RECLAIMING THE LAND
Rethinking Superfund Institutions, Methods and Practices
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On August 7, 1978, President Carter declared a state of emergency in the community of Love Canal, New York. The President urged residents of Love Canal to evacuate, not because of a recent catastrophic event, but because of something that occurred in the 1940’s and 1950’s. This Niagara Falls community had been developed on land that was formerly used as a landfill. Although the landfill was closed in 1953, it had been a dumping ground for tons of chemical wastes, and that waste would eventually create an environment extremely dangerous to human health. The image of chemicals seeping into the basements of American homes would produce widespread panic, but would also raise the environmental consciousness of a nation, and produce a legislative response that was equal to the task.

Americans celebrated the first Earth Day in April, 1970. Throughout the rest of the decade, we passed legislation intended to fulfill the promise of that day: to create a clean and safe environment. However, there were still holes in our environmental protection in 1978, evidenced by the problems at Love Canal. In response, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or, as many people call it, Superfund. Passed in 1980, this law was intended to address problems like the ones faced at Love Canal. It has now been 25 years since its passage and Superfund has proved to be a highly successful program, cleaning up over 900 sites and reducing health risks for tens of thousands of people.

One such site at which Superfund has completed activities is Love Canal itself. In 2004, the site that provided the impetus for passing the Superfund legislation was officially removed from the National Priorities List, signifying that cleanup was complete. As we celebrate the progress over the past quarter century it is also important that we look to the next 25 years with an eye toward not only continuing this progress, but also evolving the program to deal with the challenges we face today.

The removal of Love Canal from the National Priorities List is a useful metaphor for Superfund policy generally. In its early years, Superfund focused exclusively on site assessments and liability apportionment. This response was natural given the circumstances surrounding Superfund’s passage. People living near Superfund sites were petrified by the possibility of health problems that these sites could cause and angry at the sites’ very
existence. This climate was not forward-looking. People were not concerned about site reuse because of the cloud of pessimism that loomed over these sites. However, today is a new day. That era is over. We need to transform Superfund into a more nimble tool, focused on revitalization and capable of adapting as circumstances warrant.

The challenges facing Superfund today are far different than in 1980. The sites like Love Canal – a few acres of buried drums – are largely cleaned up. The sites that remain – the Hudson River, Coeur D’Alene in Idaho, the Fox River in Wisconsin – are much larger and more complex watersheds, defying easy cleanups. Further, Superfund is no longer the only tool in the shed. A wide array of other federal, state, and private cleanup programs have sprung to life. Given limited resources and the need for new models of governance that can adapt to changing intergenerational needs and scientific information, a strategic rethinking of Superfund is in order.

Over the past decade, Superfund has begun the transformation to be more forward-looking. Communities have witnessed these sites be rehabilitated and the pessimism has turned into optimism. People have begun to focus on how to use the sites once cleanup is complete. Even at Love Canal, people are beginning to move back to the homes that were abandoned in the late 1970’s. Although we are moving forward, this ethic of optimism must be institutionalized in order to address the challenges of the next 25 years. Everyone has realized that once these sites are cleaned, they represent significant opportunity for communities and developers. If Superfund and the people who administer it acknowledge this reality and operate within a framework where site reuse is an articulated goal, the law will be more effective and the American public better served. This conclusion is not intended to marginalize or obscure the fundamental goal of the program: protecting human health and the environment. It is simply a recognition that the program will achieve these goals more efficiently if plans are seen through the lens of reuse.

At this moment, hundreds of former Superfund sites are being used in every way imaginable. They have become productive once again and add value to their communities in a variety of ways. Site reuse has created tangible, economic benefits in many areas because of increased employment opportunities, property values, and tax revenues, and the potential for additional economic development on surrounding properties. Reuse of these sites provides benefits for their surrounding communities that go beyond monetary values, although the numbers alone are significant. There are many examples of sites being used for recreational activities and as ecological safe havens. Because land earmarked for these purposes is often limited, the reuse of Superfund sites also presents a much-needed opportunity to improve the aesthetic appeal of a community. Although focusing on future use seems obvious, it is an important shift in perspective. We must be mindful
throughout the entire process that the site cleanup is directed at rehabilitating the land and returning it to a productive use.

Recognizing that reuse is an important objective from the beginning of the process serves to inform decision-making throughout and improves the overall effectiveness of the program in many ways. First, when site reuse is an explicit component of the cleanup process, we see more constructive community involvement. When people are looking forward to new parks, housing, and shopping centers, they have more reason to find common areas of agreement. Second, we see stronger partnerships between government, private developers, and community organizations, because everyone wins when a neighborhood springs back to life. Third, we see more sensible cleanup plans, because they can be tailored to future uses while ensuring their long-term protectiveness. Fourth, we see easier access to private funding, because cleanup money is seen as an investment with a stream of future returns. Because the partnerships, planning, and funding are targeted at future potential, not past failures, the contamination is often cleaned up more quickly. And fifth, by encouraging sustainable reuses such as green spaces, energy efficient buildings, smart growth community developments, and wetlands, we also are able to prevent the re-contamination of former hazardous waste sites and other indirect environmental problems.

