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TACKLING THE RISK ISSUES IN THE DOE COMPLEX

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ABSTRACT

The Department of Energy manages the largest environmental cleanup program in history. About $6B are dedicated annually to restoring contaminated lands and managing waste produced during the Cold War. The legacy of the Cold War is a legacy of unique and urgent environmental problems in unprecedented volumes of contaminated soil and water, radiological hazards, and a vast number of contaminated structures and materials. The Department faces a number of challenges regarding how risks are evaluated and managed within this massive Environmental Management Program and how this information is communicated among all interested parties. Risk informed decisions must be based upon scientifically credible data to ensure the safety of workers and the public. Yet, all decisions must reflect the appropriate balance among risk and other decision criteria. The Center for Risk Excellence has undertaken projects designed to demonstrate how risk information can be effectively used in decisions for remedial operations, selection of technology, and communication with stakeholders.

INTRODUCTION

During World War II and the Cold War, the United States developed a complex of industrial facilities for the research, production, and testing of nuclear weapons. In addition, the United States government supported the development of nuclear energy for commercial applications and conducted research in high-energy physics and other basic sciences, as well as medical diagnostics and treatment. These activities required the use of a vast array of facilities that included mines, mills, chemical plants, metal machining plants, maintenance shops, research laboratories, nuclear reactors, and test sites. (1)

Beginning in the 1940s, activities were conducted by and for the United States Department of Energy (DOE) and its predecessor agencies (the Atomic Energy Commission and Energy Research and Development Administration) at over 100 sites across 30 states and territories. While DOE owns the major sites, several small sites are owned by others -- including universities, private industry, and members of the public. The individual sites range from a single building on a small plot of land to hundreds of structures on more than 3,500 square kilometers of land. All are contaminated to some degree. (1)

The DOE mission changed markedly with the end of the Cold War in the 1980s. In addition to ongoing energy programs and other basic research, taking care of the waste legacy from past defense-related activities became a primary focus. Ten years ago, the Department established a formal environmental management program to clean up and restore its contaminated properties

for other productive use. A number of facilities have been shut down, weapons are being dismantled, and a massive cleanup program is well under way at sites across the country. (1)

In reviewing DOE's clean-up program, Young and MacDonell (1) have noted that this extensive cleanup effort does not come cheap. In fact, it has been estimated that the government will spend more than $200 billion to complete DOE's active environmental management program (not yet fully accounting for long-term maintenance), and work at several of the larger sites will continue well into the 21st century. This price tag reflects the considerable scientific/technical, policy, and communication challenges facing the Department. Currently, the Department is dedicating approximately $6B annually to the Environmental Management Program.

The environmental risk issues being addressed by DOE as part of the largest cleanup program in the nation's history are many. First, sound and lasting decisions must be based on a consideration of many different risks and impacts. These include risks from multiple contaminants over large areas, long time frames, and various impact scenarios for (1) human health and safety - considering cancer and non-cancer effects for cleanup workers and the nearby public, (2) ecological and other environmental risks - including ecosystem functions and services, (3) economic effects - including the local community's infrastructure, and (4) sociocultural or quality of life effects - considering the variety of values, needs, and expectations of the many parties that can be affected within a given site.

CENTER FOR RISK EXCELLENCE

The Department of Energy's Environmental Management Office established the Center for Risk Excellence (CRE) in February 1997 to act as a focal point for the Field and other stakeholders on risk-related matters. The sponsors include the Office of Health, Safety, and Security (EM-5) and the Chicago Operations Office. The mission of the Center is to provide leadership, expertise, and integration of risk activities through strategic partnerships, and to apply science and technology to manage risks and enhance understanding of risks in environmental issues.

