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RISK MANAGEMENT IN FACILITY TRANSITION AND MANAGMENT DECISION MAKING: NEEDS AND OPPORTUNITIES

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INTRODUCTION

The U.S. Department of Energy Office of Environmental Restoration and Waste Management (DOE/EM) is charged with the mission of using cost-effective and technologically sound approaches to:

- ensure that risks to the environment and to human health and safety posed by active, inactive, and surplus facilities and sites are reduced to prescribed, acceptable levels; and
- safely and acceptably prevent/minimize, handle, treat, store, transport, and dispose of Department of Energy (DOE) waste.

Risk management, as defined herein, provides a systematic and comprehensive method for making decisions regarding risk and affected by risk in a way that enables EM to achieve this mission.

An overall approach to risk management is described in this paper. Many of these concepts have been developed and applied as part of Hanford Mission Planning (HMP) (Hanford Mission Plan, 1992). At Hanford, HMP provides a mechanism for integrating planning across all the missions and programs of the site. Recognizing the basic value of this approach to decision making, the Environmental Management (EM) Office of Transition and Management (EM-60), which was recently created to manage the transition of surplus facilities from other Principal Secretarial Offices (PSOs) or other agencies into EM for decontamination and decommissioning and final disposition. The EM-60 expressed interest in adapting the risk management concepts to EM-60 decisions. This has led to further development of the method presented here, particularly adapting it to a multiple-site, complex-wide context. In addition, working also with the EM Office of Planning (EM-14), critical risk management concepts are being incorporated into Integrated Roadmaps, the basic planning tool adopted by EM.

This paper discusses the decision context within which EM must make and defend decisions, the types of decisions that are being and will need to be made in order to progress with the cleanup of the DOE complex, and the resulting need for risk management. Risk management, in turn, requires quality health and ecological risk information to make these decisions. Other types of information are also needed, but the risk information is typically the most important and the most difficult to obtain. The paper then describes a general technical approach to risk management, including particular methods for developing the high quality of human health and ecological risk information that will be needed to support risk management. We next turn to several special issues that make risk management more complex than many other decisions. We discuss these issues and offer some practical suggestions with respect to addressing them in the risk management framework. Finally, we conclude with some discussion of other opportunities for applying risk management.

BACKGROUND

Over the upcoming decades, costs for cleaning up the nation's toxic waste could total $500 billion, "unless major technological innovations" become available (Office of Technology Assessment (OTA), 1989). Today, costs in the trillions of dollars are considered more realistic based upon using existing technologies targeted at non-risk based cleanup standards. Yet, while the need for cleanup is great, effective technologies are not available and the new, most promising technologies that could significantly reduce cleanup costs are still in the very early stages of development (OTA, 1991).

Within the U.S. Department of Energy alone, the OTA believes that the initial cost estimates for DOE site cleanup of a few tens of billions of dollars "only represents the discovery phase of a program that could require hundreds of billions of dollars to complete" (OTA, 1991). While cleanup of chemical waste problems that the nation's Resource Recovery and Conservation Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) programs have traditionally faced are yet to be resolved by the EPA, DOE must address these plus the more complex problems associated with large volumes of radioactive mixed wastes.

In light of the spiraling costs and the inadequacy of current decision methods, the U.S. Environmental Protection Agency (EPA) (1984) has noted: "One can argue about how much should be spent on environmental protection, but at some point everyone must accept that the commitment of resources for any social purpose has a finite limit. If the number of potential risk targets is very large in comparison to the number we can realistically pursue, which seems now to be the case, then some rational method of choosing which risks to reduce and deciding how far we should try to reduce them is indispensable." Taken in the context of a site such as Hanford where vast sums would be required to return the site to a pristine state and the value of that outcome (at least in terms of dollar value of the land) is relatively small, such an argument is persuasive. The major argument for cleanup of such a site must be evaluated in terms of reducing human and ecological risk relative to the other potential investments of those losdollars.

To better ensure that agencies are allocating their limited environmental management resources to have maximum risk reduction impacts, there is the need to 1) factor potential risk impacts into environmental management policies, programs, and budget allocations, 2) develop technically defensible risk-based cleanup standards, and 3) proactively evaluate the risk impacts for cleanup approaches/options. This will enable DOE and EPA to achieve their ultimate environmental management goal of reducing short- and long-term human health risks and protecting/improving the quality of the natural ecosystems.

The key benefit of an integrated risk management approach is to demonstrate what each EM action, policy, or regulatory driver does in terms of cleaning up sites and reducing (or sometimes even increasing) risk. For example, Site A could significantly reduce its long-term human health risks by simply shipping its waste offsite to Site B. Of course, now Site B has inherited contamination problems through Site A's geographic redistribution of risk (and, of course, there is an additional risk associated with the transportation of the material). Little, if any, overall risk benefit has been incurred. From a DOE complex perspective, one must consider overall human health risks and costs. These types of questions should be addressed and factored into devising DOE environmental restoration and waste management policies.