Superfund faces new challenges as it turns 25 years old and we must plan strategically in order to confront them head-on and improve this influential program. We must never compromise the lofty objective of the Superfund, protecting human health and the environment, but we must overhaul our thinking and begin to make this objective compatible with the goal of using the land productively. These goals do not have to be mutually exclusive and, in fact, can work symbiotically in order to maximize resources. However, accomplishing this task will require a fresh outlook on the entire program. Flexibility is necessary. Our approach must evolve with respect to the selection, implementation, and maintenance of remedial measures. As each project is chosen and the process begins, we need to be nimble in how we navigate through the project, while keeping the ultimate goals squarely in focus.

An explicit recognition of the value of reuse is indispensable in creating a more effective Superfund. Integrating planning for future use into the decision making process creates more workable cleanup plans that will not only save money, but will better protect the environment for future generations. Economic realities inform us that redevelopment of cleanup sites present tremendous opportunities for investors. The EPA needs to leverage this knowledge in order to generate private funding and planning that will ultimately expedite the cleanup process while saving taxpayers’ dollars. Incorporating future use into the evaluation process will allow the EPA to
achieve these benefits while building in safeguards to ensure that its role as protector of human health and the environment are never compromised.

In addition to integrating future use into its decision making process, the EPA must also take steps to remove unnecessary and excessive impediments to site reuse. A critical and transparent analysis of what worked and what did not will allow the EPA to move forward in a manner that more effectively achieves all community objectives. Being hamstrung by technical minutia is not a problem for Superfund administration alone. It is a prevailing problem in implementing many statutory mandates, especially in the environmental context. We must focus on the problems we face in a more holistic manner. Whether it be narrow statutory interpretations or a lack of innovative thinking, the EPA must break down barriers and begin to see the forest for the trees when it concerns site cleanup and reuse.

I want to underscore the fact that the EPA's primary responsibility is to protect human health and the environment and the future of Superfund must advance this objective as it always has. There must be monitoring mechanisms in place that allow for real oversight so that site use remains protective and land use controls are adhered to. However, there must also be flexibility inherent in the process so that the EPA can make informed decisions to modify directives so that the process respects changing land use patterns and community needs. Undertaking cleanups at many of these sites is incredibly complex. Issuing an inflexible set of mandates to govern the entire cleanup process is at best inefficient and at worst unworkable. Where there are private parties willing to contribute resources to the cleanup effort, the EPA needs the agility to rethink its cleanups or components of those cleanups. This agility will lead directly to quicker community revitalization while placing less strain on public funds.

Superfund is entering a new era that is both exciting and daunting. The last decade has produced much progress towards a holistic approach to site cleanup and reuse. However, the job is unfinished. In order to fulfill Superfund's promise for the next 25 years, we must look critically at our past and plan strategically for our future. The authors of this book understand this reality. The book provides the reader with a set of innovative management approaches for the new era of Superfund in which site reuse is embraced. The book seeks to tackle the greatest challenge facing Superfund in general, and reuse in particular, which is the intrinsic uncertainty involved in complex site cleanup and redevelopment. Building on the concepts of adaptive management, the book offers a vision of Superfund that is both flexible and dynamic. It envisions a program ready to respond to changes in site cleanup, while always keeping future use options in perspective. The real value of the adaptive management approach is that it provides the flexibility to deal with any uncertainty that arises. For example, the authors demonstrate how stakeholder interests can change throughout the cleanup process and how
adaptive management provides the proper approach to handle that situation and keep the project moving forward while adapting to the new circumstances.

Rethinking the broader Superfund strategy is a critical step in transforming this program into an effective tool for the future. The ultimate goal of site reuse must inform and influence the results of this transformation. The lens of site reuse allows us to focus on broader community concerns, while maximizing the effectiveness of public and private resources. The reuse of sites represents a move beyond the singular, essential goal of protecting human health and the environment, and embraces the increasing importance of land as a source and a resource for community revitalization. It is a process of theoretical and tangible integration. We will conceptualize the site as ultimately contributing to the community in order to inform the process. Additionally, we will work efficiently to physically reintegrate the site into the community. The era of leaving sites fenced off from public use for decades at a time is over. We must plan for the future, stabilize and secure the safety of the site, and utilize the resultant resource to improve the community. This project is inherently optimistic but fundamentally realistic, and it can be achieved through a simple strategic change.

This book fills an important void in the literature surrounding Superfund and will facilitate a necessary public discourse on how to transform that program so it is capable of effectively addressing the problems of the next 25 years. Both timely and insightful, this book outlines a sensible approach for the future of the program that promises to streamline implementation and transform Superfund into an optimistic tool capable of drastically improving multiple aspects of our communities and our lives.
INTRODUCTION:
The Promises and Pitfalls of Adaptive Site Stewardship

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In the late 1970's, residents of Niagara Falls, New York began to experience the effects of decisions made by one company three decades earlier. The Hooker Chemical Company dumped over 21,000 tons of chemicals, including dioxin, into a nearby canal. No one had reason to suspect that the dumping occurred until one day, the substances began to seep into the basements of homes and schools. The public outcry that followed the Love Canal incident led to passage of the most advanced hazardous waste cleanup program in the world, which to date has generated more than twelve billion dollars in commitments to remedy affected sites. Known as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or “Superfund,” after its funding mechanisms), the legislation gave the Environmental Protection Agency (EPA) the authority to clean up contamination from past disposal practices that are found to pose risks to human health or the environment.

