UNDERSTANDING ECOSYSTEM SERVICES AT SUPERFUND CLEANUPS

August 2017

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for

U.S. Environmental Protection Agency
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Office of Superfund Remediation and Technology Innovation
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This project was supported in part by a two-year appointment to the Internship/Research Participation Program at the Office of Superfund Remediation and Technology Innovation, EPA, administered by the ORISE through an interagency agreement between the U.S. Department of Energy and EPA.

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This report was the developed in collaboration with the EPA Technical Support Project (TSP) Engineering Forum and the EPA Ecological Risk Assessment Forum (ERAF).

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UNDERSTANDING ECOSYSTEM SERVICES AT SUPERFUND CLEANUPS

The purpose of this report is to help representatives of the Superfund program understand ecosystem services (ES) and their relevance to greener cleanups at contaminated sites. The discussion focuses on the use of ES evaluations to support greener cleanups and related environmental footprint analyses. It describes ES evaluation tools, as well as greener cleanups best management practices to minimize impacts of site cleanup on ES and to support land reuse. In addition, the paper describes the relationship of ES to other site-related activities.

1. Ecosystem Services

Ecosystem services (ES) are the outputs of ecological processes that contribute to human health and well-being (Text Box 1) or have the potential to do so in the future (Munns et at., 2015). Ecosystems provide services to humans (i.e., pollination, flood control) that that typically are not fully accounted for in economic markets, policy decisions, or individual projects. (Costanza et al., 1997).

Text Box 1. Ecosystems Contribute to Human Health

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. For this report, the ecosystem services (ES) term and abbreviation are used to reflect both goods and services.

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 2 defines concepts useful in the evaluation of ES.

ES evaluations have been applied in a variety of land management and decision contexts. Evaluation of ES may be qualitative or quantitative; however, replicable quantitative evaluation

facilitates communication of the decision process (National Ecosystem Services Partnership, 2016a). Listed here are a few of the ecosystem processes and services that have been quantified:

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

For examples of ecosystem services quantification by federal programs and agencies, refer to the Federal Resource Management and Ecosystem Services Guidebook (*nespguidebook.com*).

Text Box 2. Concepts for Ecosystem Services Evaluations

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" (Landers and Nahlik). At a wetland site, example beneficiaries are experiencers and viewers, anglers, researchers, farmers, and residential property owners. One individual may hold several beneficiary interests. Identifying these interests within the community and stakeholders is essential in the evaluation of ES. (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 ES: it supports many final ES. (US EPA, 2017b).

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

Measurement of ecosystem goods and services requires the selection of relevant indicators. For a site with birdwatching opportunities (recreational ES), bird species richness may be selected as an indicator. Classification systems (see **Appendix A**) may help identify indicators. (National Ecosystem Services Partnership, 2016b).

2. Role of Ecosystem Services in Greener Cleanups

Greener cleanups is the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprint of cleanup actions (US EPA 2012). Contaminated site remediation projects often operate like large construction projects with a significant environmental footprint, so the Office of Land and Emergency Management (OLEM) has implemented a greener cleanups strategy.[1] One aspect of the strategy is conducting an environmental footprint analysis. In 2012, EPA released the Methodology for Understanding and Reducing a Project's Environmental Footprint, which provides an approach to footprint analyses and quantifying four of the five Greener Cleanups Core Elements: energy, air, water, and materials/waste (Figure 1).10 Footprint analyses inform the site team of the nature and scale of the remedy's impact to the core elements, thus enabling them to reduce the footprint through best management practices (BMPs). Although the 2012 Footprint Methodology mentions Land & Ecosystems as a core element, it does not provide metrics or a means to quantify ES. Instead, the Footprint Methodology recommends a qualitative description of remedies' effects on a site's ecosystem services. Many contaminated site cleanup projects have included qualitative considerations of remedy operations' impact on ecosystems and their services to communities.[2]

Figure 1. Land & Ecosystems is one of the Greener Cleanups Core Elements

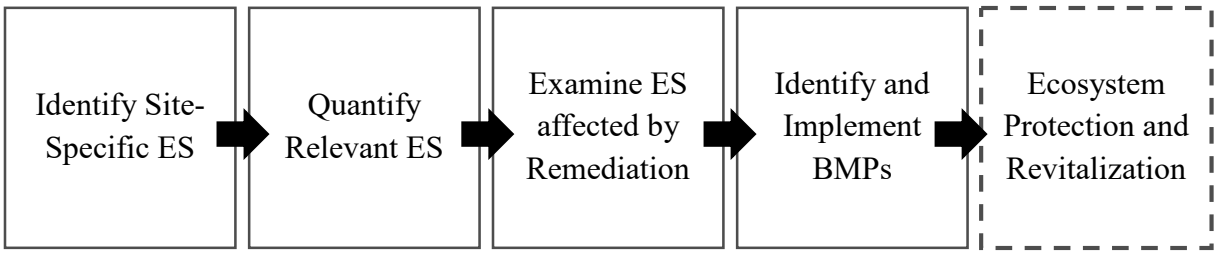
[1] Greener cleanups is synonymous with green remediation. For information about the Superfund strategy, refer to www.epa.gov/greenercleanups/superfund-green-remediation-strategy.

