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Engineering Forum Issue Paper

Agriculture-to-wetland project at the Lower Basin of Coeur d'Alene River, Superfund cleanup site in northern Idaho.

Ecosystem Services at Contaminated Site Cleanups

Contents

The Technical Support Project (TSP) Engineering Forum issue papers provide information on remediation technologies or technical issues of concern. The information is not guidance or policy.

"Ecosystem goods and services are the many life-sustaining benefits we receive from nature— clean air and water, fertile soil for crop production, pollination, and flood control."

- U.S. Environmental Protection Agency, 2017
www.epa.gov/eco-research/ecosystems-services

1. Purpose

The U.S. Environmental Protection Agency (EPA) developed this issue paper to provide cleanup site teams with information about ecosystem services. These concepts and tools are useful in communicating the positive results of cleanup in addition to achieving the goals of cleanup. Information about ecosystem services may be considered in characterization of future land use options or design of a cleanup that is consistent with anticipated ecological reuse, depending on the regulatory authority of the cleanup program. This document does not provide guidance on how ecosystem services may or may not be factored into specific cleanup programs.

2. Ecosystem Services

Ecosystem services (ES) are the outputs of ecological processes that contribute to human health and well-being or have the potential to do so in the future (Munns *et al*., 2015). Ecosystems provide services to humans, such as pollination or flood control, that typically are not fully accounted for in economic markets, policy decisions or individual projects (Costanza *et al*., 1997). **Ecosystem goods and services (EGS)** is a synonymous variation of the term ecosystem services. "Goods" refer to products like food and timber, while "services" refer to processes like water purification and coastal protection (US EPA, 2017a). Practitioners, researchers and policymakers use both the ES and EGS terms. In this paper, ES terminology is used to reflect both goods and services.

The EnviroAtlas Eco-Health Relationship Browser illustrates how ecosystems contribute to human health:
www.epa.gov/enviroatlas/enviroatlas-eco-health-relationship-browser

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Many decisions and actions influence ecosystems and their production of services. Understanding and evaluating ES at a site informs environmental decision-making, ultimately leading to more comprehensive environmental protection and better articulation of its benefits to the public (Munns *et al*., 2017). **Text Box 1** defines concepts useful in the discussion and evaluation of ES.

Text Box 1. Common Terminology for Ecosystem Services Discussion and Evaluation

Beneficiaries

Beneficiaries are "the interests of an individual that drive active or passive consumption and/or appreciation of ecosystem services resulting in an impact on their welfare." Example beneficiaries are experiencers and viewers, anglers, researchers, farmers and residential property owners (Landers *et al*., 2013).

Final and Intermediate

Humans directly consume, use or enjoy final ES. General examples include water supply, recreation and raw materials. Humans indirectly benefit from intermediate ES. Nutrient cycling is an example of an important, intermediate ecosystem service that supports many final ES (US EPA, 2017b).

Millennium Assessment Categories

The United Nations' 2005 Millennium Assessment defined four categories of ecosystem services: provisioning (e.g. water supply), regulating (e.g. erosion control), cultural (e.g., recreation) and supporting (e.g., habitat). These categories help communicate how ecosystems contribute to human well-being (Millennium Ecosystem Assessment, 2005).

Ecological Production Functions

Ecological production functions (EPFs) are usable expressions (i.e., models) of the processes that occur within an ecosystem to produce ES. Useful EPFs estimate final ES, yield quantitative outcomes and respond to management scenarios (Bruins *et al*., 2017).

Indicators

Evaluation of ecosystem goods and services requires the selection of relevant indicators. For a site with birdwatching recreational opportunities, for example, bird species richness may be selected as an indicator (National Ecosystem Services Partnership, 2016b).

