RCRA-Listed' waste and LDRs will be appropriately met? (YES) (NO) (NA)

D. Institutional or Other Controls.

1. Are institutional controls and those parties responsible for implementation (EPA, state regulators) required in the ROD or other EPA decision document for this site? If so, will an IC Implementation Plan be developed during the remedial design which will clearly describe in detail:

a. the specific types of controls anticipated (e.g., zoning) and the relationship of the controls to the remedy (e.g., protecting remedy from future excavation activities);

b. the objective, mechanism, timing and responsibility for all ICs required in the ROD or other decision document for this site;

c. activities to map all areas of contamination and/or location of all IC's; and

d. the schedule for implementing the ICs?

(YES) (NO) (NA)

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2. When land use controls are required, have provisions been included in the RD to reduce the geographic area of the institutional control as the area of contamination or contamination plume is reduced in size?
(YES) (NO) (NA)

E. RD/RA Data Requirements Regarding Nature and Extent of Contamination

General note on this section: The example questions noted below provide only a limited list of data-related questions to be considered when designing certain remedial components. These questions are provided to illustrate the type and degree of data-related questions that may be asked when reviewing a remedial design, and are not intended to comprehensively address all possible data requirements for all possible remedial components or technologies used to remediate Superfund sites. A wide range of other remedial components are available for use at Superfund sites, and the remedial design reviewer will need to consider the various data needs associated with such components, and consult available guidance, literature or experts, as appropriate, associated with the design and construction of these components or technologies to assure that the component or technology will be properly and efficiently designed and constructed.

1. Has the nature and extent of contamination to be addressed through the selected remedy been adequately defined for all appropriate media (surface soil, subsurface soil, sediment, multiple ground water aquifers, fractured bedrock, surface water, air, soil vapor, and building surfaces) and in three dimensions (for subsurface contamination)?

2. Assess whether additional sampling may be needed during design to more accurately clarify the nature and extent of contamination, particularly if several years will pass between time of sampling and time of remedial action. (YES) (NO) (NA)

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3. Have the cleanup compliance locations (e.g. ARAR driven, physical boundary) been defined? (YES) (NO) (NA)

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4. Have all potential sources of contamination that may affect the protectiveness of the remedy been identified, adequately characterized, and addressed through a specific remedial component in the ROD or other EPA decision document for the site? (YES) (NO) (NA)

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5. Were background and/or upgradient samples collected, analyzed, and considered in determining potential sources, cleanup levels, and areas of contamination that require remediation? (YES) (NO) (NA)

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6. Have geochemical principles been applied to determine whether potential contaminants in soil and ground water are at background levels or are site related? (YES) (NO) (NA)

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7. Will additional monitoring be required during remedial action to define the extent of contamination before and after remedial action commences (to both determine final areas slated for excavation or remediation, and confirm that areas slated for remedial action meet cleanup goals), and if so, are monitoring points distributed adequately in cross section to adequately monitor all contaminated media slated for remediation in three dimensions? (In most cases, monitoring points set at multiple depths are needed.) (YES) (NO) (NA)

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8. Has long-term monitoring optimization been considered in selecting monitoring points? (YES) (NO) (NA)

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9. Can dynamic work plans, screening or field analytical methods (e.g., direct push sampling, XRF, colorimetric, immunoassay tests, the TRIAD approach, or an on site lab) be used during the RD and RA to more efficiently characterize the extent of contamination or to guide the remediation? (YES) (NO) (NA)

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10. Were representative samples collected of each potentially affected media at the site? (YES) (NO (NA)

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11. Can the project benefit by doing incremental design and construction activities to assess whether the proposed remediation process meets expectations (e.g. removal efficiency, life cycle cost)? (YES) (NO) (NA)

F. Safety and Occupational Health.

1. Will the final design appropriately account for the safety and occupational health procedures required by OSHA (29 CFR 1910.120 and 29 CFR 1926.65) for working on hazardous waste sites? (YES) (NO) (NA)

2. Has the designer's safety and occupational staff determined HAZWOPER (29 CFR 1910.120/29 CFR 1926.65) training and medical surveillance applicability to construction and operation tasks? HAZWOPER training and medical surveillance requirements do not have to be applied to construction and operation tasks where workers will not be exposed to the contaminant-related hazards. In general, but not always, this means the task creates a barrier that will eliminate exposure or, the task can be managed without the use of engineering controls or personal protective equipment, in such a way that workers will not be exosed.
(YES) (NO) (NA)

III. Part Two, Independent Design Review. Performed by the Design Review Team.

A. Design Approach for Remedial Components and Technologies.

1. General (Covering All Remedy Types).

a. Have all remedial components and technologies outlined in the selected remedy portion of the ROD or other EPA decision document for the site been incorporated into the remedial design? Does the remedial design meet the technology-specific objectives mentioned in the ROD or other EPA decision document for the site as well as minimum regulatory requirements and established cleanup levels? (YES) (NO) (NA)

b. Does the documentation contain a Design Basis, including a description of major issues at the site, the nature and extent of the contamination, characteristics of the contaminated media, technology and technology specific equipment to be applied at the site, and the primary criteria used to size the remediation components? (YES) (NO) NA

c. Has an ESD or an amended ROD been written/signed by the Region, which changes the ROD's remedial requirements upon which the design is based? If so, have the requirements in the ESD or amended ROD been incorporated into the RD? (YES) (NO) (NA)

d. Has the RD resulted in any changes that may be recommended to any components of the selected remedy identified in the ROD or other EPA decision document for the site? If so, identify these changes. (YES) (NO) (NA)

e. Does the ROD or other EPA decision document for the site identify any contingent remedy activities to be conducted for any particular remedial components during the RD? If so, have such activities been conducted during the RD, and/or resulted in a preference towards a different remedial component than that selected in the ROD or other EPA decision document for the site? (YES) (NO) (NA)

f. Does the ROD or other EPA decision document for the site identify any specific studies or activities that EPA anticipates needs to be conducted during the RD? If so, are these activities included in the RD? (YES) (NO) (NA)

g. Are there any site-specific or other factors that would potentially hinder or prohibit implementation/construction of any remedial component or technology outlined in the selected remedy portion of the ROD or other EPA decision document for the site? If so, have these factors been appropriately considered in the remedial design? (YES) (NO) (NA)

h. Do the design parameters/criteria for all remedial components or technologies outlined in the selected remedy of the ROD or other EPA decision document for the site reflect actual conditions (e.g., do the groundwater contaminant levels reflect actual pumping conditions versus monitoring well contaminant levels)? (YES) (NO) (NA)

i. Have any concerns been raised by the public/community since the ROD or other EPA decision document for the site was signed which EPA agreed to address and which would either add a new remedial component, require a change to any component of the selected remedy, or may affect the protectiveness of the remedy? (YES) (NO) (NA)

j. Could multiple technologies that are required in the ROD or other EPA decision document for the site or to accomplish the remedial action objectives of the ROD or other EPA decision document for the site be phased to facilitate initial significant risk reduction at minimal cost? (YES) (NO) (NA)

