DRAFT FOR DISCUSSION ONLY
Please do not cite or quote
Comment to jzc8j@virginia.edu

Site Optimization and Adaptive Management in Superfund: Thinking Like a Contaminated Site1

Jonathan Cannon

This paper advances a concept of the Superfund program as extended stewardship of land resources for public benefit. This differs from what has been the prevailing concept of Superfund as time-limited intervention focused predominantly on public health concerns. Expressions of this new concept occur in recent program initiatives, but the concept has not been systematically articulated or implemented by EPA. This paper elaborates the concept, provides a legal and policy justification for it, and explores its implications for managing individual contaminated sites as well as for herding the entire inventory of these sites.

The program concept advanced here addresses two major aspects of Superfund, as traditionally understood and implemented. The first of these is that, given the paramount objective of protecting public health, non-environmental values are of limited or no relevance to Superfund site deliberations. This restrictive focus has been effective in forcing action to reduce health risks posed by contamination at Superfund sites but has tended to close off consideration of other dimensions of these sites that might be important to the public good – or to relegate these considerations to "off the record status." Superfund sites are resources (land and associated groundwater, etc.) whose restoration and future use may offer substantial benefits, including but not limited to the reduction of environmental risks associated with these sites. This

1 Professor, University of Virginia School of Law; Director, Center for Expertise in Superfund Site Recycling.
Research for this paper was supported by a cooperative agreement between the U.S. Environmental Protection Agency and the University of Virginia establishing an interdisciplinary Center of Expertise for Superfund Site Recycling at the University.

paper argues that the goals of the Superfund program should be broadened to encompass not only protectiveness but also the optimization of site resources across a range of objectives, including market efficiency and value to the community. This expanded scope would give reuse of sites a central importance in the decisionmaking process, rather than the ancillary role to which it has historically been relegated. The paper suggests ways that in which this shift might be accomplished within the existing program structure.

A second, related feature of Superfund addressed here is the premise that contaminated sites can be dealt with effectively and decisively through federal actions occurring over a relatively limited time. The problem is defined, a remedy is ordered and implemented, and the problem is solved (i.e., the site is "cleaned up"). The statute states a preference for treatment remedies that "permanently" reduce the volume and toxicity of contaminants.2 But, as it has turned out, most Superfund sites have contaminants remaining after the remedy is completed and will require long term monitoring and review. For these sites at least, a more useful model is one of site stewardship, in which site interventions by EPA are understood to occur over an extended period of time. Others have advanced the notion of "'long-term stewardship' of lands contaminated with hazardous substances," although they have focused on protection of public health to the exclusion of other components of site value.3 In this paper, I define stewardship as adaptive management to optimize site value as well as ensure protectiveness over time. Adaptive management in Superfund requires an institutional commitment to continuous learning about sites and applications consistent with that learning. Because Superfund sites are subject to actions not only by federal authorities but also by property owners and by state and local

2 42 USC Sec. 9621(b).

3 Carl Bauer and Katherine Probst, Long-Term Stewardship of Contaminated Sites: Trust Funds as Mechanisms for Financing and Oversight, Resources for the Future Discussion Paper 00-54, at vii (Dec. 2000); Environmental

authorities, adaptive management here also requires the integration of decisionmaking in the public and private sectors and at multiple levels of government. The paper will show how adaptive management principles can be applied to assure that the overall public interest is well served.

Superfund sites represent a relatively small portion of the universe of contaminated sites in this country, but they include many if not most of the largest, environmentally most problematic, and politically most contentious sites and thus have a policy importance disproportionate to their number. Although much progress has been made on the current inventory of Superfund sites, much work remains to be done. By the end of 2002, EPA had placed 1499 sites on Superfund's National Priority List (NPL). Of these, 267 had been deleted, leaving 1232 on the current list. Of the total 1499 sites, construction of the remedy was complete at 846 (or 56%); "construction complete" indicates that all physical remedies were in place at these sites but that long term clean up goals had not necessarily been met.4 For 649 sites, remedial construction was needed or ongoing. Only 312 of the 1499 NPL sites were in reuse or planned for reuse; a majority of the "construction complete" sites were not in use.5

Estimates of the total universe of contaminated sites in this country have ranged between 70,000 and 500,000.6 A study by Resources for the Future has projected that each year over the next decade between 20 and 50 of these sites will be added to the NPL and many more will become subject to action under state clean up programs.7 Although this paper focuses on Superfund, the principles it develops are also applicable to state programs, including clean up

---

Law Institute, An Analysis of State Superfund Programs 45 (2001).

4 55 Fed. Reg. 8699.

5 Compilation by Marasco Newton Group for Center of Expertise for Superfund Site Recycling (____).

6 Katherine N. Probst and David M. Konisky, Superfund's Future: What Will It Cost? 85 (2001).

7 Id. at 105. Earlier estimates by EPA and the Congressional Budget Office had estimated that between 1500 and 7800 sites could be added to the NPL in the next 20 years." *Id.* at 82.

and reuse of brownfield sites.

I. Stewardship

In his canonical essay, "Thinking Like A Mountain," Aldo Leopold describes a process by which he came to understand the critical role of predators in ecosystems. 8 Rather than producing a "hunters' paradise," he discovered that eliminating wolves led to overpopulation by deer, depletion of foliage and degradation of the mountain ecosystem on which the deer depend. He projects a similar effect of clearing range land of wolves, resulting in overgrazing – "hence we have dustbowls, and rivers washing to the sea." We all strive for "safety, prosperity, comfort, long life, and dullness," Leopold observes, "but too much safety seems to yield only danger in the long run."

At first glance, nothing could be more different from the mountain than a contaminated site. One represents a relatively undisturbed ecosystem; the other a highly disturbed environment, a place that is far from its "natural state:" Yet, although highly modified by human activity, Superfund sites do contain natural systems or are included within natural systems that provide important resources and services such as groundwater and surface water supply and habitat. Like the management of Leopold's wolf-deer-cow ecosystem (the "mountain"), the management of Superfund sites and the human-natural systems within which they are situated has implications for the welfare of humans and other creatures extending into the future. Thinking like a contaminated site means accepting the stewardship obligation that this entails and employing new learning, just as Leopold does in coming to think like a mountain, to improve the quality of our lives and our environment over the long term. 9

---

8 Aldo Leopold, Sand County Almanac 129 (1966 ed.).

9 Bryan G. Norton and Anne Steinemann, Environmental Values and Adaptive Management, 10 Environmental Values 473, 487 (2001) ("'think like a mountain' … requires thinking about the long-term as well as the short-term

II. The Goal of Site Optimization

Stewardship implies goals or standards against which stewardship responsibilities are to be measured. In this section, I argue that a goal of long-term stewardship in Superfund should be optimizing the value of sites or "site optimization." In simple form, site optimization is maximizing the overall net value of the site (i.e., the value of the site as cleaned up and put back into productive use minus the costs of clean up and redevelopment). In what follows I discuss constraints on site optimization imposed by the decision structure of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund)10 and then consider several techniques by which, within those constraints, we might approach value-optimizing solutions at Superfund sites.

A. Superfund Decision Structure

All Superfund remedies must meet "applicable or relevant and appropriate requirements" ("ARARs") under federal and state environmental laws and must also achieve EPA's more general requirement of "overall protection of human health and the environment;"11 EPA has designated these two requirements as "threshold criteria," and I will sometimes refer to them together as "protectiveness." EPA's regulations identify seven other decision criteria for Superfund remedy selection. Five of these are "balancing criteria:" long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost.12 The two remaining factors -- acceptability of the remedy to the state and to the local community – are "modifying criteria."13 None of the

---

impacts of decisions, and thoughtful attempts to integrate these.")

10 42 U.S.C. Sec. 9601 et seq.

11 33 C.F.R. Sec. 300.430(e)(9)(iii)(A) – (B), (f)(i)(A)..

12 33 C.F.R. Sec. 300.430(e)(9)(iii) (C) – (G), (f)(i)(B).

13 33 C.F.R. Sec. 300.430(e)(9)(iii) (H) – (I), (f)(i)(C).

balancing or modifying criteria may override the core requirement of protectiveness.

The general protectiveness criterion encompasses the environmental benefits of clean up, including those that relate directly to human health and those that do not, such as restoration of ecosystem services and protection of biodiversity. However, in the implementation of the program, ecological considerations have traditionally been subordinated to human health concerns, if not eclipsed by them. More importantly for purposes of this paper, the statute and the regulations make no express provision for the consideration of the non-environmental benefits of competing remedial alternatives.