Ecosystem services evaluations have been applied in a variety of natural resource management and decision contexts, such as urban planning, wildlife conservation and wetland restoration. Evaluation of ES may be qualitative or quantitative; however, replicable quantitative evaluation facilitates communication of the decision process (National Ecosystem Services Partnership, 2016a). Below are a few of the ecosystem processes and services that have been quantified:

- Removal of air pollutants such as nitrogen-oxygen, ozone or particulate matter.
- Quality and quantity of surface water and groundwater.
- Interception and infiltration of storm water.
- Regulation and reduction of flood risk.
- Retention of soil and sediment and reduction of erosion.
- Hunting, fishing and wildlife viewing.
- Crop production due to wild pollinators.

For examples of ecosystem services quantification by several federal programs and agencies, refer to the *Federal Resource Management and Ecosystem Services Guidebook* (National Ecosystem Services Partnership, 2016a).

3. Considerations During Cleanup

Contaminated media are removed or remediated for the protection of human health and the environment in accordance with the regulatory requirements under which the cleanup operates. During the cleanup process, additional results of interest to the public and stakeholders may arise, including protection of existing habitat or creation of habitat that provides ES. Ecological considerations during cleanup vary based on the legal stipulations, stakeholder and community interest and site-specific issues. **Text Box 2** provides examples of opportunities and limitations under the Superfund cleanup process.

Many contaminated site cleanups incorporate considerations of the remedies' impact on ecosystems and their services. For example, **ES assessment endpoints** may be incorporated into ecological risk assessment to inform remediation decisions (US EPA Risk Assessment Forum, 2016b). **Ecological revitalization**, the technical process of returning land from a contaminated state to one that supports functioning and sustainable habitat, may occur at sites with anticipated **ecological reuse** (US EPA, 2009a). Likewise, an **environmental footprint analysis** of remedy implementation and **greener cleanup best management practices (BMPs)** may inform the development of site management approaches consistent with anticipated ecological reuse (US EPA, 2009b). **Figure 1** illustrates conceptual connection between ES in ecological risk assessment and approaches for ecological reuse.

Formerly contaminated sites in ecological reuse provide ES to the surrounding communities and geographic region. For site-specific examples of ecological revitalization and reuse, refer to case study profiles on Contaminated Site Clean-Up Information (CLU-IN) webpages: *www.clu-in.org/greenremediation/profiles* and *www.clu-in.org/ecotools/case.cfm*.

Text Box 2. Ecological Considerations Relevant to Superfund Cleanups

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establish EPA's responsibilities during Superfund cleanups (US EPA, 2017d; Legal Information Institute, 2017). Superfund response actions are limited to what is needed to achieve protection of human health and the environment. During Superfund site cleanups, ecosystem services concepts may arise during discussion of the following processes:

- **Ecological Risk Assessment** *(EPA responsibility)*

  Ecological risk assessment (ERA) evaluates the likelihood that adverse effects to ecological entities may occur as a result of exposure to site contaminants (US EPA, 1997). Ecological risk assessors select site-specific assessment endpoints that serve to focus the risk assessment design and analysis. Assessment endpoints establish the risk basis of a cleanup action. Ecological risk assessors have the option to develop assessment endpoints from a set of conventional generic ecological assessment endpoints (C-GEAEs) and a set of generic endpoints based on ecosystem services (ES-GEAEs) (US EPA Risk Assessment Forum, 2016b).