[2] Refer to case study profiles on the Contaminated Site Clean-Up Information (CLU-IN) webpages: clu-in.org/greenremediation/profiles and clu-in.org/ecotools/case.cfm.

2.1 Quantifying Ecosystem Services for Greener Cleanups

The identification and measurement of ES is part of calculating the total environmental footprint of contaminated site remediation. Figure 2 provides a general framework for evaluation of ES as part of greener cleanup activities. First, site specific ES may be identified by working with the site team and/or through a stakeholder engagement process (see the Community Involvement Section). The subset of ES determined to be relevant to the cleanup effort may be quantified using existing information or through the identification of data that need to be collected. Once a relevant subset of ES are quantified, ES may be examined from the context of identifying approaches, called BMPs, to minimize impact on ES or revitalize ES. BMP implementation results in ecosystem protection and revitalization, which minimizes the environmental footprint of cleanup operations.

Figure 2. Framework for an Ecosystem Services Evaluation during Greener Cleanups



3. Relevance to Superfund Cleanups

As stated in EPA's 2016 Greener Cleanups Guidance[3] "OLEM's goal is to evaluate cleanup actions comprehensively to ensure protection of human health and the environment and to reduce the environmental footprint of cleanup activities, to the maximum extent possible." Similarly, EPA's 2010Reasonably Anticipated Future Land Use Guidance[4] affirms that "in carrying out Superfund response actions that protect human health and the environment, EPA typically considers the reasonably anticipated future land use of a site." Remedy selection criteria and performance standards for Superfund cleanups are described in the Comprehensive

[3] OLEM Memorandum "Consideration of Greener Cleanup Activities in the Superfund Cleanup Process," 2016, https://semspub.epa.gov/work/HQ/100000160.pdf.

[4] OLEM Memorandum "Considering Reasonably Anticipated Future Land Use and Reducing Barriers to Reuse at EPA-lead Superfund Remedial Sites," 2010, https://semspub.epa.gov/work/HQ/175563.pdf.

Environmental Response, Compensation, and Liability Act (CERCLA)11 and the National Contingency Plan (NCP) (US EPA, 2017c; Legal Information Institute, 2017). As it is consistent with CERCLA and the NCP, EPA may evaluate greener cleanup activities and potential reasonably anticipated future land use options.

Federal agencies may utilize ES terms and methods in existing programs (Text Box 3). ES may be evaluated to inform and support the efforts to reduce the remedies' environmental footprint and to determine future use options at a site. Highlight 1 provides an example of ecological considerations contributing to remedy footprint reduction and ecological reuse. Generally, identification of future use options may occur early in the project, while greener cleanup BMPs may be useful during remedy implementation. Opportunities to identify and quantify ES occur throughout the project timeline.

Text Box 3. Incorporating Ecosystem Services into Federal Decision Making

The Oct. 7, 2015 executive memorandum from the Office of Management and Budget directs federal agencies to integrate ecosystem services assessment methods into existing agency programs. See **Appendix B** for the full text.

Highlight 1. Ecological Considerations Reduce the Remedy's Environmental Footprint

Atlas Tack Corporation's (Region 1) original Record of Decision (ROD) called for excavating the entire wetland onsite. However, the EPA and Natural Resource Trustees recognized that through refinement of the ecological risk assessment (ERA), a greener remedial action could be designed. EPA conducted a pre-remedial design bioavailability study to determine the exact locations of wetland sediments to excavate. This targeted remedial action limited negative impacts from the remedy operations to the existing wetland. After EPA cleanup and Trustee restoration, the wetland provides habitat for migratory birds and reconnects water supply to an Estuary of National Significance. This provides ES to birdwatchers, fishermen, outdoor recreationalists, and other people in the region. (US EPA 2011)

Photos: Wetland Excavation (Left) and Wetland Revegetation (Right) at Atlas Tack

ES are relevant to other site cleanup-related activities. As explained in the bullets below, in some cases, information about ES is available from these activities. In other cases, the information gathered as part of an ES evaluation can be shared to support other site studies.