To accomplish this mission, the Center provides a link between the DOE Field Offices, Program Offices, Technology Focus Areas, and local and national stakeholders to facilitate joint progress toward protective, effective, and fiscally responsible environmental programs. The Center links multiple groups within and beyond DOE to improve the application of risk principles through an open, broadly participatory process. Current funding for risk-related activities and projects is about $8 million. This includes funding for Cooperative Agreement Institutions and peer review functions. The Center strives to leverage it's funding for projects with funding from Headquarter Units and Operation/Field Offices. Never the less, the current funding for risk programs represents a continuous decline since 1995 in funding by the Environmental Management Office.

The current business lines of the Center include:

1) Assessment -- Develop and apply scientifically credible, transparent consistent approaches to risk assessment so results can be integrated into complex-wide plans and decisions.

2) Management -- Help projects and programs improve their baseline risks, make sound risk-based decisions, prioritize their work, and demonstrate progress via risk-based performance measures.

3) Policy -- Work with Headquarters to develop and implement strategies, standards, guidance, and other directives aimed at addressing human health and environmental risks.

4) Education -- Provide timely courses, workshops, and other outreach measures to help inform interested parties on risk issues and advance the understanding of basic scientific principles, and

5) Communication -- Facilitate dialogues and the sharing of risk information and tools among DOE elements and stakeholders, so interested parties can participate meaningfully in DOE programs.

NATIONAL RISK PROGRAM ACTIVITIES

A key activity of the Center for Risk Excellence has been the preparation of a National Risk Plan (2). The Plan is intended to guide the Department in the development of risk programs and in preparing for the funding of risk activities in the annual budgets. The National Risk Program has been organized within four primary categories to most directly address the needs of integrated environmental decision making. These are (1) Risk Integration, (2) Standards and Cleanup Criteria, (3) Long-Term Stewardship/Residual Risk, and (4) Risk Interface with Science and Technology Development.

Risk Integration

As shown in Figure 1 (attached), Risk Integration is an overarching category that extends across risk assessment, management, communication, and policy; the other three categories are major component areas that provide additional focus for program activities.

The integration of risk information and issues into DOE planning and decision making and the integration of program activities across various Departmental elements are critical to the credibility and accountability of the EM program. Risk integration involves assessing multiple types of risks over different locations and time periods; managing risks associated with operations, cleanup, and long-term stewardship; making planning and budgetary decisions; and communicating with and involving affected parties throughout the process.

Risk assessments are conducted at facility/project, site, and complex-wide levels to identify hazards and possible impacts. Clear analysis of potential impacts associated with current conditions and operational alternatives is important for decision makers responsible for reducing cost and accelerating cleanup while maintaining safe operations. Given the many types of hazards and risks, the extensive spatial and time scales over which they must be assessed, and the sequencing of numerous EM projects within and among sites, sound assessments are essential to an effective cleanup program. Further, improved methods for integrating diverse assessments into a comprehensive overview of the risk picture for each site will support better evaluation of control strategies and our progress in managing hazards and risks over time.

Risk is a critical element of EM decisions at the facility/project, site, and complex-wide levels. Integrating multiple risk data with other decision criteria including cost and schedule is important to a sound program. Risk-informed decisions based on strong scientific information will help ensure the safety of workers and the public and increase their confidence in the DOE program. In making decisions about a specific problem at a given site, many administrative and engineering response options may be evaluated, ranging from no active remediation with institutional controls to in-place containment or removal and disposal off-site. These evaluations warrant careful consideration of many decision factors, including feasibility, ability to minimize net risks, and cost effectiveness. The Department can benefit from improved methods and tools for incorporating risk information into critical decision processes such as prioritizing and sequencing EM activities, selecting and implementing specific response measures, and determining what levels of residual contamination are appropriate for a given site.