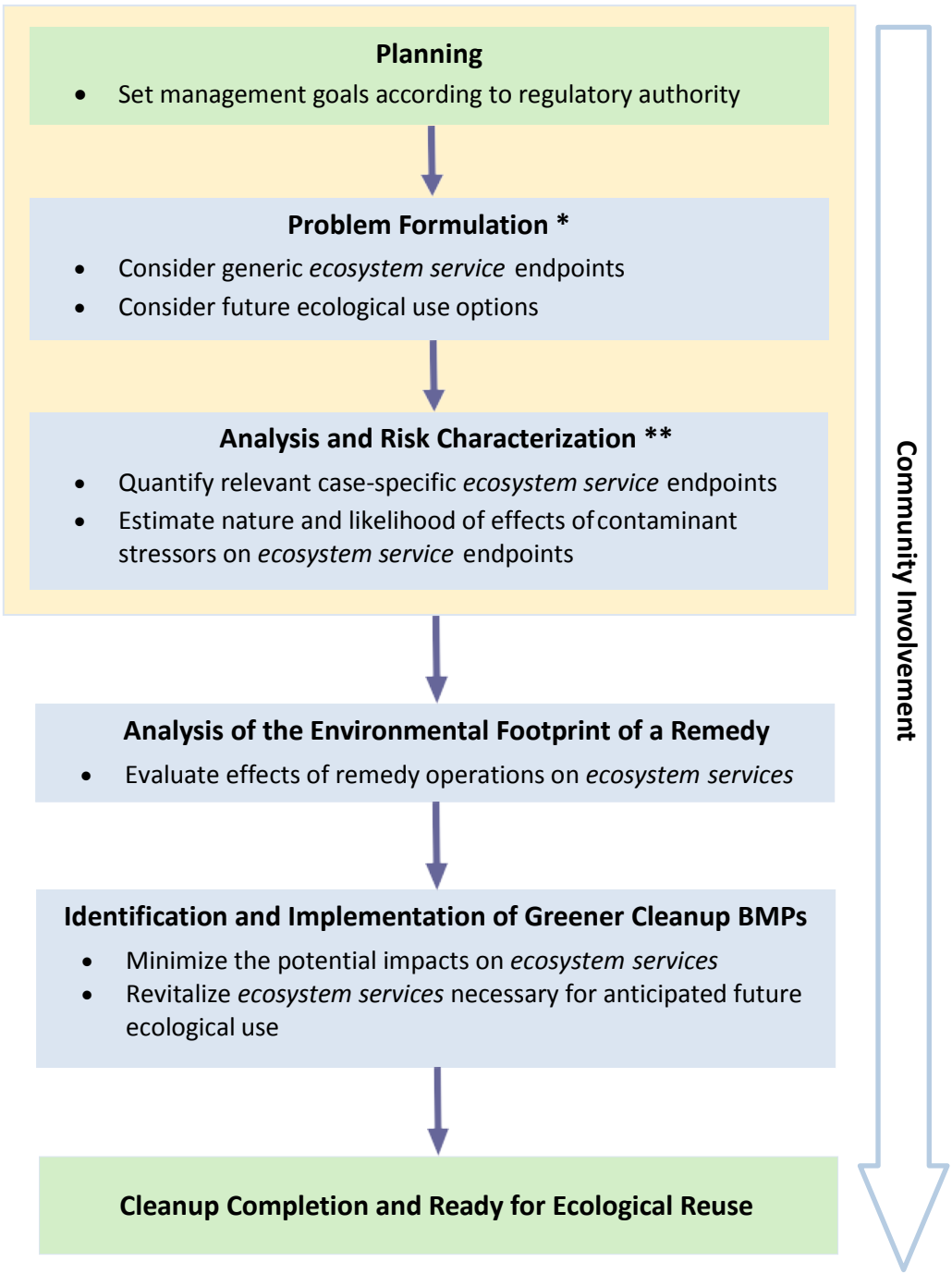
- **Natural Resource Damage Assessment** *(Natural Resource Trustee responsibility)*

  The US EPA Risk Assessment Forum explains how ES-GEAEs may translate information about natural resources: "CERCLA provides authority for remediation of contaminated sites and restoration of injured natural resources. Site remediation decisions are informed by ERA, whereas restoration and compensation decisions are informed by the natural resource damage assessment (NDRA) process. The goals of NRDA are to return natural resources injured due to the release of hazardous substances to their uninjured or baseline condition (i.e., the condition prior to the release of hazardous substances) through direct restoration or replacement of injured resources, and to compensate the public for ecosystem service losses occurring until those injured resources are restored. Ecological injuries are quantified in terms of the reduction in the physical, chemical or biological ecosystem services that the natural resources provide. Compensation for those injuries is claimed in terms of damages (monetary) or directly as restoration actions. Damages are calculated using various market and nonmarket economic techniques. Damages and direct restoration projects are scaled to the magnitude of the injury claim. The objectives for ERA conducted under CERCLA and similar state statutes are to identify and characterize the current and potential threats to the environment from a hazardous substance release and identify cleanup levels that would protect those natural resources from additional adverse effects." (US EPA, 1997; US EPA Risk Assessment Forum, 2016a)

