8. Damage Determination and Restoration Planning Approaches

Chapters 5, 6, and 7 describe injuries to and anticipated injury assessment activities for groundwater, biological, and air resources, respectively. This chapter briefly introduces general approaches to estimating damages from those injuries, then describes in more detail the restoration-based approach to damage determination. Section 8.1 explains damage determination in general and describes three approaches that the State will use to determine damages at the Arsenal. Section 8.2 presents an introduction to the restoration-based approach. Section 8.3 discusses the most common restoration-based approach: habitat and resource equivalency analyses. Section 8.4 discusses restoration project identification, selection, scaling, and costing. References cited in this chapter follow.

8.1 Damage Determination

A damage determination is intended to "establish the amount of money to be sought in compensation for injuries to natural resources resulting from a . . . release of a hazardous substance." The DOI regulations identify as the primary measure of damages the cost of "restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and the services those resources provide" [43 CFR § 11.80(b)]. In addition, the Trustees seek "the compensable value of all or a portion of the services lost to the public for the time period from the release until the attainment of the restoration, rehabilitation, replacement, and/or acquisition of equivalent of the resources and their services to baseline" [43 CFR § 11.80 (b)], also known as interim losses.

The State will quantify damages using three alternative methods for calculating damages:

- **Cost of restoration**: A restoration-based approach determines damages by quantifying how much restoration is needed to adequately restore, replace, or acquire the equivalent of the injured resources and the lost services provided by such resources. This approach is recognized as an accepted method for quantifying NRDs in the DOI regulations [43 CFR § 11.82; 43 CFR § 11.84(g)]. The State expects to use a restoration-based approach to calculate damages for terrestrial and aquatic resources, groundwater, surface water, and air resources.

- **Total value equivalency**: The State intends to determine the amount of natural resources and/or services that must be provided to produce the same value as that lost to the public due to hazardous substance releases into groundwater. This approach will determine the restoration required to compensate for losses of both use and non-use values for groundwater.

- **Use value – market price methodology**: The Front Range has a strong demand for water resources, including groundwater, and these resources are openly traded in a competitive market. The diminution in the market price of injured resources and associated lost services may be used to determine the compensable value of the injured resources [43 CFR § 11.83(c)(2)(i)]. The State will evaluate lost groundwater services and use a market price approach to estimate damages from these lost services.

As these methods measure many of the same values, the results of each analysis will not be additive. Rather, by using three approaches, the Trustees will have more robust information upon which to rely in formulating its ultimate claim for NRDs.

The remainder of this chapter describes generally the restoration-based approach to quantifying all of the State's NRDs. Chapter 9 focuses on the three damage assessment methodologies in the context of groundwater.

8.2 Restoration-Based Damage Determination: Introduction

8.2.1 Conceptual underpinnings of damage determination

Figure 8.1 is a conceptual diagram that depicts what happens to natural resource services over time following the release of a hazardous substance that causes injury. Area A represents the initial loss of services that occurs after the release of a hazardous substance and before remedial actions begin. Area B represents the time when initial recovery of natural resource services takes place as a result of remedial actions at the site. Area C represents the increase in natural resource services that occurs as a result of restoration activities that could be on-site or off-site. The goal of such activities is to restore to baseline conditions resources and services lost due to hazardous substance releases.

In addition to the costs of restoring resources and services to baseline, Trustees may also calculate damages for the interim losses of resources and services from the time of the release (or the enactment of CERCLA, whichever comes later) until full restoration to baseline is achieved. This compensatory restoration would equal the total service loss represented by the sum of the three areas representing less than baseline conditions (A + B + C) in Figure 8.1.