Actively involving interested parties in the process of evaluating hazards and risks and helping internal and external stakeholders understand how to interpret technical risk information are both critical to the success of the EM program. While the Department has made a number of recent advances in using and communicating risk information, significant opportunities exist for DOE to enhance its program effectiveness and public confidence through the improved use of risk information. Sound, credible information about the hazards and risks at each site, the measures being applied to control these hazards and risks, and the progress being made at the local and national levels are important to external acceptance of the DOE program. Working in close coordination with interested parties to support open, regular, two-way communication among internal and external stakeholders and provide opportunities for capacity building through training, educational materials, and outreach programs is a vital element of the National Risk Program.

Many parties are keenly interested in tracking the progress of DOE's environmental cleanup and management activities, including oversight agencies and Congressional, environmental, and community stakeholder group. It is important that the risk program continue to develop and refine cost/benefit methods and other approaches for indicating EM progress. These indicators should be transparent in their relationship to reducing risk or maintaining current low risk levels in accordance with appropriate program costs.

Standards and Cleanup Criteria

An important part of the National Risk Program involves evaluating proposed standards and guidelines, compiling and assessing cleanup criteria and associated risk data that have been established for DOE sites, evaluating potential recycle and release of slightly contaminated material, and understanding worker exposures and safety risks with regard to risk-based protective standards.

Determining scientifically based cleanup levels for contaminants in various media at DOE sites is crucial to setting sensible completion points for active remediation and transitioning to stewardship. Application of inappropriate standards can result in unnecessarily high EM costs, and a balance must be struck between aiming toward very low residual levels to protect hypothetical future receptors and protecting remediation workers and environmental resources

today and into the future. Sound science and risk information are important for determining what levels of contamination can appropriately remain in environmental media or materials released for other uses. An open dialogue is needed to improve communication among DOE and Federal and State agencies, industry, the scientific community, environmental groups, and the general public on related risk issues. These include ongoing worker injuries and deaths resulting from actions that may be unwarranted from a risk perspective, considering our understanding, of potential health effects at low levels of environmental exposure. Development of appropriate cleanup criteria based on the best available scientific information and relevant to site conditions, with explicit consideration given to both associated costs and benefits, can significantly enhance the overall effectiveness of the EM program.

Long-Term Stewardship/Residual Risk

The continued protection of humans and the environment at EM sites for as long as hazards remain poses a major challenge for the Department. Residual risks must be managed to maintain safe conditions and preserve valuable resources into the extended future. Significant returns on investment are possible through up-front risk management planning. Estimating long-term risks associated with contaminated materials to be left at a site is critical to developing future use options and defining stewardship needs. Stewardship support includes developing a management framework that addresses sustainable health and environmental controls, providing technical risk input to future use negotiations, designing adaptive control strategies to guide program adjustments based on post-cleanup data, helping develop a framework for collecting and managing post-closure risk and control data, and providing risk input to applied science and technology programs focused on long-term containment and monitoring systems.

Risk Interface with Science and Technology Development

Extensive research and development activities have enabled the EM program to assess and manage the risks associated with a variety of materials and conditions at DOE sites. However, knowledge gaps still exist. Filling critical gaps and addressing uncertainties through science and technology will help increase efficiency (cost and schedule) and enhance the long-term effectiveness of the integrated environmental management program. Current challenges range from understanding how certain chemical and radiological contaminants, including mixtures, are transported through the environment, to how plant and animal life process them.

Key science and technology challenges for the Department supported by the National Risk Program include (1) continuing the critical evaluation of research gaps that focus on risk issues for the EM program, which involves close coordination among researchers and the information users; (2) targeting new scientific and technological advances that are directly relevant to Field issues; (3) facilitating a stronger, more timely link between research results and Field application; and (4) partnering with other programs, agencies, and industry to solve common problems. The National Risk Program also assists with the risk-based evaluation of technologies being developed and deployed, including coordination of a system of independent peer review.