- **Reasonably Anticipated Future Land Use** *(Collaborative responsibility)*

  Ecological revitalization and reuse provides a variety of environmental, economic and social benefits (i.e., ecosystem services). Notably, as explained in the EPA publication Ecological Revitalization: Turning Contaminated Properties into Community Assets, "under the Superfund Program, EPA cannot fund ecological enhancements (that is, activities not necessary for the protection of human health and the environment); rather, it can encourage enhancement activities funded by other stakeholders and can fund aspects of a cleanup project that are necessary for the anticipated future uses of a property. Under the Superfund Program, EPA can fund activities to better understand the reasonably anticipated future land use, which informs remedy selection and implementation and helps support long-term protectiveness. Anticipating the future use of a Superfund site after cleanup completion is of key importance in selecting and designing a remedy that will be consistent with that use. In general, most ecological revitalization efforts are not considered enhancements if the activities are necessary for the anticipated future ecological use of the property." (US EPA, 2009a)

Figure 1. Conceptual Process for Considering Ecosystem Services During Cleanup Activities



* See *Valuing the Protection of Ecosystem Systems and Services* (US EPA, 2009c).

** *Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment: Second Edition with Generic Ecosystem Services Endpoints* explains how to consider ES in an ERA and demonstrates the utility of incorporating ecosystem service endpoints (US EPA Risk Assessment Forum, 2016b).

4. Community Involvement

Identification of beneficiaries is essential to the identification of ES (Text Box 1). Community groups, tribes, municipalities and other stakeholders are examples of beneficiaries of a cleanup site's ES. Their knowledge and values inform ecological reuse considerations.

The Superfund Redevelopment Initiative reuse assessment process is an example of gathering information about community interests in future land use (US EPA, 2001). For sites with planned ecological reuse, the community may share which ES they want from the site. **Highlight 1** illustrates how a citizens advisory group shared their interest in pollinator habitats.

The Superfund Redevelopment Initiative provides tools and resources for site reuse:
www.epa.gov/superfund-redevelopment-initiative/supporting-current-and-future-use

Highlight 1: Community Involvement Informs Ecological Reuse

Chemical Commodities Inc.

Superfund National Priorities List, Region 7 (US EPA, 2017e)

The former . (CCI) operations contaminated the soil and groundwater next to a suburban neighborhood in Olathe, Kansas. Residents formed the CCI Citizens Advisory Group (CAG), Inc. to actively engage in the Superfund cleanup process. With technical support from the US EPA and The Boeing Company, the CCI CAG, Inc. conducted a survey of residents' opinions about the site's redevelopment. The CAG reported that the residents valued green space and parks. Boeing enlisted the expertise of organizations such as Monarch Watch and the Pollinator Partnership to transform the former chemical recycling facility into pollinator habitat and green space. Now called the Pollinator Prairie, the site supports birds, bees and butterflies (including the monarch) while providing education, research and recreation benefits to the community. In 2013, the Pollinator Prairie was certified through the Corporate Lands for Learning program by the Wildlife Habitat Council and highlighted in a US EPA video (US EPA, 2013).

Photos from: http://www.pollinator.org/pollinator-prairie

5. Ecosystem Services Evaluation Tools

Publicly available tools can be used to document and quantify ES at a cleanup site, as consistent with regulatory cleanup authority or voluntary stakeholder interest. In some cases, ES evaluation tools may be used as part of a cleanup's environmental footprint analysis. Several positive outcomes may result from the use of ES evaluation tools:

- Engagement with the public and stakeholders about anticipated future ecological use.
- Communication of the societal relevance of ecological risk-based cleanups.
- Transparent documentation of the ecosystem conditions onsite "before and after" cleanup.
- Replicable, defensible selection of greener cleanup BMPs.

Many ES evaluation tools have been developed for different ecosystems, levels of technical expertise, management questions and result outputs. Types of tools include maps (**Highlight 2**), software models and spreadsheet kits. **Appendix A** describes a curated list of ES evaluation tools.