- **Ecological Risk Assessment** (ERA) is an integral part of the Superfund Remedial Investigation and Feasibility Study (RI/FS) process, which is designed to assist: the determination of statutory authority for site action; the evaluation of remedy options; and the risk management decision-making for Superfund sites. The 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). Description of ecological entities and attributes in terms of their associated ecosystem services may be a useful communication tool during discussion with stakeholders and the public (Text Box 4). Information determined and collected while conducting an ERA, including C-GEAEs and ES-GEAEs, may be used to inform an ES evaluation. Figure 3 shows how the generic ecosystem services endpoints (ES-GEAEs) for the ecological risk assessment (ERA) may help identify ecosystem services at a site for greener cleanups.

Text Box 4. Ecosystem Service Assessment Endpoints for a Superfund Site

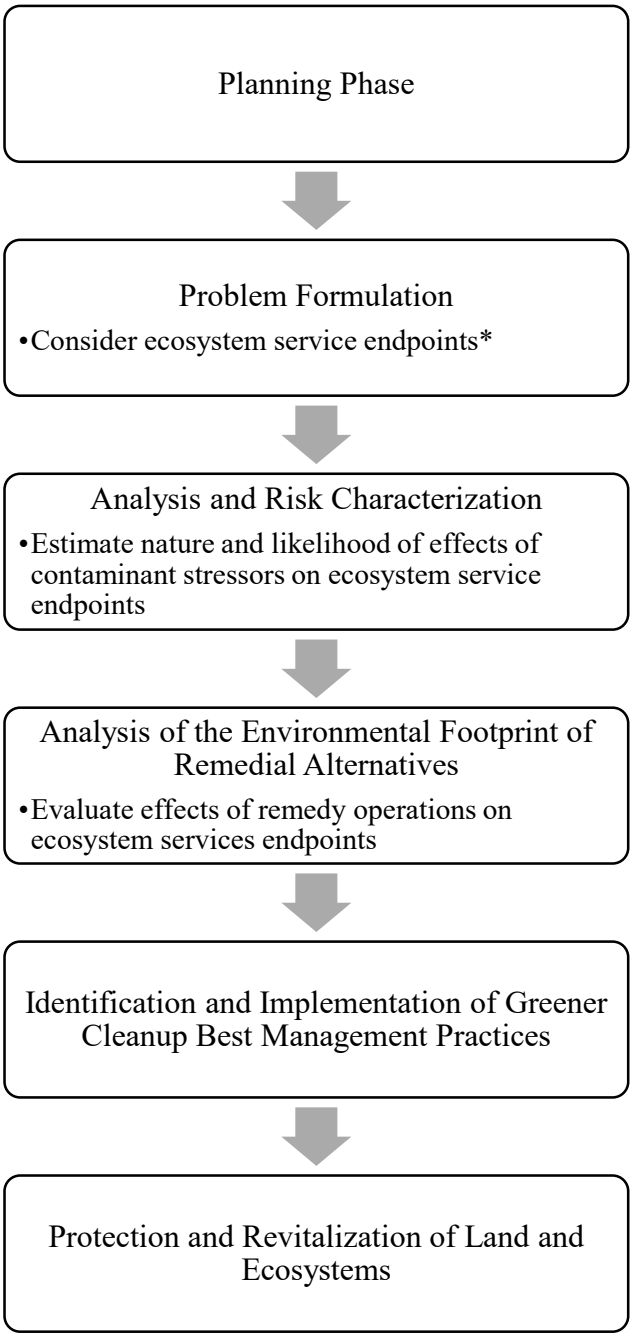
The Hazardous Waste Site Case Study (Section 5.2.5. *p. 36-37*) in *Ecosystem Services as Assessment Endpoints in Ecological Risk Assessment Technical Background Paper* involves a Superfund site located along the Raritan River in central New Jersey. The case study illustrates conceptual relationships among conventional ecological assessment endpoints and ecosystem service assessment endpoints relative to chemical stressors and ecosystem-derived benefits to humans. Explicitly considering and communicating ecosystem services likely would have changed the assessment of risks and public acceptance of remedial decisions. (US EPA 2016a).

- **Applicable or Relevant and Appropriate Requirements** (ARARs) must be met or waived during or upon completion of the remedial action at Superfund sites (US EPA, 1988). ARARs may include the Endangered Species Act, Farmland Protection Policy Act, Clean Water Act, or other protective standards that must be met. ARARs may inform the selection of relevant indicators (defined in Text Box 1) for ES evaluations.