The funding trend for risk-related scientific research is a major concern for those who need new information to answer critical project and program questions. Over the last several years, EM has funded over $75 million worth of projects to "fill the gaps" and reduce uncertainty with respect to assumptions and approaches for evaluating risks. The Consortium for Risk Evaluation

with Stakeholder Participation (CRESP), the Consortium for Environmental Risk Evaluation (CERE), the Medical University of South Carolina (MUSC), and risk-related projects of the Environmental Management Science Program have been the primary vehicles for this research. However, current funding plans do not support this level of risk-related scientific research beyond Fiscal Year 2000. The National Risk Program will work to optimize and focus the research being conducted to address risk issues most essential to the success of key projects and programs. And, as noted earlier, funding for risk activities continues to decrease is spite of significant vocal support for risk at all levels of the EM Program (3).

SITE RISK PROFILES

In December 1997, the then EM-1 charged the Field to work with the Center to complete Risk Profiles for each major Operations/Field Office. The purpose of the Profiles is to clearly and accurately describe in a single, short document, the risks that currently exist, the risk reduction planned under current baseline assumptions, and the anticipated residual risks that would be left at the sites upon project completion. Since that time, the Center has worked with each of the sites to complete Profiles that would be suitable to share outside DOE for comment. By March 1999, all profiles were completed in a draft form and were distributed for stakeholder review and comment as deemed appropriate by each Field Office.

The EM program is currently managing site risks in a variety of ways. First, the sites have defined site boundaries that exclude the public, conduct active monitoring of releases and worker exposures, and operate containment systems to manage hazards. Second, these risk management practices are enforced by outside regulatory agencies at the state and federal level and in consultation with stakeholders. As a result of these activities and boundaries, hazards currently managed by the EM program pose little risk to the public.

Current risk management approaches, however, are not viable for the long term. Issues such as cost, effectiveness, and legal requirements preclude this as an option. It is for these reasons that EM activities are focused on improved storage and remediation to reduce site hazards as a method of long-term risk reduction. EM is also planning on the availability of offsite shipment, storage, or disposal as part of their hazard management plans. All needed disposal facilities are not available. The lack of disposal facilities is a daunting problem to completing the EM mission and achieving long-term risk management objectives.

This risk profile is intended to present risk information in a user-friendly manner and to support communication of hazards to those not familiar with the sites. The document is organized into five categories of information. First, key risk-related challenges are listed. Risk-related challenges are the most significant hazards at each site. Second, hazards are briefly described in terms of the characteristics that could pose risks to the public. Third, potential pathways for exposure of the public to site hazards are discussed. Fourth, the profile describes the control, storage, treatment, disposal, characterization, and other activities that DOE has taken, is taking, or will take to limit the risks posed by the hazards. Finally, the document presents a series of graphic illustrations showing planned hazard reduction activities and major milestones.

SITE-SPECIFIC RISK-BASED CLEANUP STANDARDS

The Department of Energy has a requirement for establishing appropriate cleanup standards for remediation at contaminated former weapons sites. The general philosophy underlying the current regulatory approach to setting these standards is a site specific, risk-based one. The regulatory framework identifies a range of factors that should be taken into account, including but not necessarily restricted to:

- Human health and safety risks associated with exposure to residual contaminants;
- The potential threat to human health and the environment associated with excavation, transportation, and redisposal or containment;
- Ecological risks associated both with exposure to residual contaminants and the impact of the remedial action itself; and
- The cost-effectiveness of the proposed remedial action.

Extensive guidance has been issued by the Environmental Protection Agency (EPA) on the assessment of some of these risks and other factors in support of the process and some basic risk standards have been proposed to underpin the risk-based approach.

