CRESP II

# THE ROLE OF RISK AND FUTURE LAND USE IN CLEANUP AT THE DEPARTMENT OF ENERGY

Joanna Burger, Ph.D.
Charles Powers, Ph.D.
Michael Greenberg, Ph.D.
Michael Gochfeld, M.D., Ph.D.

## CRESP Report 03-001

March, 2003

---

Consortium for Risk Evaluation with Stakeholder Participation II
317 George Street, Suite 202, New Brunswick, New Jersey 08901
http://www.cresp.org

# THE ROLE OF RISK AND FUTURE LAND USE IN CLEANUP AT THE DEPARTMENT OF ENERGY

Joanna Burger[1,2], Charles Powers[2,3], Michael Greenberg[2,4] and Michael Gochfeld[2,3]

1. Division of Life Sciences, Rutgers University 604 Allison Road, Piscataway New Jersey 08845-8082

2. Consortium for Risk Evaluation with Stakeholder Participation (CRESP) and Environmental and Occupational Health Sciences Institute, Piscataway, New Jersey 08854

3. Environmental and Community Medicine, UMDNJ-Robert Wood Johnson Medical School, Piscataway, New Jersey 08854/

4. Bloustein School, Rutgers University, New Brunswick, New Jersey 08903.

ABSTRACT. As a result of the Legacy of the Cold War, several governmental agencies are involved in massive cleanup and remediation projects. In this paper we examine the role of risk and future land use designations in cleanup at the Department of Energy, using a self-assessment of 36 sites. We then discuss the tools that might be required to address the cleanup challenge. Much of the current cleanup program is driven by compliance with federal and state statutes and regulations, presumably to protect human health and the environment. Compliance, however, is not synonymous with cleanup. Although some of these laws and regulations take risk into account, the lack of site-specific data on exposures and risk scenarios, and the lack of attention to future land use or endstates has potentially resulted in a disconnect between risk and cleanup, risk and final endstates, and the cleanup levels and endstate or subsequent land use. Partly this disconnect results from the need for a range of technical, economic, sociological and public policy tools to address the issues. A better transfer of information among and within Department of Energy facilities and operations offices is required. Further, making decisions with the final endstate in mind involves a number of risk tradeoffs, including: 1) ecological and human health, 2) worker and public health, 3) among competing contaminated areas, 4) among temporal patterns of cleanup, 5) among species (plants vs animals, one animal vs another, and 6) among the sites across the complex. Such risk balancing is required within sites and among Department of Energy sites, and perhaps, among other remediation sites (such as those of Department of Defense or Superfund sites)

# INTRODUCTION

Cleanup and remediation of contaminated sites is a national priority in the United States and elsewhere, within a framework of protecting public and worker health, now and in the future. Further, protecting the environment is a national, regional, and local priority, particularly as people concentrate in urban centers and suburban sprawls. Maintaining healthy ecosystems that can protect the well-being of organisms living within them, including humans, requires environmental planning and management. Agencies such as the Department of Energy (DOE) and Department of Defense (DOD), facing a large remediation task, are redefining their mission, often to include protection of biodiversity and environmental resources (DOD, 2001; DOE, 1994a, 1994b; Lubbert and Chu, 2001). Other smaller contaminated sites, owned by private industry and government, called brownfields, also face cleanup and conversion to other entities and/or functions (Powers et al. 2000). The cleanup task is enormous, involving multiple agencies and private enterprises, in sites that range from less than a city block to areas exceeding 1000 square miles.

There is general agreement that cleanup and remediation of contaminated sites is an important and urgent task (Crowley and 2002). However, there is less consensus concerning the strategy for such cleanup with respect to the role of risk to humans and the environment, and the impact of future land use(s) on cleanup decisions.

In the early 1980s the prevailing view was that contaminated sites, such as superfund sites, should be cleaned up to residential standards and returned to productive uses. Residential standards are set sufficiently low that there is no risk to adults and children living and working there. Since the mid-1980s the paradigm used for assessing the risk to both human and ecological receptors has included some or all of the following phases: problem formulation, hazard identification, dose-response, exposure assessment, and risk characterization (NRC 1983, 1993). Even with an accepted risk paradigm, there are disparities in the assessment and management of health risks by different governmental agencies, and within and between federal and state agencies (Kamrin 1997). One important tenet of risk assessment is that there is no risk if receptors are not exposed (see Fig. 1). For example, the molten earth's core poses no risk to human or other receptors, except when volcanic eruptions bring molten lava (or other materials) to the surface.

The reality of the 1990s and early 2000s has imposed cost and technological constraints (Burger et al. 2003), and the realization that not all land must (or should) be used for residential purposes. Managers and policy-makers are thus besieged by a number of questions, such as: 1) Can the nation afford the complete treatment or removal of all contamination, 2) How much should future land uses influence cleanup standards, 3) What is the role of risk in determining cleanup standards, 4) What is the role of risk in determining future land uses, and 5) What is the role of the citizenry in influencing or making these decisions.

In this paper a self-assessment of 36 DOE sites is used to examine how risk is used in cleanup of DOE sites, discuss the relationship between cleanup and future land use, and propose some tools that might be required to address this challenge. We use the Department of Energy as an example because it represents 20% of the world's environmental remediation market (Sink and Frank 1996), nearly equaling the budget of the U.S. Environmental Protection Agency for all its functions. The U. S. nuclear weapons complex has some 5,000 facilities located at 16 major sites, and more than 100 smaller sites (Crowley and Ahearne 2002).

In 1989 the DOE established an Office of Environmental Management (EM) to clean up their facilities, and where necessary, to develop new cost-effective technologies to reduce risk to human and nonhuman receptors (Sink and Frank 1996, Daisey 1998). Since 1994, EM's budget has averaged $6 billion a year in constant 1992 dollars (Frisch *et al.* 1998, DOE 2000). Completion of cleanup activity is expected as early as 2006 at a few sites. Cleanup has been scheduled to extend to 2035 at some sites, although a recent a DOE top-to-bottom review has proposed an accelerated cleanup (DOE 2002).