The use of risk information as input for making informed decisions about environmental restoration and waste management is receiving increased national attention. To better ensure that DOE is allocating its environmental management resources to have maximum health and environmental (H&E) risk reduction impacts, there is the need to 1) evaluate H&E risk-based impacts for site cleanup options, 2) factor risk impacts into DOE's environmental management policies and programs, 3) factor in other relevant information (e.g., the anticipated final site use and economic development impacts) into the decisions using the same risk management framework, and 4) integrate into the decision process factors contributing to the uncertainty of the success of programmatic options at reducing H&E risks. In this manner, meaningful risk management information can become available to decision makers for optimizing decisions.

While risk-based approaches to problem solving are not new concepts, they have not been formalized or used by DOE to bring the best science and sound judgment into its decision process. Lacking a sound approach to risk management, DOE commonly places increased programmatic emphasis on collecting more data/information (thus gaining improved data precision and comprehensiveness) or in conducting more feasibility studies. Thus, a nearly infinite set of cleanup options remain open with the result that minimal true risk-reduction activities are pursued. All the while contaminants are spreading and aging, engineered structures are losing their ability to contain the containments. Thus, a balance must be struck between waiting for improved information and using existing information (or high-payback, low cost new information) to make informed risk management decisions today.

EM Decision Needs

In dealing with its waste problems, DOE-EM must make decisions that require analysis and interpretation of widely disparate data to resolve issues of varying complexity. In addition, the DOE is increasingly subject to scrutiny of and even impact to its decisions from outside organizations. A range of stakeholders have begun more and more to seek information about the basis of decisions involving the complex cleanup; then to use that information to propose legislation, foster litigation, or simply seek justification for actions.

The relationship of EM decisions to other DOE and governmental decisions is also being recognized. For example, the Office of Facility Transition and Management is focused on decisions about acceptance criteria that will jointly impact performance of both the Defense Programs (DP) and the EM missions. Other components of EM increasingly find themselves negotiating (rather than deciding) issues with other components of DOE (for example, EH) as well as other governmental (e.g., EPA, Occupational Safety and Health Administration (OSHA), and non-government organizations.

Information is required to support this decision making. While the required information covers a range of substantive contexts including cost, technology needs, regulatory issues, and land use options risk information is typically a major driver and particularly difficult to obtain. Headquarters (HQ) does not necessarily need all of this information. But to make informed decisions, DOE-HQ must be assured that quality information in these and other substantive areas underlies and serves as the basis for the more aggregate information provided to DOE-HQ, and for decisions made at lower levels.

Many of the initial decisions of concern to EM-60 and EM more generally focus on identifying the scope and magnitude of the job they face, and the organizational capabilities and resources needed to meet that need. At the same time, EM must make some immediate decisions and/or enter into negotiations that require understanding of the implications of those decisions on key decision criteria. Both of these types of decisions will require data developed at the field offices to support the decision process.

Many, if not most of the significant decision problems faced by EM fall in five topic areas: program scoping/direction, financial, policy, regulatory, and technical. Following is a brief discussion of each type of decision topic area with examples (mostly from EM-60) of decisions that come under that area.

- <u>Program scoping/direction decisions</u> require that the magnitude of the cleanup problem across the complex be established. The scope of the problem will need to be understood in terms of such issues as the aggregate risk and its key sources associated with these problems, the rate at which risk is increasing as the facilities age and other problems remain unmitigated, and capability (in terms of both resources and technology) necessary to cleanup these problems. At DOE-HQ, this information will be used to establish the size and needed capabilities programs, and their direction, goals, and mission.

- <u>Financial decisions</u> will be of three types: establishing the resource needs of the programs, allocation of resources to activities at the Sites in order to maximize the impact of the expenditure of those resources, and management of those resources during the performance of the clean-up process.

- Policy decisions are both internally focused on procedures and guidance and externally focused on the process of negotiating policy with other organizations within EM (e.g., between EM-60 and EM-40), within DOE (for example, with Environment, Safety and Health (EH), Nuclear Energy (NE), and Defense Programs (DP), and external to DOE (for example, with EPA and state governments). A key example of this type of decision is that of setting the acceptance policy and criteria for bringing facilities into EM from DP.

- Regulatory decisions can be of several types, usually addressed as a part of a decision process between DOE and one or more regulatory agencies. Much of the information needed for these types of decisions involves the impacts of and technical justification for decisions driven by regulations (e.g., federal facility agreements (FFAs) and standards for specific chemicals) at specific sites or across the complex. This information will be necessary during the negotiation process as the DOE considers justification for either site-specific exemptions or complex-wide regulatory change. It will also be necessary for understanding when negotiating schedule or workscope adjustment to FFAs.