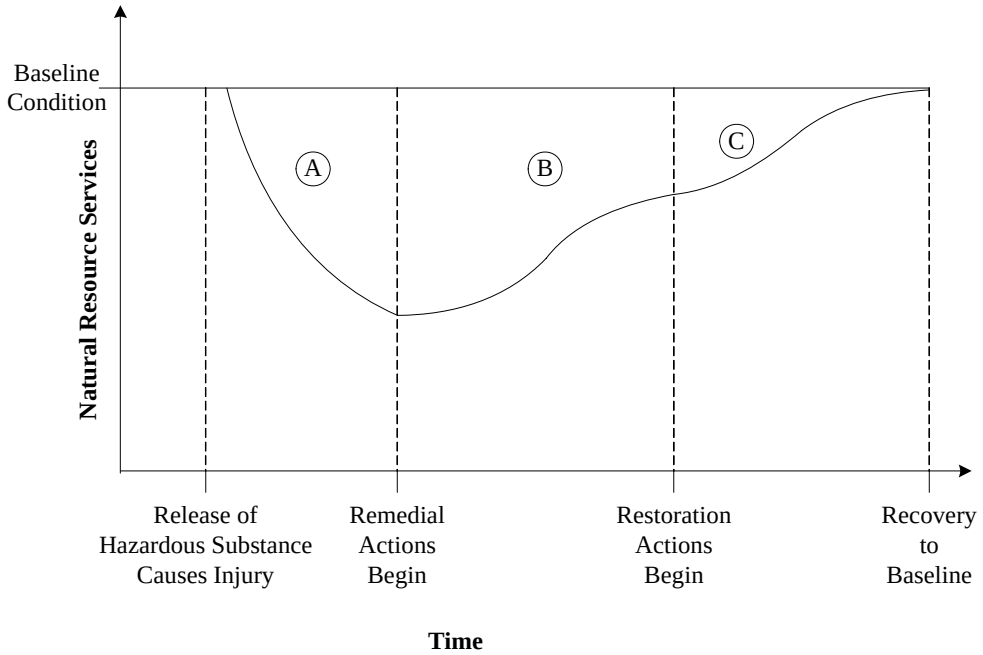

Figure 8.1. Conceptual diagram showing adverse impacts to a natural resource from the time of a release until baseline conditions are restored.

8.2.2 Summary of approach

The State Trustees plan to seek recovery for both components of NRDs: (1) costs of restoring injured resources to baseline conditions, and (2) compensable damages to account for lost services in the past, present, and future until the natural resources have been restored to baseline.

The State's NRD calculations will take into account the remedial actions at the Arsenal. For resources where the remedial actions will return or have returned resources to baseline conditions, the State's damage calculations will include the period from the onset of injury (or 1981) until baseline conditions are (or were) achieved. The State may also account for remedial actions that restore natural resources beyond baseline conditions.

For all injuries, the amount of restoration required for offset will be determined using service-to-service scaling methods such as HEA or REA. These methods are described in Section 8.3.

The State will use input from the public and interested stakeholders to identify potential restoration projects for evaluation using criteria established by the State; select potential restoration projects; scale those projects to offset quantified injuries; and determine the cost of restoration projects at the identified scale of implementation. Section 8.4 describes each of these components of the restoration-based damage determination approach in more detail.

8.3 Overview of HEA and REA

HEA and REA methods have been published in peer-reviewed literature, codified in the National Oceanic and Atmospheric Administration's regulations for NRDA, accepted by Federal Courts [*United States v. Melvin A. Fisher et al., Case No. 92-10027-CIVIL-DAVIS; United States v. Great Lakes Dredge and Dock Co., 259 F. 3d 1300 (11th Cir. 2001)*], and are routinely performed by Trustees and responsible parties at NRD sites throughout the United States.

Under HEA, service losses are expressed in terms of habitat (e.g., acres of grassland) and are offset by restoration of similar habitat. Under REA, losses are expressed in terms of resource units (such as numbers of fish or birds or acre-feet of groundwater), and are offset by projects that restore equivalent resource units. The HEA method has been described in a number of published technical articles (e.g., Unsworth and Bishop, 1994; Chapman et al., 1998; Peacock, 1999; Strange et al., 2002, 2004; Allen et al., 2005; NOAA, 2006).

HEA/REA is used to quantify the impacts to services resulting from injuries to natural resources (i.e., the debit) as well as the expected benefits from restoration (Figure 8.2). Determining equivalency (scaling) between the debit and credit is conceptually simple:

- Sum the reductions in services caused by the injury
- Determine the amount and timing of improvement in services expected per unit of restoration
- Divide the total losses by the benefit per restored unit to calculate the scale of required restoration.