In light of experience gained during cleanup projects both in the U.S. and internationally, consideration is now being given to enhancement of the site-specific risk-based approach to setting cleanup standards. The Center for Risk Excellence invited AEA Technology (United Kingdom) to assist in preparing a discussion document that puts forward a protocol for on site-specific risk based cleanup standards (4). The protocol takes as a starting point the basic principles and philosophies set out in the regulatory framework provided by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Specific objectives that the remedial solution and related cleanup standards should seek to meet have been identified and are as follows:

- Minimize holistic human health and safety risk, including:
  - public health and safety risk from exposure to hazardous materials post site closure;
  - worker health and safety risk during remedial action; and,
  - transportation risks to public and workers during remedial action.
- Minimize environmental risk, including:
  - ecological risk;
  - cultural risk.
- Minimize the uncertainty associated with the remedial solution;
- Maximize cost-effectiveness of risk reduction provided by the remedial solution;
- Maximize land utility provided by the remedial solution, having regard to the restrictions on use that may be required to maintain adequate health protection for certain residual contaminant levels and taking account of local needs; and,
- Provide public reassurance, manage anxiety and address public risk perception issues.

The review to date has identified a number of issues that may deserve particular attention in the further development of the holistic risk-based protocol. These include:

- Pragmatic Risk Standards. The effective implementation of the approach will require appropriate risk standards that can provide an appropriate balance between the protection of human health and economic and technical feasibility. EPA's proposed standards, that are significantly tighter than those applied more generally internationally, would warrant further consideration.
- Land-Use Assumptions. DOE cleanup efforts must address particularly large and complex sites, placing specific constraints in particular concerning future land use options. The process will need to facilitate the determination of an acceptable end state for the site and define a management strategy that strikes a balance between costs, risks and benefits associated with potential shorter-term cleanup and longer-term stewardship activities.
- Worker Risk. EPA focuses in particular on longer-term public health and safety risk and largely ignores worker risk. To ensure that selected remedial actions provide an overall net benefit, it may be necessary to develop approaches for evaluating worker risk and integrating this into the decision making process.
- Cost-effectiveness. A methodology for evaluating cost-effectiveness in the decision-making process may be required.
- Uncertainty. Conservative assumptions made in current risk assessment approaches, have often been made in the face of uncertainty and may lead to overestimates of the extent of cleanup required to provide a chosen degree of protection of human health. In the face of technological constraints and significant costs, it may be appropriate to give more explicit consideration to uncertainty in the decision-making process, and,
- Compatibility with the Regulatory Process. Consideration will need to be given to the current regulatory framework and any constraints it may impose upon the future implementation of a risk-based protocol for setting environmental cleanup standards.

These issues, when considered holistically, can be used for making appropriate decisions. This is illustrated in Figure 2 (attached) showing how to arrive at a balanced environmental cleanup decision when considering cost, risk, and land re-use.

It is not the objective of the current exercise to develop extensive technical assessment methodologies and associated guidance. A significant body of experience, guidance and supporting methods is already available and may support the development and implementation of a suitable protocol (3).

HANFORD GROUNDWATER/VADOSE ZONE RISK PROJECT

Over the past decade, Tribal Nations, Federal and state regulators, and stakeholders have continued to voice concerns about the potential threats posed by site contaminants to resources at the Hanford Nuclear Site in the Columbia River region that are being addressed by the environmental program. Many of these concerns were brought together in a 1998 report prepared for the Columbia River Comprehensive Impact Assessment Initiative. In response to these concerns and in recognition of program efficiencies to be gained by linking similar activities of multiple ongoing projects more closely, DOE established the Groundwater/Vadose Zone (GW/VZ) Integration Project in late 1997. In October 1998, the Center for Risk Excellence was asked to assist the Department's Richland Operations Office (DOE/RL) in

developing the risk component for the GW/VZ Integration Project. The Final Technical Report was published in December 1999 (5).

This Risk/Impact Technical Report was prepared to support the risk plan being developed by Hanford GW/VZ Integration Project team to help guide future environmental research and contribute to effective decisions on site cleanup and long-term management. The specific intent was to help:

- Bring together existing information on how to assess different types of risks and effects, to help advance the site's integrated risk/impact assessment process.
- Identify approaches and tools that will produce high-quality results that can be directly used to inform site decisions to protect and maintain human health and the environment;
- Develop a scientifically sound framework for integrating risk and impact assessments across multiple contamination sources and broad environmental resources into the long-term future;
- Define information gaps - both in basic scientific knowledge and in technologies - to suggest scoping studies and future research that can provide the foundation for solving key site problems; and,
- Present site risk information in a clear, transparent manner that promotes broad understanding and acceptance.