- Technical decisions are primarily focused internally to the programs at specific sites. Thus DOE-HQ organizations are often not directly involved. There are, however, some aspects of technical decision making that DOE-HQ must be aware of in order to support the sites in their missions. A key example of this type of decision making involves technology needs. Where there are gaps in the technology base needed to meet the EM mission, EM-50 must act in conjunction with the line EM organizations (i.e., EM-30, EM-40, and EM-60) as the agent to create an understanding of the importance of the need from a complex-wide perspective. This will help to ensure that the need receives the appropriate priority in research and development funding decisions.

Information Requirements

The decision areas and examples described above suggest a requirement for various information for quality decision making to be possible. Decisions involving program scoping and direction require complex-level information about the magnitude of the problems faced by EM, regulatory requirements, and relative risk and the urgency/immediacy of that risk for different problems. Financial decisions will require information about the cost of activities associated with the cleanup process, as well as the costs of maintaining facilities and other cleanup problems in alternative interim states. This information will need to be understood in a framework common across problems to determine the relative value of investing in one program element over another. The information necessary to support policy and regulatory decision making and negotiation is about the potential impacts of changes, and the priority associated with pursuing various policy decisions and negotiations. Often, stronger information will be required when a change to a policy or regulation has no impact than when a change is required to establish consensus across stakeholders. Finally, technical decisions will require information about the performance of baseline technologies (i.e., those that are currently part of the planning base) and of possible alternatives being developed. DOE-EM will need to establish a complex-wide understanding of gaps in availabile technology to address key problems and the potential impacts of technological breakthroughs across the complex.

While much of the necessary information exists, access may be difficult, particularly for use by senior decision makers. Substantial efforts are under way in EM to develop and aggregate the necessary information to address many of the decisions discussed above. These individual efforts, however, usually focus on a single or limited set of issues and will often use or recreate the same information from another effort. An integrating framework is needed that allows the full range of decisions to be addressed with a common set of assumptions and, as much as possible, a common data source. In addition, a process needs to be defined that provides for decision making in the near term, with the best information currently available, but that also defines the longer term objective of an integrated decision framework. In the remainder of this paper we discuss a generalized decision framework, called risk management, based upon the precepts of decision theory. A process is then discussed that maintains that framework while allowing short term decision needs to be addressed. Finally, an approach is discussed, again, consistent with the decision-theoretic framework, for meeting the longer term objective of developing a common source of cost and health and ecological risk information that can serve as the basis for risk management in the future.

TECHNICAL APPROACH

The basis of this risk management approach is a clear separation of: the description (characteristics) of an existing system which, in the case of EM, is a description of the existing condition of the complex; options (also called alternatives) that might be used to change the condition of the existing system; and value sets for an individual, organization, or group that determine present or future worth of the existing and alternative systems in terms of how well they meet the objectives of that individual, organization, or group. Descriptions of existing systems are derived from observable data using the precepts of systems analysis, and are relatively objective and stable. Options are evaluated with respect to their ability to produce future change in the existing system. Various options can be envisioned to produce a single desired change. Thus, options introduce estimates, projections, branching, and time flow into the decision process.

Institutional value sets are specific to individuals, organizations, or groups, and may differ substantially among different organizations. Alternatives are evaluated by comparing the values achieved with the existing system and alternative systems. A systematic separation and description of the existing system, options, and institutional value set forms the logical basis for application of existing decision-making tools to risk management.

The basic approach evolves directly out of decision analysis (e.g., von Winterfeldt and Edwards, 1986). The approach structures decisions in terms of the options or alternatives, the objectives those options are designed to achieved, the relative importance of different objectives, and the likelihood of achieving the objectives with each specific option. The concept, outlined in more detail below, is based upon work conducted as a part of the integrated planning process developed for the Hanford site.

Options

Options, sometimes called alternatives, refer to the specific strategies that can be undertaken in any specific decision. Thus, they may range from sets of detailed systems to be deployed to cleanup Hanford as part of Hanford Mission Planning; to more specific policy and program decisions, such as discussed in the Introduction as examples of EM-60 decisions; to technical decisions about, say, how best to deactivate a specific facility with an existing technology or with a new one now under development. The important link among such different types of decisions for a particular organization is that they all help determine how well the organizational objectives or values are achieved, and, therefore, should all be driven by these same objectives (though possibly defined at different levels of detail).

Developing options is a creative process that experience shows can be helped by several processes such as focusing on the objectives (e.g., Keeney, 1992), involving broad representatives of different stakeholders, or involving experts with different technical expertise.