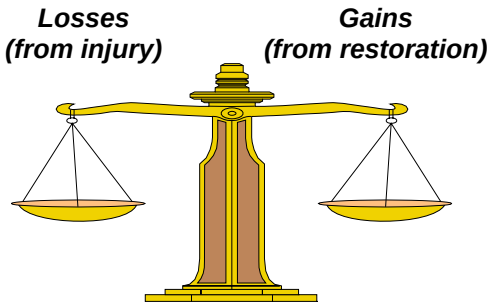

Figure 8.2. HEA and REA are used to determine the type and amount of restoration needed to balance losses from natural resource injuries.

8.3.1 Variables in a HEA/REA model

Necessary input parameters for HEA or REA include:

Start year. A start year must be specified for both the debit and the credit sides of the model. On the debit side, the start year usually is either the year in which injuries began or 1981 (following enactment of CERCLA in December 1980). On the credit side, the start year is the year in which restoration actions are expected to begin generating services.

End year. An end year can be specified, if appropriate. On the debit side, the end year is the year in which injuries stop because resources have returned to baseline conditions, through natural recovery, remedial actions, or projected restoration. On the credit side, the end year is the last year in which the credit from the restoration project is expected. For some restoration projects, benefits are expected to accrue in perpetuity. In that case, one typically specifies an end year at least 100 years after implementation.

Spatial extent. On the debit side, the spatial extent is the area where natural resource services have been degraded as a result of the release of hazardous substances. On the credit side, the spatial extent defines the area where restoration actions will be implemented and where resource service flows will improve.

Service loss. For a HEA, this is the degree of resource or service loss within the spatial extent relative to baseline conditions. Loss can vary from 0% (no loss) to 100% loss (complete loss). The degree of loss can vary over time (as can baseline conditions). The degree of loss will decrease over time if resource conditions improve and will eventually become 0% (no loss) when resource services return to baseline conditions. For a REA, the degree of loss can be expressed in terms of numbers of individuals lost, population reductions, loss of reproductive output or viability (including lost lifespan or reduced number of young), or other measures ("metrics") of resource impairment. Toxicity data such as soil contaminant concentrations can be an important source of information for determining the degree of loss by translating dose-response models into either a service loss assignment (for HEA) or a measure of resource impairment (for REA). If soil concentrations decrease over time as a result of remedial actions, then service or resource losses decrease as well.

Service gain. This is the amount of benefit expected to derive from implementation of a restoration project. Once a project is implemented, benefits begin to accrue, but full services might not be expected until some time in the future. Service gain could be 100% if entirely new habitat is created that functions at baseline levels, or it could be some percentage of baseline if actions enhance the services of habitat that already exists. As with debit calculations, the amount of service gain is estimated relative to baseline conditions.

Baseline conditions. The conditions that would have existed absent the releases of hazardous substances.

Metric. This is not an input parameter to HEA or REA, but instead is the unit of measure of the service loss and gain.

Damage or recovery trajectory. This also is not an input parameter, but a description of the service losses or gains over time.

Discount rate. To make past, current, and future losses and gains comparable, while accounting for well established time preferences, (i.e., people are generally willing to pay more for things in the present as opposed to the far future), the changes in service flow levels from past and future years are discounted to present-day terms (i.e., "present value"). An annual "social" discount rate of 3.0% is typically used in HEA and REA present value calculations for service flows (NOAA, 1999).

Base year. The base year is typically the year in which the analysis is conducted. The present value factor is greater than one for years before the base year and less than one for years after the base year.

Present value factor. The present value factor in the base year is one. Because of the discount rate, the value of a service in the past is greater than the value of the service today; thus, the present value factor is greater than one. Similarly, the value of a service in the future is less than the value of that service today; thus, the present value factor is less than one. Present value factors are calculated as follows:

$$\textit{Present value factor} = 1 / (1 + \text{discount rate})^{(\text{year} - \text{base year})}.$$

8.3.2 Calculation methods

For a HEA, all of these variables are used to equate injured areas and restored areas in summary units that integrate space and time. For example, a debit of 1 acre-year could reflect 1 acre of land having 100% loss of habitat for one year or 2 acres with 50% loss of services for one year. However, the HEA method incorporates a discount rate into the calculations, so that impacts and benefits that occur in different years are converted to present-value equivalents. Impacts and benefits are therefore generally quantified using units of "discounted service-acre years" (DSAYs), which account for the acreage of habitat impacted or benefited, the duration of impacts or benefits, the level of services provided by the impacted or benefited parcels, and time values, to convert changes in services in different years to a common currency.