While DOE is a major source of contamination, it also presents a unique challenge to environmental managers who are used to dealing with a single source of pollution on a relatively small site, which is chemical in nature, and can be successfully remediated in less than a decade. DOE has sites that are over 100 square miles, its most hazardous materials are radiological, and are housed in massive tanks that are unique to the DOE complex. DOE sites cannot be easily managed in the same way as most other waste sites without potentially increasing ecological and occupational risks. Many of the larger sites will be hazardous for many decades (Crowley and Ahearne 2002). The uniqueness of DOE's problems suggests a need to rethink the compliance-based approach to remediation in favor of one that starts with the assumption that future land use and risk should influence the levels of cleanup.

## METHODS: A SELF-ASSESSMENT

Following the top-to-bottom review of EM, a number of Project Teams were set up to implement some of the review's recommendations, including developing "corporate" policy and guidance. One recommendation was to use risk-based endstates as a driver for cleanup and remediation (DOE 2002). Perhaps the key corporate project was one initiated to develop a cleanup strategy that had a coordinated path forward rather than one based on compliance with diversely defined state and federal requirements and actions (Geiser, pers. comm, Corporate Project 7). Using risk-based endstates is a method of "starting with the end in mind" (e.g. end land use), as a way of designing a clear path forward.

As part of project 7's task, 36 of the DOE sites were asked to complete a self-assessment questionnaire about their site, their site wide models of contamination, their future use plans, and their use of risk in cleanup and future land use decisions. In this paper we use information provided by these sites to examine the role of regulations and risk in future land use and cleanup decisions.

The self-assessment included 36 sites with an EM mission (Table 1); 17 of these sites (or parts of the site) will have a continuing energy research mission in the DOE. The sites examined are in 17 states: Alaska (1), California (5), Colorado (3), Idaho (2), Illinois (1), Kentucky (1), Missouri (2), Mississippi (1), New Mexico (4), New York (3), Nevada (3), Ohio (5), South Carolina (1), Tennessee (1), Texas (1), Utah (1), and Washington (1). They range in size from several buildings in a small industrial complex to 1350 mi$^2$.

In this paper, individual sites are not identified because the overall intent is to examine the relationship between risk, cleanup and future land use (endstates) across the DOE complex, rather than highlight particular sites. This analysis provides a unique data set on the use of risk in cleanup and land management.

Specific questions of interest were: 1) What laws govern cleanup, 2) What receptors were of concern for cleanup, 3) Were risk-balancing decisions made concerning cleanup, 4) Are the pathways from source to receptors known, and 5) Are stakeholders adequately involved. If the answer to the last four question is no or insufficient information is available, this raises the question of the tools that might be useful, and we suggest a number of tools to address these issues. Such tools should be of use generally to a wide range of sites faced with cleaning up hazardous materials or contaminated sites.

## DOE CONTEXT: WHAT LAWS AND REGULATIONS GOVERN CLEANUP?

DOE environmental management actions have been driven largely by compliance with a series of federal-state triparty compliance agreements, with DOE orders, and with federal laws. The triparty agreements were negotiated with EPA and various states beginning in the late 1980s and the early 1990s (DOE 1994a,b). The regulating laws include Comprehensive Environmental Response Compensation and Liability Act (CERCLA, also called "Superfund"), the Resource Conservation and Recovery Act (RCRA), the Safe Drinking Water Act, and other federal environmental statutes that deal with cleanup and waste management, and the Atomic Energy Act (AEA, Table 1).

There are a number of other applicable laws of consequence, including the Clean Air Act, the Clean Water Act, and Toxics Substances Control Act. However, CERCLA, RCRA and AEA are the primary drivers for DOE cleanup. The 36 different sites have different combinations of regulatory drivers, even at the federal level (Table 1). For example:

|  |  |
|---|---|
| AEA only - | 5 sites |
| AEA/RCRA - | 10 sites |
| AEA/CERCLA - | 3 sites |
| AEA/CERCLA/RCRA - | 8 sites |
| CERCLA only - | 6 sites |
| RCRA only - | 2 sites |
| CERCLA/RCRA | 2 sites |

When the laws and regulations of states are added, along with existing Triparty Agreements, several different and often conflicting regulations apply. Sometimes the regulations are applied differently even within one site. This is particularly true for the large sites, such as Hanford, Idaho National Engineering and Environmental Laboratory (INEEL), Savannah River Site (SRS), and Oak Ridge.

To some extent the cleanup is driven by compliance because the federal regulators use the regulations as a basis for Records of Decision (ROD) that outline the cleanup actions to be completed. The risk assessments used as a basis for the RODs are thus driven by the regulating laws (Fig. 2). Presumably risk assessments are the basis for the regulatory laws and standards; this allowed some of the DOE sites to respond that they used risk because the clean-up levels were risk-based. However, resources are not always being spent to appropriate match risk (EPA 1987, 1996).

Looking at the current compliance-driven program, the DOE Top-to-Bottom Review Team (2002, p. ES-2) asserted that "since the program's inception in 1989, more than $60 billion has been spent without a corresponding reduction in actual risk." While their assertion may understate the reduction in risk that has been accomplished, we think that it points to the reality that a compliance-driven cleanup program has been less than optimum for the Department."

## UNDERSTANDING CONTAMINANT PATHWAYS FROM SOURCE TO RECEPTOR

One key element of understanding the risk that contaminants pose to human and ecological receptors is to understand the potential pathways from source to receptor (Fig. 1). For most sites, an integrated conceptual model that identifies sources, pathways and receptors is critical. When asked whether they had such a model, only 9 of 36 sites said they had an integrated conceptual model that included both groundwater and surface soil and water models, and another 5 had each model separately. Three said they had no model, and six has limited models. We contend that linking risk to receptors and using risk to inform cleanup decisions requires understanding the pathways, as well as the potential for the pathways to be blocked.

## HEALTH RISK, RISK BALANCING, AND CLEANUP

Using risk as one basis for cleanup should imply using site specific information on the contaminants, media (including transport mechanism) and receptors. These factors can be combined to produce a site-wide model, which in turn can be used as a basis for cleanup decisions and endstate determination (land use, Fig. 3).