An approach to option development being examined by EM-60 (coming out of the Hanford work) is based upon a systems analysis of cleanup options. The analysis starts with definition of problem areas (tanks at Hanford, for example) for each site, on a site-by-site basis. These problems are then broken down by chemical engineers to establish parametric descriptions of the material balances that, taken together, make up each problem. For example, the first level of breakdown for the tank problem area might be tank waste, tank structures, corollary structures, and surrounding soil contamination (not captured in the environmental restoration problem description).

These separate problem subsets are further broken down to describe the volume of material and types and level of contamination. The needed level of detail must be such that the chemical engineers are able to specify technologies and/or processes that stabilize, isolate, or remediate each material balance. Process steps are then specified that take the material balance through the entire cleanup or mitigation process to a final end state for that material (either storage, destruction, or shipment), as depicted on the far right of Fig. 1. They also identified corollary waste streams created in some process steps that then entered other process streams. For example, a number of chemical separation processes (e.g., for tank waste) will create substantial volumes of liquid effluent that will then enter the liquid effluent process stream.

[Place Fig. 1 here]

We sought to define site-level options (combinations of the process steps for all site problems) to cover a range of site-level future use scenarios from "unrestricted use" (essentially a pristine site according to regulatory definitions) to "exclusive use" (a state very much like the limited access state that currently exists). It should be noted that the exclusive-use, end-state still requires substantial cleanup activity to, for example, limit the migration of certain materials off offsite.

There were two reasons for defining such a broad set of strategies for analysis. The first is that there are many groups and individuals with interest and concern about Hanford Site decisions. Creating a broad range of end-state-based options maximizes the chance that the full set of stakeholders will be able to find their "preferred" option among the analyzed set. The second reason is to explore the relationship between key decision criteria (for example, cost and risk) across the full range of possible options. This provides the opportunity to examine tradeoffs between key decision criteria; for example, the amount of site area returned to various levels of use for a given investment.

The next step in the systems analysis is to identify technologies and/or processes that accomplish the process steps identified in the systems diagrams. Inserting a technology into a process step allows description of the performance of that technology against the material balance to be dealt with in that process step and definition of the material balances that result from the application of the technology. These material balances then serve as the input to the next process step. The resulting system model allows manipulation of flows of material balances in order to determine the impacts on the entire system of changes to specific combinations of technologies. A complete set of these process steps for the entire site, with their associated technologies, constitute an option for the cleanup of the site.

<u>Objectives</u>

Objectives define the purpose of the decision, issue, or, in the case of strategic decision making, the organization, specifying what it is trying to achieve. In developing this approach to risk management, the focus may be on only part of the mission of the organization, or on the total mission. The mission of EM is to reduce the health and ecological risk associated with the DOE complex. Thus, a key objective of the organization is minimization of health and ecological risk. But a broad range of other objectives contribute to achieving, or more concretely defining that mission. Other objectives include cost minimization, regulatory compliance, future site use development, and regional economic development.

The systems analysis model serves as a basis to integrate information about multiple objectives and to compare options. Each activity or process step (as depicted in Fig. 1) provides information that allows estimates of key objectives to be generated. For example, material balances information is used in conjunction with other information about population, etc., to determine the public and worker health risk associated with the materials. The material balance process steps and associated application of technology also provide the basis for estimating the cost for each step and a method for aggregating those costs under a given site-wide strategy. Further, contaminant concentrations from the material balances are used to identify regulatory requirements that stipulate cleanup standards of concern to the programs.

The development of health risk information has been a key focus of the methodology developed to date. It was determined that three distinct components of health risk needed to be developed in order to fully compare cleanup options: information about the "baseline" of health risk for the DOE complex under current conditions; risk from end-states that result from alternative strategies for complex remediation activities; and risk to workers, public, and ecosystems for the remediation activities themselves.

Initial focus was on development of a quantitative assessment of public health and worker safety and health risks for material balances currently present on the complex sites. The goal of this activity is to provide decision makers with the tools and data to determine the overall risk associated with the complex as it currently exists and into the foreseeable future, and identify and compare current sources that lead to that overall risk. A key activity for development of this product is a comprehensive source term identification of all currently existing inventories of hazardous and radiologically active materials. Where risk assessment has already been conducted (for example, substantial public health risk information has been developed for the complex in an Environmental Survey conducted in 1987), that risk information has been consolidated into a common format for insertion into the systems analysis. This activity identifies exposure pathways by source term and estimates risk by type. For those source terms for which risk data does not already exist, exposure pathways are being identified for each source term. Data will then be developed, primarily using expert judgment, to provide preliminary estimates of the necessary parameters for development of public and worker health, worker safety, and ecological risk for the baseline.

The second component of health risk information is a quantitative assessment of the public health, worker, and ecosystem risk that will result from remediation activities under alternative strategies for cleanup. Work in this area has focused initially on a baseline strategy as identified by the Hanford Site, but will eventually need to provide information across a full set of sites and alternative cleanup strategies.