- **Ecological revitalization** is the technical process of returning land from a contaminated state to one that supports functioning and sustainable habitat.18 This technical process cannot compromise the protectiveness of the cleanup, but may complement the site's remedy and the anticipated ecological reuse of a site. The outcome of ecological revitalization may provide a co-benefit of alleviating some of the impacts of the remedy operations on ES. For example, native plants can stabilize the soil to prevent erosion, and can also provide habitat for pollinators. Erosion control for site remediation and the resulting habitat availability are ecosystem services commonly affected by cleanup activities. (US EPA, 2009a)

- **Natural Resource Damage Assessment (NRDA)** is a Natural Resource Trustee responsibility. NRDA identifies additional actions, beyond the Superfund cleanup, to address injuries to natural resources caused by hazardous waste at a site. Damages to natural resources are evaluated by the Trustees, in part, through the identification of the functions or "services" provided by the resources, determining the baseline level of the services provided by the injured resource(s), and quantifying the reduction in service levels attributed to the presence of contamination. The services assessed as part of the NRDA process may or may not be the same ES considered during an environmental footprint analysis. Discussion of ES, which may be facilitated by the use of ERA endpoints and ES evaluations, may improve communication of information between site remediation and NRDA restoration efforts. ("Natural Resource Damages Assessments," 2017)

Figure 3. Incorporating Ecosystem Services Endpoints and Environmental Footprint Analysis into Cleanups



* *Generic Ecological Assessment Endpoints (GEAE) for Ecological Risk Assessment (Second Edition) with Generic Ecosystem Services Endpoints explains how to consider ES in the ERA and demonstrates the utility of using ecosystem service endpoints.*

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 ES evaluations.

The Superfund Redevelopment Initiative Reuse Assessment is useful for gathering information about community values (US EPA, 2001), which may be discussed in terms of ES. For sites with planned ecological reuse, the community may share which ES they want from the site. Highlight 2 illustrates how a citizens advisory group shared their interest in pollinator habitats.

Workshops and surveys may also aid in the collection of community values, including ES. Text Box 5 shares an effective discussion framework to include ES in community involvement activities. Involving the community in ES evaluations helps ensure the identification of appropriate ES to measure, and the selection of effective greener cleanup BMPs. Through an ES evaluation, the community has improved understanding of benefits of the cleanup.

Text Box 5. Discussing Ecosystem Services with Communities

As part of an EPA ORD Sustainable and Healthy Communities project in Pensacola, Florida, residents identified community values during a facilitated, interactive workshop. They identified the values, related to a land management decision, to develop a list of goals and priority actions that could be matched up to domains of the Human Well-Being Index (HWBI). This process offers an effective framework for conversation about community values around a decision. The HWBI workshop structure may be used as a community engagement tool to discuss relevant ES.

Pensacola, FL Project Contact: Rich Fulford EPA ORD/NHEERL/GED, HWBI Project Contact: Lisa Smith EPA ORD/NHEERL/GED. US EPA. 2016. Sustainability at the Community Level: Searching for Common Ground as a Part of a National Strategy for Decision Support. EPA/600/R-16/178.

Highlight 2. Community Involvement Informs Ecological Reuse of Superfund Site

The former Chemical Commodities Inc. (CCI) (Region 7) 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 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, including 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 has been highlighted in a video by the EPA (https://youtu.be/q_fUKrB3ASk). (US EPA 2017d)

Photos: Community Volunteers (Left) and completed Pollinator Prairie (Right) at former CCI site

5. Ecosystem Services Evaluation Tools

Publicly available tools can be used to quantify ES at a cleanup site. Several positive outcomes may result from the use of evaluation tools:

- Identification of ecosystem service providing areas within or surrounding the site.
- Documentation of the ES "before and after" remediation and ecological revitalization.
- Engagement with the public and stakeholders about ES considerations in greener cleanup activities and future land use.