The scope of the document encompassed radioactive and chemical contaminants from all major site sources that could affect the vadose zone, groundwater, or Columbia River in the near or long term. The general categories of effects considered were human health, ecological, sociocultural, and economic. The focus of this report was on technical risk and impact assessment issues. It did not address regulatory issues, site-related agreements, or cleanup goals.

At its most basic level, the question facing the Integration Project was: "How serious a problem is the Hanford GW/VZ contamination, especially in terms of the potential for contaminants to migrate to the Columbia River?" If the risks are not trivial, then a related question arises: "What management strategies are most likely to succeed in avoiding major impacts?"

The challenge lies in defining focused questions and a process for answering them that applies to each of the exposure/receptor combinations potentially affected. The seriousness of the problem may be judged on three primary bases: risk to human health, risk of ecological function impairment or resource loss, and lack of access to cultural resources for Native Americans (e.g., due to losses occasioned by health or ecological risks). These considerations drive the formulation of a socioeconomic and quality-of-life impact assessment process. To define the specific risk issues to be investigated, a set of targeted questions must be applied to each of these three areas:

- What is the magnitude of risk from current and future GW/VZ contamination, to what receptors and resources in what locations, and in what time frame?
- What are the dominant factors driving the risk?

A two-tiered approach for prioritizing impact issues was suggested for each of the main impact categories (human health, ecological, sociocultural, and economic). The process for each

category would be to first develop a broad-based "candidate set" of impact issues and then apply screening techniques to reduce that list to a "study set" of issues to be assessed in detail. Procedures suggested for use in this approach were outlined for each of the impact categories.

COMMUNICATIONS OF RISKS

Underlying all these issues is the tremendous importance of clear communication regarding the current risk problems at DOE sites, the ongoing and planned measures for controlling and reducing these risks, and the opportunities for multiple interested parties to be involved in the process. These parties extend from regulatory entities to industry and academia research groups, environmental organizations, and members of local communities. It is already difficult to have levelheaded discussions about environmental risks, as the topic is an emotional one, but it is even more complicated for DOE because of heightened public concerns about radiation and the weapons production program. To reverse the mistrust engendered by years of secrecy during the Cold War, the Department, and the Center for Risk Excellence have pursued a broad exchange of information on cleanup work and will continue to make active communication a priority throughout the environmental management program. The Center is also pursuing educational initiatives aimed at explaining the scientific and technical aspects of the risk issues and the evolving plans for addressing contamination problems at the Operations Office sites. The Center has established a Web Site (http://riskcenter.doe.gov) designed to provide sources of current information, risk assessment tools, and expertise. The Center's newsletter, *Risk Excellence Notes*, is widely distributed with a circulation of more than 10,000 copies.

SUMMARY

In summary, the DOE is aggressively pursuing a comprehensive cleanup program to address the many risk challenges resulting from its past nuclear weapons research, development, and testing activities. Success depends on partnering with many different federal, state, public, and private groups in the United States, as well as with those in the international community who face similar problems. The Department looks forward to working hand in hand with these key partners, to apply sound science and technology to achieve significant progress in understanding and responsibly managing environmental risks during the coming years. The Center for Risk Excellence is positioned to meet these challenges.