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k. Have all remedial components or technologies outlined in the selected remedy of the ROD or other EPA decision document for the site been used successfully on previous projects with similar scope? (YES) (NO) (NA)

---

l. Has the designer considered and incorporated into the design the possible need for large onsite and/or offsite areas to stage materials and to construct or operate the project? For example, incineration, solidification or stabilization, and other soil or sludge treatment remedies often require space for the following activities: dewatering; source separation; dredging; ash, sludge, materials treatment and storage; tank containment; stockpiling; staging of equipment or materials; decontamination; treating; location of access roads, trailers, and buildings; and additional surface area that might be needed to expand the work area if the remedial action contractor needs such area for additional unit processes or other items/materials. (YES) (NO) (NA)

---

2. <u>General Requirements for Remedies Involving Treatment</u>.

a. Is bench and/or pilot treatability testing needed to effectively design the remedy, and if so, has such testing been incorporated into the RD? Did the ROD or other EPA decision document for the site specify the need for any treatability testing? (YES) (NO) (NA)

---

b. Is pretreatment required and has it been properly evaluated? (YES) (NO) (NA)

---

c. Does the ROD or other EPA decision document for the site specify any treatment performance criteria, such as input and output rates, maximum and minimum flow rates, extraction rates, influent or effluent quality, sampling frequency and test methods, minimum compressive strength requirements, or other requirements? (YES) (NO) (NA)

---

d. Are there any unusual operating or site conditions that could affect the specified technology (e.g., limitations on operating hours; emission requirements; schedule constraints regarding length of time required to reach construction completion)? (YES) (NO) (NA)

---

e. Are there any available alternatives to the design approach provided in the ROD, other EPA decision document for the site, or RD that would effectively meet the remedial action objectives and cleanup goals required in the ROD or other EPA decision document for the site? (YES) (NO) (NA)

---

3. Remedial Component- and/or Technology-Specific Requirements.

General note on this section: The example questions noted below provide only a limited list of questions to be considered when designing certain remedial components. These questions are provided to illustrate the type and degree of questions that may be asked when reviewing a remedial design, and are not intended to comprehensively address all possible design requirements for all possible remedial components or technologies used to remediate Superfund sites. The reviewer will need to consider the various components, and consult available guidance, literature or experts, as appropriate, to assure that the component or technology will be properly and efficiently designed and constructed.

1. Is the proposed discharge point (e.g. sewer, stream etc.) the most efficient location? (YES) (NO) (NA)

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2. If plume restoration is one objective, is the source zone controlled or removed through the remedial design? (YES) (NO) (NA)

B. RD/RA Data Requirements.

1. General Data Needs.

a. Are there significant data gaps associated with any remedial component that hinder either the design of the remedy or proceeding to the next phase of work? If yes:

1. Does the RD include plans to address these data gaps?

2. Will all necessary data be collected pursuant to a reasonable schedule, taking into account weather concerns, budgetary constraints, and according to the noted schedule for plans and specifications? (YES) (NO) (NA)

---

b. In the absence of adequate data needed to design equipment properly, would it be beneficial to rent equipment temporarily until design parameters can be defined, or is it practical to perform some treatability testing to define design parameters? (YES) (NO) (NA)

---

c. Have provisions been provided in the RD for clear labeling and proper storage of data to be collected during design and construction? (YES) (NO) (NA)

---

2. Media- and Contaminant-Specific Data Requirements.

a. Soil Remedy Data Requirements.

1. Is it necessary to collect data on soil physical parameters to aid in designing the remedial action (sieve analysis, moisture content, bulk density, organic carbon content, cation exchange capacity, etc.)? (YES) (NO) (NA)

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2. Is it necessary to collect particular data or conduct any studies to ensure that the remedial component will be appropriately designed (e.g., landfill cap settlement studies; geotechnical data for liners, caps or slurry walls)? (YES) (NO) (NA)

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3. If buried tanks and drums, or active or abandoned utility services, are suspected to be present on site and are within the area slated for remediation as described in the ROD or other EPA decision document for the site, have they been located? If so, are there any actions that need to be incorporated into the RD and taken during the RA related to these buried tanks and drums, or active or abandoned utility services, to help assure protectiveness of the remedy? (YES) (NO) (NA)

---

4. Consider whether criteria for disposal of excavated and/or treated materials have been identified in the ROD or other EPA decision document for the site (e.g., have treatment/regulatory requirements for disposal been appropriately met in the RD?). (YES) (NO) (NA)

---

b. Groundwater Remedy Data Requirements.

1. Have all needed extraction well system tests been conducted, were representative data for groundwater aquifer parameters (e.g. radius of influence, hydraulic conductivity, effective

porosity, transmissivity, etc) collected? (YES) (NO) (NA)

2. Is general water chemistry data available (e.g., TDS, hardness, Fe) and reasonable for the hydrogeology? (YES) (NO) (NA)

3. Is it necessary to collect data on soil physical parameters to aid in designing the remedial action (sieve analysis, moisture content, bulk density, organic carbon content, cation exchange capacity, etc.)? (YES) (NO) (NA)

4. Is it necessary to collect data on soil physical parameters to aid in designing the remedial action (sieve analysis, moisture content, bulk density, organic carbon content, cation exchange capacity, etc.)? (YES) (NO) (NA)

5. Is it necessary to conduct groundwater contaminant fate/transport modeling, or groundwater pumping/slug tests, to assist in the remedial design (e.g., with determining locations/number of monitoring/pumping wells; groundwater pumping rates; system design parameters)? (YES) (NO) (NA)

6. Has a groundwater model been developed for the site, has it been updated and calibrated based upon field data? Has the responsible party for further updates been identified? (YES) (NO) (NA)

C. Design Considerations for Remedial Components and Technologies.

General note on this section: The example questions noted below are not intended to comprehensively address all possible design requirements for all possible remedial components or technologies used to remediate Superfund sites. The remedial design reviewer will need to consider the various design needs associated with such components, and consult available guidance, literature or experts, as appropriate, to assure that the component or technology will be properly and efficiently designed and constructed.