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 3),

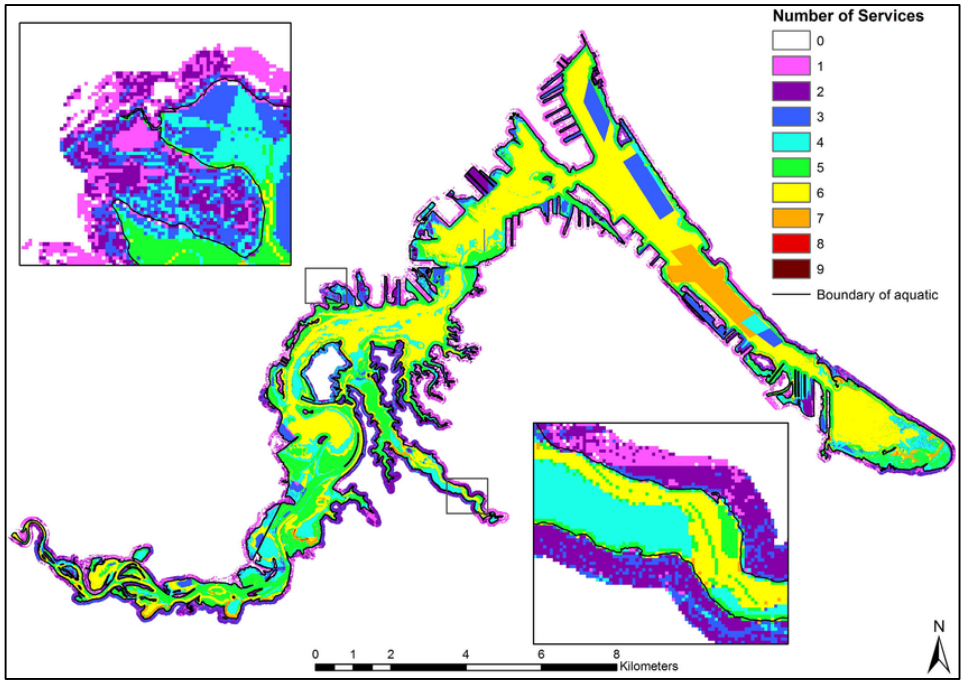
software models, and spreadsheet kits. Appendix A describes a selection of ES evaluation tools. Text Box 6 refers to a research project which applies ES tools to Superfund sites.

Highlight 3. Service Providing Area Maps of Contaminated Areas

The U.S. Steel Superfund site (Region 5) is within the larger St. Louis River Area of Concern (AOC), located on the Minnesota/Wisconsin border at Lake Superior. Remediation plans involve excavating contaminated sediments and constructing a confined disposal facility. An EPA ORD-led team created service providing area (SPA) maps as a tool to evaluate the impact of remedial actions on ES. Drawing from the St. Louis River Habitat Plan drafted by the citizen's action committee, data availability, and relevance to AOC delisting targets, the team identified twenty-three final ES provided in the St. Louis River estuary. They selected biophysical indicators for each final ES and used ArcGIS spatial models to map indicator presence/absence at high resolution for 10x10-m map pixels. The SPA map displayed areas of the St. Louis River estuary with the most and fewest final ES (Image). Then the team mapped changes in SPA (km2) for final ES by predicting biophysical changes resulting from proposed remedial actions. By quantifying changes in SPA, the team revealed area tradeoff advantages for remediation plans at the U.S. Steel site. This project demonstrates how SPA maps may be used to evaluate the impacts of cleanup activities on ES. (Angradi et al 2016)

Project contact: Joel Hoffman ORD/NHEERL/MED

Image: Service Providing Area (SPA) Map of St. Louis River Estuary, from Angradi et al. 2016



Text Box 6. Trial Application of Ecosystem Services Concepts and Tools at Superfund Sites

EPA's Regional Sustainability and Environmental Sciences (RESES) project *Understanding and Evaluating EGS at Site Remediation Projects and Applying their Benefits to Sustainability and Livability for Surrounding Communities* (2015-2017) explores the applicability of ES evaluation tools at Superfund sites. This report and its companion EPA issue paper, *Ecosystem Services at Contaminated Site Cleanups* (EPA 542-R-17-004) were produced in collaboration with the RESES project. Future publications may result from the project.

6. Best Management Practices for Ecosystem Services

Cleanup project work plans may include greener cleanup BMPs intended to minimize negative impacts on ES and revitalize ES as identified for anticipated future land use. Remedial activities may contribute to soil compaction, loss of natural contours and drainage patterns, sediment runoff into waterways, habitat loss, and noise and light pollution (Slack, 2010). These alter the quality and/or quantity of ES. The quantification of ES characterizes the potential relationships between remedial actions and ES impacted by the remedy. By using an ES evaluation as a tool, approaches can be developed to manage the effects of remedy operations on ES. Greener cleanup BMPs that address ES may be considered throughout the Superfund process.

Table 1 provides examples of greener cleanup BMPs which may be used during the site assessment and remedial phases to sustain and/or revitalize ES. Example greener cleanup BMPs are linked to three example ES commonly managed at cleanup sites.