In the self-assessment, 53 % of sites said that both human and ecological receptors were the primary receptor of concern, and the rest mentioned only human health. Of the total, nearly all mentioned public health, while 67 % noted that worker health was a significant receptor of concern. Where ecological concerns were mentioned, it was mainly in connection with surface cleanup. Specific receptors (such as endangered or threatened species) were mentioned only by one site.

There was a great deal of variability in how the sites thought they should use risk balancing, ranging from lack of clarity on what to balance to a clear concept of which receptors or other factors are balanced. The importance of the following list lies not in the individual sites that responded, but in the picture that emerges - one of a lack of clear qualitative and quantitative risk balancing. Most mentioned balancing among the three classes of receptors (worker, public, ecological), without giving examples or any details. Others mentioned sequencing and balancing long-term versus short-term. Eight sites (22 %) said they did not balance different risks or did not need to. Responses of those sites that balanced risks were as follows:

Yes, but no data given - 10

Yes, health, safety and political - 1

Yes, worker and public - 3

Yes, worker, ecological, cultural - 4

Yes, worker, ecological, public (but no data) - 3

Yes, worker, ecological, public (with some data) - 2

Yes, for prioritization and sequencing projects - 2

Yes, long term vs short term - 2

Yes, intend to use it in the future - 1

For the sites that provided no data it was not clear what they were balancing, and for most of the sites it was unclear whether they balanced risk qualitatively or quantitatively. Where risk is the key component of making cleanup decisions, with the end state in mind, a number of risk balancing issues arise. Table 2 is a compilation of issues mentioned by the sites, those inherent in their other comments, and our additions. Some of the key balancing involves 1) ecological and human health, 2) worker and public health, 3) among competing contaminated areas, 4) among temporal patterns of cleanup, 5) among species (plants vs animals, one animal vs another), and 6) among the sites across the complex. The ability to use risk to prioritize or to determine sequencing is a key aspect of risk balancing that was not expressed by most sites. Yet in a climate with resource constraints, and pressure to accelerate cleanup, risk balancing is a key method. For any one cleanup project, only some of these risk balancing issues would drive decisions.

Eleven of the 36 sites (31 %) stated there were no barriers to using risk as a basis for cleanup. However, a number of sites listed barriers to using a risk-informed approach to cleanup, including acceptance of different cleanup standards or closure standards by state and federal regulatory agencies (61 %), trust of DOE among regulators, tribal nations and other stakeholders (14 %), stable funding (11 %), land ownership (8 %), and knowledge for future institutional controls, life cycle costs, and DOE continued presence (3 % each). Only one site mentioned technology as a barrier to using risk as a basis for cleanup. This is somewhat surprising since technology is partly driving remediation methods, what waste can and should be left in place, and how to secure and stabilize waste that will remain in place. Respondents were asked what changes would occur in land use, land boundaries, or cleanup if risk were the sole driver. Half (18) of the sites mentioned that basing cleanup solely on risk would result in less stringent cleanup. Most of the remainder said it would not change their cleanup plans. Three sites mentioned the possibility of changes in the site boundaries, one mentioned a change in allowable release levels, and one each mentioned more aggressive use of an industrial designation as a future land use, and leaving more buildings in place. One of the larger, continuing mission sites mentioned that it would change the timing of their remediation, allowing them to address the areas with the highest risk first. Several voiced concerns that stakeholders would view new risk considerations as relaxing prior cleanup commitments or "doing less than promised".

Many factors influence whether risk is being used as the main driver in cleanup actions (see Table 3). These include getting agreement with regulators and other oversight agencies, gaining trust among these and other stakeholders, and ability to prioritize or set the time table for work based on reducing the greatest risk, and finally, adequate funding.

As noted above, compliance-driven cleanup is not necessarily based on risk, although several respondents mentioned that CERCLA and RCRA have risk as a basis. Finally, it should be mentioned that compliance and cleanup are not necessarily the same thing. While compliance surely drives cleanup, compliance in itself does not ensure cleanup. Further, the different requirements implied by the different compliance drivers at DOE sites results in different approaches to making decisions about cleanup and different cleanup strategies.

## STAKEHOLDER INVOLVEMENT: OTHER RISK COMPONENTS

One key component of achieving cleanup at contaminated sites is involvement of a wide range of Native American groups and stakeholders, including regulators, other governmental agencies, and the public. This greater involvement is essential, partly because it broadens the discussion of risk to include other social and economic risks of cleanup. These risks are often of equal concern to a range of stakeholders.

While asking DOE sites whether they have involved stakeholders begs for a "yes" answer, it is revealing to examine which stakeholders are mentioned. State regulators were most often mentioned as the stakeholders they involved, followed by the US Environmental Protection Agency, Citizens Advisory Boards or committees, and Native Tribes (Table 4). In this table, a given site often reported many different stakeholders, while two sites said there was little involvement.

Similarly, the vehicles respondents chose to report as methods of communication and dialogue are revealing (Table 5). These form a continuum from sites that provide briefings or information in newspapers, to those providing a "broad array of communication products, tailored to meet the needs of individual customers", to those that have a full range of interactive dialogues and workshops where stakeholders are active participants rather than recipients of information or decisions (Table 5). Products include multimedia presentations, fact sheets, brochures, newsletters, videos, exhibits, displays, graphics, and web-based information. One site merely said that "stakeholders are apprized of site progress" - certainly less than optimal for interactive stakeholder participation.

## TOOLS NEEDS TO MELD RISK, CLEANUP GOALS AND ENDSTATES

One important goal of the self-assessment was to understand the information and tools needed to move the DOE sites toward cleanup that is risk-informed and is related to the site endstate. For many of the EM sites, long-term stewardship of residual waste will be required (Crowley and Ahearne 2002). Tool needs thus could include those related to risk assessment, cleanup, land use, and stewardship monitoring and surveillance (Probst and McGovern, 1998).

Accordingly, respondents were asked what tools would help them move forward. Nearly half (N = 16) of the sites did not feel that they needed any additional tools or technologies to complete their cleanup mission in a timely fashion. However, the other sites listed a number of tools or other headquarters support that would facilitate accelerated cleanup, including uncertainty analysis, models (GIS and statistical), budgetary stability, additional funding (for uncertainty analysis), memorandums of agreement with regulatory agencies, access to risk assessment experts, and particularly risk communication tools.