1. Would it be beneficial to conduct removal efficiency tests, life cycle cost analyses, or other studies/analyses to assess whether the proposed remediation process meets remedial action? (YES) (NO) (NA)

2. Are objectives/cleanup goals specified in the ROD or other EPA decision document for the site clearly stated in the design documents? (YES) (NO) (NA)

3. Has a long period of time elapsed since the design was completed? (YES) (NO) (NA)

4. Do the designs for ground water or soil vapor extraction systems consider declining contaminant concentrations over time (e.g. was modular design considered for major treatment components, such as two small air strippers in lieu of one large unit) and their potential impact on off-gas treatment system efficiency (e.g. soil vapor extraction, air stripper off gas treatment)? (YES) (NO) (NA)

5. Are there any aspects of the project design that could be optimized either within the treatment process or the monitoring program? (YES) (NO) (NA)

6. Is the groundwater chemistry compatible with the treatment plant discharge when injection wells are used, and has bacterial fouling been considered? (YES) (NO) (NA)

7. Can the groundwater remedial design activities be phased such that it would improve the design (e.g. extraction wells installed, developed, flow rate and contaminant concentrations identified prior to the treatment plant design)? (YES) (NO) (NA)

8. Have air emissions been accounted for, and appropriate emission control equipment and air monitoring requirements specified? (YES) (NO) (NA)

9. Is a site hydrogeologic characterization through modeling recommended during the RD to assess contaminant fate and transport behavior, to help refine the MNA design, assess potential issues associated with a MNA remedy, and identify when the MNA remediation goals would be achieved? (YES) (NO) (NA)

10. If water enters excavations will treatment be needed, can the water be treated at the local POTW? What discharge parameters must be identified, and who has responsibility to determine if water should be discharged to surface water or POTW? (YES) (NO) (NA)

D. <u>Remedial Design Plans and Specifications</u>.

1. <u>Questions Covering All Remedy Types/Remedial Components</u>.

a. Have all project drawings and specifications necessary for the RA been identified? Can some plans and specifications be combined? (YES) (NO) (NA)

b. For each component of the remedy, should drawings be developed, or should the contractor develop the layout based on process and instrumentation diagrams (P&ID) or performance-based specifications?
(Specific Equipment P&ID) (Performance Based Specifications) ((NA)

c. For each component of the remedy, would it be appropriate to write the specifications as either detailed design or performance based? (*note: see further discussion on this topic in Section G: Contracting*) (YES) (NO) (NA)

d. Can the remedy be easily implemented and operated for the life of the project?
(YES) (NO) (NA)

e. Have any structures that need to be constructed been laid out to ensure there is adequate space to perform O&M on equipment and provide adequate office/work space for site personnel?
(YES) (NO) (NA)

f. Will there be an operation transition plan following the first year of operation by the construction contractor to the long term O&M contractor? (YES) (NO) (NA)

g. Have plans, specifications, and responsibilities for activities generally required during remedial action been addressed, such as: utility clearances, permitting, manifesting, as-built preparation and format, O&M manual development, operator training, environmental protection, traffic control, temporary utilities, site security during RD and RA, remedial action schedule, RA field sampling and analysis plans/requirements, quality assurance/quality control project plans, RA records management plans, mobilization/demobilization, and community involvement plans? (YES) (NO) (NA)

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h. Do the materials of construction meet the durability needs, and length of service for the project? Have appropriate design-life assumptions been incorporated for materials to be used for certain design components (taking into account physical and chemical characteristics/stresses associated with those components, such as wet/dry, freeze/thaw, corrosion)? (YES) (NO) (NA)

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____

i. Are there reusable resources present on the site (e.g., capping materials, treatment equipment) that would be compatible with the proposed remedial action? (YES) (NO) (NA)

____

____

j. Have material handling characteristics associated with constructing/implementing all remedial components or technologies outlined in the selected remedy of the ROD or other EPA decision document for the site been considered and/or evaluated adequately? Is bench/pilot testing needed to assure materials handling success? (YES) (NO) (NA)

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k. Are there items that should be purchased vs. rented at a cost savings to the government (government furnished or contractor purchased for the government)?
(YES) (NO) (NA)

____

____

l. Is there existing equipment in the EPA used equipment inventory (e.g. treatment equipment, earth moving equipment for very large contracts) that could be made available for this project? Refer to the following web site for a list of available equipment.
http://www.environmental.usace.army.mil/info/technical/process/protools/protools.html
(YES) (NO) (NA)

____

____

m. Have technology venders been consulted and provided with sufficient data to make realistic determinations as to whether their technology will meet the performance criteria for the project and to determine what additional design criteria is needed? (YES) (NO) (NA)

n. Are there any aspects of the project design that could be optimized either within the treatment process or the monitoring program? (YES) (NO) (NA)

o. Have access requirements to conduct the RA been addressed in the remedial design, including potential schedule requirements associated with gaining access? (YES) (NO) (NA)

p. Are Real Estate concerns such as property acquisition, relocations, rights of way and easements being properly addressed? If property acquisition or easements are contemplated, was a real estate planning report prepared and submitted with the 30% RD? (YES) (NO) (NA)

q. Is the design sufficiently flexible to allow for expansion and contraction of the influent waste stream, with logical connection points included for adding future components? (YES) (NO) (NA)