There is considerable play, however, in what protectiveness requires, and it is in this realm of discretion that a broader consideration of the public good may enter. For example, for carcinogenic contaminants, EPA's regulations require clean up to an individual excess cancer risk of no more than 10^{-4} (one in 10,000) to 10^{-6} (one in 1,000,000). Thus, the permissible residual cancer risk after clean up varies by two orders of magnitude. Moreover, the assessment of risk will vary widely depending on the assumptions made about such factors as actual and potential exposure to hazardous substances at the site, which – as we shall see – will vary with projections on future use and other conditions affecting the site. EPA also has discretion in the application of ARARs, including the authority to waive ARARs under certain circumstances.14

Thus, the Agency's definition of protectiveness provides room for a range of possible remedies, some of which we can assume will be more in the overall public interest than others. There are several techniques by which we might select among the alternatives – cost-benefit analysis, multi-objective analysis, and deliberative process. I deal with each of these below. The discussion includes consideration not only of the costs and benefits of the clean up itself but

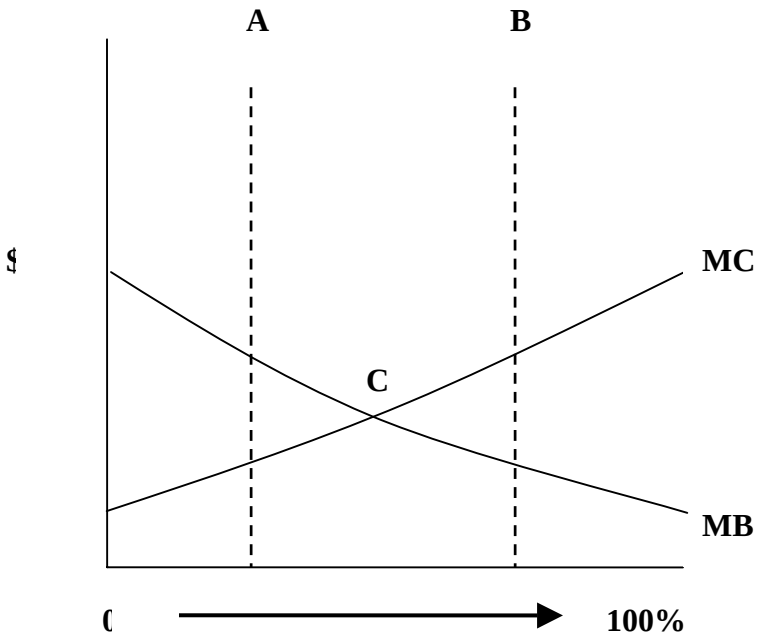
14 42 U.S.C. Sec. 9621(d)(2); United States v. Akzo Coatings of America, Inc., 949 F.2d 1409, 1446-50 (6th Cir.

also the costs and benefits of the reuse options that may be associated with various levels or types of clean up, because – as will be developed in detail -- reuse is an important factor in realizing the value of the resources imbedded in the site and thus in site optimization. The remedy selected not only determines the costs of clean up, which has an obvious impact on site optimization, but it also conditions the future use or development of the site in ways that can enhance or limit the flow of future benefits.

B. Cost-Benefit Analysis

A neoclassical economist would likely interpret the program goal advanced here as maximizing welfare within the statutory constraint of protectiveness and argue that clean up should be set at the level at which the marginal costs of cleaning up and preparing the site for reuse equal the marginal benefits, or the level that maximizes the net benefits of clean up and associated reuse. She might determine this level using cost-benefit analysis, in which the incremental costs and benefits of successively more stringent clean up options and their associated uses would be determined and compared to each other. The results of a hypothetical cost-benefit analysis are shown in Figure 1, which plots the level of clean up and associated reuse options (y axis) against the marginal costs and benefits of these options (x axis).

1991) (upholding EPA's implicit waiver of state ARAR).



In this hypothetical, more aggressive (and expensive) clean up levels are associated with more intensive (and higher exposure) reuse. Curve MC represents the marginal costs across a range of alternatives, from no clean up at all (zero) to removal and destruction or immobilization of all contaminants onsite (100%). Marginal costs are presumed to increase with successively more stringent clean up/reuse options. Curve MB represents the marginal benefits of clean up/reuse across the same alternatives; marginal benefits are presumed to decrease with successively more stringent clean up/reuse options. Vertical lines A and B represent the lower and upper limits respectively of protectiveness as currently defined by the statute and EPA regulations. An option to the left of A would not be acceptable because it would be not be

protective. An option to the right of B could not be ordered by EPA because it would be in excess of the remediation required by the statute, although a party could voluntarily undertake a clean up/reuse option beyond B, a possibility to which we will return.

Point C, the intersection of MC and MB, represents the optimal clean up/reuse option, as it is the point at which marginal costs equal marginal benefits or the point at which the net benefits of clean up/reuse are highest. Thus, within the protectiveness range defined by A and B, C is the option that offers the highest welfare returns. As discussed above, if the intersection of MC and MB occurred to the left of A, the optimal clean up/reuse level would not be consistent with the constraint of protectiveness and therefore would not be allowed; if it occurred to the right of B, it could probably not be ordered by EPA but could be voluntarily implemented.

Although often viewed skeptically by environmentalists, cost-benefit analysis does not necessarily direct environmentally less desirable measures. For example, in a cost-benefit analysis of remedy/reuse options for the Emelle Septic Landfill site in New Jersey, a student researcher concluded that the option of making the site available for ecological services (pineland, grassland and wildlife habitat) was preferable to the option of commercial development.15 A net benefit was developed for each option "by determining the costs of groundwater and ... soil remediation from volatile organic compounds (VOC) contamination and the costs of redevelopment and subtracting these costs from the public and private benefits of reuse."16 Ecological reuse showed a positive net benefit, whereas the net benefit for commercial reuse was negative.

Commentators have criticized cost-benefit analysis, particularly as applied to

15 Melissa A. Kenney, Development of a Value-Based Model to Provide Options for Reuse of Superfund Sites (2002) (student thesis on file with author).
16 *Id.* at 27.

environmental issues, and its limitations suggest that it should be used with caution in Superfund site analysis. Cost-benefit analysis, like other single-criteria evaluative systems, is carried out in terms of a single metric – dollars; reducing the value of environmental amenities (such as uncontaminated groundwater) and other non-market goods (such as community identity or sense of well-being) to a dollar figure based on willingness to pay is controversial in itself.17 Moreover, there is dispute among economists about how benefits of clean up are best measured; indirect methods, such as the hedonic price technique, can yield results significantly different from direct methods, such as contingent valuation.18 Direct methods are commonly criticized because they rely on the survey results and do not require respondents to act on their responses.19 Indirect methods avoid this criticism by using actual consumer decisions to model preferences. For example, economists have applied the hedonic method to price data from housing sales in order to approximate the benefits of clean up for those living in the vicinity of contaminated sites.20 The hedonic method, however, may suffer from the difficulty of isolating

17 Vatn and Bromley (1994); Heinzerling (1999); Sagoff (____).

18 Jill J. McClusky and Gordon C Rausser, Estimation of Perceived Risk and Its Effect on Property Values, 77 Land Economics 42, 43 (2001).

19 *Id.*

20 *E.g.*, Katherine Kiel and Jeffrey Zabel, Estimating the Economic Benefits of Cleaning Up Superfund Sites: The Case of Woburn, Massachusetts, 22 Journal of Real Estate Finance and Economics 163-184 (2001); Larry Dale, James C. Murdoch, Mark A. Thayer and Paul A. Waddell, Do Property Values Rebound from Environmental Stigmas? Evidence from Dallas (July 1997); Katherine A. Kiel and Katherine T. McClain, House Price Recovery and Stigma After a Failed Siting, 28 Applied Economics 1351-58 (1996); Katherine A. Kiel, Measuring the Impact of the Discovery and Learning of Identified Hazardous Waste Sites on House Values, 71 Land Economics 428 (1995); Mark Thayer, Heidi Albers, Morteza Rahmatian, Benefits of Reducing Exposure to Waste Disposal Sites: A Hedonic Housing Value Approach, 7 Journal of Real Estate Research 265 (1992); Janet E. Kohlhase, Impact of Toxic Waste Sites on Housing Values 1 (1991).

Hedonic studies have also sought to estimate the welfare impacts of contamination or clean up on the property subject to contamination. *E.g.*, Jill J. McClusky and Gordon C. Rausser, Stigmatized Asset Value: Is It Temporary or Permanent? (June 10, 1999); A. R. Wilson, Emerging Approaches to Impaired Property Valuation, 64 Appraisal Journal 155-70 (1996); B. Mundy, Impact of Hazardous Materials on Property Value, 60 Appraisal Journal 155-62 (1992); B. Mundy, Stigma and Value, 60 Appraisal Journal 7-13 (1992); P. J. Patchin, Contaminated Properties – Stigma Revisited, 59 Appraisal Journal; P.J. Patchin, Valuation of Contaminated Properties, 56 Appraisal Journal 7-16 (1988).

the factors that affect consumer choices.21 It may also fail to capture all the benefits associated with contaminated site restoration and reuse. Hedonic-price studies on the effect of cleaning up contaminated properties, for example, do not capture existence values of site clean up, *i.e.*, benefits to "non-users" within the larger community.