A key activity in the development of this product is end-state, source-term definitions. Working from systems analysis end-state material balances defined in terms of remediation activities, detailed source-term definitions will be developed that are comparable to those identified for the baseline. End-state source terms will then be linked to baseline source terms in order to facilitate comparison of risk before and after remediation activities. Relevant exposure pathways by source term will then be identified and the risk by type (public and worker health, worker safety, and ecological) for each source term will be estimated.

The third component is a quantitative assessment of public health, worker, and ecosystem risk associated with remediation activities. This area is by far the most complex, with separate approaches needed for worker safety, work health, ecological damage, and public health components. But it will be necessary to compare the elevated risk likely to occur. These risks are to the public from opening new exposure pathways, workers from both a safety and exposure perspective, and damage to the ecology from construction and other activities with the onset of the cleanup activities against the reduced long-term health risk associated with cleaning up contamination problems. In the near term, it is likely that much of the information used here will have to be based upon expert judgment.

Likelihood Options for Achieving Objectives

Given a specific option and a specific objective, usually there will be some uncertainty regarding how well that objective will be met with the given option. For example, in considering an existing and a new technology now under development for use in deactivating a particular facility, EM-60 may know that the new technology is expected to perform much more effectively than the current technology, but there may be considerable uncertainly regarding when the new technology will be ready and how much it will cost. In some instances, this uncertainty could be modeled explicitly using probability distributions and then computing expectations; in other instances it may simply suggest an ad hoc adjustment in how the option is measured with respect to the particular objective.

This type of uncertainty can occur regarding any options and any objectives. It may or may not be handled explicitly, but it needs to be understood and considered in the decision process.

One point of clarification may be important here. Many times, the uncertainty associated with the time, cost, and outcome of a particular program will be referred to as "programmatic risk," and lumped in with health and ecological risk under the general rubric of "risk." This "programmatic risk" is a very different type of risk, one that is not logically related to health or ecological risk; and, therefore, should be considered separately when it is relevant to a decision.

Information and Data Needs

The basic types of information needed for a particular decision include 1) estimates of how well each option will achieve each objective, 2) estimates of the uncertainty in those estimates.

The degree of detail needed in these measurements will depend on the specific decision being addressed. In many cases, the second type of information may be ignored. In general, relatively high-level decisions can get by with less precise data; for example, expert opinion rather than detailed analyses or modeling. Some methods exist that can help determine where more detailed or precise information could be most valuable, i.e., sensitivity analysis or value of information analysis. Frequently, however, some general determination can be made by careful, thoughtful examination of the decision and the differences among the options.

In the overall planning and management of an organization, the collection of data cannot generally be done on a decision-by-decision basis. This would be too costly and time consuming. Therefore, one of the features of this risk management approach is to attempt to identify the most critical data elements ahead of their use in specific decision analyses. Thus, for example, the broad spectrum of EM-60 decisions has been identified, and the data elements needed for these types of decisions have been specified. These data elements then form the basis of a general database that can ultimately support a wide range of EM-60 decisions.

The sources of data for such a database will be numerous, depending on what data are available from other sources, what level of precision is needed given the decisions to be made, and the resources available for data collecting. Take health risks, for example. Some information on health risks associated with EM-60 and D&D activities may be available from the Programmatic Environmental Impact Statement (PEIS). Such data would be obtained and used as appropriate. More comprehensive risk data could be obtained rather quickly, if needed, by some form of expert judgment. Finally, more precise risk data could be obtained from a complex-wide risk assessment, or at least risk assessments for selected significant sites/facilities. This risk management process will help determine what level of risk data is needed.

Integration

The general approach described above decomposes overall risk management into a number of components. The decomposition occurs both horizontally, e.g., by decomposing the organizational objectives and the types of decisions; and vertically, again by different types of decisions and by the level of detail or precision needed in data. It is this decomposition that allows us to identify the specific work that must be done to support risk management in a context that otherwise is too complex to handle. However, it is in the integration of these components that the real value occurs, new insights are developed, and a total systems perspective is achieved. The integration ensures consistency in both the vertical and horizontal components. It allows (provides) trade off among the objectives that are necessary for most difficult decisions.

SPECIAL ISSUES

Because of the nature of the decisions involved in EM risk management (or probably in any similar context where the methodology is relevant), many external factors come into play that must be addressed in making the decisions. Preferably, they will be integrated into the risk management process to ensure its ultimate effectiveness. Most of these issues have been alluded to above. Here we discuss them, and their effects on decisions, and suggest methods for incorporating treatment of the issues into the risk management framework. The special issues addressed are 1) new technologies, 2) regulations and standards, 3) multiple stakeholders, 4) risk perception and communication, 5) site/facility use.