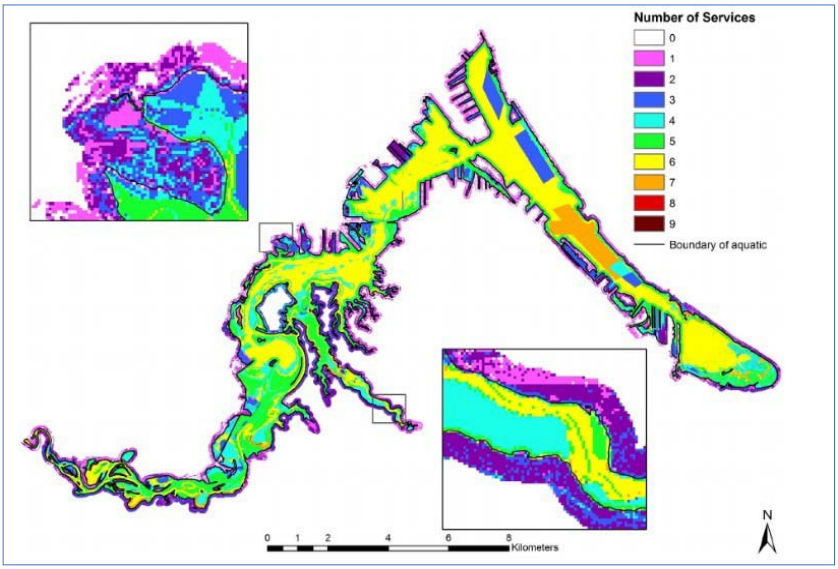
Highlight 2: Service Providing Area Maps of Contaminated Areas

St. Louis River U.S. Steel Site

Cooperative Areas of Concern-Superfund National Priorities List, Region 5 (Angradi et al., 2016)

The U.S. Steel Superfund site is part of the St. Louis River Estuary Area of Concern (AOC)† on the Minnesota-Wisconsin border at Lake Superior. Remediation plans involve excavating contaminated sediment and constructing a confined disposal facility. A team led by the U.S. EPA Office of Research and Development created a service providing area (SPA) map as a tool to understand the impact of remedial actions on ES. Based on the St. Louis River Habitat Plan drafted by the citizen's action committee, available data and relevance to AOC delisting targets, the team identified 23 ES in the St. Louis River estuary. They selected biophysical indicators for each final ES and used ArcGIS spatial models to map indicator presence or absence at high resolution. The SPA map displayed areas of the St. Louis River estuary with the most or fewest final ES (Figure 2). Then the team quantified changes in SPA (km^2) for ES by predicting biophysical changes resulting from proposed remedial actions. The map and quantitative information may be used to communicate the effect of cleanup activities on ES with the public and to inform coordinated action among Superfund and AOC authorities.

Figure 2. SPA map of St. Louis River estuary with inset of U.S.



Graphic from: https://www.researchgate.net/profile/Brent_Bellinger/publication/301757266/figure/fig3/AS:357729559433216@1462300781249/Fig-5-Composite-SPA-map-for-the-SLRE-showing-the-number-of-final-ecosystem-services-for.jpg

† The US EPA oversees AOC restoration under the Great Lakes Water Quality Agreement, with Great Lakes Legacy Act and Great Lakes Restoration Initiative funding (US EPA, 2017c).

6. Best Management Practices for Ecosystem Services

As part of considering reasonably anticipated future land use, ES revitalization may be factored into remedy implementation. Remedial activities may contribute to soil compaction, loss of natural contours and drainage patterns, sediment runoff into waterways, habitat loss and noise or light pollution (Slack, 2010). These effects alter the quality and/or quantity of ES. Site management approaches can be developed to manage the effects of remedy operations on ES. Greener cleanup BMPs that address ES may be considered.

Table 1 provides examples of greener cleanup BMPs. Example greener cleanup BMPs are linked to three example ES commonly impacted at cleanup sites. **Highlight 3** describes an example of the responsible party voluntarily implementing greener cleanup BMPs for ecological reuse.