The federal government's keeper of the cost-benefit flame, the Office of Management and Budget (OMB), has acknowledged that "monetizing some of the effects of [environmental, health and safety] regulation is difficult, and quantifying some effects may not be feasible."22 OMB's cost-benefit methodology allows benefits that can't be monetized – such as "ecological gains, improvements in the quality of life, and aesthetic beauty" -- to be represented qualitatively.23 However, critics of cost-benefit analysis remain concerned that in an analysis consisting otherwise of "hard" numbers, qualitative representations will be systematically discounted by decisionmakers.

Cost-benefit analysis typically discounts future costs and benefits to present value in order to take into account the time value of money and other resources in the analysis. Such discounting in the environmental arena has been criticized generally and is particularly problematic when applied to environmental and other community resources that have cross-generational implications.24 Thus, the lengthy projected time frames of both costs and benefits flowing from implementing and maintaining protective remedies and productive reuse at Superfund sites raise further questions about the appropriateness of cost-benefit analysis, at least as typically performed. Discount rates can be reduced or eliminated entirely in order to address

---

21 Thomas O. Jackson, 9 Journal of Real Estate Literature 93, 100-07, 110-14 (including Figure 1) (2001).
22 Office of Management and Budget, Informing Regulatory Decisions: 2003 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local and Tribal Entities 167 (2003) (responding to comments on cost-benefit methodology).
23 OMB Circular A-4, Regulatory Analysis 144 (____).
24 [Revesz, Farber]

this issue, although OMB is reluctant to use a zero discount rate, even for costs and benefits that are clearly inter-generational.25

A related criticism of cost-benefit analysis is the failure to take into account other distributional effects of decisionmaking. The costs and benefits of Superfund decisions may not only be unevenly distributed over time but also may vary sharply across affected subpopulations distinguished by geography, race, income or economic sector. Many Superfund sites are located in poor or minority communities, and environmental justice advocates have argued that clean up decisions have discriminated against those communities. Cost-benefit analysis can include a description of the distributional effects of alternatives (i.e., a discussion of who bears the costs and benefits),26 but the technique is designed to serve the goal of efficiency, not fairness. Whether justice concerns can be effectively integrated into cost-benefit analysis, rather than merely footnoting it, remains unclear.

Finally, at the time the remedy is selected at a Superfund site, the computation of costs and benefits, assuming it is otherwise feasible, is fraught with contingencies, such as uncertainties about conditions at the site, the effectiveness and costs of remedial alternatives, and future land use at the site. Cost-benefit analysis can attempt to take such uncertainties into account in several ways. First, significant uncertainties can be identified and their sources analyzed; analysts can then assess the way in which costs and benefits might be affected under a range of assumptions. OMB prefers that probabilities be quantified, but acknowledges that "the level of … uncertainty may be so large that you can only present discrete alternative scenarios without assessing the relative likelihood of each scenario quantitatively."27 Second, where

25 OMB Circular A-4, *supra*, at 153.
26 See OMB Circular A-4, Regulatory Analysis 131.
27 OMB Circular A-4, Regulatory Analysis 156.

additional information (e.g., data from additional site sampling) would narrow the range of uncertainty, the decisionmaker can consider delaying a decision until that additional information can be obtained. Whether to delay for this reason may require a kind of secondary cost-benefit analysis, in which the potential benefits of the additional information are weighed against the costs of delay. 28 As developed below, adaptive management provides yet a third possibility – to proceed in the face of uncertainty but to retain flexibility for adjustments in future decisions, and to ensure that information generated by the initial decision is collected and analyzed to inform subsequent ones.

C. Multi-Objective Modeling

An alternative to cost-benefit analysis, although closely related, is multi-objective analysis that optimizes across a range of objectives. This methodology provides a framework for systematic weighing of incommensurable preferences or values. At Superfund sites these preferences or values might be associated with potentially competing objectives as such as environmental protection, market efficiency, and value to the community. Multi-objective modeling avoids the incommensurables problem by not attempting to reduce all preferences or values to a single metric but seeks to identify optimal solutions across competing objectives.29 Like cost-benefit analysis it can be framed to reflect the intergenerational and other distributional effects of site decisions as well as the contingencies affecting them. Researchers at the University of Virginia have constructed a preliminary form of a multi-objective model of the Superfund site decision process that would account for contingencies.30 For Superfund sites,

---

28 OMB, Informing Regulatory Decisions 60 (2003).

29 Yacov Y. Haimes, Risk Modeling, Assessment, and Management 23-26 (1998).

30 Faheem A. Rahman, Systems Analysis and Adaptive Learning for Superfund for Portfolio Management of Superfund Sites (Aug. 2003) (M.S. Thesis, Department of Systems and Information Engineering, University of Virginia) (on file with author). For other applications of multi-objective risk analysis, see James H. Lambert, Jeffrey A. Baker, and Kenneth D. Peterson, 35 Accident Analysis and Prevention 47-57 (2003); Joshua L Tsang, James H.

given the incommensurables problem in particular, multi-objective modeling may provide an analytical technique that is superior to cost-benefit analysis.31

D. Deliberative Process

Neither cost-benefit analysis nor multi-objective modeling can capture the full complexity of factors affecting Superfund decisions designed to optimize site value. Most proponents of these methodologies advance them as aids to decisionmaking, rather than as the sole determiners of decisions.32

Ultimately, the Superfund decision process is deliberative, not technocratic. Neither the statute nor EPA regulations mentions cost-benefit analysis; White House/ OMB policies do not require cost-benefit studies for these decisions; and they are not typically done. Instead, the statute and EPA regulations identify general factors to be balanced and provide some soft signals about how they are to be weighed. They require the Agency to consult with the community during the RI/FS process; hold a public meeting on its proposed plan for the site; provide for opportunity public comment before the remedy is selected; and, as discussed more fully below,

---

Lambert, and Robert C. Patev, 8 Journal of Infrastructure Systems 42-48 9 (2002); Yacov Y. Haimes, Stan Kaplan, and James H. Lambert, Risk Filtering, Ranking and Management Framework Using Hierarchical Holographic Modeling, 22 Risk Analysis 383 (2002); Jeffrey A. Baker and James H. Lambert, Information System for Risks, Costs, and Benefits of Infrastructure Improvement Projects, 5 Public Works Management and Policy 199 (2001); James H. Lambert, Yacov Y. Haimes, Duan Li, Richard M. Schooff, Vijay Tulsiani, Identification, Ranking and Management of Risks in a Major System Acquisition, 72 Reliability Engineering and System Safety 315-24 (2001); Hendrik I. Frohwein and James H. Lambert, Risk of Extreme Events in Multiobjective Decision Trees: Part 1. Severe Events, 20 Risk Analysis 113 (2000); J. Rolf Olsen, Peter A. Beling and James H. Lambert, Dynamic Models for Floodplain Management, Journal of Water resources Planning and Management 167 (May/June 2000); Hendrik I. Frohwein, Yacov Y. Haimes, and James H. Lambert, Risk of Extreme Events in Multiobjective Decision Trees: Part 2: Rare Events, 20 Risk Analysis 125 (2000); H.I. Frohwein, J.H. Lambert, and Y.Y. Haimes, Alternative Measures of Risk of Extreme Events in Decision Trees, 66 Reliability Engineering and System Safety 69 (1999); Hendrik I. Frohwein, James H. Lambert, Yacov H. Haimes, and Lauren A. Schiff, Multicriteria Framework to Aid Comparison of Roadway Improvement Projects, Journal of Transportation Engineering 224 (May/June 1999); Vicki M. Bier, Yacov Y. Haimes, James H. Lambert, Nicholas C. Matalas, and Rae Zimmerman, A Survey of Approaches for Assessing and Managing the Risk of Extremes, 19 Risk Analysis 83 (1999); J. Rolf Olsen, Peter A. Beling, James H. Lambert, and Yacov Y. Haimes, Input-Output Economic Evaluation of System of Levees, Journal of Water Resources Planning and Management 237 (September/October 1998).

31 For the balance of the paper, I use “costs” and “benefits” in a non-technical sense to refer to the “pros” and “cons” or the positive and negative impacts of alternatives.

consider the acceptability of the plan to the state and the community.33 In response to public reaction to the proposed plan, EPA is required to reassess "its initial determination that the preferred alternative provides the best balance of trade-offs, now factoring in any new information or points of view expressed."34 Drawing on information about the site, the nature and extent of its contamination, and the advantages and disadvantages of various alternatives for addressing the site, the final balance is then struck by an EPA decisionmaker.

While not required, quantitative techniques already discussed may provide useful inputs into this process. The disciplined thinking involved in modeling may itself improve decisionmaking, helping decisionmakers counter the effects of "cognitive problems" that have been identified as affecting environmental decisionmaking.35 For example, EPA decisionmakers and others concerned with a site may have difficulty accurately assessing the range and probability of possible outcomes in a context of uncertainty. Systematic analysis and quantification of contingencies, even though subject to uncertainties themselves, can sharpen the judgment of decisionmakers about how to factor uncertainty into their decision. These methodologies may also improve the deliberative or democratic process by limiting the ability of interest groups to exploit distorted perceptions of risks and probabilities to their advantage.