New Technologies

Many currently available technologies are inadequate or cost-prohibitive. While EM is developing new technologies through the Office of Technology Development (EM-50) Integrated Demonstrations and Integrated Programs, certainly all technology needs are not being addressed. Nor are decisions regarding technologies currently under development being made in an integrated risk management framework. One of the issues typically raised by those responsible for environmental management is that they cannot count on the results of a technology currently under development. There is too much uncertainty about the effectiveness, the cost, and the timing of the availability of the technology for it to be considered in a baseline program that must comply with a given set of regulations and prescribed legal milestones.

The risk management framework offers an approach to deal explicitly with the uncertainty surrounding the development of new technology. For example, on a complex-wide basis the potential risk reduction effectiveness of a new technology can be estimated, as can the uncertainty regarding this estimate. Similarly, cost and timing can be estimated along with uncertainties. Formal methods can then be used to compute expectations for these parameters that can be compared to existing technologies. If the risk reduction/cost values are sufficiently better than the existing technology, then DOE can go to regulators to argue for accepting the uncertainty regarding the use of the new technology in return for the expected substantial return in reduced risk and/or cost. It is the integrated risk management framework that strongly supports such arguments.

The same risk management framework should be used to guide decisions about the development of new technologies. Potential risk and cost reduction should be used to prioritize technology investments.

Regulations and Standards

When the RCRA (and later CERCLA) regulations driving much of the DOE cleanup were enacted, national waste management and site cleanup efforts were focused on individual waste sites or waste generators, and most cleanup and waste treatment technologies were believed to be adequate to characterize and cleanup waste sites to acceptable (contaminant-specific or risk) levels. Cleanup of the nation's waste sites was thought to cost a few billion dollars and to be completed within a decade. Fifteen years later, few permanent cleanups have been completed. A major reason for this was the initial belief that existing technologies, imposed through a stiff regulatory framework, would meet the nation's cleanup goals.

Thinking that our nation's waste problem was just a special form of solid waste garbage, the EPA and industry overlooked the possibility that their planning assumptions and targeted standards were incorrect.

Meeting regulatory requirements for cleanup is further made difficult by the sometimes conflicting regulations imposed by individual states and other agencies with regulatory or legal authority. In addition, DOE facilities have negotiated FFAs with states and EPA regional offices that impose legal milestones. Many aspects of these agreements were negotiated in the absence of knowledge, and as new information becomes available, they must be renegotiated, which can damage the credibility of the DOE. Here again, if DOE decisions are based on the risk management framework and sound data, negotiations can be more effective and less damaging.

In general, a risk management approach to setting standards could improve the overall effectiveness of environmental management. Appropriate standards could be set within the risk management framework, and agreed to by relevant parties to reduce the current fragmented regulations and standards. This common approach would allow more precise risk and cost data to be collected which would help to ensure agreement among the parties, and would bring the best science and management discipline into the environmental management decision process.

Multiple Stakeholders

DOE cannot make decisions regarding environmental management in a vacuum without considering the concerns of other organizations and interest groups, referred to generically as "stakeholders." The days of totally secretive decisions about the production of weapons are over. Now, DOE must deal with a number of stakeholders on a regular basis. Typically, stakeholders involved in environmental management decisions will include federal and state regulatory agencies, tribes, local communities, local and national environmental groups, and local development organizations. These stakeholders have a variety of regulatory and legal strategies that can be implemented if they are not satisfied with the DOE decision process.

Involving these stakeholders in decision making achieves several objectives:

- these stakeholders are educated about the issues surrounding environmental management
- DOE is educated about the perspectives of others affected by its decisions and receives additional relevant information, so it can take these perspectives into account and improve the overall quality of decisions
- stakeholders' involvement will help to achieve buy in support for decisions.

Risk management provides an excellent mechanism for including stakeholders in decision making. It provides a comprehensive and systematic way of communicating what decisions are about and why they are made. The risk management framework can also be used to represent the potentially different values of the different stakeholders and to assess the effects of these different values on decisions.

The key to involving stakeholders in risk management is to undertake early, frequent, and open two-way communications. Stakeholders should be involved in determining the objectives or values to be achieved by decisions. They should help to identify options to be considered. They should be involved in determining what information is to be developed, and in assessing the quality of information used in decision making. More generally, stakeholders should be involved in deciding how they are going to be involved. Limits on involvement should also be communicated clearly. Most actual decisions will have to be made by DOE. This should be made clear. DOE will consider stakeholder perspectives, but ultimately must assume responsibility.

Historically, DOE has only provided limited opportunity for involvement of stakeholders, and this jeopardizes the credibility of decsions being made. Only through these stakeholders will DOE be able to achieve credibility in its decisions. Risk management offers an approach that many stakeholders are willing to accept as reasonable, and one in which they can actively be involved in ensuring the appropriateness of decisions.