Such a vast federal program, already many times larger than originally intended, still pales in comparison to the scope of the problem posed by contaminated properties. Roughly one in four Americans, including ten million children, lives within four miles of a toxic waste dump. And while estimates vary, at least 200,000, and probably more than 500,000 sites (sometimes referred to as “brownfields”) in the United States contain either soil or groundwater that may require remediation to overcome the negative effects of past industrial operations. Many of these are ideally located in industrial or commercial zones close to urban centers and essential infrastructure, yet they continue to sit idle, contributing to urban blight and limiting job creation as well as tax revenues for local governments. These properties do not even include the large expanses of land operated by the Department of Defense and Department of Energy. For example, the DOE spends between $5.6 and 7.2 billion per year on the environmental management of its sites.
COEUR D’ALENE: A THIRD GENERATION CERCLA CHALLENGE

Estimates of the number of contaminated properties in the United States also leave out vast geographies that call for complex cleanup efforts, including the Hudson River, New Bedford Harbor, and the Palo Verde Shelf in the Pacific Ocean offshore from Los Angeles. These megasites exacerbate the challenges posed by contemporary contaminated lands, including the uncertainties surrounding risks posed, effectiveness of cleanup options, and complex social, economic, and political settings in which they exist. One such area that gives us a sense of the magnitude of these challenges was formerly one of the leading silver, lead, and zinc-producing regions in the world. The Coeur d’Alene (CDA) Superfund site, spanning the states of Washington, Idaho, and Montana, was added to the National Priorities List in 1983. It is an immense landscape, incorporating “mining-contaminated areas...adjacent floodplains, downstream waterbodies, tributaries, and fill areas” near the Coeur d’Alene River corridor, in addition to a 21-square mile region of historic smelting operations known as the “Bunker Hill Box” (EPA 2002: 1-1). As is standard practice, the site was divided into different geographic units by the EPA: an Upper Basin (former and current mining, milling, and processing), Lower Basin (the river itself, adjacent lateral lakes, the floodplain, and associated wetlands), Coeur d’Alene Lake, and depositional areas of the Spokane River. Three operable units (OU’s) were identified in order to facilitate management of the range of remediation challenges facing the region: (a) populated areas of the Bunker Hill Box, (b) non-populated areas of the Box, and (c) mining-related contamination in the river basin. Contaminants that threatened human health (metals such as lead and arsenic) and ecological receptors (lead, cadmium, and zinc) were identified, remnants of the nearly 900 mining and milling-related features in the region that over the years yielded 1.2 billion ounces of silver, 8 million tons of lead, and 3.2 million tons of zinc. An operation of such scale naturally resulted in a broad range of waste products, including tailings (parts of the ore from which metals could not be recovered economically), waste rock (non-ore rock that had been taken from a mine), and smelter emissions. The EPA estimated that the total mass of impacted materials was more than “100 million tons dispersed over thousands of acres” (EPA 2002: 2-5).

EPA documents demonstrate the enormity of the remediation challenge presented by such a large-scale operation: more than ten years after regulatory actions began on the site, the EPA reported that “given the extensive contamination present, the bulk of the mining-related wastes that are deposited throughout the river and floodplain still remain” (EPA 2002: 2-6). The speed of remediation efforts masks an even more fundamental challenge posed by such a site: the pervasive uncertainty under which agency officials must operate and make decisions for the region. For example, the first study
of household effects of mining-related contaminants (particularly lead absorption by children) to take place outside the immediate area of the Box began in 1996. The Idaho Department of Health and Welfare and the Agency for Toxic Substances Disease Registry (ATSDR) collected a variety of samples in 1997: soil, sediment, groundwater, surface water, indoor dust, lead-based paint, and garden produce throughout the CDA Basin. An RI/FS (remedial investigation/feasibility study) process commenced the following year, including field sampling and a quality assurance plan. The sampling occurred in waves, including sampling plans developed as "field sampling plan addenda to the base plan" to address data gaps found after "reviewing available historical data and results of previous field sampling" (EPA 2002: 2-6). Over ten thousand samples were collected. Yet in 2002, the EPA concluded that

[T]he large geographic area of the Basin made it impractical to collect all the data needed to fully characterize each source area or watershed. Further data collection will be necessary to support remedial design for areas identified as requiring cleanup. This may include areas where previous cleanup actions have taken place, such as floodplain areas of the Union Pacific Railroad right-of-way or other areas where previous removal actions have addressed some, but not all, contamination present (EPA 2002: 2-7).

The extent of the public health threat remained partially obscured even after such interventions as a Lead Health Intervention Program by the Centers for Disease Control and ATSDR, a time-critical removal action of sixteen public properties (such as city parks and school playgrounds), and a yard soil removal program. Agencies working on such efforts learned that they would have to remediate "at least 200 residential yards each year" in order to avoid recontamination from parcels that had yet to be cleaned up (EPA 2002: 4-1). The parties involved in cleanup efforts benefited from five-year reviews of the individual operable units, and adjusted their activities accordingly. For instance, the EPA determined that house dust would have to undergo extensive sampling "should house dust lead levels remain elevated following completion of yard soil remediation" (EPA 2002: 4-2).