The deliberative process can also incorporate qualitative techniques applied to the site, such as cultural and historical reviews, creation of alternative design futures for the site, and group processes to facilitate consensus or at least to narrow disagreement. These processes can be used to foster a rich sense of alternative site trajectories among diverse stakeholders and to

---

32 Cass R. Sunstein, The Cost-Benefit State: the Future of Regulatory Protection (2002).
33 40 CFR Sec. 300.430(c); (d)(7)(iii)(H); (f)(3).
34 40 CFR Sec. 300.430(f)(4).
35 Cass R. Sunstein, *supra*, at 9 (discussing "cognitive problems" affecting environmental decisionmaking, such as the "availability heuristic," effects of emotions or "hysteria" on estimates of probability, and fragmentary thinking).

develop and explore community preferences and values. Site optimization – the highest overall net value to the community and other stakeholders – is thus understood as the outcome of a deliberative process rather than as an objectively or analytically determinable endpoint. This goal incorporates considerations of fairness as well as welfare maximization or efficiency.

III. Establishing the Deliberative Scope of CERCLA

Having posited site optimization as a goal for Superfund site decisionmaking, an important question remains: whether and to what extent CERCLA and the NCP allow EPA to consider the full range of values implicated in site optimization, including the non-environmental dimensions of clean up and reuse. As we have seen, the statute requires consideration of environmental concerns in its protectiveness criteria and also of the costs and technical feasibility of clean up options. It does not expressly provide for consideration of the non-environmental benefits associated with remedial alternatives or with the costs or benefits of alternative reuse scenarios. But these costs and benefits may enter the deliberations in at least two connections. The first is the Agency's consideration of "reasonably anticipated future land use," under guidance issued for the preparation of the RI/FS. The second is the statutory requirement that EPA consider the views of the community on its proposed remedy. Both are discussed below.

A. Reasonably Anticipated Future Land Use

As part of the remedial investigation, EPA conducts a baseline risk assessment and sets clean up goals based on the risks to the "maximally exposed individual." In OSWER Directive 9355.7-04, May 1995, the Agency stated that "[f]uture use of the land will affect the types of exposures and the frequency of exposures that may occur to any residual contamination

remaining on site, which in turn affects the nature of the remedy chosen."36 The guidance requires that clean up objectives reflect "reasonably anticipated future land use" and states further that "land uses that will be available following completion of remedial action are determined as part of the remedy." Thus, the reasonably anticipated future land use becomes embedded in the remedial decision and may exclude certain future reuse options while facilitating others. EPA has recently acknowledged this effect of the future land use determination, stressing the importance of "integrating realistic assumptions of future land use into Superfund response [as] an important step toward facilitating the reuse of sites following cleanup." OSWER 9355.7-06P, June 2001.

The 1995 land use directive came in response to criticisms that the Agency's risk assessments and remedial decisions had reflexively assumed the future use would be residential. This assumption, critics argued, raised projected levels of exposure to contaminants left on site, leading to more aggressive clean up objectives and more expensive remedies. Although the directive does not explain it this way, by considering "reasonably anticipated future land use," EPA can avoid remedies whose incremental costs would not be justified by the incremental benefits, *e.g.*, an aggressive remedy that made a site "safe" for residential use when only industrial use was likely.

Consideration of future land uses allows, in some rough sense, a comparison of the benefits as well as the costs of various remedial/reuse options. Each potential land use will be associated with potential benefits – profits to the site owner, increases in neighboring property values, and contributions to community values not fully captured in property values – that are in

36 For an excellent, detailed account of how land use is considered in the remedial process, see Robert Hersh, Katherine Probst, Kris Wernstedt, and Janice Mazurek, Linking Land Use and Superfund Clean Ups: Unchartered Territory 21-38 (1997).

addition to the human health and environmental benefits flowing from the clean up. Each land use scenario will also be associated with redevelopment costs, in addition to the expense of the clean up that would be required to support it.

Under the current guidance, EPA does not represent itself as selecting a "reasonably anticipated future land use" based on a determination of what would be in the overall public interest (a preference or value judgment); instead it sees itself as developing realistic assumptions about what land use will occur (a factual determination). However, the relative likelihood of various reuse options reflects a determination by someone or some institution (e.g., the owner, the real estate market, zoning officials, or some combination thereof) that, in the particular circumstances of a site, some uses are preferable to others. It contains an implicit value judgment.

Moreover, EPA does not automatically accept a "reasonably anticipated land use" proffered by the community, but

> "must balance this preference for future land use with other technical and legal considerations provided in the Superfund law and its implementing regulations…. Specifically EPA balances the requirements to treat principal threats, to use engineering controls such as containment for low level threats, to use institutional controls to supplement engineering controls, and to consider the use of innovative technologies. In addition, EPA must comply with other laws when they are 'applicable or relevant and appropriate.'"37

Thus, EPA adds its own review to the community preferences reflected in the "reasonably anticipated future land use." In sum, consideration of land use can provide indications of how market efficiency and value to the community may be affected by various site management options and, when combined with other information within EPA's consideration, will aid

---

37 U.S. Environmental Protection Agency, Reusing Superfund Sites: Recreational Use of Land Above Hazardous Waste Containment Areas 14 (March 2001). *See* 40 CFR 3000.430(a)(1)(iii).

selection of a remedial/reuse option that is in the overall public interest.

Ideally, the agency's remedial decision will facilitate a clean up/reuse package that optimizes value for the community (and the nation) within the statutory constraints of protectiveness. It will be the agency's responsibility to manage sites in ways that encourage, or at least do not foreclose, optimal long term strategies. This is not easy, particularly if reuse plays the role in optimizing site value urged here, for several reasons. First, determining "reasonably anticipated future land use" may be very difficult during the remedial decisionmaking process. "At nearly 80% of sites on the NPL, there are adjacent residential areas. Predicting the 'future land use' of these sites could be difficult."38 Second, even where "reasonably anticipated future land use" can be determined, that determination may only be possible in broad categories – e.g., industrial, commercial, recreational, or ecological. Indeed, EPA anticipates that the reuse assessment will be documented in these broad terms and that "[m]ore specific end uses (e.g., office complex, shopping center, or soccer facility) can be considered during the response process when detailed planning information is readily available."39 A study published by Resources for the Future found that "anticipated use of the site often evolves in tandem with the remedy."40 It may take years for reuse plans to take on specific form, if they emerge at all. Third, the "reasonably anticipated land use" may change. Site ownership, market conditions and political alignments within the local jurisdiction with land use control authority over the site can all change unpredictably, with direct implications for future land use.

Despite these difficulties, there are several steps that EPA could take to enhance the accuracy and usefulness of reuse assessments over the long term, particularly where those

38 Hersh, et al. *supra*, at 97, citing U.S. Environmental Protection Agency, Superfund Administrative Reform Fact Sheet (May 25, 1995).
39 Reuse Assessment Guide, OSWER Directive 9355.7 – 06P, at 7.

assessments are likely have determinative effect on remedy selection, design or implementation. The first step would be to reduce uncertainty by investing in more vigorous examination of future land use options in the Remedial Investigation/Feasibility Study (RI/FS) phase than is currently done. Current guidance emphasizes that the reuse assessment should "rely on readily available information."41 Given the role of future land use envisioned here, however, as capturing important public values that might otherwise be missing from site deliberations and reflecting particularly the concerns and preferences of the community most immediately affected by EPA's decisions, going beyond "readily available information" may be necessary. Second, the Agency should take affirmative steps to enhance the likelihood that the "reasonably anticipated future land use" has institutional support within the local jurisdiction. In determining reasonable future land use EPA is to consult with "local land use planning authorities, local officials, and the public."42 But more than "consultation" may be appropriate. These sectors and individuals within them might be expected to have a diversity of views on what should be done with a site. Reconciling those views may warrant EPA sponsorship of focused deliberation on the future of the site, rather than the more passive inquiry contemplated by the guidance, and if resolution is achieved, the memorialization of results in contractual commitments and/or planning and zoning measures. Finally, particularly where significant uncertainty about future land use remains, EPA should retain flexibility for adjustments in the remedy or its implementation in response to the emergence or refinement of promising reuse proposals. This last point will be developed further in the section on adaptive management.

A recent pilot project funded by EPA and conducted by E^2 Inc. and the University of

---

40 Hersh et al., *supra*, at 96.
41 Reuse Assessment Guide, *supra*, at 1.
42 OSWER Directive No. 9344.7-04, at 4 (May 25, 1995).