Risk Perception and Communication

This issue is closely related to the previous one. Stakeholders and the public generally perceive risks as being different from those determined by accepted scientific and risk assessment practices. Simply communicating the "real" risk does not change this perception. And it is these perceptions that determine stakeholder and public reaction to environmental management issues. Slovic, Fischhoff, and Lichtenstein (1982) describe several judgmental biases that can help account for the differences in perceived and "scientific" risk.

More recently, attention has focused on risk communication: the process of informing the public and other stakeholders about "scientific" risk estimates. The method of communicating risk information can have a tremendous effect on risk perception. For example, as Slovic et al. point out, an increase in risk of 1.0 to 1.3 instances per 10,000 people seems much smaller than a 30 percent increase in risk. Using the risk management framework with multiple stakeholders as discussed above is one approach that can help to achieve the desired risk communication. It puts information about risks in an appropriate decision context that helps in interpreting of the risk information.

Conversely, the risk management framework can also take into account risk perception. It may explicitly or implicitly include public response/acceptability as an objective and thus a decision criteria. In the explicit formulation, this public acceptability would then trade off with other objectives (i.e., risk reduction, cost, etc.) in evaluating options and making decisions.

Site/Facility Use Planning

DOE cleanup of a particular site or facility should depend in part on the anticipated use of the site/facility after cleanup. Future agricultural use would require cleanup to a pristine state, while use to support other DOE waste management activities with DOE maintaining full administrative control over access would not require as stringent a cleanup. In the risk management framework, these final cleanup levels are characterized by specific levels of risk, and, thus, provide the definition of the amount of risk reduction needed. This need, in turn, will help to determine the cleanup technology to be employed and the relative priority of the cleanup of the specific site/facility.

Also affecting the priority will be the value of the final site/facility use. For example, sites/facilities intended for activities associated with economic development would generally have more value than those over which DOE would maintain administrative control and restrict access. All other things being equal, sites/facilities with more valuable final uses should have a higher cleanup priority than those with lesser valuable uses. The sooner the higher value can begin to be achieved, the better. This final value can be explicitly incorporated into the risk management decisions as another objective that trades off with other objectives.

The determination of final use itself should also be made within the risk management framework. It should not be made independently of information regarding the costs and technological ability needed to achieve the risk reduction implied by various uses. Large increases in cost to achieve a cleaner site/facility may not be offset by the increased value of its final use. Involvement of multiple stakeholders in site/facility use decisions is particularly critical because of the effect such decisions will have on them.

OPPORTUNITIES FOR RISK MANAGEMENT

The challenge facing the Department and the Nation is to make truly wise decisions that optimize benefit, risk, and cost of environmental remediation activities. Within the overall EM goals and objectives, EM-60 must establish the direction and work scope of facilities that no longer have a production mission. Their efforts must be effectively integrated with both the Department's D&D programs and future site use/economic development activities. EM-60 and EM also have the opportunity to establish the language of tradeoffs as the common language of all affected stakeholders. As the magnitude and complexities of the cleanup of the DOE complex become better understood, the decisionmaking dialog needs to be shifted from absolutes (e.g., clean up all sites to a pristine condition) to one of the practical realities with which the nation is faced. This implies that we will need to understand the context for these decisions;

for example, that money spent cleaning up Hanford will not be available for Rocky, or, more broadly, for health care. The question should not be "do we clean up to pristine?," but rather, "given the full set of priorities and concerns with which the nation is faced, would it be more impactful to invest these dollars elsewhere?"

A new approach to resolving environmental management problems in a cost effective fashion can be developed by cooperation amongst the U.S. government, the States, and industry, and provide a model that could be applied world-wide in making risk-based decisions. A related benefit could well be that the U.S. environmental industry would become a global leader, thereby enhancing U.S. competitiveness.

To achieve EM-60's and the broader National goals, the following conclusions and recommendations are made:

The advances in the state of the art of risk assessment and risk management methodologies have evolved to the point that they offer a practical means of decision making on a systematic basis. EM-60 plans to integrate these methodologies into an overall systems approach to decision making which allows maximum risk reduction at minimum costs. Based on EM-60's successes and lessons learned, this systems approach could be applied to management decisions related to technology development to enhance the broader goals of DOE-EM and the nation's competitiveness in environmental remediation and waste management technology. Using risk management to achieve this level of rationally supported decision making will provide the justification needed to support DOE's and others cleanup budgets in OMB and Congress. As a common approach is adopted across agencies, it can ensure effective use of funds for all, not just DOE, cleanup.

Given the magnitude and breadth of the facility transition and management activities and the broader environmental restoration and waste management activities across federal facilities, these problems would be best dealt with through multi-stakeholder cooperation. The risk management framework provides a mechanism for this cooperation, and an opportunity for the federal agencies to demonstrate that they can make a difference by working together. The idealized model would also include a close partnering with industry. EM-60 is interested in being a test bed for this interagency and industry cooperation.

