A SURVEY OF ECOLOGICAL RISK ASSESSMENT AT DOE FACILITIES

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INTRODUCTION

The U.S. Department of Energy (DOE) Risk-Based Standards Working Group is studying standard-setting and remedial action based on realistic estimates of human health and ecological risks. Federal and state regulations require DOE to assess ecological risks due to present and past operation of DOE facilities and ecological damage caused by remedial actions. Unfortunately, little technical guidance has been provided by regulatory agencies about how these assessments should be performed or what constitutes an adequate assessment. The U.S. Environmental Protection Agency (EPA)'s superfund guidance manual for ecological risk assessment (EPA 1989) is targeted at project managers rather than technical staff. EPA's recently-published "Framework for Ecological Risk Assessment" (EPA 1992) provides basic definitions and principles for ecological risk assessments but no concrete technical guidance. Fortunately, DOE's own facilities employ many highly qualified environmental scientists. Active ecological research, environmental characterization, and ecological risk asessment programs are already underway at many locations. Some of these programs were established more than 30 years ago. Because of the strength of its existing programs and the depth of expertise available within the DOE complex, the agency is in a position to lead in developing ecological risk assessment procedures that are fully consistent with the general principles defined by EPA and that will ensure environmentally sound and cost-effective restoration of its sites.

As a prelude to guidance development, the working group conducted a survey of ecological risk assessment activities at a subset of major DOE facilities. The survey was intended to (1) identify approaches now being used in ecological risk assessments performed by DOE staff and contractors at each site, (2) record successes and failures of these approaches, (3) identify new technical developments with potential for general application to many DOE facilities, and (4) identify major data needs, data resources, and methodological deficiencies.

Ten sites were visited between March and September, 1992: Oak Ridge, Savannah River, Los Alamos, Sandia, Livermore, Fernald, Hanford, the Idaho National Engineering

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Laboratory (INEL), Rocky Flats, and Argonne. At each site a representative of the working group met with DOE and contractor staff, held discussions with contractor technical staff, and collected bibliographic material on past and present studies. The meeting notes and other materials were then evaluated and synthesized in a final report to the group.

CAPABILITIES OF THE DOE FACILITIES

All of the facilities visited had significant technical expertise in ecological risk assessment. Oak Ridge, Savannah River, Los Alamos, Hanford, and INEL conduct long-standing on-site ecological research programs as part of DOE's National Environmental Research Park system. These base programs provide core information on the sites and, in most cases, a core staff that can provide expert assistance as needed. Most of the sites support active research programs in physical, biological, and mathematical sciences that can contribute to ecological risk assessments. Some form of ecological assessment, driven by either CERCLA/RCRA or National Environmental Policy Act (NEPA) compliance, is ongoing at every site. Much of the environmental research performed at the national laboratories now directly supports environmental restoration activities through monitoring and technology development (in-situ biological degradation, burial ground technology). The following disciplinary areas are of special relevance to ecological risk assessment:

Aquatic and Wetland Ecology

Major programs and capabilities in aquatic ecology exist at Oak Ridge, Savannah River, and Hanford. Oak Ridge has strong programs in fish population biology, biomonitoring, and integrated watershed studies. Savannah River (including the combined capabilities of the Savannah River Ecology Lab and the Westinghouse staff) has active programs in limnology, aquatic invertebrate ecology, fisheries ecology, and wetland ecology. The Batelle Pacific Northwest Laboratory at Hanford has several decades of data on the Hanford Reach of the Columbia River. At Fernald, university-based researchers supported by the operating contractor have studied impacts of site operations on on-site fish and amphibian populations. At Rocky Flats and INEL, on-site wetlands that serve as wildlife habitat are monitored for environmental contamination and potential adverse effects of facility operations.

Terrestrial Ecology

DOE and its operating contractors perform terrestrial ecological research and monitoring at many sites spanning a wide range of climatic regimes and ecosystem types. Savannah River has programs in forestry and soil science, including remote sensing of vegetation health. Los Alamos, Hanford, and INEL are major centers for research in arid land ecology, including hydrology, vegetation science, and wildlife ecology. Oak Ridge is active in biogeochemical cycling and responses of forests to environmental stress.

Environmental Toxicology

Aquatic toxicology laboratories at Oak Ridge and Savannah River perform all standard EPA tests. Researchers at Oak Ridge have used artifical ponds, streams, and modeling studies to extrapolate laboratory test results to field conditions. Livermore and Oak Ridge conduct research on biochemical markers of contaminant exposure and effects. Academic scientists working at Fernald have studied effects of contaminants on the genetic structure of fish, amphibian, and bird populations. Effects of atmospheric

pollutants on plant growth have been major research topics at Oak Ridge since the 1970s. Most of the available information on the effects of radionuclides on nonhuman biota has been developed at the DOE laboratories. Although the research effort devoted to this problem is now substantially less than it was 20 years ago many of the scientists who performed the studies are still active.