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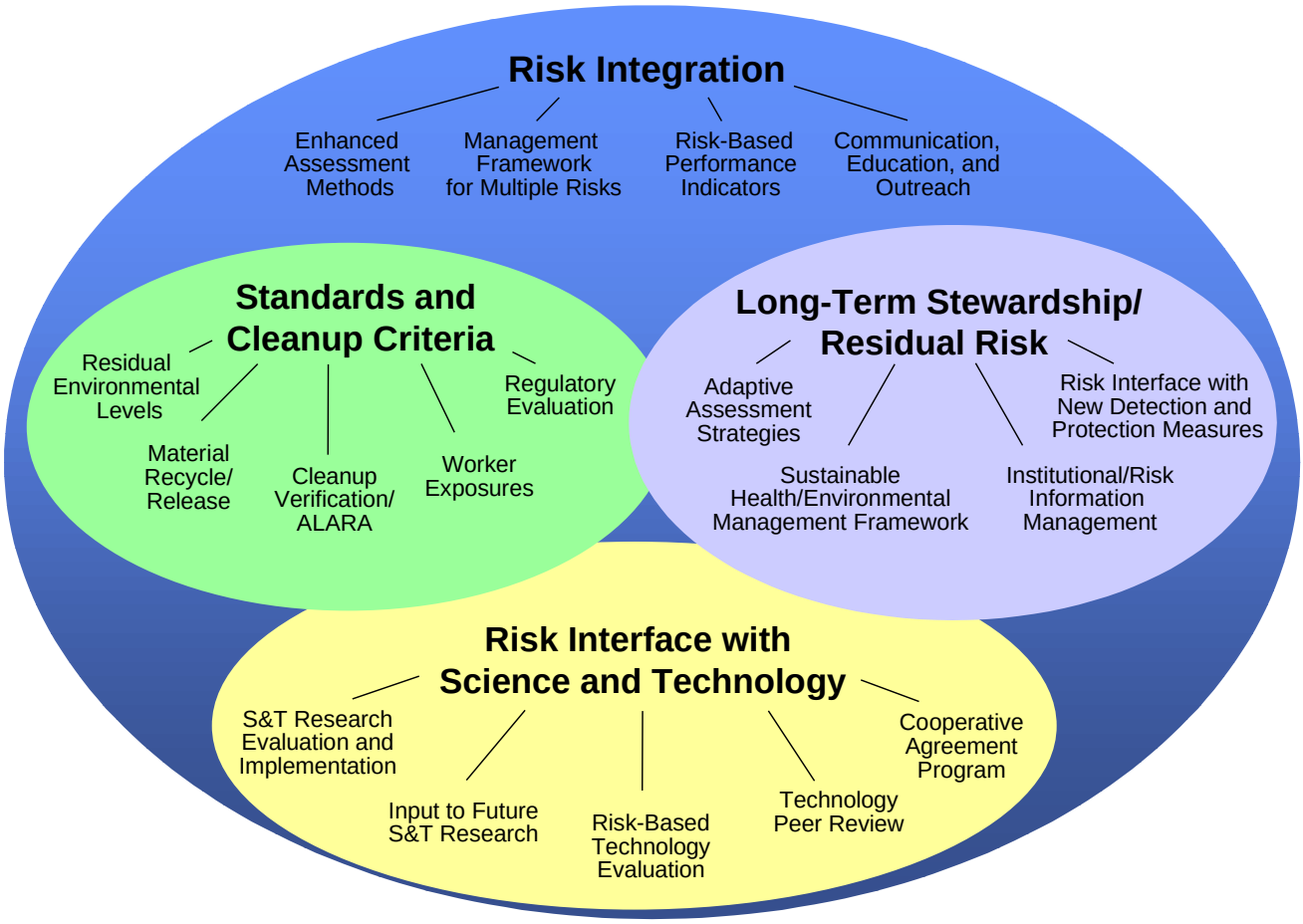

Figure 1. Overview of the Major Risk Activities of the Center for Risk Excellence (2).