EM-60 recognizes that stakeholder participation in risk management is the key to success. Effective communication of risks and alternative management choices available to deal with these risks should be given a high priority across the federal government. Effective communication should include educational activities to ensure the public can interpret the information provided to them and should also include provisions for receiving and acting on input from the public.

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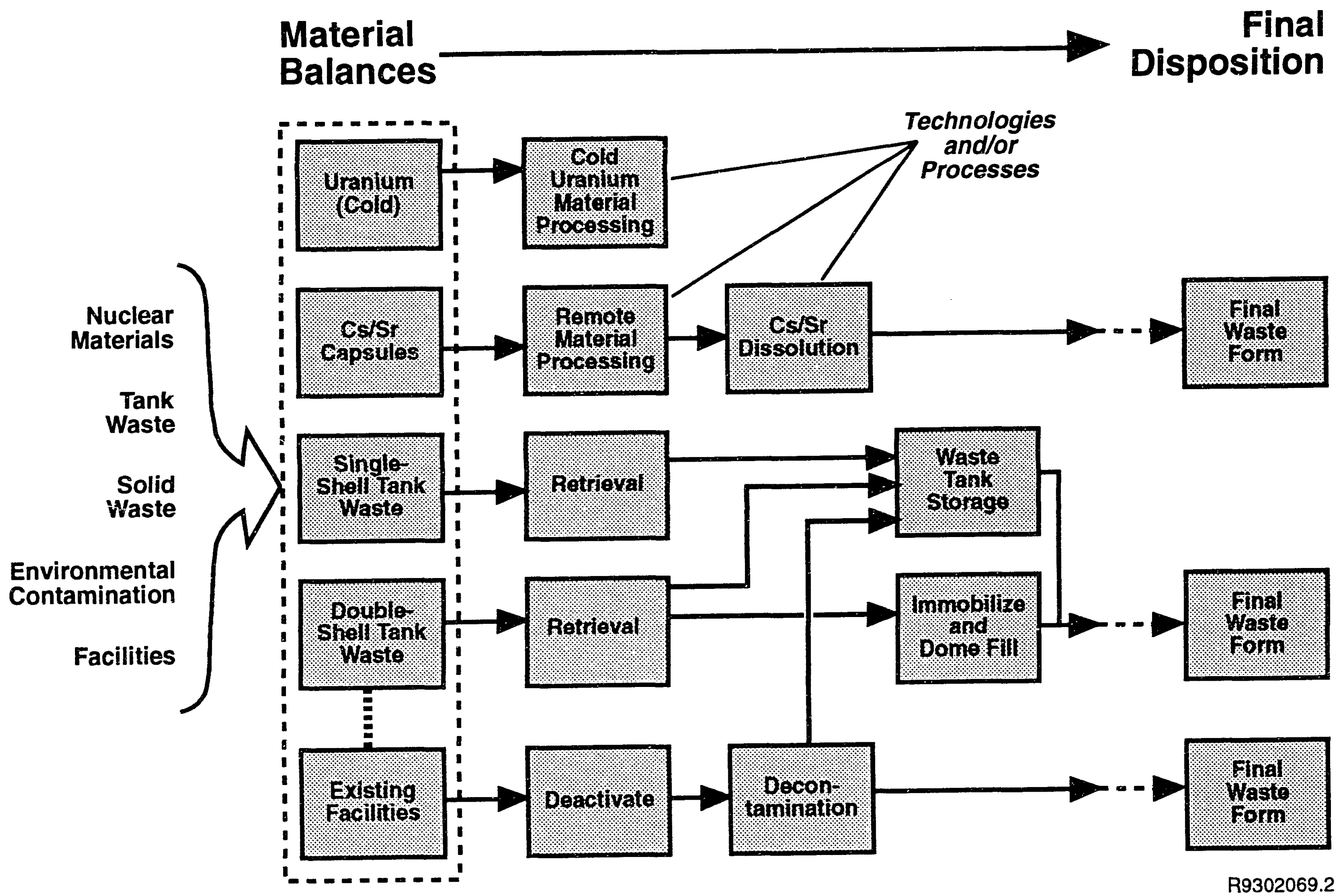

Fig. 1 Systems Analysis Model of Cleanup Process

assumptions, and key site-wide and programmatic issues. Each of these requests would, before HMP, have required a separate data development effort of a much more costly nature.

A new, more effective approach to stakeholder involvement in decision making must be developed. Decision environment is extremely complex and not well understood. Recognition of this new decision environment requires the implementation of a stakeholder involvement process that enhances communication and begins to provide a framework which can serve to integrate various disjointed processes. Even small efforts in this area will yield substantial results.

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