While respondents did not list very many tools or protocols that would help them move toward developing an endstate vision that encompassed risk, we developed a list from their written answers to the overall questionnaire, and from our interviews with personnel at each site (Table 6). Some needs were mentioned in other questions, and were implied in their responses to barriers to cleanup completion. Taken in total, they indicate a great need for comparative risk assessment tools, risk management decision trees, and risk communication tools that would allow them to reach agreement with their regulators and other stakeholders, as well as an understanding of the relationship between risk parameters, regulatory constraints, and cleanup solutions.

## CONCLUSIONS AND RECOMMENDATIONS

The Department of Energy, like many other federal agencies and non-federal entities, is faced with massive cleanup tasks as a legacy from the Cold War or other industrial operations. There are many laws and regulations that apply to cleanup. However, while some of these laws and regulations take risk into account, the lack of site-specific data on exposures and risk scenarios, and the lack of attention to future land use or endstates has potentially resulted in a disconnect between risk and cleanup, risk and final endstates, and the cleanup levels and endstate or subsequent land use (Fig. 4). This disconnect results from the need for a range of technical, economic, sociological, and public policy tools to address the issues. Considering the final endstate before and during cleanup can ensure that risk and other factors inform the decisions.

Making decisions with the final endstate in mind requires a number of risk tradeoffs, including: 1) ecological and human health, 2) worker and public health, 3) among competing contaminated areas, 4) among temporal patterns of cleanup, 5) among species (plants vs animals, one animal vs another, and 6) among the sites across the complex. Such risk balancing is required within and among sites for a complex such as the DOE.

We suggest that for DOE sites, and perhaps, among other remediation sites (such as those of DOD or Superfund sites), there is a need to be clear whether and when risk is being used, to qualitatively and quantitatively compare risks to different receptors, and to use risk to develop a temporal pattern and sequencing of activities. A better transfer of approaches and information among and within facilities and operations offices would help. In addition, there are a number of approaches and tools needed to inform policy decisions, management decisions, and operations that include: risk assessment, risk management and cleanup, risk communication and dialogue, and endstate and land use determination. For each of these categories there are guidance, decision analysis, and technical tools. The range of approaches and tools required assumes the cooperation and collaboration between managers with different disciplines. The process should be one of maximum dialogue and iterations among the agency or company responsible for cleanup, state and federal regulators, scientists, and a variety of other stakeholders.

Thus we make the following recommendations to include risk in remediation and end state decisions:

**Risk-balancing should occur at all cleanup sites and be consistent across sites**. While risk-balancing occurs at some sites, it is usually not explicit and clearly analyzed within a risk framework. Risk-balancing should include, where applicable, human vs ecological health, and public vs worker health. These considerations should involve not only DOE, but relevant tribal governments, regulators, and other stakeholders. In developing risk-based endstates it is critical that risks be clarified and that risk be an important element in final negotiations of cleanup options with regulators and stakeholders.

**Risk-balancing should occur among remediation sites, methods, and schedule**. While informal balancing of risk has occurred at some sites, DOE personnel should more formally examine health risks (both human and ecological) under different exposure scenarios, which would directly influence which sites should be remediated by which methods, in which order. It is necessary to balance risks from acting now vs risks of delaying actions until better technologies are available. The overall effectiveness of risk balancing will be dramatically increased by having a consistent mapping program for current geophysical and chemical conditions and future risk-based endstates applicable to all sites.

**Risk-balancing should occur among DOE facilities to address environmental management in a consistent pattern.** While it is difficult to examine health risks across the entire DOE complex, it is essential to understand the relative risks before making budgetary considerations. Trade-offs between health risks, costs and other resources, and technologies available for transportation and remediation should be examined complex wide, within a framework of DOE personnel, tribal, state and local governments, and other stakeholders.

**Risk, remediation decisions, and future land use designations should be consistent.** Risk assessment, remediation decisions, and future land use designations have been developed at many sites independently of one another. While health risk is not the only driver of remediation and future land use, it is essential to make both remediation and future land use designations risk-based. The residual risk remaining after remediation should be consistent with future land use plans. DOE, tribal and local governmental agencies, regulators, and a variety of stakeholders should be involved in insuring that remediation is consistent with both future health risk and future land use.

**Types of stakeholder participation and information transfer categories should be consistent.** Forms of stakeholder participation have been developed independently at each site, and range from information briefings to massive interactive forms. Thus, the forms of communication and co-management involving various stakeholders, varies and is not necessarily consistent with the specific needs of each site. Risk-balancing, and appropriate decision-making with respect to environmental management and future land uses would benefit from interactive communication/participation methods. A list of available information/participation tools should be available to all sites, with sufficient information to implement these locally where applicable.

**Tools to meld risk, cleanup goals, and endstates should be available to all DOE sites.** A variety of risk assessment, risk management, risk communication, end-state determination, and land use determination tools are currently available for DOE and other cleanup sites. A mechanism should be developed to make these tools explicitly available to sites within DOE, and to tribal, state and local governments, regulators, and other stakeholders involved in making environmental management and future land use decisions at DOE sites. Where specific tools are needed but are unavailable in a clear protocol, DOE should take an active role in their development.

**Decision-matrix tools for risk-balancing should be further developed and made available to all sites.** While a variety of technical tools are recognized as essential for environmental management across the DOE complex, less attention has been devoted to the formal use of decision matrices involving risk-balancing and other aspects of cleanup. Yet the basis for decisions, and the decisions themselves, are of great interest to tribal governments, regulators, and other stakeholders, including the general public. A consistent and explicit application of decision-matrix tools to DOE environmental decisions would enhance the selection of the best solution, thereby increasing confidence among stakeholders.

## Acknowledgements

We thank the DOE sites for the information provided in the questionnaires, and EM corporate project 7 for allowing us to be part of the process. Over the years our thinking about endstates has been influenced by B. D. Goldstein, B. Friedlander, J. Clark, and D. Kosson. This research was funded by the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) through the Department of Energy (AI # DE-FC01-95EW55084, DE-FG 26-00NT 40938), although of course, the questionnaires themselves were those of the Department of Energy. The results, conclusions and interpretations reported herein are the sole responsibility of the authors, and should not in any way be interpreted as representing the views of the funding agency.