Below: Block quotation from *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites*, US EPA 2008

"Green remediation practices provide a whole-site approach that accelerates reuse of degraded land while preserving wildlife habitat and enhancing biodiversity. BMPs can provide novel tools for measuring a site's progress toward meeting both short- and long-term ecological goals involving:

- *Increased wildlife habitat*
- *Increased carbon sequestration*
- *Reduced wind and water erosion*
- *Protection of water resources*
- *Establishment of new greenspaces or corridors*
- *Increases in surrounding property values, and*
- *Improved community perception of a site during cleanup."*

Table 1. Greener cleanup best management practices 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.	✓	✓	✓

Notes for Table 1:

- Descriptive information about ecological considerations for cleanups, including policy, regulatory, and technical concerns, is in the document *Ecological Revitalization: Turning Contaminated Properties into Community Assets.*
- BMPs for Land & Ecosystems are listed in Table X3.1 Greener Cleanup BMP of the *Standard Guide for Greener Cleanups* (ASTM E2893).

Highlight 4. Greener Cleanups Best Management Practices Support Ecological Reuse

When the EPA site team and Phillips 66 began discussion for the containment cell closure, the site team recognized an opportunity to revitalize ES at the Bayou Verdine cleanup site (Region 6) in Lake Charles, Louisiana. Phillips 66 collaborated with EPA and community stakeholders to complete a work plan that supported ecological land reuse. During cleanup, 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, 2016)

Project Contact: Casey Luckett, US EPA Region 6.
Photos are the courtesy of the Bayou Verdine project team.

Photos: New wetland habitat supports migratory birds (Left), Native wildflowers on the cap provide pollination services (Middle), trees are reused onsite as habitat features (Right).

7. Conclusion

Understanding ES at cleanups informs the reduction of the environmental footprint of the remedy and the determination of reasonably anticipated future land use. As the first analytical step for consideration of ES during a remediation project, a site's ecological risk assessment may utilize ecosystem service endpoints. The evaluation of ES at Superfund sites may help improve site management and communication with the public, engagement with stakeholders, and selection of best management practices for greener cleanups and ecological revitalization and reuse. Ultimately, a replicable ES evaluation process for cleanup could provide a consistent, data-driven approach to safeguarding existing ecosystems onsite and planning for future ecological reuse.

8. Selected Resources

www.clu-in.org/ecotools is regularly updated with news and 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. 2009. EPA 542-R08-003.
- Superfund Redevelopment Initiative. U.S. Environmental Protection Agency. November 28, 2016. www.epa.gov/superfund-redevelopment-initiative
- Superfund Sites with Green Space Reuse. U.S. Environmental Protection Agency. www.epa.gov/superfund-redevelopment-initiative/superfund-sites-green-space-reuse#ecological
- Superfund Reuse Coordinators. U.S. Environmental Protection Agency. www.epa.gov/superfund-redevelopment-initiative/regional-redevelopment-contacts

Green Remediation

- "ASTM Standard Guide for Greener Cleanups." Green Remediation Focus. U.S. EPA Office of Superfund Remediation and Technology Innovation. May 20, 2016. www.clu-in.org/greenremediation/standard
- Methodology for Understanding and Reducing a Project's Environmental Footprint. U.S. Environmental Protection Agency. 2012. EPA 542-R-12-002.
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APPENDIX A. ECOSYSTEM SERVICES EVALUATION TOOLS

This list of ecosystem services (ES) evaluation tools has been curated for potential applicability to EPA's cleanup programs. It is not an exhaustive list of all ES evaluation tools and it should not be considered endorsement of any one tool or resource. The ES evaluation tools 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.

Table A1. List of ES evaluation tools (developed by US EPA)

Name	Description
Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES)[30] *Web-based model* nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100DSGE.txt	DASEES is a web-based, open source structured decision making interface supporting problem formulation, scoping, prioritization, and integrated systems level assessment of alternative scenarios. It can incorporate input from many stakeholders. DASEES is intended to help incorporate ES into decision making. (ORD SHC 1.61) **Level of expertise:** Low-Moderate
FEGS-CS Query Tool *List of services and indicators* gispub.epa.gov/FEGS/FEGS_customize.html	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 that 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
EcoService Models Library (ESML) *Searchable Database* www2.epa.gov/eco-research/ecoservice-models-library	The EcoServices 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

Table A2. List of ES evaluation tools (not developed by US EPA)

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/nse/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. GIS is not required. **Level of expertise:** Low-Moderate
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 set 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 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

October 7, 2015

M-16-01

MEMORANDUM FOR EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: Shaun Donovan, Director
Office of Management and Budget

Christina Goldfuss, Managing Director
Council on Environmental Quality

John Holdren, Director
Office of Science and Technology Policy

SUBJECT: Incorporating Ecosystem Services into Federal Decision Making

Overview. Nature provides vital contributions to economic and social well-being that are often not traded in markets or fully considered in decisions. This memorandum provides direction to agencies on incorporating ecosystem services into Federal planning and decision making. (Broadly defined, ecosystem services are the benefits that flow from nature to people, e.g., nature's contributions to the production of food and timber; life-support processes, such as water purification and coastal protection; and life-fulfilling benefits, such as places to recreate.)