2. General Requirements for Remedies Involving Treatment.

a. In situations involving multiple treatment units, is performance to be measured for each individual piece of major equipment? (YES) (NO) (NA)

b. Has the responsibility and criteria for commissioning treatment facilities been addressed (e.g. effluent treatment standards are continuously achieved with no non-compliance, minimum system start-up time, operating time, or down-time goals)? (YES) (NO) (NA)

c. Will each of the treatment components been provided with capabilities to bypass the unit in the future if concentrations no longer require the unit? (YES) (NO) (NA)

d. Do the plans and specifications clearly identify the treatment standards that must be achieved for all waste streams (e.g. solids, off gas emissions, water effluent) and the applicable discharge point? (YES) (NO) (NA)

e. Are permit equivalencies required for the work such as any construction permits, state permits, wetland permits, well drilling permits, etc? Have responsibilities been identified who will coordinate them? Has the designer delineated these permits, coordinated with appropriate agencies and prepared drafts of all the permits or are they addressed in the contract specifications? Yes No (NA)

3. Remedial Component- and/or Technology-Specific Requirements.

General note on this section: The example questions noted below provide only a limited list of questions to be considered when designing certain remedial components. These questions are provided to illustrate the type and degree of questions that may be asked when reviewing a remedial design, and are not intended to comprehensively address all possible design requirements for all possible remedial components or technologies used to remediate Superfund sites. A wide range of other remedial components are available for use at Superfund sites, and the remedial design reviewer will need to consider the various design needs associated with such components, and consult available guidance, literature or experts, as appropriate, associated with the design and construction of these components or technologies to assure that the component or technology will be properly and efficiently designed and constructed.

a. Are multi-well SVE systems designed to operate in a balanced configuration, e.g. is airflow adequately distributed among the various wells? (YES) (NO) (NA)

b. If pretreatment and/or direct discharge to a POTW is contemplated in the treatment plan, have discussions commenced with the POTW regarding discharge requirements, rates, etc? Does the POTW require any preliminary studies regarding acceptable pretreatment requirements/rates, or before it decides whether to accept the discharges? Has the responsible party for negotiation of an agreement been identified? (YES) (NO) (NA)

c. Are technical specifications being developed for the following: drilling and well installation; laboratory analytical services; surveying; waste disposal; permit acquisition for off-site activities (potentially including NPDES, erosion/sedimentation control, local municipality)? (YES) (NO) (NA)

d. Are technical specifications being developed for the following: drilling; laboratory analytical services; geotechnical laboratory services; surveying; waste disposal; permit acquisition for off-site activities (potentially including NPDES, erosion/sedimentation control, local municipality)? (YES) (NO) (NA)

e. Are dewatering requirements incorporated into the design, if appropriate (including how liquids produced during excavation process will be disposed of)? (YES) (NO) (NA)

f. Are technical specifications being developed to identify how depth of excavation will be determined (e.g., how deep excavation will go, any criteria/factors for when excavation should go deeper than specified, and/or any criteria/factors for when excavation should stop)? (YES) (NO) (NA)

g. Has the impact of geologic heterogeneity on the design of the selected remedy been considered? (YES) (NO) (NA)

E. <u>Cost Considerations</u>.

1. Was a remedial action cost estimate developed, and is it reasonable? (YES) (NO) (NA)

2. Are investigative/analytical costs for construction and O&M included and reasonable? (YES) (NO) (NA)

3. Are major work items identified and adequate quantity take offs in the estimate? (YES) (NO) (NA)

4. Are site work, mobilization/demobilization costs included? (YES) (NO) (NA)

5. Are markups (overhead, profit) and contingencies included? (YES) (NO) (NA)

6. Are other factors present that might cause undue price escalation, such as unnecessary bonding costs, fees and taxes? (YES) (NO) (NA)

7. Are non-routine O&M cost expenditures for equipment (such as pumps) and other items (such as GAC, well redevelopment) that occur intermittently, individually negotiated on an as needed basis rather than part of the basic contract? (YES) (NO) (NA)

F. Value Engineering Evaluation.

1. Has Life Cycle Cost Analysis (LCCA) been applied to the project selected solution (e.g. building construction materials: prefabricated metal building vs. concrete block and brick, skid mounted preassembled equipment vs. in place assembly), including costs for O&M and five-year reviews? (YES) (NO) (NA)

2. Has the user/customer been involved with all design decisions? (YES) (NO) (NA)

3. Are there any items in the design that are not required or essential for the project success? (YES) (NO) (NA)

4. Identify any high cost items. Are these items required, or are there other less expensive substitutes? Are there any sole-source, special or expedited procurement procedures that should be considered or developed for any particular item/component being designed. For example, are there any long-lead procurement requirements associated with limited source materials, such as nearby off-site borrow sources of clay for liners, capping or slurry walls? (YES) (NO) (NA)

5. Are there any aspects of the design that are complex? Can they be simplified? (YES) (NO) (NA)

6. Could an alternate construction method or sequence result in a capital or operation and maintenance cost savings? (YES) (NO) (NA)

7. Are all components consistent with the final remedy? (YES) (NO) (NA)

8. Was the design period compressed? Could certain portions of the project design be reevaluated? (YES) (NO) (NA)

9. Is the design behind the state of the art? (YES) (NO) (NA)

10) Is there any "custom, tradition, or opinion" built into the design? (YES) (NO) (NA)

11) Does the design use obsolete materials or construction methods? (YES) (NO) (NA)

G. Contracting.

1. Is the selected contract type for the RA (i.e., fixed price, cost reimbursement, and/or time and materials) for each component of the remedy proper/appropriate? (YES) (NO) (NA)

2. Use of fixed price contracts should be preferred if the scope of the construction is well defined. If the scope is not well defined, use of another contract vehicle should be considered. Has FAR subpart 16.104 been consulted to determine the proper contracting method (available at the following FAR website:
http://www.acquisition.gov/far/current/html/Subpart%2016_1.html#wp1085495)?
(YES) (NO) (NA)

3. Will certain performance based or prescriptive specifications have advantages for the RA proposed (e.g. treatment equipment, commissioning)? (YES) (NO) (NA)

4. Fixed priced bid items should be used as extensively as practicable, since they generally require less field oversight. Identify those items that would be appropriate to bid using fixed price line items. (YES) (NO) (NA)

5) If performance based specifications are to be used, can measurable performance standards be developed? (YES) (NO) (NA)