## REFERENCES

Burger, T. M. Leschine, M. Greenberg, J. Karr, M. Gochfeld, and C. W. Powers. 2003. Shifting Priorities at the Department of Energy's Bomb factories: Protecting Human and Ecological Health. *Environmental Management*, in press.

Crowley, K. D. and J. F. Ahearne. 2002. Managing the environmental legacy of U.S. nuclear-weapons production. *American Scientist* 90:514-523.

Daisey, J. M. 1998. A report on the workshop on improving exposure analysis for DOE sites, September, 1996, San Francisco, CA. *Journal of Exposure Analysis and Environmental Epidemiology* 8:3-8.

Department of Defense (DOD)(2001) *Coming in from the cold: Military heritage in the Cold War.* Department of Defense. http://128.174.5.51/denix/public/ES-Programs/Conservation/Cold War/coldwar.html.

Department of Energy (DOE). 2000. *Paths to Closure: Status Report 2000*. Washington, D. C.: Office of Environmental Management (DOE-EM-0526).

Department of Energy (DOE). 2001. *Long-Term Stewardship Report to Congress.* Prepared to fulfill a requirement in the FY 2000 National Defense Authorization Act (NDAA.

Department of Energy (DOE). 2002. *A Review of the Environmental Management Program.* A report to the Assistant Secretary for Environmental Management by the top-to-bottom review team. Washington, D. C. : Department of Energy, February 4, 2002. (called the top-to-bottom review).

Department of Energy (DOE) (1994a) *Stewards of a national resources.* Department of Energy (DOE/FM-0002), Washington D.C.

Department of Energy (DOE)(1994b) *National Environmental Research Parks.* Department of Energy, Office of Energy Research. Washington, D. C..

Department of Energy (DOE) (1996a) *Charting the Course: the Future Use Report*. (Department of Energy, Washington, D. C. DOE/EM-0283).

Department of Energy (DOE) 2002. A Review of the Environmental Management Program. Top to bottom review team, Washington, D.C.

Frisch, M., L. Solitare, M. Greenberg, and K. Lowrie. 1998. Regional economic benefits of environmental management at the US Department of Energy's major nuclear weapons sites. *Journal of Environmental Management*. 54:23-37.

Kamrin, M. A. 1997. Environmental risk harmonization: federal/state approaches to risk assessment and management. Regul. Toxicol. Pharmacol. 25:158-165.

Levin, Michael. 1990. Implementing pollution prevention: incentives and irrationalities, *Jouranl of Air and Waste Management* 40:1227-1231.

Lubbert, R. F. and Chu, T. J. (2001). Challenges to cleaning up formerly used defense sites in the twenty-first century. *Remediation,* 11, pp. 19-31.

National Research Council. 1983. *Risk assessment in the federal government: Managing the process*. National Academy Press, Washington, D.C.

National Research Council. 1993. *Issues in risk assessment*. National Academy Press, Washington, D.C.

Powers, C. W., F. E. Hoffman, D. E. Brown, and C. Conner. 2000. *Great experiment: brownfields pilots catalyze revitalization*. The Institute for Responsible Management, New Brunswick, New Jersey.

Probst, K. N. and M. H. McGoven. 1998. *Long-term stewardship and the nuclear weapons complex: the challenge ahead*. Center for Risk Management. Washington, D.C.

Sink, C. H. and C. W. Frank. 1996. DOE forges partnerships for environmental cleanup. *Forum for Applied Research and Public Policy* 11:65-69.

U.S. Environmental Protection Agency. 1987. *Unfinished Business.* A Comparative Assessment of Environmental Problems, February 1987.

U.S. Environmental Protection Agency. 1996. *Reinventing Environmental Regulation, Progress Report*, Washington, D.C.

Table 1. Location, regulatory laws, and mission of 36 Department of Energy sites involved in the self assessment.

Table 1. DOE sites considered in Self Assessment

| DOE Office or Program | LTS Site | State | Regulating Law | EM Mission Completion Date | Continuing Mission |
|---|---|---|---|---|---|
| | | | | | |
| NV | Amchitka Island | Alaska | AEA,RCRA | 2004 | No |
| CH | Argonne National Laboratory East | Illinois | RCRA | 2003 | Yes |
| CH | Argonne National Laboratory West | Idaho | CERCLA | 2001 | Yes |
| OH | Astabula | Ohio | AEA/RCRA | | No |
| CH | Brookhaven National Laboratory | New York | AEA, CERCLA, RCRA | 2005 | Yes |
| NV | Central Nevada Test Area | Nevada | AEA,RCRA | 2012 | No |
| OH | Columbus-Battelle | Ohio | AEA | | No |
| OK | Energy Technology Center | California | AEA | | No |
| OH | Fernald | Ohio | CERCLA/RCRA | | No |
| NV | Gasbuggy Site | New Mexico | AEA,RCRA | 2014 | No |
| OK | General Electric Vallecitos | | AEA | 2014 | No |
| NV | Gnome-Coach Site | New Mexico | AEA | 2014 | No |
| RL | Hanford Site | Washington | CERCLA, RCRA (TRIPARTY) AEA | 2035 | Yes |
| ID | INEEL | Idaho | CERCLA, AEA, RCRA | | Yes |
| AL | Kansas City Plant | Missouri | AEA, CERCLA, RCRA | 2006 | Yes |
| OK | Laboratory for Energy Related Health Research | California | CERLCA | 2005 | No |
| OK | Lawrence Berkeley National Laboratory | California | AEA,CERCLA | 2006 | Yes |
| OK | Lawrence Livermore National Laboratory - Main Site | California | AEA, CERCLA | 2007 | Yes |
| OK | Lawrence Livermore National Laboratory - Site 300 | California | AEA, CERCLA | 2008 | No |
| AL | Los Alamos National Laboratory | New Mexico | AEA, RCRA | 2015 | Yes |
| GJ | Moab | Utah | AEA/CERCLA | | No |
| OH | Mound (Miamisburg) | Ohio | CERCLA | 2006 | No |
| NV | Nevada Test Site | Nevada | AEA, RCRA | 2027 | Yes |
| OR | Oak Ridge Reservation | Tennessee | CERCLA, RCRA, AEA, | 2013 | Yes |
| OR | Paducah Gaseous Diffusion Plant | Kentucky | CERCLA, RCRA | 2010 | Yes |
| AL | Pantex Plant | Texas | CERCLA, RCRA | 2017 | Yes |
| OR | Portsmouth Gaseous Diffusion Plant | Ohio | RCRA,CERLCA, AEA | 2019 | Yes |
| NV | Project Shoal Area | Nevada | AEA | 2008 | No |
| NV | Rio Blanco Site | Colorado | AEA/RCRA | 2009 | No |
| RF | Rocky Flats | Colorado | CERCLA (FFA) RCRA,AEA | 2007 | No |
| NV | Rulison Site | Colorado | AEA/RCRA | 2011 | No |
| NV | Salmon Site | MS | AEA/RCRA | 2010 | No |
| AL | Sandia National Laboratories - NM | New Mexico | RCRA | 2006 | Yes |
| SR | Savannah River Site | South Carolina | CERCLA, RCRA (FFCA) and AEA | 2047 | Yes |
| OK | Separation Process Research Unit | New York | AEA/RCRA | 2014 | No |
| OK | Stanford Linear  Accelator (SLAC) | California | CERCLA | 2006 | Yes |
| GJ | Weldon | Missouri | CERCLA | | No |
| OH | West Valley | New York | AEA | 2112 | No |