Virginia's Institute for Environmental Negotiation offers a model of an intensive community-based process to elicit future land use preferences serving the decision needs addressed above.43 In this case, involving the Central Chemical site in Hagerstown, Maryland, a Land Use Committee was convened whose eighteen members included residents and property owners from around the site and from around the city; local business interests and government officials; and the site owner and other potentially responsible parties.44 The Land Use Committee was sponsored by Hagerstown's Planning Department; was attended by representatives of the Planning Department, Hagerstown's Fire Department and Maryland's Department of the Environment as "'resource' members;"45 and met a half dozen times among themselves and on three occasions with the general public. Among the "guiding principles" or values expressly incorporated into the committee's deliberations were to "protect the long-term health and safety of community residents;" ensure compatibility of "site reuses … with surrounding neighborhoods;" "provide community-wide benefits," including creation of tax benefits and new jobs; "integrate the natural environment into site's reuse;" and understand "the site within its local surroundings and as part of the larger community."46

The committee reached consensus, recommending mixed light industrial, commercial office park and natural buffer uses for the site; its recommendations included actual site sketches showing the location and size of the natural buffers and areas designated for commercial and light industrial use. Although these uses were consistent with the existing zoning for the site, the committee's recommendations were adopted by the Hagerstown's City

43 Hagerstown Land Use Committee, E^2 Inc. and University of Virginia's Institute for Environmental Negotiation, Central Chemical Superfund Redevelopment Initiative Pilot Project: Project Report (July 2003).
44 *Id.* at 34.
45 *Id.*
46 *Id.* at 6.

Council for inclusion in the city's Comprehensive Plan. The committee recognized that additional information about the site could affect "types of appropriate land uses allowed at the site in the future" and urged EPA "continue to work closely with the City of Hagerstown and community residents in the future to address community concerns and work with the community to clean up the Central Chemical site and return the site to successful reuse."47

B. Community Views

Another portal through which market considerations and value to the community may enter site deliberations along with environmental protection is the requirement that EPA solicit community views48 and consider the acceptability of the Agency's preferred remedy to the state and the community in selecting a remedy.49 The state and the local community may be expected to have strong concerns about the environmental risks at the site, but they also may have concerns about other aspects of the site, such as the magnitude of operation and maintenance costs to be shouldered by the state or the effect of the remedy on site reuse and related issues, such as effects on jobs, property values, tax revenues and the living environment. Under EPA regulations, acceptability of a remedy to the state and community is a consideration that comes relatively late in the process and, as a "modifying criteria," assumes a less central role in EPA's deliberations than the "threshold" protectiveness criteria or even the "primary balancing criteria" such as effectiveness and implementability.50 [Check guidance.] Nevertheless, like consideration of land use, consultation with the state and local community on remedy selection provides a vehicle for a broader range of concerns to enter the process. In most cases, the local community is the primary if not the sole consumer of the environmental risks

47 *Id.* at 39.
48 40 CFR Sec. 300.430(c).
49 40 CFR Sec. 300.430(e)(9)(iii)(H)-(I).

posted by the site, and its views will therefore bear importantly on the relative environmental value of various clean up scenarios. The local community also stands to reap a substantial portion of the non-environmental benefits of clean up, including the benefits that flow from reuse of the site, and may also be in the best position to assess those benefits.

To provide a well-integrated or holistic view of community preferences or values affecting site decisions, EPA should coordinate consultation on "reasonably anticipated future land use" with solicitation of views on the appropriate remedy and site management more generally.51 Because the land use issue is addressed early in the process, as in Hagerstown's case, EPA should arrange to have the results of community deliberations on this issue pour over into the community's consideration of remedy selection. Subject to concerns about fairness and effective representation of diverse interests, the Agency can enhance the depth and continuity of community consultations by directly engaging public officials along with private citizens and by fostering institutional commitments that reflect the preferences and values elicited in the process.

IV. Adaptive Management

Adaptive management provides a process framework for site optimization as well as protectiveness, offering a systematic way of dealing with contingency and change to approximate optimal solutions over time. This approach had its origins in ecosystem management, where scientists and policy makers encounter high degrees of uncertainty (and surprise) in the responses of natural systems to human intervention.52 In Compass and

---

50 40 CFR Sec. 300.439(1)(I).

51 *But see* Kris Wernstedt and Katherine N. Probst, Land Use and Remedy Selection: Experience from the Industri-Plex Site, Resources for the Future Discussion Paper 97-27 (July 1997) (questioning "whether the benefits of public involvement that many assert would follow from combining reuse and clean up are as uncomplicated or unambiguous as many would like to admit").

52 See, e.g., C.S. Holling, Adaptive Environmental Assessment and Management (1978); _____ Walters, Adaptive

Gyroscope: Integrating Science and Politics for the Environment, Kai Lee argued that adaptive management should be used where (1) data is sparse because it is difficult to observe the state of the natural system and the human economy interacting with it; (2) theory is limited and does not permit deductive logic to extrapolate very far from experience; and (3) surprise is unexceptional, so that predictions are often wrong.53

In adaptive management, policy decisions have a provisional, experimental quality. Decision makers maintain flexibility and adjust as they go on the basis of monitoring the effects of their past decisions and new information from other sources. A National Research Council-National Academy of Science study describes adaptive management as

> "involving a decision-making process based on trial, monitoring and feedback … and recognizing the imperfect knowledge of interdependencies existing within and among natural and social systems, which requires plans to be modified as technical knowledge improves."54

Adaptive management addresses both human and natural systems. One of its early proponents, C.S. Holling, has argued that there are fundamental similarities in the way complex ecological and human systems behave and has suggested that the focus of adaptive management should be on the "coupled dynamics of nature, society and resource institutions."55 Kai Lee characterizes it as "[l]inking science and human purpose."56 Adaptive management proponents sometimes feature the hierarchical qualities of both the natural and human systems they address, with linkages between nested systems operating at different spatial and temporal scales offering

---

Management of Renewable Resources (1986); and Kai N. Lee, Compass and Gyroscope: Integrating Science and Politics for the Environment (1993).

53 Kai Lee, *supra,* at ___.

54 Quoted in A. Dan Tarlock, Beyond the Balance of Nature: Environmental Law Faces the New Ecology, 7 Duke Envtl L & Pol'y F. 193, 205-06 (1996).

55 Lance H. Gunderson, C.S. Holling and Stephen S. Light, Barriers Broken and Bridges Built: A Synthesis, in Barriers and Bridges to the Renewal of Ecosystems and Institutions (Lance H. Gunderson, C.S. Holling and Stephen S. Light eds. 1995).

56 Kai Lee, *supra,* at 9.

additional complexity and uncertainty.57 Adaptive management has been identified with place-based or community-based management, oriented around *"a specific locale, which represents a point within a complex dynamic, and multi-scalar system.*" 58 It has also been associated with participatory and deliberative decisional processes seeking to define and apply values of the relevant human community.59

Although Superfund sites differ in some ways from the natural systems to which adaptive management is most often applied, there are reasons to believe that this approach could be appropriately and usefully applied to Superfund. These sites have been intensively developed, but natural processes (e.g., microbiological action in the soil and groundwater) occur on them nonetheless. They provide habitat for living creatures from microbes in soil and groundwater to rare or endangered mega fauna. All of them contain ecosystems and are parts of larger ecosystems. Often located in areas with large concentrations of humans, they are heavily affected by the operation of social, political and economic systems. Generally, they represent a "mixed system," in which human influences are pervasive but in which natural processes are also important. Thus, they are within the ken of adaptive management.

Superfund sites also present the sorts of uncertainties and opportunities for learning over extended periods for which adaptive management is particularly suited. Decisions require information about (1) the nature, quantity and location of contaminants on site; (2) site characteristics, including ecosystem processes such as ground water flow and microbial activity; (3) costs and effectiveness of remedies; and (4) political and economic conditions affecting clean up and reuse. Studies are done to obtain this information, but significant uncertainties

57 Bryan G. Norton and Anne C. Steinemann, Environmental Values and Adaptive Management, 10 Environmental Values 473, 479 (2001)
58 *Id.*, at 482 (emphasis in original).

often remain after the studies are complete, and new information is generated throughout the process. Some of this information may come by way of response to decisions made and implemented or sought to be implemented at the site. For example, an attempt to carry out a groundwater pump and treat remedy may reveal new information about cost or effectiveness that would cause decisionmakers to rethink the remedy.

Superfund also obviously lends itself to management that is oriented to a particular place or resource – the site – and that emphasizes deliberation among stakeholders identified particularly to that site. Compared to other environmental programs in which detailed regulatory standards drive decisions toward uniform results across diverse environmental and socio-economic settings, Superfund's decision criteria for clean ups, as articulated in CERCLA and the NCP, are relatively open and flexible. Thus there is room to tailor decisions according to both the physical circumstances of the site (as well as the larger systems to which the site is connected) and the preferences or values of the community around it (as well as those of institutions at the state or national level). The statue and regulations also allow, indeed in some cases require, that those decisions be modified in response to new information gleaned from implementation and from other sources.