Across the OU's, federal and state agencies applied numerous cleanup tools at their disposal: source removals, surface capping, surface water creek reconstruction, milling and processing facility demolition, closures for waste consolidated on site, revegetation efforts, and surface and groundwater controls and wetlands treatment. But the limits to comprehensive site characterization and cleanup emerged in OU's focused on human health and ecological receptors alike. OU 2 consisted of non-populated areas including
the former industrial complex, mine operations areas, and the Bunker Hill Mine. Smelter stabilization work began in 1989 and ended in 1993. After this, potentially responsible parties signed a consent decree to conduct cleanup activities in the area and the EPA and the State of Idaho entered a State Superfund Contract to carry out remaining site remedial actions in 1995. A five year review of OU 2 followed in 2000. While efforts to consolidate contamination from various areas of the site were completed by 2001, the ROD for OU 2 failed to indicate a response action for mine water:

The ROD, therefore, did not address control of acid mine drainage from the Bunker Hill Mine or operation of the Central Treatment Plant (CTP) in any significant way. The ROD briefly addressed the mine water by requiring that it continue to be treated in the CTP prior to discharge to a wetlands treatment system for removal of residual metals. During studies conducted between 1994 and 1996 by the US Bureau of Mines, the wetlands treatment system was found to be incapable of meeting the treatment levels established in the ROD. The 1992 ROD did not contain or otherwise identify any plans for the control or long-term management of the mine water flows. The ROD also did not address the long-term management of treatment residuals (sludge) from the CTP, which are currently pumped into an unlined pond on the CIA. At the current disposal rates it is estimated that the pond will be filled in 3 to 5 years (EPA 2002: 4-3).

Such challenges as dealing with treatment residuals were addressed in amendments to the OU 2 ROD, illustrating the kind of learning and adjustment that the five year review process encourages. The true limits to the EPA's ability to address the scope of remediation challenges posed by the CDA site, however, emerged during implementation of the ROD for OU 3, which focused on the CDA Basin itself. The EPA joined the State of Idaho, Coeur d'Alene Tribe, and other federal, state, and local agencies to form the CDA Basin Restoration Project, an initiative that the EPA concluded "had limited success as a systematic approach to addressing contamination in the Basin" (EPA 2002: 4-4). The scope of the challenge for OU 3 was immense: develop a water quality improvement program for the Basin by coordinating regulatory authorities under the Clean Water Act, CERCLA, RCRA, and other programs, an effort that would have to address non-discrete sources as "the primary sources of metals in surface water in the Basin" (EPA 2002: 4-4). Even the 2002 ROD for OU 3 recognized exposure pathways that remained unaddressed, including recreational use areas in the upper and lower basin, subsistence fishing by the CDA and Spokane Tribes, and potential future use
of groundwater that remained contaminated with metals. The Selected Remedy for OU 3 identified “thirty years of prioritized actions in areas of the Basin upstream of the CDA lake” (EPA 2002: 4-5). The EPA was keenly aware of its limited ability to forecast how its efforts would impact the region:

EPA expressly recognizes that after the selected remedial actions are implemented, conditions in the Upper and Lower Basin may differ substantially from EPA’s current forecast of those future conditions, which is solely based on present knowledge. The tremendous amount of additional knowledge that will be gained by the end of this period through long-term monitoring and five-year review processes may provide bases for future Applicable or Relevant and Appropriate Requirement (ARAR) waivers. In addition, this new information and advances in science and technology may allow for additional actions to achieve ARARs and protect human health and the environment in a more cost-effective manner (EPA 2002: 4-5-4-6).

The EPA reiterated the incompleteness of its actions under any given ROD in its discussion of OU 3:

The remedial actions selected in this ROD are not intended to fully address contamination within the Basin. Thus, achieving certain water quality standards developed under the Clean Water Act and the Safe Drinking Water Act, such as water quality standards and Maximum Contaminant Levels, are outside of the scope of the remedial action selected in this ROD and are not applicable or relevant and appropriate at this time. Similarly, special status species protection requirements under the Migratory Bird Treaty Act and Endangered Species Act are only applicable or relevant and appropriate as they apply to the remedial actions included within the scope of the Selected Remedy...Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, statutory reviews will be conducted at least every five years after initiation of remedial action to ensure that the Selected Remedy is, or will be, protective of human health and the environment (EPA 2002: 13-2, 13-20).

Possessed with insufficient information “to characterize all the specific sources of metals contamination impacting the streams and floodplains, as well as the anticipated effectiveness of certain remedial actions,” the EPA
designed its initial set of actions to take place in “defined locations” and to achieve “specific benchmarks.” But the range of possible actions that might be called for as the Selected Remedy for OU 3 progressed, and the scope of uncertainty facing parties to the cleanup process remained. The estimated present value cost of the Selected Remedy for OU 3 was $359 million in 2002, with cost accuracy listed as between -30 and +50% of that value. The size and complexity of the site called for a new approach to remediation, which the EPA referred to as “an adaptive management strategy to implement cleanup.”