6. Are the proper bonding requirements outlined in the document? Are there bonding requirements that must be approved by higher authorities? (YES) (NO) (NA)

7. If a process or service is unique and has a single subcontractor that will perform a large portion of the work, the government should obtain a quote directly from that entity and place it in the bid form to eliminate the subcontractor from making individual proposals to multiple contractors, and perhaps influencing the bid process by inflating the bids given to certain contractors. Does this apply? (YES) (NO) (NA)

8. Is the submittal review and approval process clearly defined? (YES) (NO) (NA)

9. Will treatment plant operations be included in the contract, or will prove out and the first year of operation included as an option to the construction contract?. (YES) (NO) (NA)

10. Is progress documentation via photo and video defined? (YES) (NO) (NA)

Appendix B
Acronyms

ACSIM	Army Assistant Chief of Staff for Installation Management
AFCEE	Air Force Center for Engineering and the Environment
ARAR	Applicable or Relevant and Appropriate Requirement
AWEA	American Wind Energy Association
BMP	Best Management Practice
CERCLA	Comprehensive Environmental Response Compensation and Liabilities Act
CFR	Code of Federal Regulations
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
CSM	Conceptual Site Model
DoD	US Department of Defense
DOE	US Department of Energy
DQO	Data Quality Objective
EISA	Energy Independence and Security Act
EMCX	Environmental and Munitions Center of Expertise
EMS	Environmental Management System
EO	Executive Order
EPA	US Environmental Protection Agency
ESD	Explanation of Significant Differences
FAR	Federal Acquisition Regulations
FS	Feasibility Study
HTRW	Hazardous, Toxic, and Radioactive Waste
IC	Institutional Controls
ID/IQ	Indefinite Delivery Indefinite Quantity
IMR	Industrial Materials Reuse
IDW	Investigation Derived Waste
ISO	International Organization for Standardization
ITRC	Interstate Technology & Regulatory Council
LEED	Leadership in Energy and Environmental Design
LDR	Land Disposal Restriction
LID	Low Impact Development
NCP	National Contingency Plan
NCSC	North Carolina Solar Center
NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
OSHA	Occupational Safety and Heath Administration
OSWER	Office of Solid Waste and Emergency Response
PM	Particulate Matter
POTW	Publicly Owned Treatment Works
PRP	Potentially responsible party

RA	Remedial Action
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RFI	RCRA Facility Investigation
RI	Remedial Investigation
ROD	Record of Decision
ROT	Rules of Thumb
RPM	Remedial Project Manager
RSE	Remediation System Evaluation
SER	Sustainable Environmental Remediation
SURF	Sustainability Remediation Forum
SRT	Sustainable Remediation Tool
SVE	Soil/Vapor Extraction
TPP	Technical Project Planning
USACE	US Army Corps of Engineers
USDC	US Department of Commerce
VE	Value Engineering

Appendix C

Case Studies

This Appendix presents case studies compiled by the Sustainable Remediation Forum (SURF 2009) where sustainability metrics were an explicit element in the overall remediation assessment. Exhibit 6-1 summarizes case studies compiled from the United States, Exhibit 6-2 shows the geographical distribution of the case studies summarized in Exhibit 6-1, and Exhibit 6-3 summarizes some of the case studies conducted by the international community.

Exhibit 6-1. Summary of U.S. sustainability assessment examples

						Theme					Triple Bottom Line				
Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Minimize/Eliminate Energy or Natural Resource Consumption	Harness/Mimic a Natural Process	Reduce/ Eliminate Releases to Environment, Especially Air	Reuse/Recycle Inactive Land or Discarded Materials	Use of Technologies that Permanently Destroy Contaminants	Environmental	Economic	Social	Reference or Source	Contact
Altus Air Force Base	CERCLA 6 (OK)	Supported explanation of significant differences. Chose solar power used to recirculate contaminated groundwater in low-energy *in situ* bioreactor.	Landfill Leachate Chlorinated solvents	Soil vapor extraction and pump and treat	Optimization Implemented	X	X	X		X	X	X	X	EPA Technology News and Trends, Issue 30, May 2007	Erica.Becvar@brooks.af.mil
Altus Air Force Base	CERCLA 6 (OK)	Investigate passive treatment system as replacement for pump and treat	Groundwater Chlorinated solvents	Biowall	Optimization Implemented	X	X	X	X	X	X	X		Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Baird and McGuire	CERCLA 1 (MA)	Minimize carbon dioxide equivalent emissions from long-term operation and maintenance of pump-and-treat system.	Groundwater SVOCs	Combined heat and power engine or turbine with heat transfer	Optimization Proposed	X		X			X	X		Dorothy Allen, Massachusetts Dept. of Environmental Protection	Dorothy.T.Allen@state.ma.us
Bell Landfill	CERCLA 3 (PA)	Supported explanation of significant differences	Landfill Leachate Dissolved iron	Off-site disposal, constructed wetlands, spray irrigation	Optimization Implemented	X		X			X	X	X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com
Brevard	Closed Landfill 4 (NC)	Supported viability of recycling landfilled waste polyethylene terephthalate (PET)	N/A N/A	Production of virgin plastic vs. recycling landfilled waste	Recycle Studied	X		X	X		X	X	X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com

(continued)

Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
Burlington Mine Site	State VCP 8 (CO)	Reclaimed mine site	Soils and Surface Water Acid mine drainage, metals	Passive stream diversion, containment of waste rock, and mitigation of avian impacts	Remediation Implemented	X	X	X	X		X	X	X	EPA Technology News and Trends, Issue 37, July 2008	jcowart@walshenv.com
Carswell Joint Reserve Base	CERCLA 6 (TX)	Investigate passive, bio-based technology	Groundwater Chlorinated solvents	Biowall	Optimization, Implemented		X	X	X	X	X	X		Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Carteret	State 2 (NJ)	Supported remedy selection	Soil Arsenic and lead	Excavation and off-site disposal, *ex situ* stabilization, capping	Re-development Proposed	X		X	X		X	X	X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com
Chambers Works - Salem Canal	RCRA, State 2 (NJ)	Supported remedy selection	Groundwater Impacting Surface Water SVOCs	Extraction well, groundwater collection trench, sheet pile barrier with and without pumping wells, sand cap, geocomposite layer thin cap, aquablock cap, hydraulic dredging, clamshell dredging, *in situ* stabilization	Remediation Approved	X		X			X	X	X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com