Find descriptive information about ecological considerations for cleanups in:
Ecological Revitalization: Turning Contaminated Properties into Community Assets

Find BMPs in the "land and ecosystems" category of "Table X3.1 Greener Cleanup BMPs" in:
ASTM Standard Guide for Greener Cleanups (E2893)

Table 1. Examples of Greener Cleanup BMPs Related to Ecosystem Services

	Example Greener Cleanup BMPs	Example Ecosystem Services		
		Habitat	***Erosion Control***	***Recreation***
Site Assessment Phase	Consider and document property characteristics for habitat connectivity, topography, site access, etc.	✓	✓	✓
Remedial Phase	Design works zones, traffic plans and construction phases to avoid habitat disruption.	✓	✓	✓
	Retain existing habitat and vegetation, especially habitats with high ES value and large trees.	✓	✓	✓
	Eradicate invasive plant species on site and use control measures to prevent invasion of non-native plants.	✓		
	Place mulch and metal grates over traffic corridor surfaces.		✓	
	Construct long-term ecological structural controls such as bio-swales and vegetated riprap.	✓	✓	
	Plant regionally native vegetation and pollinator habitats on bare soil and caps.	✓	✓	✓

Highlight 3: Greener Cleanup BMPs Support Ecological Reuse

Bayou Verdine

Superfund Non-Time Critical Removal Action, Region 6 (US EPA, 2016)

When the US EPA site team and Phillips 66 began discussing closure of a waste containment cell, the site team recognized an opportunity to revitalize ES at the Bayou Verdine cleanup site in Lake Charles, Louisiana. Phillips 66 collaborated with the US EPA and community stakeholders to complete a work plan that supported ecological land reuse. During cleanup, the US EPA and Phillips 66 implemented a greener cleanup strategy with BMPs to protect the existing ecosystem. BMPs included: minimizing activity along the shore to preserve riparian habitat, keeping large trees by adjusting access road construction or by pruning them, reusing cleared trees onsite to create new habitat, and relocating fish before constructing the containment cell from an existing pond. To repair and revitalize the ecosystem, Phillips 66 created pond and wetland habitat around the containment cell and constructed a bio-swale to hydraulically connect the new habitat to Bayou Verdine. Additionally, they established a pollinator habitat on the capped containment cell. The revitalized Bayou Verdine site now provides habitat for wetland birds, fish, aquatic wildlife and pollinators. The functional ecosystem, in turn, contributes to human well-being (US EPA, 2017f).

The new wetland habitat supports migratory birds.

Wildflowers on the cap provide pollination services.

The site team reused cleared trees onsite as habitat features.

Photos provided by: Chris McGowan, Project Manager, Phillips 66

7. Summary

This issue paper introduces ES concepts and tools to managers of contaminated site cleanups. ES terminology explains how ecosystems connect to human health and well-being. The discussion and evaluation of ES at Superfund sites may help improve site management, communication with the public and engagement with stakeholders. Likewise, a site's ecological risk assessment may utilize ES as assessment endpoints. Quantitative information about ES at a site supports the characterization of reasonably anticipated future land use and selection of greener cleanup BMPs for ecological reuse.

8. Acknowledgements

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9. Notice and Disclaimer

The Engineering Forum, a component of the U.S. EPA Superfund Technical Support Project, has authored this issue paper. Information and opinions contained in this paper are technical in nature, and represent the professional opinions of the participants. This issue paper underwent US EPA expert review and was approved for publication as a US EPA document. The information is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation with the United States or any other party. Use or mention of trade names does not constitute an endorsement or recommendation for use.

A PDF version of this issue paper, *Ecosystem Services at Contaminated Site Cleanups,* is available to view or download at the US EPA TSP – Engineering Forum website, *www.epa.gov/remedytech/technical-support-project-cleaning-contaminated-sites-engineering-forum*.

10. Selected Resources

www.clu-in.org/ecotools is regularly updated with resources for ecological issues at contaminated sites.