Whether the EPA’s use of an “adaptive management strategy” for the CDA site offered a unique approach to dealing with environmental contamination on a large scale, which posed an array of human and ecological health risks and demanded the attention of numerous agencies and a timeline that would span decades, is unclear from EPA documents. Immediately following the EPA’s use of the term “adaptive management,” the ROD for OU 3 lapses into a standard depiction of how the agency will deal with uncertainty: a selected remedy included prioritized actions for certain areas, a remedial investigation will collect data needed to characterize the site, remedial alternatives will be developed and evaluated, a remedy will be selected, and additional data will be collected to support the design of the remedy. Indeed, the EPA characterizes this process of anticipating the need for additional design data as “not unique to the CDA Basin.” The centrality of long-term effectiveness and monitoring within the choice and evaluation of a Selected Remedy, while encouraging, relied less on a complete reordering of Superfund tools to meet a unique challenge posed by large-scale sites and more on the selective use of some of the more immediately accessible elements of adaptive management.

Such was the conclusion of the National Research Council in an exhaustive study of the CDA Superfund Site’s remediation objectives and approaches to date, a document that ends with the recommendation that adaptive management be “unequivocally incorporated into every step of the Superfund process, beginning with the Remedial Investigation (NRC 2005: 273). The report focused on the difficulties facing “megasites” such as the CDA River Basin. Their geographic scope, volume and complexity of contaminated material, lack of obvious engineering solutions, and unthinkably long time horizons (which for natural recovery and achievement of ARAR’s were projected “up to 1,000 years” for the CDA site) figured prominently in the report (NRC 2005: 264). The need to manage megasites under conditions of uncertainty was a common motif repeated throughout the NRC’s findings. Examples included the lack of a “definitively identified” causal link between remediated yards and decreased blood lead levels, the presence of “floods and other actions” that “eroded the installed remedies or caused recontamination” in the Box, the need for “institutional mechanisms to monitor…effectiveness, repair any failures, and remain in place and effective for an extremely long
time (at least hundreds of years),” and the lack of remedies “to address risks from possible future uses of contaminated groundwater and risks to residents who engage in subsistence lifestyles” (NRC 2005: 262-263). In the face of such challenges, the present architecture of the Superfund program as summarized by the NRC appears strikingly outmoded and overmatched:

The Superfund process calls for EPA first to gather all the necessary information (the remedial investigation phase), then evaluate alternatives for addressing all the human health and environmental risks identified in the information-gathering stage (the feasibility study stage), and then decide on the best remedies for reducing these risks to acceptable levels (the Record of Decision)...At most sites, the OU being assessed addresses only one or two closely related problems, and this process works reasonably well. In the CDA OU-3, however, there are a large number of different problems. Some, like the contamination of yards, are fairly easy to assess. Others, like the reduction of dissolved metals in the main stem of the river are much more difficult. By combining these different problems into one OU and subjecting them to the process established in the NCP, EPA must attempt to answer all the questions for all the problems before it can attempt to remedy any of them (NRC 2005: 317).

The NRC ended its discussion of the Superfund program by noting that whatever flexibility could be found within CERCLA and the NCP “does not appear sufficient to address all the issues identified by the committee” (NRC 2005: 320).

MEETING THE CHALLENGE

The realities unearthed by the NRC report call upon the Superfund program to evolve in a way that accommodates new scales of operation, dealing with the intricacies of large-scale projects while not posing obstacles to redevelopment of smaller parcels of land such as brownfields. There has yet to emerge a cohesive strategy for doing this. While the Superfund program (in conjunction with other legislation designed to track hazardous chemicals from production to disposal) has generated some clear success stories, its focus on the liability of those who benefited from improper disposal of hazardous waste is considered the major obstacle to redeveloping brownfields. At the same time, the program as it was created emphasized rapid and complete cleanups, operating under the assumption that
contaminated sites can be dealt with effectively over a relatively short period of time. Such an approach leaves the EPA and other parties ill-prepared for the challenges posed by sites that, like Love Canal, are only brought to federal attention after decades of gradual or intermittent contamination, or by potential Superfund sites that, either because of their size or characteristics, are themselves a part of larger ecosystems that require more than short-term intervention.

Reauthorization legislation, three rounds of reform in the mid-1990’s, and passage of the Brownfields Revitalization Act of 2002 have left the essential architecture of the program intact and inappropriately designed for the next generation of environmental challenges and redevelopment needs posed by contaminated properties. To date, there has been a tendency of state and federal programs to try to remove barriers to the redevelopment of contaminated sites one at a time: incentives for voluntary cleanup are enacted, grants are offered for site assessment, and technical assistance is given to developers, among other efforts. When faced with large-scale contamination, Superfund allows for some flexibility in addressing the uncertainties posed by interventions within a watershed, mountain ridge, or densely populated urban center: sites can be broken into operable units and addressed separately, and interim remedies are sometimes authorized. These piecemeal tactics do not offer agency officials, responsible parties, or affected communities a lens through which to view and evaluate the program’s ability to cope with the uncertainties posed by large contaminated sites. They attempt, through such innovations as prospective purchaser agreements and pollution liability insurance, to bring some level of certainty to the process so that potential landowners are able to pursue their redevelopment goals. What they neglect is the inherent uncertainty involved in complex site cleanup and redevelopment, a reality that calls for a fundamentally different framework and approach.