(continued)

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Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
Chambers Works - Solid Waste Management Unit 8	RCRA, State 2 (NJ)	Supported remedy selection	Waste and Soil Impacting Groundwater VOCs, SVOCs, metals	Excavation and disposal, *in situ* stabilization, *in situ* biodegradation	Remediation Proposed	X	X	X		X	X	X	X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com
Confidential Former Electronics Manufacturing Facility	State 9 (CA)	Maximized reuse of demolition waste	Soil Petroleum hydrocarbons and VOCs	Chemical oxidation (*in situ* and *ex situ*), soil vapor extraction, lime stabilization	Remediation Implemented			X		X	X	X		Alan Leavitt, Northgate Environmental Management	alan.leavitt@ngem.com
Confidential Landfill	CERCLA 7 (Midwest)	Support remedy selection	Groundwater VOCs, SVOCs, metals	Groundwater collection (with and without a cut-off trench) and treatment, on-site and/or off-site treatment with subsequent on- and/or off-site disposal	Remediation Studied	X		X	X	X	X	X	X	Dave Hagen and Karin Holland, Haley & Aldrich	kholland@haleyaldrich.com
Dallas Naval Air Station	RCRA 6 (TX)	Select remedy for park development	Soil Pesticides	Cover in place	Remediation, Redevelopment Implemented	X		X	X		X	X	X	Allan Posnick, Texas Commission on Environmental Quality	posnick.allan@tceq.state.tx.us

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Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
Denver Federal Center	State 8 (CO)	Increase use of renewable energy for remediation, reduce sediment releases to storm water, reduce hazardous chemical use and the transfer of chemicals to other media, and re-develop site	Soil and Groundwater Trichloroethylene, PAHs, asbestos	Excavation, groundwater extraction, *in situ* chemical oxidation, monitored natural attenuation	Re-development Studied	X		X	X		X		X	Erik Petrovskis, GeoSyntec Consultants John Klein-schmidt, GSA	epetrovskis@geosyntec.com
De Sale Restoration Area	Voluntary 3 (PA)	Remediation of land	Surface Water Acid mine drainage, metals	Coal ash, settling ponds, vertical-flow ponds, and constructed wetlands to treat surface water	Remediation Implemented	X	X	X	X		X	X		EPA Technology News and Trends, Issue 37, July 2008	jayroberts@state.pa.us
Dover Air Force Base	CERCLA 3 (DE)	Investigate passive, bio-based technology versus pump and treat	Groundwater Chlorinated solvents	Biowall	Remediation Implemented		X	X	X	X	X	X		Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Fairchild Air Force Base	CERCLA 10 (WA)	Investigate passive, bio-based treatment system to achieve remedy in place	Groundwater Chlorinated solvents	Phytoremediation	Optimization Proposed		X	X			X	X	X	Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Ferdula Landfill	CERCLA, State 2 (NY)	Evaluated wind-driven vacuum processes vs. electrically powered air blowers for soil vapor extraction	Soil and Groundwater Toluene, trichloroethylene	Soil vapor extraction with carbon treatment	Remediation Implemented	X		X			X	X		David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com

(continued)

Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
F.E. Warren Air Force Base	CERCLA 8 (WY)	Compared passive, bio-based technology to zero-valent iron and an electronic barrier	Groundwater Chlorinated solvents	Biowall	Remediation Implemented		X	X	X	X	X	X		Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Florence	State 4 (SC)	Supported remedy selection	Soil Chlorinated VOCs	Excavation and off-site disposal, zero-valent iron clay *in situ* treatment, excavation and off-site thermal oxidation	Remediation Implemented	X		X	X	X	X	X	X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com
Former BP Refinery	RCRA, State VCP 8 (WY)	Worked with City of Casper to develop a cleanup strategy that could accommodate re-development of site, including commercial and multiple recreational uses	Soil and Groundwater BTEX	Pump and treat vs. groundwater pumping with engineered wetlands	Remediation, Re-development Implemented	X	X	X	X		X	X	X	EPA Technology News and Trends, Issue 36, May 2008	vmered@wyo.gov
Ft. Bliss Rod and Gun Club	RCRA 6 (TX)	Reclaimed contaminated soils	Soil Lead	Munitions recycling, soil reuse, mechanical and hand separation of lead bullet fragments, and lead bullet fragments reclamation	Remediation Implemented	X		X	X		X	X	X	Allan Posnick, Texas Commission on Environmental Quality	posnick.allan@tceq.state.tx.us
Hickam Air Force Base	CERCLA 9 (HI)	Investigate passive, bio-based solar-powered treatment system to achieve remedy in place	Soil and Groundwater Chlorinated solvents/leachate	In situ bioreactor	Remediation Proposed	X	X	X	X	X	X		X	Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil

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Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
Maricopa	CERCLA 9 (AZ)	Feasibility study for technical and financial risk management	Soil Recalcitrant VOCs, LNAPL	Soil vapor extraction	Optimization Studied	X	X	X		X	X	X		Mike Reardon, GeoSyntec Consultants Lowell Kessell, Good EarthKeeping Organization	mreardon@geosyntec.com lkessel@envirologek.com

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Exhibit 6-1. Continued

						Theme					Triple Bottom Line				
Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Minimize/Eliminate Energy or Natural Resource Consumption	Harness/Mimic a Natural Process	Reduce/ Eliminate Releases to Environment, Especially Air	Reuse/Recycle Inactive Land or Discarded Materials	Use of Technologies that Permanently Destroy Contaminants	Environmental	Economic	Social	Reference or Source	Contact
Martinsville	RCRA3 (VA)	Supported corrective measures study	Soil and Groundwater Chlorinated VOCs, BTEX, Freon®	Soil: *in situ* bioventing, enhanced biostimulation, passive bioventing, capping, off-site disposal, soil vapor extraction, excavation, off-site treatment, landfarm, *ex situ* thermal treatment, institutional controls, zero-valent iron clay Groundwater: pump and treat, constructed wetlands, phytoremediation, enhanced biostimulation, permeable reactive barrier, sparging, in-well stripping	Remediation Proposed	X	X	X	X	X	X	X	X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com