Table 2. Types of risk-balancing required for cleanup and endstate planning.

| Type | Example |
|---|---|
| Human vs ecological | Using an endangered species as the risk driver vs public or worker health. At Moab, the mill tailings provide a potential risk to endangered fish in the Colorado River, while the removal of the tailings provide risks to workers on site. |
| Public vs worker health | Trade-offs between the risk (lives lost due to injuries, accidents and future health risks) against risks to the public's exposure. This occurs at most DOE sites where remediation is occurring. |
| Among species | Trade-offs between the risk to one species or group of species and another. Removal of soil disrupts on-site ecosystems and all the organisms therein; leaving pollution in place may be less disruptive where levels are not causing adverse ecological effects. |
| One area vs another | Trade-offs between the risk generated from one contaminated site versus another on the same DOE property At Brookhaven, the risk to the public from potentially consuming contaminated fish (requiring removal of sediment from the Peconic River) is pitted against risk to the public from contaminated soils in the Boneyard (requiring soil removal). |
| Among temporal patterns | Remediation now versus later affects the risk to on- and off-site receptors. |
| Sequencing | Some risk balancing might affect sequencing of cleanup, without necessarily delaying the temporal pattern. |
| Among DOE sites | Which risk reductions should be conducted in which order. Is it better to cleanup smaller sites with less contamination, smaller sites with greater contamination, or larger sites with greater contamination, and in what order? |

Table 3. Issues preventing DOE sites from using mainly risk in cleanup decisions. Below are some representative comments to the questions: What are the barriers to using risk, or how would using risk alone change cleanup approaches?

---

| Type of Site | Comment |
|---|---|
| Closure | “The level of distrust and conflicting agendas of the state and local entities creates a situation likely to require significant additional resources to satisfy." (Amchitka). |
| Continuing | "The over-riding issue still is one of trust between DOE and its site neighbors and regulators." (Brookhaven |
| Closure | "The only barrier is funding." (Argonne) |
| Closure | "Release limits would change along with accepting deed restrictions..." (Ashtabula) |
| Continuing | "Eliminate future residential use and take advantage of longer periods of DOE ownership. (Brookhaven) |
| Closure | "Provision must be made for adequately assessing the impact of future demands on subsurface waters." (Central Nevada TC) |
| Closure | Cleanup levels of metals should take into account background and other contributors to the source.(Fernald) |
| Closure | "Regulator agreement on criteria for closure."(Gasbuggy) |
| Continuing | "DOE policy and guidance alone is not a basis for changing the current approach to cleanup decisions." (i.e RCRA, CERCLA or others affect cleanup) (INEEL) |
| Continuing | "If we were allowed to ignore the state policies and regulations...five of the eleven groundwater contamination plumes would not require any corrective action." (Lawrence Berkeley) |
| Continuing | "The state lacks environmental covenant legislation that would allow the state to be more flexible. (Los Alamos) |
| Closure | "A risk-based approach is not accepted by NRC.(Moab). |
| Continuing | "Regulator agreement on criteria for soil cleanup." Nevada test site |
| Continuing | "Arguably, some of the remedial plans go beyond those absolutely required to control risk." Oak Ridge |
| Continuing | "There are some disagreements about the targets to be used." (i.e. $10^{-6}$ or $10^{-4}$) Paducah. |
| Continuing | "Recommend prioritizing cleanup work to result is the greatest risk reduction. Reaching agreement with the regulatory and oversight agencies to complete the work which results in the greatest risk reduction."(SRS) |

Table 4. Agencies or entities listed as stakeholders by Department of Energy sites. Given are percents (N= 36 sites).

| | Percent mentioning |
|---|---|
| State regulators | 81 |
| EPA | 42 |
| Native tribes | 22 |
| Citizen's Advisory Boards/committees | 31 |
| City or county government | 19 |
| "stakeholders/public" | 19 |
| Governor's office | 8 |
| US Fish & Wildlife Service | 8 |
| NRC | 8 |
| Local water board | 6 |

Note: Mentioned only once: ranchers, landlord, Navy, reporters, business, CRESP.

Table 5. Types of stakeholder participation mentioned by Department of Energy sites

| | Percent Mentioning |
|---|---|
| Public meeting | 72 |
| Public workshops | 42 |
| Products | 31 |
| Briefings | 11 |
| None mentioned | 28 |

Note. Products include multimedia presentations, fact sheets, brochures, newsletters, videos, exhibits, displays, graphics, and web-based information.

Table 6. Types of tools needed for achieving cleanup at Department of Energy sites using risk-based endstates. In this scenario, risk would drive both cleanup and future land use.