Environmental Fate Assessment

Most of the existing methodologies for quantifying the environmental fate of contaminants have their origins in radionuclide fate assessment studies performed at the DOE laboratories in the 1950s and 1960s. Major programs in environmental chemistry and environmental transport modeling currently exist at Sandia, Livermore, Oak Ridge, and Hanford. Although much of the work is driven by human health risk considerations, the methods and results are equally relevant to ecological endpoints. Modeling of food chain pathways, especially for radionuclides but also for chemical contaminants, has been a major activity at Oak Ridge and Livermore.

Statistics and Modeling

DOE labs have long been known as centers of excellence in statistics and computer modeling; many facilities have drawn on this expertise for their ecological research and assessment programs. Biomonitoring programs at Savannah River and Oak Ridge have employed innovative statistical techniques to identify trends and test for site-related environmental changes. Model uncertainty analysis techniques developed at Livermore were used at Oak Ridge to develop the first published methods for quantifying ecological uncertainties.

Geographic Information Systems

Many DOE facilities have now developed major capabilities for using geographic information systems (GIS) to store, retrieve, and analyze data for ecological assessments. Site-wide GIS's either are already in place or are being developed at most of the facilties visited. Especially innovative GIS programs exist at Savannah River, Sandia, and Argonne. The Westinghouse staff at the Savannah River Plant has developed a site-wide GIS containing data on soils, land use/land cover, topography, NPDES outfalls, and gamma-emitter distributions. Information on site-wide conditions is obtained from remote sensing, including satellite imagery. Argonne has developed methods for linking environmental transport models to a GIS and used them in risk assessments for DOE's Weldon Springs site. Sandia is developing a user interface for linking groundwater simulation models to a GIS; non-expert users will be able to select models and perform analyses.

CURRENT RISK ASSESSMENT ACTIVITIES

Ecological risk assessments, in most cases to support environmental restoration or waste management activities, are already ongoing at all of the sites visited. Data acquisition to support both on-site and off-site ecological risk assessments at Oak Ridge began several years ago; initial risk assessments have already been performed to identify important sites, contaminants, and ecological endpoints (Suter and Loar 1992). Risk assessment activities at Savannah River are emphasizing site-by-site assessments at individual operable units. An ecological risk assessment program plan is being prepared to ensure consistency in the way these assessments are performed. A site-wide ecological characterization has been compiled at Fernald (Facemire et al. 1990) and an ecological risk assessment work plan has been published (DOE 1992a). A generalized ecological

risk assessment methodology for Hanford has been published (DOE 1992b). Ecological risk assessments are also being performed at Livermore (site 501), INEL, and Rocky Flats. Los Alamos and Sandia have active NEPA groups, but risk assessment activities are only beginning.

EVALUATION OF STRENGTHS AND POTENTIAL IMPROVEMENTS

The survey clearly demonstrates the breadth and depth of DOE's capabilities in ecological risk assessment. In part due to the history of DOE support for ecological research at its facilities, the environmental data for these facilities is far superior to that available for typical Superfund sites. Much of the information is already on line in geographic information systems and in the near future most should be available in this form. Experienced scientists are available to interpret this information and collect any additional data needed to support sould environmental restoration decisions. The national laboratories are internationally recognized centers of excellence in the quantitative sciences, including statistics, modeling, and expert systems. This expertise has been used to design biomonitoring programs, environmental transport models, ecological effects assessment models, and integrated spatial data analysis systems that link environmental transport models to geographic information systems. A final source of strength is collaboration with local or regional academic institutions. Most of the sites have long-standing ties with university scientists; these relationships are regularly used to expand the pool of expertise available to the site managers, especially when unique situations are encountered and innovative approaches are required.

The survey found that even without new guidance or improved methodologies, project managers could make better use of the technical resources available to them. More involvement of senior scientists could be sought, at least in an advisory capacity. Assessment plans could in some cases place less emphasis on generic assessment techniques designed for situations in which little data are available, and more emphasis on approaches that make full use of the data available for DOE sites.