This book offers such a lens. Its authors, many of whom participated in the Center for Expertise for Superfund Site Recycling (based at the University of Virginia), have for the last three years considered new approaches to revitalizing contaminated land. Their approach is interdisciplinary, combining advanced quantitative methods for site characterization and optimization with qualitative tools for site visualization and design and community participation. These techniques were developed with an understanding that contaminated sites should be treated not as isolated spaces to be defined by regulatory boundaries and addressed one medium (water, soil) at a time, but as part of broader ecosystems, which call for site interventions in multiple phases, over extended periods of time, and under conditions of uncertainty and change. In this spirit, our book, Reclaiming the Land, builds upon thirty years of lessons learned by an approach to natural resource management known as adaptive management.
THE ADAPTIVE MANAGEMENT APPROACH

Adaptive management established itself as an alternative approach to natural resource management in the 1970’s (Holling 1978). Lee, who popularized the approach in the literature, defines adaptive management as “treating economic uses of nature as experiments, so that we may learn efficiently from experience” (Lessard 1998). His book, *Compass and Gyroscope*, is the most widely cited treatment of the subject in the literature (Lee 1993). Lee’s work is instructive in that it focuses on the organizational dimension of “learning while doing” as a complement to more technical approaches. He declared that “the field is profoundly different from a laboratory” (Lee 1999: 3), a reality that calls upon natural and social scientists to make use of new and different modes of learning if they are to effectively manage at the ecosystem level. Some challenges to learning posed by ecosystem-level management include:

1) Causal understanding emerges at a slower rate than the efforts to understand them;
2) Usually it is not possible for scientists to separate the effects of management decisions from those of concurrent shifts in the natural environment; and
3) Problems are identified at moments of crisis (such as when there is a rapid decline in the vitality of a given species); these extreme moments tend to be followed by less extreme periods, giving the illusion that management decisions were successful (Lee 1999).

Effective experimentation occurs when the limits of learning resulting from human interaction at the ecosystem level are addressed in the design of managing institutions. “A key unanswered question,” therefore, “is whether the adaptive capacity of both ecological and social systems can keep pace” with the expanding influence of human constructs on their environment (Prichard et al. 2000: 38). The central project of adaptive management is to develop flexible institutions that are attuned to ecosystem dynamics (Folke et al. 1998). Where policymakers fall short in meeting this objective, it is often

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1 Mc Daniels and Gregory (2004) added that “Adaptive management proceeds from the premise that policies can be treated as experiments. It involves trying different policy actions in informative contexts, creating experimental designs with controls where possible, avoiding costly failures, monitoring and evaluating outcomes, and selecting a basis for judging what has been learned.” The National Research Council (1994) defines “the core adaptive management experiment” as including the involvement of stakeholders in a collaborative process, development of a vision, creating a mission statement, and setting measurable management objectives and informational needs.
due to flaws in institutional design, problems with governance (Ostrom 1990), or the pathology of resource management. The latter involves a process where policy decisions prove successful, leading to myopic research and management behavior that eventually reduces ecosystem resilience (Holling & Meffe 1996).

True to the common conception of adaptive management, a growing number of management experiments have been developed to try to modify fisheries regulations, balance hydropower uses, restore riparian habitat, balance agricultural and other uses, develop storm water management plans, and improve the implementation of Habitat Conservation Plans, among other applications (Freedman et al. 2004). These efforts have led researchers to recast adaptive management's experimental focus as part of a broader framework for dealing with the uncertainty and longer time horizons that confront environmental managers who function at the level of ecosystems. For example, Torrell (2000: 354) defines adaptive management as designed “to cope with the uncertainty and complexity of ecosystems by creating spaces in which reflection and learning can occur and by allowing management processes to take action in light of new information.” His approach treats experimentation as one of three dimensions, the others being project strategy adjustments as new information is obtained and active participation by relevant stakeholders.

The participatory dimension of adaptive management is in keeping with Lee’s assertion that political conflict and dispute resolution can provide means of error recognition, which is a necessary complement to the kind of “self-conscious learning” to which adaptive management aspires (Lee 1993: 87). Negotiation and planning are the means through which policy-oriented learning is accomplished.

Because control over large ecosystems is fragmented, the search for sustainability requires extensive social interaction: sharing analytical information such as simulation models and databases, identifying tradeoffs and coalitions for joint action, and learning from surprising outcomes. These interactions become ways to

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2 Several institutional conditions can encourage adaptive management: (a) a mandate to take action in the face of uncertainty, (b) awareness among decisionmakers that they are experimenting, (c) care taken to improve outcomes over biological time scales, (d) understanding that human intervention cannot produce desired outcomes predictably, (e) sufficient resources to measure ecosystem-scale behavior, (f) availability of theory, models, and field methods to estimate ecosystem-scale behavior, (g) the ability to formulate hypotheses, (h) an organizational culture that encourages learning from experience, and (i) sufficient stability and institutional patience to measure long-term outcomes (Lee 1993: 63).
negotiate shared substantive agendas that individual organizations and interests cannot achieve by themselves... Once a framework for conducting the dispute is in place, it is possible for parties to undertake the substantive task of planning – the assembly of information and analytical skills to describe the world shared by the parties and to identify the uncertain consequences of action within it (Lee 1991: 785, 787).