---

RISK ASSESSMENT

- Understanding and evaluating hazards as sources
    - -Current toxicity/hazardousness
    - -Hazardousness over time (particularly for volatiles and radionuclides
    - -Incorporating bioavailability
    - -Hazard transport
    - -Linkages between soil surface and sub-surface
    - -Linkages between aquifers
- Selecting the correct receptors
    - -Where to locate receptors (at boundary of site or of hazardous waste site)
    - -Linking receptor locations (near and long-term)
    - -Including diverse receptors in one assessment
- Selecting appropriate receptors for long-term monitoring
- Guidance on how to select correct scenarios for current and future risk
- Guidance on Use of Default vs site-specific assumptions
- Guidance on the use of site-specific information in risk assessment and long-term monitoring needs
- Guidance on appropriate temporal parameters of risk (e.g. 50 vs 100yrs, vs longer)
- Understanding deterministic and probabilistic risk assessment techniques
- Template for site wide models, and models to link watersheds

## RISK MANAGEMENT AND CLEANUP

Understanding how assessment informs action (or no action)

Understanding how assessment leads to choice of remediation option

Understanding the use of precedent in risk management (with examples)

Understanding and communicating re: monitored natural attenuation

Linking Risk Assessments to applicable statutes and regulation

-Linking risk assessment under specific regulations to corrective action (for CERCLA, RCRA, NRC, NEA).

-Understanding and linking risk calculations to risk

-Best available technology
-ALARA
-MCL's
-ARAR's
-Soil screening standards
-Hazard quotients and Hazard Index

Developing decision matrices for the above calculations

Understanding of EPA's or California's "non-degradation policy" as it applies to aquifers

Developing decision matrices for risk balancing

-Human vs ecological
-Different ecological receptors
-Worker vs public health
-Health (human or ecological) vs economic or social risks

Understanding the role of the courts in remediation disputes

Developing and understanding an Exit Strategy

Technologies for specific clean up problems

## RISK COMMUNICATION AND DIALOGUE

Developing memorandums of understanding with different regulators

- -within different EPA regions
- -between state and federal

Understanding public concerns about risk; providing examples to reduce fears that:

- -Risk assessment can give any desired answer
- -Risk-based favors less cleanup
- -Risk requires complex solutions
- -Risk is not understandable or not understood by stakeholders

Development of communications tools:

- -Simple graphics for:
  - -Risk paradigm
  - -Fate and transport
  - -Extent and level of contamination
- -Interactive information sources for stakeholders
- -Standard, complex-wide maps of contamination

Developing interactive communication tools

## END STATE AND LAND USE DETERMINATIONS

Guidance on different end state visions, including relationship to any on-going missions

Understanding how different statutes link land use and risk

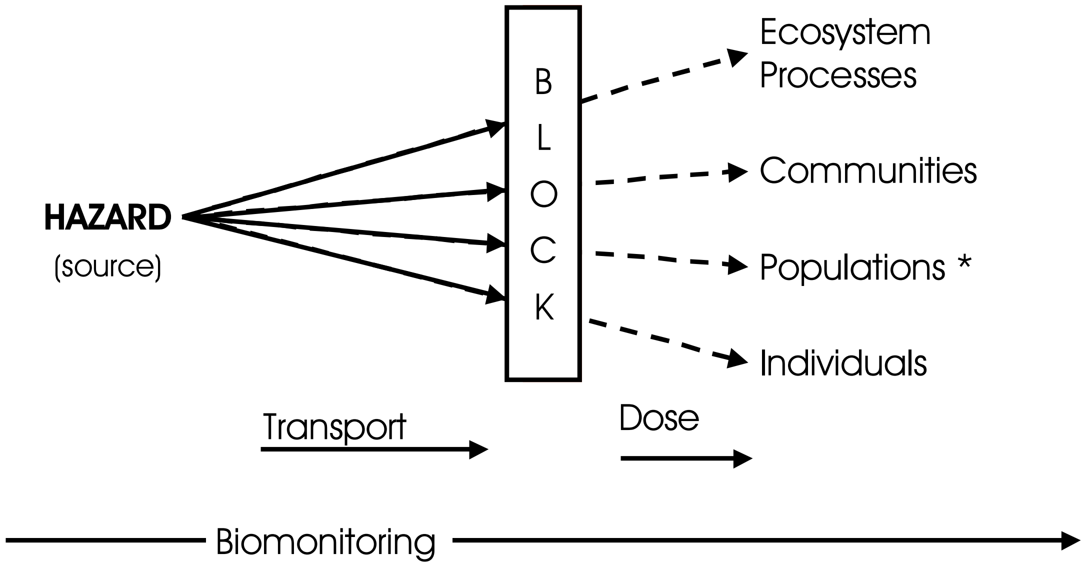
Understanding who makes risk, remediation, and land use decisions.

Integration of receptor risk and land use decisions

Integration of institutional controls with risk and land use

Figure Legend

1. Schematic of receptor risk, showing that a block can be placed between the source and the receptor, reducing or eliminating risk.