Adaptive management in Superfund can be applied on site-by-site basis and also a site portfolio basis, as the Agency adjusts its management of its entire inventory of sites or distinct portions thereof in light of its program experience and other sources of new information. I explore the site applications first.

A. Site Level Adaptive Management

The Superfund process is extended in time, made up of myriad information-gathering

---

59 Kai Lee, *supra*; Norton and Steinemann, *supra*, at 482.

activities and decisions. These include the initial identification and scoring of the site; listing on the National Priority List (NPL); the RI/FS (including the reasonably anticipated future land use determination); remedy selection, implementation and evaluation; possible remedy revision; deletion from NPL; and post-remedial five-year review for the roughly 60% of "construction complete" sites where some residual waste remains on site. This process is lengthy. EPA has estimated the average time from proposal for listing on the NPL to completion of the remedial action at approximately 8 years; a recent study by Resources for the Future calculates the average instead at over 11 years.60 Remedy implementation – i.e., actually achieving final cleanup goals -- may take 30 years or longer at some sites. For the roughly 60% of sites where waste remains on site after completion of the remedy, monitoring and review are mandated for as long as contamination remains above a level that allows "unlimited use and unrestricted exposure."61 For some Department of Energy sites involving radioactive contaminants, the projected period of agency involvement extends for thousands of years.62

Adaptive management leads us to think of this process as a series of interventions over time, with the aim of ensuring that each intervention is informed by current information, including information about what occurred in response to previous interventions. It anticipates that decisions will leave maximum flexibility for later adjustments and that they will be revisited and revised, if appropriate, in light of new information. It also anticipates effective coordination of site decisions made by the public and private sectors and by multiple levels of government. These management characteristics will depend on Superfund institutions that (1) provide for adequate monitoring and feedback mechanisms (information flow); (2) do not foreclose options

60 Probst and Konisky, supra, at 47-52.
61 U.S. Environmental Protection Agency, Comprehensive Five-Year Review Guidance, OSWER Directive No. 9355.7-03B-P (2001).

unnecessarily while proceeding with the tasks of decision and implementation (flexibility); (3) enable revisiting and adjusting prior decisions as warranted (self-criticality); and (4) integrate across sectors and jurisdictional scales (hierarchical linkages). The discussion that follows explores how such institutions might work in practice, within the structure of the Superfund process as currently fixed by EPA's statutory mandates, regulations and interpretations thereof. It concludes that although the current structure has some ability to accommodate an adaptive management approach, including modifications of remedies to ensure protectiveness over time, it does not make adequate provision for such an approach with respect to reuse options or the goal of site optimization.

1. Adaptive Management in Superfund Site Remediation

a. From Site Study to Remedy Completion

As mentioned above, it takes 11+ years on average for a Superfund site to move from proposed listing on the NPL to completion of the remedy. The process defined by EPA regulations and related guidance provides multiple decision opportunities during this extended period for adjustments to be made in response to new or evolving information and thus for the application of adaptive management principles.

During this phase, EPA conducts the remedial investigation/feasibility study and selects, designs and implements a remedy. The remedial investigation (RI) characterizes the site, conducting field studies and a baseline risk assessment, and sets protectiveness goals that are used to develop remedial alternatives and to measure the efficacy of those alternatives. EPA regulations recognize that "estimates of actual or potential exposures and associated impacts on human and environmental receptors may be refined throughout the phases of the RI as new

---

62 National Academy of Sciences, Long-Term Stewardship of DOE Legacy Waste Sites: A Status Report (2003).

information is obtained" and therefore that these goals may change during the remedial investigation. In the baseline risk assessment, as we have discussed, the reasonably anticipated future land use is determined and used to set clean up objectives. By implication then assumptions about future land use, along with other elements of EPA's risk assessment, will be reviewed and refined in light of "new information" prior to the selection of a remedy.

The feasibility study (FS), which is developed in coordination with the RI, defines and assesses (practicable and cost-effective) remedial alternatives to meet clean up objectives for the site. EPA regulations require that EPA's assessment of alternatives take into account uncertainties affecting the success and long-term effectiveness of the remedy.63 Information gleaned during the RI/FS may help limit or at least quantify these uncertainties.

The remedial decision selects the remedy that will be undertaken at the site and issues a record-of-decision (ROD). Issuance of the ROD is followed by remedial design and implementation (RD/RA). During this post-ROD phase, conditions at the site may change and new information will certainly emerge during the construction and evaluation of the remedy, including sampling and analysis to determine whether clean up levels have been achieved by the remedy.64 Other developments during the RD/RA phase that may affect clean up plans include the outcome of negotiations with responsible parties to carry out the clean up with private funds rather than with public funds. In provisions that recognize that there may be changes in the ROD between its issuance and final implementation, the NCP provides a mechanism by which new information and developments bearing on the remedy can be considered and acted upon during

63 40 CFR Sec 300.430(e)(9)(iii)(C) (assessment of alternatives by the degree of certainty that they will prove successful); 300.430(e)(9)(iii)(C)(1) (consideration of the adequacy and reliability of containment systems and institutional controls); 300l.430 (e)(9)(iii)(F)(1) (evaluation of technical feasibility, including "unknowns" associated with the construction and operation of the remedy).

64 40 CFR Sec. 300.435(b).

the RD/RA.65 ROD amendments provide an important adaptive management tool, both during and after the RD/RA.

EPA regulations do not expressly address how EPA is to manage uncertainty or new information affecting the reasonably anticipated future land use during the RI/FS. EPA guidance states that "where the future land use is relatively certain, … the remedial action objective could be established with a very high degree of certainty to reflect the reasonably anticipated land use."66 If uncertainty surrounds the reasonably anticipated future land use, "a range of reasonably possible land uses should be considered.'' Each reasonably possible land use may be consistent with some remedial alternative, including engineering measures and institutional controls, but not with others.67 Thus, the guidance directs that "[t]hese likely future land uses can be reflected by developing a range of remedial alternatives that will achieve different land use potentials."68 By developing this range, the Agency retains flexibility to respond to new information on future land use at least through remedy selection.

Similarly, EPA regulations make no specific mention of future land use in the RD/RA phase. EPA guidance states that remedy selection process includes determination of "[l]and uses that will be available following completion of the remedial action" and planning of site activities that are "consistent with the reasonably anticipated future land use."69 Where reuse plans are well-developed at the time of remedy selection, the remedy can be tailored in its design and implementation to ensure both protectiveness and the realization of the reuse plans. In some

65 40 CFR Sec. 300.435(c)(2) (providing for public explanation of significant (but not fundamentally altering) changes in the ROD and for public notice and comment on amendments to the ROD for fundamental alteration of basic features of the remedy).
66 OSWER 9355.7-04, at 7.
67 Margaret Calder Ferguson, Evaluation of Remediation Technologies for Various Contaminants Found on Superfund Sites
68 *Id*., at 7-8.
69 OSWER Directive No. 9344.7-04, at 2.

cases, where site preparation requirements for future development may exceed what is necessary to achieve a protective remedy, arrangements can be worked out to accommodate those requirements prior to implementing the remedy. For example, at the Raymark site in Stratford, Connecticut, the remedy chosen was an engineered containment system. A minimum amount of compaction was necessary to minimize the settling of the cover. The planned redevelopment for the site required additional compaction to site a building. The prospective developer paid for dynamic compaction and the installation of pilings during the construction of the containment system.70 Thus by reducing the total costs of remedy implementation and site preparation, the net value of the clean up and redevelopment of the site was increased.

Reuse plans are often not well developed at the time of remedy selection, in which case the Agency may make protective remedy decisions that anticipate the most likely category or categories of redevelopment and preserve maximum flexibility for future adjustments. Under its general remedy revision authority, discussed above, the Agency may modify its remedy to accommodate proposals that emerge during the RD/RA phase. For example, at the Rentokil, Inc. site, a former wood treating plant in Henrico County, Virginia, the remedy provided for removing wood treating equipment and some contaminated sediments and for building control structures to reduce further migration of contaminants into a creek. During implementation, the remedy was revised to provide for redevelopment, allowing building foundations to be incorporated into the cover and other structures necessary for construction and consistent with long-term maintenance of the remedy.71 The Rentokil site illustrates the importance, as part of an adaptive management approach, of retaining flexibility to respond to new information on land

70 U.S. Environmental Protection Agency, Reusing Superfund Sites: Commercial Use Where Waste is Left on Site 8 (Feb. 2002).
71 *Id.*, at 41.

use preferences as well as other value dimensions of the site even after the remedy has been selected and is being implemented.