Specifically, this memorandum:

(1) Directs agencies to develop and institutionalize policies to promote consideration of ecosystem services, where appropriate and practicable, in planning, investments, and regulatory contexts. (Consideration of ecosystem services may be accomplished through a range of qualitative and quantitative methods to identify and characterize ecosystem services, affected communities' needs for those services, metrics for changes to those services and, where appropriate, monetary or nonmonetary values for those services.)
(2) Sets forth the process for development of implementation guidance and directs agencies to implement aforementioned policies and integrate assessments of ecosystem services, at the

appropriate scale, into relevant programs and projects, in accordance with their statutory authority.

Purpose. The goal of this memorandum and subsequent implementation guidance is to better integrate into Federal decision making due consideration of the full range of benefits and tradeoffs among ecosystem services associated with potential Federal actions, including benefits and costs that may not be recognized in private markets because of the public-good nature of some ecosystem services. An ecosystem-services approach can: (1) more completely inform planning and decisions, (2) preserve and enhance the benefits provided by ecosystems to society, (3) reduce the likelihood of unintended consequences, and, (4) where monetization is appropriate and feasible, promote cost efficiencies and increase returns on investment. Adoption of an ecosystem-services approach is one way to organize potential effects of an action within a framework that explicitly recognizes the interconnectedness of environmental, social, and, in some cases, economic considerations, and fosters consideration of both quantified and unquantified information. This memorandum sets a course to implement this approach.

Scope. This memorandum complements but does not supersede agency activities prescribed by or pursuant to law, tribal consultation policy, Executive Order, regulation, or other relevant guidance. This document provides direction for relevant Federal programmatic and planning activities (including activities such as natural-resource management and land-use planning, climate-adaptation planning and risk-reduction efforts, and, where appropriate, environmental reviews under the National Environmental Policy Act (NEPA)) and other analyses of Federal and Federally-assisted programs, policies, projects, and regulatory proposals. For example, should an agency's analysis require consideration of costs, the agency should consider ecosystem-services assessment methods, where appropriate and feasible.

Background. Ecosystem services provide vital contributions to economic and social well-being. These include, but are not limited to, provisioning food and materials, improving the quality and moderating the quantity of water, providing wildlife habitat and spawning and nursery habitats for fisheries, enhancing climate resilience, mitigating storms and floods, buffering pollutants, providing greater resilience for communities and ecosystems, and supporting a wide array of cultural benefits, recreational opportunities, and aesthetic values. Since the President's Council of Advisors on Science and Technology (PCAST) underscored the value of the Nation's natural capital in its 1998 report, *Teaming with Life*, successive Administrations have worked to develop methodologies and have convened interagency dialogues to advance ecosystem-services approaches in Federal decision making. In 2011, the PCAST revisited the 1998 report, making a specific recommendation to improve the capabilities of Federal agencies to promote consideration of ecosystem services in decision making. The Federal government has made progress toward this goal within individual agencies—for example, in the U.S. Forest Service's 2012 Forest Planning Rule—and in setting broad policy across agencies—for example, by including ecosystem-services concepts in the recent Principles, Requirements and Guidelines for Federal Investment in Water Resources (PR&G).

In recent years, considerable attention has also focused on the role that healthy and intact natural habitats can play in enhancing resilience of communities and ecosystems, including reducing

vulnerability to climate-change impacts. Multiple efforts are underway to incorporate natural and nature-based infrastructure (e.g., dunes and barrier islands) to enhance storm and flood protection, along with efforts to restore natural features (e.g., oyster reefs in the Chesapeake Bay) to benefit multiple ecosystem services, such as fish habitat and water quality. Increased emphasis on ecosystem services to enhance resilience underscores the need for a consistent framework for incorporating ecosystem services into Federal decision making.

Today, the links among land, air, fresh water, ocean, and human activities are better understood. Advances in science and technology have provided timely and usable information to guide decision making. For example, advances in the social sciences have further developed methods to articulate the value of ecosystem services in both monetary and non-monetary terms. By incorporating ecosystem services into Federal agency planning and decision making, and recognizing that healthy ecosystems are essential to human welfare, security, and the health of social and economic systems, Federal agencies will more effectively address the challenges facing the Nation and ensure ecosystems are healthy for this and future generations.

Directive. Agencies shall develop policies to promote consideration of ecosystem-services assessments within existing agency planning and decision frameworks, where appropriate and practicable, in accordance with their statutory authorities and consistent with their specific missions.