(continued)

Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
Massachusetts Military Reservation (CS-10)	CERCLA 2 (MA)	Optimize existing pump-and-treat system and monitoring network (sustainability assessment incorporated into the feasibility study)	Groundwater	No action, long-term monitoring, *in situ* chemical oxidation (pilot test), pump and treat	Optimization Studied	X		X		X	X	X	X	Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Massachusetts Military Reservation (Wind Turbine)	CERCLA 2 (MA)	Compared energy and air emissions by treatment systems to alternate energy source	Groundwater Ethylene dibromide and chlorinated solvents	Energy conservation, solar energy, wind energy	Optimization Implemented	X		X			X	X	X	Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
McGregor Naval Weapons Industrial Reserve Plant	CERCLA 6 (TX)	Investigated passive, bio-based technology versus pump and treat	Groundwater Chlorinated solvents	Biowall	Remediation Implemented		X	X	X	X	X			Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Mountain View Manufacturing Area	CERCLA 9 (CA)	Support optimization evaluation	Soil and Groundwater Trichloroethylene and other VOCs	In situ oxidation and bioremediation, traditional and enhanced pump and treat, subsurface cutoff walls, permeable reactive barriers, deep soil mixing, excavation in the saturated zone, exposure point and institutional controls	Optimization Studied	X		X		X	X	X	X	Maile Smith, Northgate Environmental Management	Maile.Smith@ngem.com

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Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
Navy Exchange	State Action 4 (MS)	Evaluate sustainable remediation	Soil and Groundwater BTEX	Air sparging, excavation, and monitored natural attenuation	Remediation Studied	X		X			X			Isis Rivadineyra, Naval FESC	Isis.Rivadineyra@navy.mil
Oakley	RCRA, State 9 (CA)	Assess investigation options for carbon dioxide, energy, resource consumption, and exposure hours	Soil Tetrachloroethylene	Geophysics, test pits, passive absorbers, membrane interface probe, Geoprobe©, drill rig	Remediation Proposed	X		X			X		X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com
Pompton Lakes	State 2 (NJ)	Support value engineering and remedy optimization for sustainability metrics	Sediment Mercury and lead	Hydraulic dredging, dry excavation, mechanical excavation	Remediation Studied	X	X	X			X		X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com
Pueblo Army Depot	CERCLA 8 (CO)	Investigated passive, bio-based technology	Groundwater RDX	Biowall	Remediation Implemented		X	X	X	X	X	X		Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Reemay	State 4 (TN)	Evaluated pump and treat and stimulated bioremediation.	Groundwater Trichloroethylene	Pump and treat and enhanced bioremediation	Optimization Implemented	X		X		X	X		X	David E. Ellis, DuPont	David.E.Ellis@usa.dupont.com
Romic	RCRA 9 (CA)	Investigated alternate treatment technologies	Soil and Groundwater Trichloroethene	Capping, hydraulic containment, excavation and off-site disposal, *in situ* bioremediation	Remediation Approved	X	X	X		X	X			Karen Scheuermann, USEPA Region 9	scheuermann.karen@epa.gov
Seneca Army Depot	CERCLA 2 (NY)	Investigated passive, bio-based technology	Groundwater Chlorinated solvents	Biowall	Remediation Implemented		X	X	X	X	X	X		Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil

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Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
State Road 114 Ground Water Plume Superfund Site	CERCLA 6 (TX)	Augmented treatment of VOCs by soil vapor extraction system and air stripper with cryogenic compression and condensation technology to recover hydrocarbons	Groundwater 1,2-Dichloroethane, vanadium	Soil vapor extraction with thermal oxidation, activated carbon, or C-3 technology; air stripper off-gas with activated carbon	Optimization Implemented	X		X	X		X	X	X	Vince Malott, USEPA Region 6	malott.vincent@epa.gov
Tourtelot	State 9 (CA)	Establish open space and wetlands	Soil and Groundwater Ordnance, explosives, metals, petroleum hydrocarbons	Bioremediation, *in situ* treatment using mechanical mixers, mechanical removal, soil sifting, blow-in-place, excavation and disposal, spread and scan, geophysical scanning, recycling of metal debris, and blast chamber	Remediation Implemented				X	X	X	X	X	Alan Leavitt, Northgate Environmental Management Scott Goldie, Brooks Street James Austreg, California DTSC	alan.leavitt@ngem.com

(continued)

Exhibit 6-1. Continued

Site	Regulatory Framework, EPA Region, Location (State)	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Theme: Minimize/Eliminate Energy or Natural Resource Consumption	Theme: Harness/Mimic a Natural Process	Theme: Reduce/ Eliminate Releases to Environment, Especially Air	Theme: Reuse/Recycle Inactive Land or Discarded Materials	Theme: Use of Technologies that Permanently Destroy Contaminants	Triple Bottom Line: Environmental	Triple Bottom Line: Economic	Triple Bottom Line: Social	Reference or Source	Contact
Travis Air Force Base	CERCLA 9 (CA)	Investigate passive, bio-based solar-powered treatment system to achieve remedy in place	Soil and Groundwater Chlorinated solvents	*In situ* bioreactor	Remediation Proposed	X	X	X	X	X	X		X	Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Travis Air Force Base	CERCLA 9 (CA)	Reduce energy consumption for groundwater extraction at remote site	Groundwater Chlorinated solvents	Solar powered extraction pumps	Optimization Implemented	X		X				X	X	Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Travis Air Force Base	CERCLA 9 (CA)	Investigate of passive, bio-based treatment system to achieve remedy in place	Groundwater Chlorinated solvents	Phytoremediation	Optimization Proposed		X	X			X	X	X	Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil
Whiteman Air Force Base	CERCLA 5 (IL)	Investigated passive, bio-based technology	Groundwater Chlorinated solvents	Biowall	Remediation Implemented	X	X	X	X	X	X	X	X	Erica Becvar, AFCEE	Erica.Becvar@brooks.af.mil