While this aspect of adaptive management has received little formal treatment in the literature (McDaniels & Gregory (2004: 1921) note that “adaptive management has sometimes floundered because of inattention to concepts of good collective decision-making with stakeholders, while stakeholder processes have often neglected the importance of learning and adaptation”), the challenge is clear: take public involvement, which is often relegated to a discrete event in environmental decision-making (“a snapshot of pre-project conditions”), and reconstruct it as a dynamic process that is cognizant of changes over time (Shepherd & Bowler 1997). The move toward viewing Superfund sites as ecosystems, the shift in objectives from remediation to reuse to long-term stewardship, and the need to involve residents who are seeking to reclaim their communities, build narratives around abandoned sites, and question assumptions underlying the models and mindsets of government agencies, speak to the relevance of the adaptive management framework, particularly its neglected emphasis on participatory process.

A well-developed treatment of adaptive management sets experimentalism next to two additional core principles of the approach: multi-scalar analysis (“adaptive managers model and monitor natural systems on multiple scales of space and time”) and place sensitivity (“adaptive managers adopt local places, understood as humanly occupied geographic places, as the perspective from which multi-scalar management orients”) (Norton & Steinemann (2001: 477). Scholars view these principles as operating within a nonlinear process including several commonly used steps, such as monitoring, evaluation, and feedback. For instance, Lessard (1998: 81) outlines the following components of the approach:

1. **Assessment**: understanding the current ecological conditions of places of interest, changes in ecosystem components over time, and likely trends within them; developing scale-relevant assessments that place social, economic, biological, chemical, and physical components of a management area into a larger ecological context;

2. **Scenario planning**: identifying “critical uncertainties,” obtaining the best information on them, and designing a monitoring and evaluation system to track decisions; this component is cognizant of the trade-off between designs aimed at avoiding failure and those that respond and survive in the face of failure;
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(3) **Goals and objectives:** using assessment to assign values to current conditions and describe desired future ecological conditions; efforts to encourage public ownership of this step are critical;

(4) **Hypothesis development:** creating an experimental design and readying it for implementation; focus is on identifying techniques that reduce uncertainty and benefit from it; and

(5) **Monitoring and evaluation:** determining what information should lead to changes in policy; new information is gathered from a broad range of sources, including monitoring, regulatory shifts, and organizational assessments.

Perhaps the easiest way to define adaptive management is through an understanding of its alternatives: trial-and-error learning and deferred action. Trial-and-error learning pervades much of natural resource management, emphasizing resource use while ignoring error detection (which requires costly monitoring systems). Trial-and-error has been implicated in the kind of reactive learning that characterizes the pathology of resource management (Wilhere 2002). Walters (1986) first described the pattern of crisis and opportunity that occurs in resource systems, a pattern of ecological surprise and policy response that has been identified at various scales of resource as well as bureaucratic systems (Johnson et al. 1999). Deferred action means that attempts at ecosystem management are postponed until after the system is understood. By contrast, adaptive management acknowledges the need for regular adjustments to policies and designs them so that change is internally driven.

**PROBLEMS AND PROMISES FOR ADOPTING THE APPROACH**

While few have questioned the need to move from deferred action and trial-and-error learning to experimental interactions with nature (Lee & Lawrence 1986), the limitations to an experimental approach to resource stewardship have been well-documented. A broad-based criticism of adaptive management is that the bulk of the literature “has not moved far beyond individual, place-based experiences – most experiments in adaptive management work in isolation, with little interaction, sharing of lessons learned, or comparative assessments of how various efforts are contributing to the advancement of knowledge” (Light 2002: 43). Indeed, a plethora of n = 1 case studies dominates the literature, serving a useful role but including little comparative or statistical analysis.

Perhaps of greater concern are the “perverse incentives” that adaptive management programs often encourage. Ascher (2001) noted that in order to implement adaptive management principles,
Government agencies and officials often do not meet such challenges, because the complexity of ecosystem management either “threatens the institutional interests of these agencies or provides opportunities to enhance their interests” (Ascher 2001). Ascher outlines the characteristics of adaptive management that are most prone to perverse incentives, including oversimplification in the face of complexity, the persistence of established organizations designed for resource management, and time horizons that reflect institutional interests rather than areas of concern. They are reminiscent of the work of organizational theorists such as Meyer and Rowan (1977) and March and Simon (1958), who helped to define the ceremonial qualities of formal organizational structures that are often at odds with the preferences of internal actors or pressures exerted by the environment in which they function.