Because future land use is so heavily dependent on decisionmakers other than EPA – the site owner, potential developers, local land use authorities and state officials – and because future land use and the evaluation and implementation of remedial measures are so closely related, focused stakeholder processes of the sort piloted in Hagerstown Maryland provide an important adaptive management tool. These processes can provide information on evolving stakeholder preferences and values relating to site planning and management over the course of the RI/FS and the DR/RA and even beyond.72 They can also help integrate perspectives across multiple scales within the decisional hierarchy.

b. Site Reviews

The period after completion of the remedy presents perhaps an even broader field for adaptive management, yet the potential for adaptive management in this field is poorly developed in the EPA regulations and guidance, particularly as regards land use. For sites on which hazardous substances remain, EPA conducts post-remedial inspections and reviews. For remedies adopted after the Superfund amendments of 1986, the statute requires that the Agency conduct an in-depth review of the effectiveness of the remedy every five years.73 This review produces (1) an assessment of whether the remedy is still protecting human health and the environment and (2) recommendations for actions that need to be taken to ensure continued effectiveness (if the remedy has performed adequately to date) or to restore protectiveness (if it

72 *See* text accompanying notes ___ - ___, *supra*.

73 As a policy matter the Agency also requires five-year reviews for remedial actions taking more than five years to complete; pre-1986 remedies where hazardous substances are left on site above levels that allow for unlimited use and exposure; and similarly for removal-only sites (i.e., sites that have been addressed solely under EPA's emergency removal authority) where hazardous substances are left on site above levels that allow for unlimited use and exposure. See U.S. Environmental Protection Agency, Comprehensive Five-Year Review Guidance1-3 to 1-4

has not). The Agency's review includes community notification, a site inspection and interviews, a review of data from site monitoring, and "any other information [that has] come to light that could call into question the protectiveness of the remedy."74 The Agency may require additional sampling and collection of other data as necessary to decide whether the remedy is functioning adequately. Five year reviews are discontinued only when the Agency determines that contaminant levels on site are below levels that allow for unlimited use and unrestricted exposure.75

The five-year review gives the agency both the information and the occasion to act if the protectiveness of the remedy is in question; it is crafted particularly to ensure the continued effectiveness of engineering measures designed to contain remaining on-site contamination (such as caps) and institutional controls designed to limit human exposure (such as land use controls). However, EPA's five-year review guidance does not direct the Agency to inquire into other dimensions of the remedy/reuse or to take action if it is apparent that the remedy is not functioning well along these dimensions. The guidance does direct EPA to consider "changes in land use" as part of its review, but such changes are only relevant to the issue of whether unanticipated exposures have undermined the protectiveness of the remedy. There is no consideration of whether the reuse option anticipated by the remedy has been carried out; whether the current use represents a productive use of the site and otherwise accords with the wishes of the community; or whether alternative uses have materialized that promise more productive use of the site without compromising the remedy's protectiveness. In short, the five-year review is ideally suited to carry out adaptive management of sites after remedy completion

---

(June 2001).
74 *Id.*, at 3-7.
75 *Id.* at 1-4.

but, as it is currently structured, that is so only for some of the considerations that are relevant to site optimization. Dimensions related to economic development and community values are not integrated and therefore the review wastes an opportunity for EPA, in consultation with the state, local officials, community groups and business interests to exercise its full stewardship role.

It remains open at any time for an interested party to propose modification of a remedy to accommodate a different, more beneficial use. A town may propose remedy enhancements that would allow use of a site as a park or a developer changes that would allow more intensive (i.e., high exposure) uses of the site. If the proponent will fund the enhancements and if they insure that the amended remedy will be protective, EPA may approve it. Because of the stigma attached to hazardous waste sites, however, underutilized Superfund sites may not receive the attention either from private development interests or public entities that other properties might.76 The five year review offers a strategic opportunity for EPA to re-engage the community on the issue of site utilization as well as the issue of protectiveness and to facilitate consideration of alternative uses of the site where there is evidence that the land is being underutilized in terms of its economic, community or ecological potential. The characteristics of Superfund sites, as among a relatively small group of the most contaminated sites in the nation, are not within the range of information or expertise typically possessed by local real estate markets or local governments. Niche entrepreneurs specializing in developing contaminated sites may help supply that information and expertise to the affected community, but EPA remains an important and arguably more transparent additional source. Certainly where the Agency is required to maintain contact with the site, as under the 5-year review provisions, its

76 There is evidence that previously contaminated sites remain depressed in value even after clean up. *See, e.g.,* Jill J. McCluskey and Gordon C. Rausser, Stigmatized Asset Value: Is It Temporary or Permanent? (1999); Bill Mundy, Stigma and Value, 60 Appraisal Journal 7 (Jan. 1992).

seems appropriate that its ongoing consultations with local private and public interests endeavor to ensure that the site is well-used as well as safe.

2. Hierarchical Linkages

Adaptive management attends to hierarchical linkages, in both natural and human systems.77 It requires Superfund decisionmakers to locate their understanding of the physical and biological resources of a site in the larger physical and biological systems affecting the site. It also requires decisionmakers to understand their place within the multi-level institutional hierarchy of human decisions affecting the site. Because – as distinct from other categories of land generally managed by private markets and local regulation – Superfund sites also enjoy (or suffer) a substantial federal presence, the hierarchical considerations affecting these sites are both unusual and complex.

To understand how the hierarchical aspects of Superfund sites might best be addressed within an adaptive management framework, it is helpful to understand the possible theoretical rationales for federal involvement in these sites. Economists offer the subsidiarity or matching principle to determine the level of government at which regulatory decisions should be made: the smallest unit of government whose geographic scope includes all the significant costs and benefits of the regulation.78

The matching principle supports federal regulation where a localized activity, such as site contamination, would have significant environmental or economic effects in other states. Physical interstate spillovers of the sort generally acknowledged to warrant federal intervention are not apparent at most Superfund sites, as the effects of soil and groundwater contamination

---

77 Kai N. Lee, *supra*; Bryan G. Norton, *supra*.
78 [Site Oates]

tend to be geographically confined. In *USA v. Olin Corp*., however, in upholding Superfund as within the federal Commerce Power, the Court of Appeals for the Eleventh Circuit noted comments in the legislative history on the effects of site contamination on interstate fishing resources.79 The Court also cited congressional findings that "accidents associated with purely intrastate, on-site disposal activities" adversely affected interstate commerce, and it concluded that "the regulation of intrastate, on-site waste disposal constitutes an appropriate element of Congress' broader scheme to protect interstate commerce and industries thereof from pollution."80 Nevertheless, the interstate externalities argument for Superfund does not seem particularly strong compared to similar arguments for other federal environmental statutes, such as the Clean Air Act and Clean Water Act, in which the interstate pollution problems figure much more prominently.

There are at least two other possible theoretical justifications for the federalization of programs for cleaning up seriously contaminated sites. First, many of these sites are traceable to the business activities of large national or multinational corporations. Given the size of these corporations, their substantial economic leverage within the individual states, and the hefty costs of clean up, one might argue that a federal liability system is necessary in order to prevent a race-to-the-bottom in clean up programs among states, resulting in too little clean up. This possible destructive interstate competition provides an independent justification for a federal scheme. However, Richard Revesz and others have criticized the race-to-the-bottom rationale in environmental applications as insufficient theoretical basis for the federalization of environmental programs.81 There may be competition for economic development, Revesz

79 107 F.3d 1506, 1511 n.10.
80 *Id*. at 1511.
81 Richard L. Revesz, Rehabilitating Interstate Competition: Rethinking the "Race-to-the-Bottom" Rationale for

argues, in which states are forced to balance their desire for jobs with their preference for a clean environment, but that competition is not necessarily a race to the bottom. Indeed it may be welfare enhancing.

Second, it might be argued that the states lack the capability – the scientific, technical or legal sophistication – to effectively deal with the largest and riskiest contaminated sites. Only the federal government, with its advantages of scale, can marshal the requisite expertise to manage these sites effectively and thus the federal regime is justified. However, the federal government's advantages of scale in scientific, technical and legal expertise do not necessarily support locating decisionmaking authority at the federal level rather than simply making federal expertise available to state or local decisionmakers.

Despite the relatively weak rationale for locating decisionmaking authority for contaminated site cleanup at the federal level, Superfund is one of the most pervasively federal environmental programs. Unlike most other federal environmental programs, Superfund does not provide for formal delegation of decisionmaking authority (i.e., ROD-signing authority) to the states. However, under strong devolutionary pressures federal program managers have developed various mechanisms by which power is effectively shared with state governments.

The interests of states, localities and private parties in the management of Superfund sites justify a substantial and ongoing role in site decisionmaking. Typically the benefits of cleaning up and redeveloping a Superfund site are realized predominantly within the state and indeed within the local jurisdiction in which the site is located. A significant portion of the costs of clean up and reuse are also likely to be felt within the state and the locality. Even if federal funds are used for clean up, spreading most of the remedial costs nationally, the state remains

---

Federal Environmental Regulation, 67 N.Y.U.L. Rev. 1210, 1233-44 (1992); *but see* Daniel C. Esty, Revitalizing

obligated for a share of those costs and for long-term operation and maintenance costs as well. Moreover, the land use aspects of Superfund sites fall within the traditional purview of state and local regulation. Accordingly, adaptive management in Superfund site management suggests that EPA invest heavily in processes to elicit the preferences of state and local stakeholders early and often -- with particular emphasis on the community where the impacts of site activities will be concentrated -- and to facilitate integration of the results into federal, state and local decisions affecting the site, as is being done in the case of Central Chemical.