Ecological Revitalization and Reuse at Contaminated Sites

- *Ecological Revitalization: Turning Contaminated Properties into Community Assets.* U.S. Environmental Protection Agency. EPA 542-R08-003. February 2009.
- *Superfund Redevelopment Initiative.* U.S. Environmental Protection Agency. *www.epa.gov/superfund-redevelopment-initiative*.
- *Superfund Sites with Green Space Reuse–Sites with Ecological Reuse*. U.S. Environmental Protection Agency. *www.epa.gov/superfund-redevelopment-initiative/superfund-sites-green-space-reuse#ecological*.
- *Superfund Regional Redevelopment Contacts.* U.S. Environmental Protection Agency. *www.epa.gov/superfund-redevelopment-initiative/regional-redevelopment-contacts*.

Greener Cleanup Best Management Practices

- *ASTM Standard Guide for Greener Cleanups* (E2893-16). ASTM International. Available through the US EPA CLU-IN Green Remediation Focus website, at *clu-in.org/greenremediation/standard*.
- *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites.* U.S. Environmental Protection Agency. EPA 542-R-08-002. April 2008.
- *Methodology for Understanding and Reducing a Project's Environmental Footprint.* U.S. Environmental Protection Agency. EPA 542-R-12-002. February 2012.
- *The Incorporation of an Ecosystem Services Assessment into the Remediation of Contaminated Sites.* Slack, S. National Network for Environmental Management Studies. August 2010.

Ecosystem Services

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Appendix A. Ecosystem Services Evaluation Tools

This appendix lists ecosystem services (ES) evaluation tools that have been curated for potential applicability to contaminated sites. The ES evaluation tools described in the following two lists are included because (1) they are publicly accessible for no charge, (2) they can be used in any region of the United States, (3) they are intended for use in land management, and (4) they have outputs to share with general audiences. This information is not an exhaustive listing of all ES evaluation tools and it should not be considered endorsement of any one tool or resource.

Table A-1. List of ES Evaluation Tools Developed by the US EPA

Name	Description
FEGS-CS Query Tool *List of services and indicators* *https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-classification-system*	The Final Ecosystem Goods and Services Classification System (FEGS-CS) Query Tool is an identification tool with a standard process. It includes a total of 352 specific FEGS provided by 15 environmental subclasses and utilized by 38 beneficiary subcategories. The Query Tool helps guide the user through customizing the FEGS Matrices for a particular site. The Query Tool allows the user to query by environmental sub-class, beneficiary subcategory or category of FEGS. (ORD SHC 2.61.2) **Level of expertise:** Low
NESCS Classification Structure *Identification system* *www.epa.gov/eco-research/national-ecosystem-services-classification-system-framework-design-and-policy*	The National Ecosystem Services Classification System (NESCS) supports the identification step of analyses. Its Classification Structure provides a four-group structure composed of environment, end-product, direct-use and direct user. This allows the user to trace a unique and comprehensive set of pathways from the ecological systems that generate ES to the humans who use or appreciate them. (ORD SHC 2.61) **Level of expertise:** Low
EnviroAtlas *Interactive map* *www.epa.gov/enviroatlas*	EnviroAtlas is designed to help anyone interested in learning the benefits or impacts of a decision that influences ecosystems. EnviroAtlas layers include intermediate and final ecosystem services. The layers correspond to ES indicators, which can be analyzed to depict how various decisions can affect ecological and human health outcomes. (ORD SHC 1.62) **Level of expertise:** Low-Moderate
EPA H2O *GIS application* *www.epa.gov/water-research/ecosystem-services-scenario-assessment-using-epa-h2o*	The EPA H2O Tool allows users to create maps of the spatial arrangement of ecosystem goods and services at regional to local scales. Land managers can gain understanding of how land use change affects the provision of ecosystem services. **Level of expertise:** Moderate