Another blind spot in the literature is what Moir and Block (2001: 141) term adaptive management’s “weakest link”: the information feedback system. While they acknowledge that a failed adaptive management approach may be attributed to a variety of factors (such as agency resistance to change and poorly defined monitoring), Moir and Block are more concerned about adaptive management’s claim that “activity will be modified or stopped at the earliest sign of adverse impact or when it becomes clear that there is significant divergence from the trajectory towards stated goals” (142). Knowing when there is truly an adverse impact or divergence is an art and a science riddled with challenges: monitoring systems are usually scaled to the near-term, managers do not notice warning signs that emerge as part of slower-moving processes (Holling 1995), and early responses to interventions can be both noisy and fleeting while certain thresholds or latency periods remain hidden. To correct this shortcoming, the authors note that managers must be able to “understand the frequency and amplitude of the processes and functions of the ecosystem,” “recognize the slower, longer cycles in ecosystem dynamics and design the monitoring frequency to accommodate those cycles,” and

Consider what happens when extreme events occur; when there are high levels of noise; when and if complex, nonlinear, highly interactive ecosystem processes converge at some critical point,
and when ecological thresholds might be exceeded in the long-term (146).

Faced with challenges such as avoiding perverse learning and identifying new information or thresholds that would compel adjustment, the design of experimental management programs continues. The collective experience of researchers in the field of adaptive management offers a rich set of ideas for those involved in the next generation of Superfund law and practice, which attempts to view contaminated sites on multiple scales over extended time horizons and with new roles and responsibilities for citizens, developers, agencies, and responsible parties. It also suggests several roadblocks in the path toward focusing on ecological systems that cross administrative boundaries, applying systems dynamics and approaches that are attuned to matters of scale and ensuring ecological resilience (Pritchard et al. 2000), and encouraging broad-based involvement in implementation.

The first lies in statutory and organizational resistance to change within agencies, other stakeholder groups, and environmental management as a field. Walters (1997) noted that because adaptive management policies result primarily from court decisions and legislative acts, and because most funding comes from such acts, “sculpting the legislation in a manner that dictates adaptive management philosophies” is key. One can find numerous statutes where adaptive management is called for to some extent. For example, Freedman et al. (2004) show how the Clean Water Act includes a number of adaptive processes rather than definitive determinations (such as NPDES permit reevaluation over five-year cycles, triennial review of state water quality standards, multiyear cycles for state water quality assessments, and continuing planning processes throughout). They take the conventional framework for Total Maximum Daily Loads and convert it to an adaptive process, where managers begin with preliminary allocations and progressively improve controls as their understanding of a water system improves. This frees stakeholders from time-consuming and often irresolvable disputes over uncertainty of numeric values and whether “final” recommendations are optimal. Similarly, Phillips and Randolph (2000) compare goals described in the National Environmental Policy Act with ecosystem management principles. They suggest that an ecosystem management approach could provide the means for agencies to get beyond the dominance of procedural requirements embodied in Section 102(2)(c) of the Act. Steyer and Llewellyn (2000) provide a thoughtful account of regulations designed to slow coastal land loss through passage of Act 6 by the Louisiana Department of Natural Resources. Adaptive management principles were embedded within the programs that resulted.

The EPA and other agencies will at times implement programs using a logic that is opposed to the principles of adaptive management. Landy,
Roberts, and Thomas (1994) discuss this logic in *The Environmental Protection Agency: Asking the Wrong Questions*. They describe how the EPA, since its creation, has been reluctant to deal with matters of uncertainty, pushing them to the side and functioning as though ecosystems contained well-defined distinctions that can be identified and linked to words used in regulations (for example, the suggestion that there is such a thing as a "most sensitive group" in human settlements, while the real world suggests a continuum of sensitivity). The statutory constraints to implementing adaptive management principles for Superfund site stewardship that are imposed by CERCLA are one focus of Chapter 2, "Adaptive Management in Superfund: Thinking Like a Contaminated Site."

Chapter 2 also addresses the institutional barriers to effective use of adaptive management in the Superfund program, an approach that its author argues involves recharacterizing Superfund sites as part of the broader ecosystems in which they exist. The first step toward removing institutional barriers demands a realization that organizational decision-making and learning does not always proceed according to rational choice, a fact that was assumed in the design of many of our environmental policies. Lee (1993: 138-139) highlighted recommendations made by environmental policies that assume a rational learning process. NEPA calls upon planners to protect against foreseeable serious hazards, the Endangered Species Act assumes that managers will be able to rely on past experience to determine which species are endangered, pesticides regulations express confidence that laboratory experiments can reduce uncertainty, and nuclear regulators operate under the assumption that the most "important" hazards can be identified and addressed through the redirection of resources. Rational choice assumes that individual actors in organizations update their understanding, modify choices as new information improves comprehension, view competing goals together, and make tradeoffs, compromises, and creative solutions that integrate conflicting values into a coherent set of goals.

In contrast, organizational theorists would argue, starting with March and Olsen (1989), that decision-making is often contextual, infused with ritual, and concerned as much with interpretation as it is with specific choices. This realization has led theorists, such as Weick (1993), to shift the focus in part from decision-making to meaning, investigating how organizations create order and "retrospective sense" of situations. While decision-making seeks to remove ignorance, sensemaking tries to reduce confusion. The latter strives for resilience in the work groups, agencies, and corporations that face crises or the need for change. Improvisation, understanding that ignorance and knowledge grow together (and that confidence and caution eliminate curiosity, openness, and complex sensing, which are most needed for change), and moving away from attempts to make role systems change fast enough to keep up with changing environments can each lead to increased adaptability.