Table 8.1 demonstrates how the HEA debit would be calculated for one acre of land with a constant service loss of 50%, from the start of 2000 to the end of 2010. The total HEA debit for one acre during this time period is 5.9 DSAYs.

Table 8.1. Example of HEA debit calculations. This example assumes 1 acre of land with a 50% service loss from the beginning of 2000 to the end of 2010, with a 2007 base year and 3% discount rate.

Year	Percent service loss	Present value factor[a]	Debit[b] (DSAYs)
2000	50%	1.23	0.62
2001	50%	1.19	0.60
2002	50%	1.16	0.58
2003	50%	1.13	0.56
2004	50%	1.09	0.55
2005	50%	1.06	0.53
2006	50%	1.03	0.52
2007	50%	1.00	0.50
2008	50%	0.97	0.48
2009	50%	0.94	0.47
2010	50%	0.92	0.46
		Total	**5.9**

a. Present value factor = 1 / (1+ discount rate)$^{(\text{year} - \text{base year})}$. Values rounded to two decimal places for presentation.
b. Debit is calculated by multiplying percent service loss by present value factor.

HEA credits for service gains associated with restoration are calculated similarly. Table 8.2 demonstrates how HEA credits would be calculated for a restoration project on one acre of land that improves service flows, as a percentage of baseline, by 50% in equal annual increments over the five-year time period from 2010 to 2014, and then maintains the 50% service improvement for the next five years (2015–2019). Again, the base year in this example is 2007 and the discount rate is 3%. The total HEA credit for this acre, for the period 2010–2019, is 3.1 DSAYs.

REA is similar to HEA but uses resource metrics (such as numbers of birds injured) instead of habitat units to quantify changes in services over time. An example of a simple REA might be a single event bird kill. The metric might be lost bird-years, where the loss is the sum of the expected remaining years of life for the killed birds. The data to support expected life spans come from bird population and survival models. Multiplying the estimated number of killed birds by years of life lost gives lost bird-years. This value is discounted to quantify the injury in discounted-lost-bird-years.

Table 8.2. Example of HEA credit calculations. This example assumes 1 acre of land with a service gain increasing from 0% to 50% over baseline service levels from 2010 to 2014 and the 50% improvement maintained from 2015–2019, assuming a 2007 base year and 3% discount rate.

Year	Percent service flow above baseline at end of year	Present value factor[a]	Credit[b] (DSAYs)
2010	10%	0.92	0.09
2011	20%	0.89	0.18
2012	30%	0.86	0.26
2013	40%	0.84	0.34
2014	50%	0.81	0.41
2015	50%	0.79	0.40
2016	50%	0.77	0.38
2017	50%	0.74	0.37
2018	50%	0.72	0.36
2019	50%	0.70	0.35
		Total	**3.1**

a. Present value factor = 1 / (1+ discount rate)$^{(\text{year} - \text{base year})}$. Values rounded to two decimal places for presentation.
b. Credit is calculated by multiplying percent service gain by present value factor.

REA approaches can be used for other resources as well. For example, if one quantified air injury in units of volume of air injured, then one could quantify air improvements from restoration projects in units of volume of air restored. The metric for scaling the restoration project would then be discounted-volume-years.

8.3.3 Assessment approach

The State plans to quantify natural resource injuries using HEA and/or REA approaches. The State will choose the appropriate approach (HEA or REA) based on the results of the injury assessment process and the types of information available, including restoration benefit information. Once injury is quantified using appropriate units (DSAYs for HEA; discounted lost-resources or resource years for REA), the State will select potential restoration projects using the project evaluation criteria, and calculate the scale of required restoration to offset the injury.