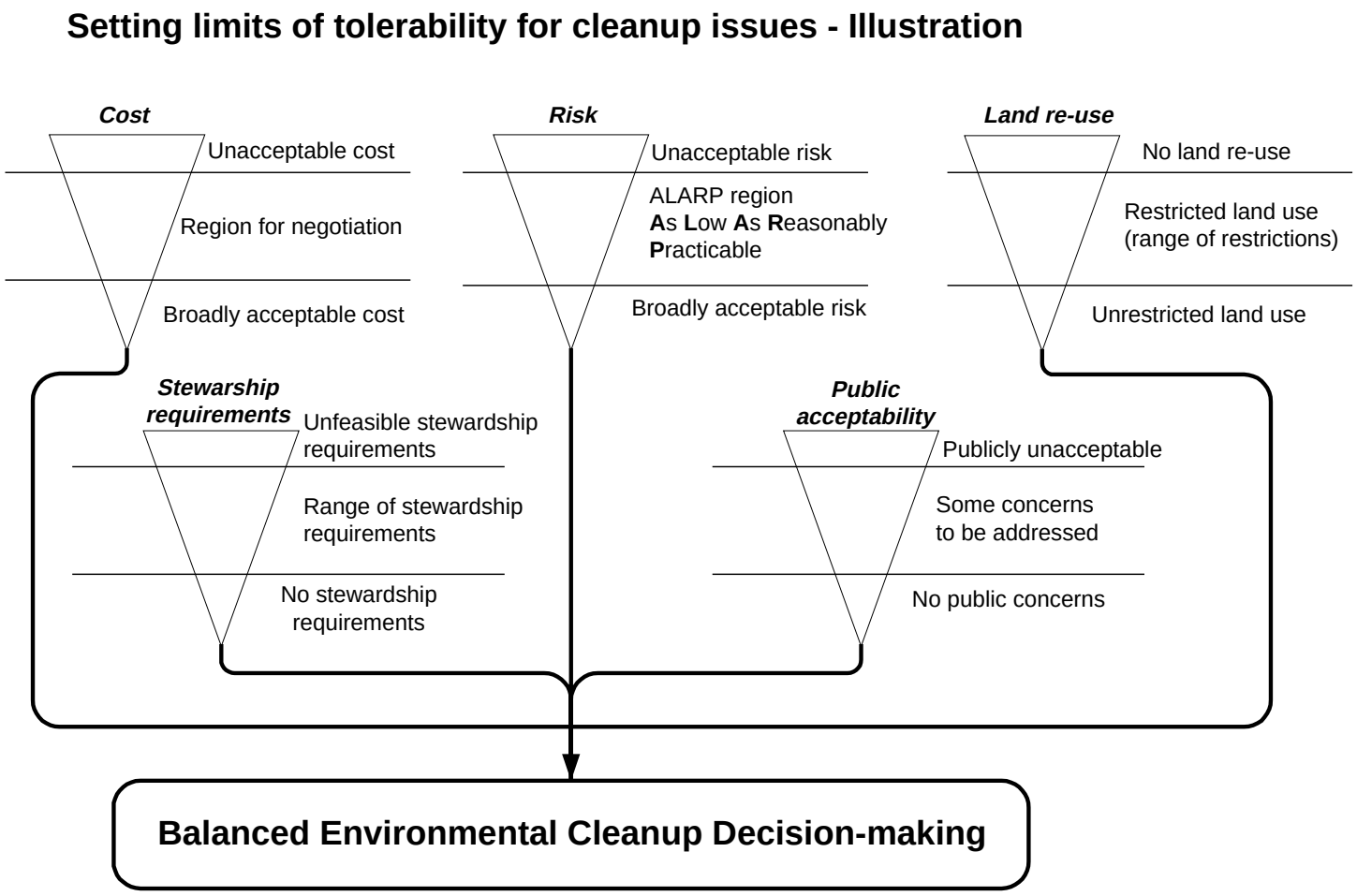

Figure 2. A Concept for Balancing Cost, Risk, and Stewardship in Decisions (4).