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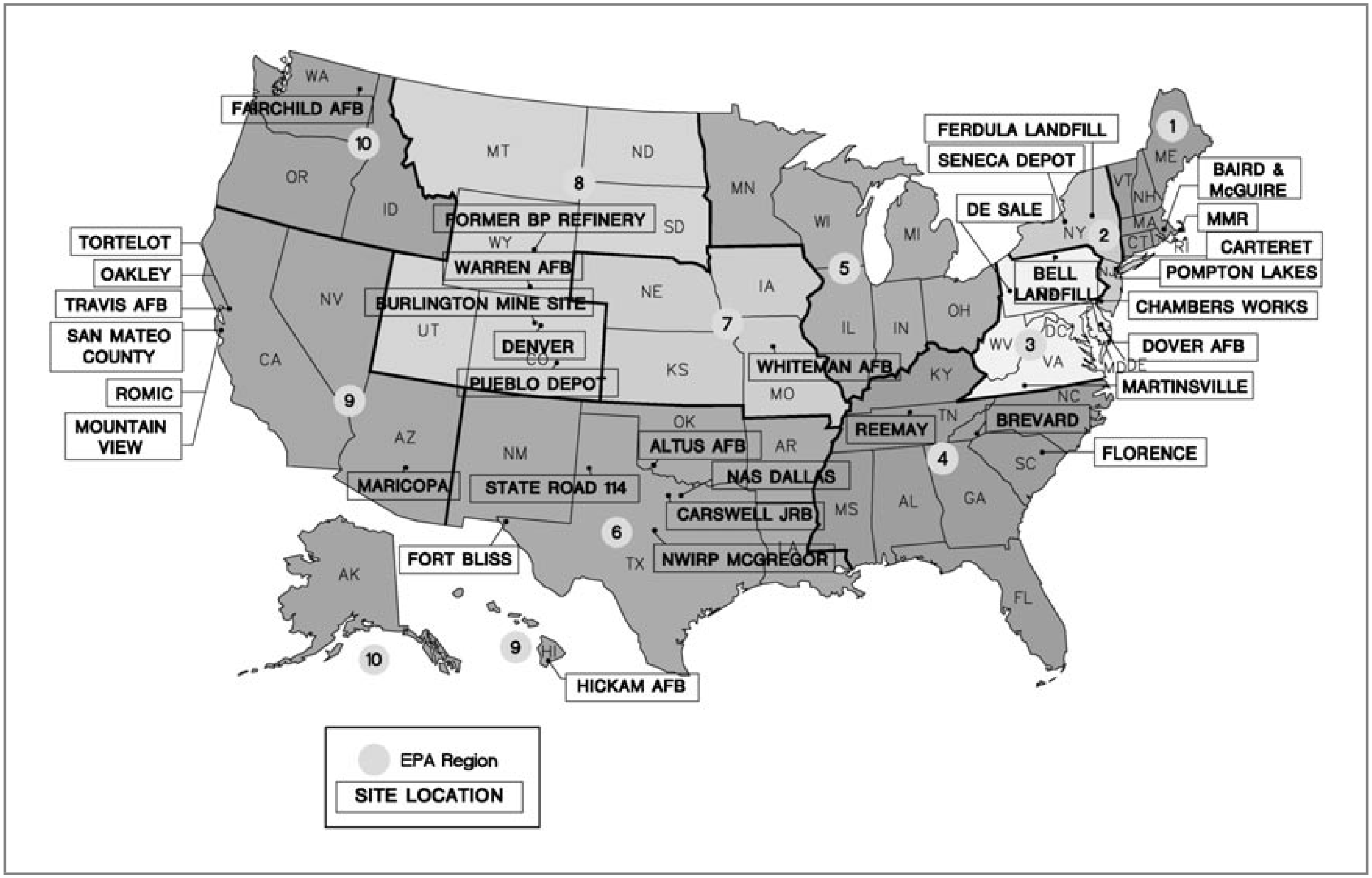

Exhibit 6-2. Sustainability assessments in the United States

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Exhibit 6-3. Summary of international sustainability assessment examples

						Theme					Triple Bottom Line				
Site	Regulatory Framework, Location	Purpose	Impacted Media, Contaminant(s)	Technologies Evaluated	Primary Driver and Status	Minimize/Eliminate Energy or Natural Resource Consumption	Harness/Mimic a Natural Process	Reduce/ Eliminate Releases to Environment, Especially Air	Reuse/Recycle Inactive Land or Discarded Materials	Use of Technologies that Permanently Destroy Contaminants	Environmental	Economic	Social	Reference or Source	Contact
Railroad Tie Treatment Site	Provincial Order, British Columbia, Canada	Remedy selection	Sediments and Groundwater Dense Nonaqueous Phase Liquid	Pump and treat, caisson dredging, capping, risk assessment, sealed sheet pile wall and marsh construction	Remediation Studied	X	X	X	X		X	X	X	Stella Karnis, Canadian National, Don Bryant, Keystone Environment	stella.karnis@cn.ca
Rail Yard	Voluntary, Ontario, Canada	Multicriteria analysis tool.	Soil and Groundwater Diesel	Interceptor sumps, interceptor trench, multiphase extraction, hydraulic barrier, injection of oxygenated water	Optimization Studied	X		X		X	X	X	X	Stella Karnis, Canadian National, Robert Noel de Tilly, Golder	stella.karnis@cn.ca
Typical Gas Station	Study, Sweden	Assessment tool development	Soil BETX	On-site composting, off-site composting, In-situ aeration	N/A Studied	X	X	X			X	X	X	Lars Davidsson, WSP Environment & Energy, Halmstad, Sweden	lars.davidsson@wspgroup.se
Gela Plain, Sicily	Unknown, Italy	Feasibility Study	Soil TPH	Thermal desorption, ex situ landfarming, in situ landfarming, vertical barrier	Remediation Studied	X	X	X			X		X	Alessandro Battaglia, ENSR	abattaglia@ensr.aecom.com
Multiple: Manufactured Gas Plant, Waste Depository, Dry Cleaners	Various, Germany	Evaluate alternative technologies	Soil Chlorinated VOCs and BETX	Steam-enhanced SVE, conductive heating-enhanced SVE and "cold" SVE	Optimization Studied	X		X			X	X	X	Uwe Hiester, reconsite TTI GmbH ConSoil 2003 and 2005	uwe.hiester@reconsite.com

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