8.4 Restoration Projects

8.4.1 Identification

Consistent with DOI regulations, the State plans to identify a "reasonable number of possible alternatives for the restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources" [43 CFR § 11.82 (a)]. The State will consider projects from existing regional restoration plans (e.g., from the Northeast Greenway Corridor project) and solicit proposals from State agencies such as the DOW, interested nonprofit organizations, and the general public when identifying a list of potential restoration projects. Such projects would benefit the resources that have been injured at the Arsenal. Examples include:

- *Projects that provide benefits to terrestrial grassland (e.g., prairie) habitats and species.*
- *Projects that provide benefits to riparian-wetland habitats and species*.
- *Projects that provide benefits to groundwater systems, aquifers, groundwater-surface water interactions, or water users*. These potential projects are discussed further in Chapter 9.

Specific types of projects may include:

- *Preservation of existing habitat at risk for development.* The State may identify parcels of land with high habitat value for wildlife or high rates of groundwater recharge that can be preserved through acquisition or conservation easements. Preservation provides benefits when potential future development would result in the loss of natural resource services.
- *Restoration and enhancement of existing degraded habitats.* The State may identify degraded grasslands, wetlands or stream corridors that can be restored or enhanced to increase the wildlife services provided.
- *Preservation of protective buffers for core areas of high wildlife value.* The State may preserve land to protect areas of high wildlife value that would be lost if the surrounding land use changed. Residential development near habitat areas, for example, can result in impacts to birds and wildlife from a variety of factors, including the introduction of non-native predators such as domestic cats and dogs (USDA NRCS, 2007).

8.4.2 Evaluation and selection

Potential restoration projects will be evaluated and ranked using criteria developed by the State. These criteria build on factors identified in the DOI NRDA regulations [43 CFR § 11.82]. The State has grouped criteria into "threshold acceptance criteria" and "project preference criteria" (Table 8.3). Projects will first be evaluated against threshold acceptance criteria. Failure to meet all the threshold criteria would result in elimination of a project from consideration. Projects that meet threshold criteria would then be investigated further to gather information necessary to evaluate the projects using the preference criteria. Projects that best meet the preference criteria will be used for restoration scaling (see Section 8.4.3) and costing (see Section 8.4.4).

Table 8.3. Summary of Trustee criteria for evaluating restoration projects

Threshold acceptance criteria
1. Project must restore, replace, or acquire natural resources, not merely human services.
2. Project must be subject to a reasonable degree of State management, control, and monitoring.
3. Project must have a reasonable likelihood of success. The project should be technically feasible and viable.
4. Project must comply with laws and be protective of health and safety.
5. Project must be generally acceptable to the public.
Project preference criteria
1. Projects that are consistent with existing state, regional, and local resource management and development plans will be strongly preferred.
2. Projects that provide higher flows of services throughout the project lifetime will be preferred. It is preferable and more cost-effective for projects to provide higher levels of near-term benefits as compared to projects that require protracted periods to realize benefits. Projects that provide long-term sustainable service flows are also preferred.
3. Projects with less long-term operations and maintenance (O&M) will be preferred unless those costs are assumed by other parties and the State is assured that O&M will be adequately carried out for as long as necessary.
4. Projects that are likely to benefit more than one resource will be preferred.
5. Projects that can be reasonably monitored and have benefits that can be measured and verified will be preferred.
6. Projects that provide actual resource improvements will be preferred over projects that entail only conservation of open space, unless development threats are imminent or the conservation opportunity is of an advantageous scale or timing.
7. Projects that provide a high ratio of expected benefits compared to expected long-term costs for planning, implementation, operations, and maintenance will be preferred. Cost-effectiveness may be assessed relative to other projects that benefit the same resources.
8. Projects will be preferred if they are not likely to be funded through other mechanisms, or if implementation of the project would free restoration funding sources to finance other restoration projects.
9. Projects will be preferred if they leverage damage recoveries to match other funding sources and thereby enable projects to be larger or more comprehensive in scope.

8.4.3 Scaling

After quantifying reductions in services from injured resources, Trustees will determine the appropriate scale of restoration projects. For wildlife, service flow reductions may include:

- Loss of species diversity
- Loss of threatened and endangered species
- Loss of common wildlife species
- Loss of human active-use services (such as hunting or wildlife viewing)
- Loss of human passive-use services (such as bequest values – valuing the availability of resources for future generations).