B. Adaptive Management of the Superfund Site Inventory

Adaptive management supplies principles for managing the universe of existing and likely Superfund sites as well as individual sites. For example, adaptive management's principle of continuous learning can be applied collectively. Past experience at sites can help decisionmakers address new sites more effectively, eliminating or narrowing uncertainties, and better reflect the preferences and values of affected constituencies. The broad transition of the program that this paper encourages would itself represent an adaptive response at the macro level, as the program matures from its early crisis response mode to long-term site management and as it responds to signals from the political system favoring attention to the values associated with reuse as well as reduction of environmental risk.

Adaptive management can improve program efficiency and effectiveness across a range of determinations, including what remedies work best in what types of sites or with what types of contaminants; what remedies work best with what types of land use; what community processes are most effective in eliciting useful and reliable information about community preferences; how best to integrate decisions across private and public sectors and across federal, state and local

---

Environmental Federalism, 95 Mich. L. Rev. 570, 627-38 (1996) (responding to Revesz).

jurisdictions; and what are the relevant contingencies and how best to manage them. This kind of institutional learning has been going on since the program began, albeit not under the name of adaptive management, and thus is nothing new. However, there are ways in which it could be improved. In particular, despite various Superfund data bases, there are a paucity of data about the interventions at the 1499 past and present NPL sites that have already taken place. Well-developed case studies of Superfund site decisionmaking are scarce. Documents, such as the Remedial Investigation/Feasibility Study and the Record of Decision, are prepared as part of the administrative record at each site, but do not record all the steps in the decision reached, the uncertainties addressed, and the lessons learned. There are also few well developed accounts of the post-ROD process, including remedy review and reuse decisions. The absence of such accounts makes it very difficult to determine, for example, frequently occurring contingencies and the most effective responses or moderating measures for those contingencies for the Superfund universe as a whole. Perhaps for this reason, there has been no systematic contingency analysis of the Superfund program. Systematic recordation and analysis of program experience could produce substantial additional improvements in performance.

Finally, with adequate data and application of systems analytical methods, adaptive management can be applied to optimize value over time for the entire Superfund site inventory as well as individual sites. For example, activities at sites can be prioritized to maximize the portfolio value of the whole and that prioritization can be reviewed and adjusted as new information flows into the system. The Agency has already engaged in this kind of prioritization anecdotally, focusing on the “worst sites first” or on sites that are “ready for reuse.” However, it appears to lack the data and the analytical framework to systematically manage sites in this manner.

V. Issues and Concerns

A. Environmentalist Concerns

Environmentalists might be troubled by both aspects of the long-term stewardship approach advanced here – site optimization and adaptive management. They might resist the notion of site optimization as compromising the statute's arguably more single-minded focus on eliminating or minimizing environmental risks. Long-term management is only necessary, they might argue, where cleanups are less than complete. Doing clean ups "right" the first time – that is choosing and implementing remedies that reflect the statutory preference for permanence and avoid the need for engineering controls and institutional controls – minimizes the need for long-term care and the uncertainties associated with such care. Markets and/or local government officials then have maximum flexibility to determine reuse without need of further involvement by EPA.

This criticism is an argument to retain the early emphasis of the Superfund program, that environmental concerns should preempt other values that may be implicated at Superfund sites. It is certainly the case that long-term stewardship entails transaction costs that would not be incurred if every site were left in pristine condition at the conclusion of the remedy, assuming for the moment that that were practicable. But those additional transaction costs may be justified by providing a more beneficial balance between protection and other values over time than would be achieved by a decision model of more limited scope. Moreover, where treatment or removal of all contaminants is not practical, extended management must be provided for in any event to assure continued protectiveness of the remedy. Because of the challenges presented to local decisionmakers by the special characteristics of Superfund sites, expanding the federal management process to include ongoing consideration of land use potential and community

wishes may be well worth the costs. Facilitating productive reuse of sites may help secure management consistent with long-term public health protection.

B. Agency Concerns

One might expect the EPA, or some within it, to reflect the environmentalists' concerns. The Agency might be concerned not only about a dilution of protectiveness associated with site optimization. It might also have practical concerns about the expansion of its long-term responsibilities at sites. With resources for the program already eroding,82 the Agency may see itself as having limited capacity for conducting more intensive, community-based inquiries into remedy/reuse options or in expanding its long-term stewardship obligations, such as broadening consideration of land use in its five year reviews.

The answer to these concerns is similar to the answer to environmentalists' concerns. If an agency goal is to use public funds to maximum effect for the public interest, then the program adjustments suggested here should be considered against alternative uses of agency resources. With limited funds, the Agency must triage among sites and among activities relating to a specific site. The argument is, at least with respect to specific sites, that greater public good is achievable through relatively inexpensive process changes. The Agency must decide whether that argument is persuasive, and it must further decide whether the benefits of expending additional resources in site management justify the postponement of work at other sites in the queue.

The Agency might also be concerned about perceptions that the long-term stewardship model suggested here would convert Superfund into a federal land use program. By conditioning the uses to which land can be put and the terms on which those uses can be carried

82 Robert Hennelly, Superfund Heading for a Super Crisis, 32 New Jersey Reporter 20 (Jan.-Feb. 2003).

on, however, Superfund unavoidably intrudes on the process of land management normally carried out between private markets and local officials. Given the fact of that intrusion, it would seem incumbent on the Agency to provide, to the extent it is able, for a disposition of sites that reflects the market realities and citizen preferences of the affected locality.

C. Responsible Party Concerns

Although pleased presumably that consideration of future land use can reduce the present costs of clean up, responsible parties may have serious reservations about the management approach suggested here to the extent that it would encourage ongoing attention to the use of sites and potential remedy changes to accommodate more "valuable" or "desirable" uses. Responsible parties that are also present site owners in particular may resent the sustained intrusion of these considerations, threatening, they might argue, to turn a federal clean up program into a federal land use program, as just discussed.

It is not clear, however, that this approach would place additional constraints on the prerogatives of Superfund site owners. In its five-year review, EPA will determine either that a remedy continues to be protective or that it does not. The remedy may not be protective for any one of a number of reasons – the contamination may be more extensive than originally understood, the remedy may not be operating as effectively as projected, or the land use on which the remedy was predicated may have changed, leading to higher exposure than was contemplated by the remedy. In any of these circumstances the responsible parties, including any that are also site owners, will be liable for additional remedial actions necessary to assure protectiveness. This has always been the case under EPA's interpretation of the statute.

Under a comprehensive adaptive management approach, EPA would also use the five year review, in consultation with the site owner and the community, to assess the suitability of

the current land use. Assuming the remedy is protective under the current use, however, EPA would have no authority based on its review to order a different land use – a decision left to the owner and local land use authorities. An owner might seek to upgrade a remedy to accommodate a new use. But under EPA's legal interpretation, such an upgrade could not be compelled by the statute and would not be chargeable to the responsible parties unless undertaken by them voluntarily.83 Thus, there would seem to be little or no additional clean up liability risks for responsible parties in the extended attention to land use suggested here.

Imposing the costs of upgrading an otherwise protective remedy on the party or parties benefiting from the upgrade, rather than on the originally responsible party, tests the marginal utility of a use requiring more intensive clean up. A site owner will proceed with a new use only if the increase in the value of the property resulting from the new use outweighs the cost of upgrading the remedy and other costs of development. If the owner is a public entity, it will proceed with the new use only if the public benefits flowing from the new use outweigh the upgrade costs.

An important concern for many Superfund site owners is limiting liability that may be triggered by future actions on site. Owners of a number of large Superfund sites refuse to consider selling them or otherwise making them available for use by others, such as by lease, due to liability concerns.84 Their concerns include the fear not only that the actions or omissions of third parties on the site might occasion the need for additional remedial work (e.g., due to failure to maintain a cap or adhere to site use restrictions) but also and perhaps even more significantly that third party access could expose the company to toxic tort litigation. These concerns are compounded by the widely perceived inability of institutional controls such as covenants or local

83 See Reusing Superfund Sites, 3/01, at 16; 2/02, at 5.

land use regulations to ensure compliance over the long term. Adoption of a uniform environmental covenants act among the states could help remedy this problem by binding subsequent owners to maintain the remedy and to take other precautions to minimize risks at the site.85 Such legislation may prove attractive to disparate interests -- property owners concerned about future liability, environmentalists concerned about the long term integrity of the remedy, and developers seeking to increase the number of properties available for development.

---

84 Telephone conservation with John Quarles, Nov. 10, 2003.

85 *See* National Commissioners of Uniform State Laws, Model Uniform Environmental Covenants Act www.nccusl.org.