Name	Description
EcoService Models Library (ESML) *Searchable database* *www2.epa.gov/eco-research/ecoservice-models-library*	The EcoService Model library serves as a single site to make ecological model descriptions more available and informative for developing tools and models that illustrate the important connections between healthy ecosystems and people. The ESML is a website and database for finding, examining and comparing ecological models that may be useful for estimating ecosystem goods and services. The ESML was designed for scientists and economists who provide advice to communities, businesses and conservation organizations. (ORD SHC 2.61.3) **Level of expertise:** Low
Rapid Benefits Indicators (RBI) Approach *Toolkit* *www.epa.gov/water-research/rapid-benefit-indicators-rbi-approach*	The RBI approach toolkit includes an interactive Excel spreadsheet and fillable checklist form (PDF). It uses readily-available data to estimate and quantify non-monetary benefits to people around an ecological restoration site. The analysis will allow site managers and stakeholders to systematically document and select restoration actions. **Level of expertise:** Low

Table A-2. List of ES Evaluation Tools Developed by Other Agencies or Organizations

Name	Description
TESSA *Toolkit* *tessa.tools*	The Toolkit for Ecosystem Service Site-Based Assessment (TESSA) is designed to provide practical guidance on the entire ecosystem services evaluation process. It informs how to identify services at the site, what data are needed to measure them, what methods or sources can be used to obtain the data, and how to communicate the results. **Level of expertise:** Low
ValuES Method Database *Searchable database* *aboutvalues.net/method_database*	The ValuES interactive database allows the user to select ecosystem service evaluation tools and methods that best match the site decision context. User can filter by purposes, type of method, and ecosystem services. **Level of expertise:** Low
SolVES *GIS application* *solves.cr.usgs.gov*	The Social Values for Ecosystem Services (SolVES) tool incorporates spatially explicit measures of social values into ecosystem services assessments. Users can generate social-value maps and derive a quantitative index score for environments. **Level of expertise:** Moderate
Wetland Ecosystem Services Protocol for the United States (WESPUS) *Toolkit, wetland sites* *www.novascotia.ca/nest/wetland/docs/Manual_WESPUS.pdf*	The Wetland Ecosystem Services Protocol for the United States (WESPUS) is a standardized method to assess ecosystem services at the scale of an individual wetland. The evaluation requires completing an Excel spreadsheet which automatically generates scores for wetland functions and values. Aerial imagery and observations during a single site visit are needed to fill out the form. Use of a GIS is not required. **Level of expertise:** Low-Moderate

Name	Description
InVEST *Computer Model* *www.naturalcapitalproject.org/invest*	InVEST is a suite of free, open-source software models. The models use maps as information sources and produce maps as outputs. It requires GIS software. Models include: Carbon, Crop Pollination, Fisheries, Habitat Quality, Habitat Risk Assessment, Recreation, Scenic Quality, Sediment Retention, and Water Purification. **Level of expertise:** High
i-Tree Eco *Computer Model, forested sites* *www.itreetools.org/eco/overview.php*	i-Tree Eco is a software application designed to use field data measurements of trees throughout a community along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects and value to communities. Baseline data can be used for making effective resource management decisions and setting priorities. Many U.S. cities use i-Tree Eco to evaluate the services of trees throughout the city. **Level of expertise:** Low-Moderate
Ecosystem Services Identification & Inventory Tool (ESII Tool) *Field app and web interface* *www.esiitool.com*	The ESII Field App allows the user to download maps for their site, then go into the field and collect spatially-explicit ecological data for their site. In the ESII web interface, the user can review and edit the data, run the ESII Tool's ecological models, and generate results in a variety of user-friendly formats. The tool provides the option for several forms of outputs. It is designed for the non-ecologist. **Level of expertise:** Low

To explore more ES evaluation tools, please refer to the following resources:

- **Data and Modeling Paper** by the National Ecosystem Services Partnership
  https://nespguidebook.com/assessment-framework/data-and-modeling-paper/
- **Appendix: Categories of Tools** in *Making the Invisible Visible: Analytical Tools for Assessing Business Impacts and Dependencies Upon Ecosystem Services* by BSR
  http://www.bsr.org/reports/BSR_Analytical_Tools_for_Ecosystem_Services_2014.pdf