* all receptors, including human

Figure 1

2. Schematic of the relationship between regulatory drivers and cleanup for the Department of Energy.

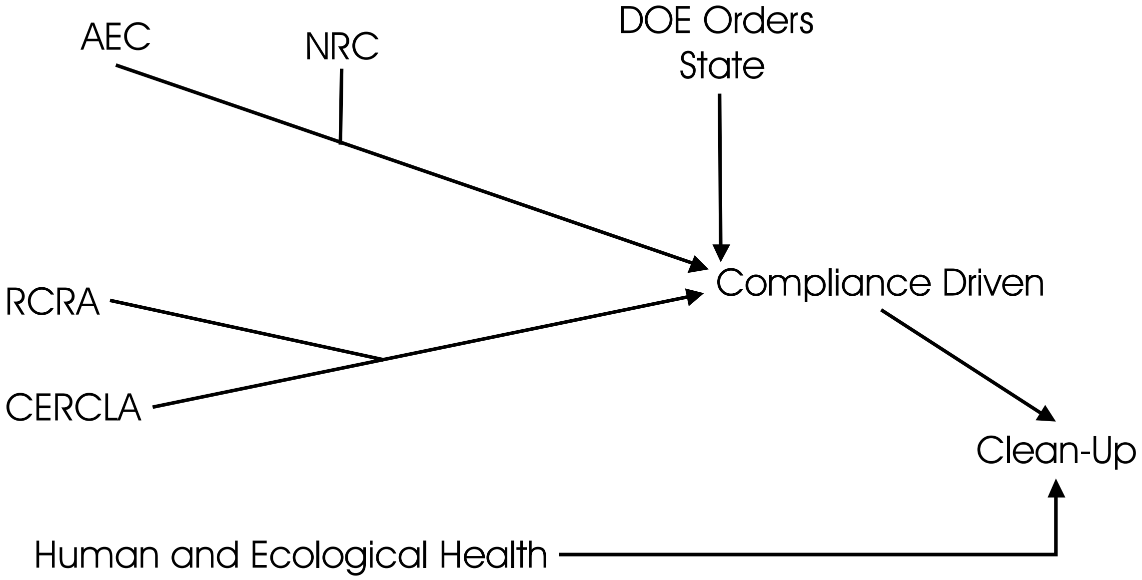


Figure 2

3. Developing a site-wide model is critical to understanding risk, cleanup, and future land use.

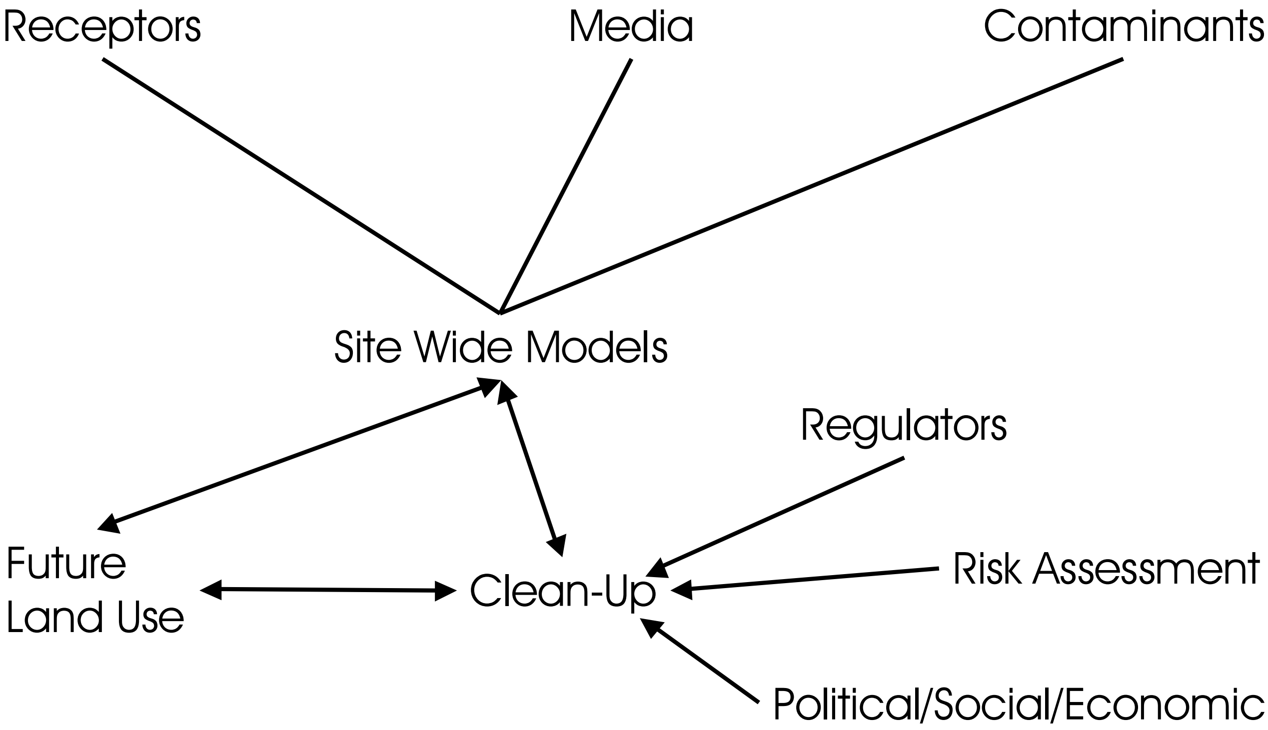


Figure 3

4. Relationship between risk, cleanup, regulation, and future land use.

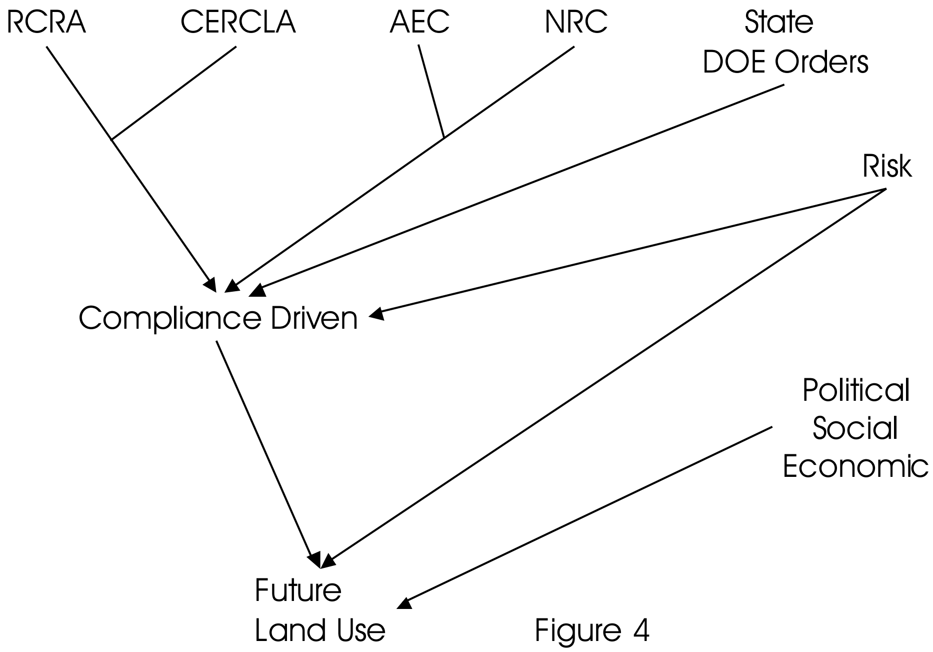


Figure 4