Reductions in services provided by surface water may include:

- Loss of aquatic habitat
- Loss of species diversity or density
- Loss of clean water for recharge of alluvial groundwater.

Reductions in services provided by groundwater and aquifers may include:

- Loss of human active-use services such as drinking water
- Loss of human passive-use services
- Loss of clean water for recharge to surface water and wetlands
- Loss of aquifers for recharge, storage and transportation of groundwater.

Reductions in services provided by air may include:

- Loss of human active-use services such as unhampered breathing.

For the restoration scaling phase, the State will determine the required size (or “scale”) and timing of implementation for the preferred restoration projects such that increases in services from restoration is equal to the loss of services from injured resources at the Arsenal, with both losses and gains adjusted to present-value equivalents. This scaling would compensate for interim losses and quantify any restoration required to return injured resources to baseline conditions.

As part of the scaling effort, the spatial connectivity, and the timing and magnitude, of anticipated service flow improvements will be considered. For example, acquisition of or habitat restoration on, two adjacent parcels would likely provide greater benefits than identical acquisitions or restoration on parcels separated by miles of developed land. Likewise, projects that yield dramatic improvements in a short period of time would likely provide greater benefits than projects with more subtle improvements that would take longer to accrue. Also, a project

that involves creating riparian habitat around a two-acre gravel pit pond may be fixed in its scope because it involves habitat improvements to an existing site with fixed dimensions. In contrast, a river restoration project often can vary in size depending on the resources available to the project. Projects also can vary in the degree and duration of service improvement depending on the intensity of the restoration work and the commitment to long-term monitoring and maintenance. For example, a project that removes invasive species a single time would generate benefits over a shorter period of time than a project that provides ongoing control of invasive species as necessary.

The State plans to determine the best size and scope for each proposed project to maximize project benefits and overall cost-effectiveness across the suite of selected restoration projects. The State will take advantage of "economies of scale" where possible – sizing projects to get the maximum per-unit benefit, while at the same time being conscious of "diminishing returns" where additional resources spent on a project yield lower per-unit benefits.

The type of scaling described above for HEAs and REAs is called "service to service" scaling, where the services gained from restoration offset the services lost from injury. Projects that involve replacement or acquisition of equivalent resources can be scaled directly using the same metric. However, the State may also consider replacement or acquisition projects that provide services of a different type or quality than those lost if, for example, the replacement or acquisition of equivalent resources is technically infeasible or prohibitively expensive. When a replacement or acquisition project provides services that are not the same as those lost, additional information may be needed to determine when the project has produced "equivalent" resources as measured by the services. Alternative scaling methods such as weighting factors or value-to-value analysis, as opposed to "service-to-service" scaling, may be employed in these situations.

The State expects to use service-to-service scaling for terrestrial and aquatic wildlife injuries because restoration alternatives are available that provide the same or similar types and quality of services as those lost. The State may also use service-to-service scaling for injuries to air and surface and groundwater resources, if appropriate restoration alternatives that provide services of the same or similar type and quality can be quantified.

8.4.4 Costing

After determining the required size of each proposed restoration project, the State will estimate the cost to implement these projects. Costs will be based on preliminary project designs because full engineering designs are not feasible or appropriate to develop during the assessment process. Total cost estimates will include project design, implementation, monitoring, continued operation and maintenance, contingencies, Trustee oversight, and adaptive management. Adaptive management allows project changes to be made if monitoring indicates that goals are

not being achieved. As part of this process, information will be developed that can be used to adjust project cost estimates according to the scale of implementation for projects where the size of the project can vary.

8.4.5 Summary

The determination of damages using the restoration-based cost approach involves the following steps:

- Quantification of the spatial and temporal extent of natural resource service losses as a result of the release of hazardous substances
- Identification of projects that can provide restoration, rehabilitation, replacement, and/or acquisition of equivalent of the resources and their services
- Scaling of the projects such that the service gains that the project provides offset the service losses as a result of the hazardous substance releases
- Estimation of the total cost to implement the restoration projects that will provide equivalent resources and their services.

The responsible party may either choose to implement the restoration projects directly or provide the Trustees with monetary compensation for the estimated cost of implementing the projects.

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