1. Policies should describe approaches for conducting decision-relevant and scale-specific ecosystem-services assessments, as well as plans for effective monitoring and evaluation.
2. These policies do not need to be standalone documents and may be most useful when incorporated into existing decision-making frameworks and analyses. Agencies are encouraged to carry out the provisions of this guidance through existing planning and strategic processes such as: Agency and Departmental Strategic Plans, Strategic Sustainability Performance Plans, and Annual Performance Reports.
3. To support agencies in this process, a forthcoming appendix will provide implementation guidance for this memorandum to suggest best practices for ecosystem-services assessment. The implementation guidance will outline an assessment framework for integrating consideration of ecosystem services into existing agency decision process and will describe the elements and approaches for sound integration of ecosystem-services concepts, such as: (1) describing the Federal action; (2) identifying and classifying key ecosystem services in the location of interest; (3) assessing the impact of the Federal action on ecosystem services relative to baseline; (4) assessing the effect of the changes in ecosystem services associated with the Federal action; and (5) integrating ecosystem-services analyses into decision making.

Implementation Process and Timelines. This policy guidance is intended to support those agencies already using ecosystem-services approaches and to encourage other agencies to prepare for implementation in a manner consistent with the forthcoming implementation guidance.

All agencies should begin or continue developing their policies. Agencies already deploying ecosystem-services analyses are encouraged to continue their efforts, but should be prepared to demonstrate over time how their approaches relate to the standards of best practice identified in

the implementation guidance, or to make appropriate adjustments going forward. Implementation of this memorandum will follow the timeline below.

1. **Description of current agency practice and work plans** (6 months; Agencies)
   (a) To inform future governance considerations, agencies shall describe how ecosystem services are currently defined, classified, and incorporated in planning, management, and regulatory decisions. This written description should characterize the current state of agency practice and provide a narrative description of current challenges, if any, which could or do impede the consideration of ecosystem services in Federal decision making. To help with this process, agencies are encouraged, but not required, to review or update existing inventories with relevant efforts, using common definitions and a common framework.
   (b) Each agency shall create a work plan, developed in an internally coordinated manner, laying out how it intends to move toward the goals of this policy directive. These work plans should build off agency descriptions of existing efforts developed in (a). They should identify specific examples of policies planned for the future, as well as identify high-priority programs, projects, or analyses appropriate for integrating ecosystem services assessments within existing decision frameworks.
   (c) Written descriptions (a) and work plans (b) should be completed and submitted to CEQ no later than March 30, 2016.
   (d) Following the release of the implementation guidance (timeline below), agencies will be expected to revise and refine their work plans to show that they are consistent with that document. Revised work plans should be submitted to CEQ within 120 days of the release of the final implementation guidance.

2. **Implementation guidance** (14 months; CEQ)
   (a) The implementation guidance will be developed in collaboration with subject-matter experts from relevant Federal departments and agencies and will be informed by the significant body of research published in the peer-reviewed literature. The guidance will be issued as an appendix to this memorandum.
   (b) The implementation guidance will be subject to an external peer review and public comment period, consistent with the requirements of the Office of Management and Budget (OMB)'s Final Information Quality Bulletin for Peer Review.
   (c) Prior to release for external peer review, there shall be an interagency review period of the implementation guidance of not less than 30 days.
   (d) External peer review will commence no later than November 30, 2016. The memo will be finalized and released following the resolution of the peer review and public-comment process.
   (e) The implementation guidance is intended to be a living document and will be updated as needed to incorporate emerging science and new methodological advances.

Governance and Interagency Coordination. Full integration of ecosystem services into agency decisions will be a long-term process, taking place over many years, as agencies modify existing programs and policies in accordance with the practices outlined in the implementation guidance. Ultimately, successful implementation of the concepts in this directive may require Federal

agencies to modify certain practices, policies, or existing regulations to address evolving understandings of the value of ecosystem services.

Moving forward, CEQ, in consultation with OMB, OSTP, and CEA, will facilitate interagency coordination and engagement around ecosystem services, including supporting agencies in their work to incorporate ecosystem-services assessments in decision making. CEQ, in consultation with OMB, OSTP, and CEA, will also coordinate with existing work groups and other governance structures to develop a longer-term strategy for providing sustained leadership and interagency coordination around ecosystem services. Such ongoing coordination is needed to provide support and oversight for agency work plans and to share best practices for integrating ecosystem services into Federal decision making, including policy development and institutionalization, alignment of data and tools, implementation of relevant research priorities, and integrating assessments into program and project analysis.