EVALUATION OF NEW TECHNICAL DEVELOPMENTS

Four general categories of new technical developments were identified during the survey: remote sensing, geographic information systems, modeling, and biomarkers. Remote sensing refers to the use of aerial surveys or satellite imagery to characterize ecological conditions at large spatial scales. This capability is essential for assessing site-wide conditions at large reservations such as Savannah River, Hanford, and INEL, each of which covers several hundred square miles. Savannah River has been active in remote sensing for more than five years and INEL is now initiating a program. The ability to store and analyze remote sensing data requires a geographic information system; such systems are also needed to organize and display the many kinds of data (e.g., soil types, land use, groundwater resources, distributions of important plant and animal species) needed to perform ecological assessments. These kinds of data and information systems will be essential when the facilities address site-wide (as opposed to operational unit-specific) risks and and benefits of their environmental restoration and waste management programs. Savannah River, Sandia, and Argonne have especially well-developed GIS programs that can be generalized to other sites.

Statistics and modeling are essential to ecological risk assessment, just as they are for human health risk assessment. These tools are needed to distinguish between adverse effects of site activities and natural environmental variability, to separate site-derived contamination from background, and to predict or measure environmental recovery

following remedial actions. Livermore, Sandia, Hanford, and Oak Ridge all have outstanding statistics and modeling groups..

The term "biomarkers" refers to the use of biochemical , physiological, or histopathological data to determine whether organisms have been exposed to or affected by toxic contaminants. In principle, biomarkers can be used to demonstrate exposure to specific contaminants or classes of contaminants, to provide direct measurements of the degree of exposure, and even to link specific exposures to impairments of the health of the exposed organisms. Biomarker studies are directly supporting environmental restoration activities at Oak Ridge; biomarkers research that could eventually be used to support environmental restoration is being performed at Fernald and Livermore.

EVALUATION OF NEEDS

Of the many needs for data or methods, or technical assistance identified through the survey, three stand out as affecting most or all of the facilities and being suitable for action by the Risk-Based Standards Working Group: databases for ecological risk assessment, guidelines for using data and models, and increased communication among the staff performing assessments at different sites. Standardized databases containing ecotoxicological data and other generic risk assessment parameters (e.g., transfer coefficients) are needed. Large quantities of data are available, but are scattered among a number of EPA and other federally-supported data bases. Subsets of the data have already been synthesized at some laboratories; with a modest amount of additional effort a more complete suite of data could be assembled, evaluated, and distributed in digital form to all DOE facilities.

More generally, there is a need for DOE-wide guidance on screening-level ecological risk assessments: assessments performed early in the remedial investigation process to determine the scope of future environmental studies at a site. These kinds of assessments must usually be performed using limited information on contaminant concentrations in environmental media, with no toxicity tests or biological field studies. Generic databases such as the ones described above are necessary components of screening-level ecological risk assessments. However, in addition guidance is required on: *de minimis* criteria (how large an impact is "significant?"), endpoints (what variables should we be looking at?), exposure scenarios, reference values, data quality and quantity, and inference guidelines for using data and models. Screening-level ecological assessments are being performed now at most of DOE's sites; the agency cannot wait for EPA to provide the necessary guidance. Although less urgent, guidance is also needed on a variety of technical topics including interpreting community and ecosystem-level data, designing biomonitoring programs, and using ecological models.

Increased communication through some forum would also greatly benefit DOE's ecological risk assessment programs. This is a rapidly changing field in which new methods are continuously being developed and existing methods are being tested, and refined or discarded. A method for rapidly communicating new developments between sites would improve the quality of risk assessments at all sites.

CONCLUSIONS

There are several immediate steps the Risk-Based Standards Working Group could take to improve the quality and realism of ecological risk assessments at DOE facilities. As suggested above, the agency can use the group as a means to draw on its own experts to provide basic technical tools and guidance for screening-level assessments. This step requires no new research, but would benefit from cooperation with EPA and state

technical staff. The group already serves as an informal means of communication between environmental scientists at different sites. More formal steps such as publication of a directory of experts in different disciplines or establishment of recognized expert groups (modeled on EPA's Biological Technical Assistance Groups) could be easily accomplished.

This short-term effort should be supplemented with a longer-term program to provide guidance and tools on more technical topics such as modeling, uncertainty analysis, ecosystem-level assessment, and ecological epidemiology. These subjects are relevant primarily for off-site or reservation-wide assessments; development of appropriate methods may require research funding from other units within DOE.

Finally, the group could work to promote flexibility on the part of the regulators and project managers who determine schedules, make funding decisions, and approve assessment documents for the sites. Regulatory guidance is in theory intended to set a minimum standard for the quality of assessments, yet the guidance is often interpreted as a cookbook that must be followed or a maximum level of effort that should not be exceeded. It is in everyone's interest to see more flexible approaches adopted that can take advantage of unique data available for a site and accomodate advances in the science underlying ecological risk assessment.

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