

EP 200-1-8
15 Feb 96

an increasing interest in using ecological risk assessments as a basis for environmental decisions. This increased emphasis is illustrated by a recent report by the EPA Science Advisory Board. Among their recommendations, the board suggested that EPA (1) target its environmental protection efforts on the basis of opportunities for the greatest risk reduction; (2) attach as much importance to reducing ecological risk as it does to reducing human health risk; and (3) improve the data and analytical methodologies that support the assessment, comparison, and reduction of different environmental risks. This article summarizes the recently published EPA Framework for Ecological Risk Assessment (1992) that describes the basic elements of ecological risk assessment. In addition, the article discusses several of the scientific issues that have been highlighted through the development of the framework report.

EXAMPLE/Commercial

Bernard, H.; Bixler, B.; Lamont, D.; Masters, H.; Rollo, J.; Sanning, D.; Snyder, H.J., Jr.; Tusa, W.K. Date: 1982. Title: Abandoned Site Risk Assessment Modeling and Sensitivity Analysis. Corporate Author: TRC Environmental Consultants, East Hartford, CT. Pub: Management of Uncontrolled Hazardous Waste Sites, Proceedings of a Conference, Washington, DC, November 29-December 1, 1982; (pp. 396-398).

EXAMPLE/DOD

Bernhardt, D.E. Date: 1992. Title: Depleted Uranium Cleanup Criteria and Associated Risks. Corporate Author: Rogers and Associates Engineering Corporation, Salt Lake City, UT. Pub: CONF-920617; Proceedings of the 37th Annual Meeting of the Health Physics Society, Columbus, OH, June 21-25, 1992; (13 pp.) Abstract: Depleted uranium (DU), a by-product from uranium enrichment, is used extensively for armor-piercing munitions by the military and as a catalyst in industry, and has also been used in various Department of Energy activities. Manufacturing and testing of the DU munitions and use of DU catalysts have resulted in residual contamination at DU facilities. This paper focuses on criteria that have been applied related to private party actions, however it also has application to government actions. Private party cleanup projects have been performed by Rogers and Associates for DU contamination at manufacturing sites in Tennessee and California that were based on criteria accepted under Agreement State licenses. The criteria for these projects were based on site-specific radiological pathways assessments and on the Nuclear

Regulatory Agency technical position (SECY-81-756) that was published in the Federal Register 46/205:52061 (October 23, 1981). The base criterion has been 1.3 Bq/g (35 pCi/g) of total uranium. This visual presentation addresses (1) the past and present DU cleanup criteria; (2) sampling techniques for implementing the criteria; (3) related criteria based on NUREG/CR-5512, "Residual Radioactive Contamination from Decommissioning;" and (4) an independent pathways risk assessment for cleanup criteria for DU. Several options for cleanup criteria are given.

EXAMPLE/DOD

Tate, D.J.; Jones, M.; Schulz, T.; Guo, X.; Fordham, C.L.; Ober, R.; Swalko, M. Date: 1992. Title: Innovative Probabilistic Assessment of Ecological Risk on a Federal Facility. Corporate Author: Ebasco Environmental, Lakewood, CO; Terra Technologies, Golden, CO; U.S. Army, Commerce City, CO; U.S. Army, Aurora, CO. Pub: CONF-9204110; Proceedings of the 1992 Hazardous Materials Control Research Institute Federal Environmental Restoration Conference and Exhibition, Vienna, VA, April 15-17, 1992. Hazardous Materials Control Resources Institute, Greenbelt, MD, 472 pp.; (pp. 147-152) Abstract: This paper presents an overview of an innovative probabilistic approach to ecological risk assessment (ERA) as applied to the onsite area of Rocky Mountain Arsenal (RMA). This 27-square-mile site contains multiple trophic levels in both aquatic and terrestrial ecosystems and is being considered for National Wildlife Refuge status in Congress. Therefore, ecological considerations are of particular importance in the assessment of risk and development of remediation goals at this site. The ERA will provide information for establishment of cleanup goals protective of wildlife on RMA. This ERA approach uses a computerized food web model that is most applicable to bioaccumulative contaminants of concern (COCs). It is tailored to site-specific ecological concerns and builds on the 1989 U.S. EPA guidance for ERAs. Literature data to develop probabilistic and fixed parameter values provide input to a model that uses Latin Hypercube Sampling to estimate terrestrial and aquatic biomagnification factor (BMF) distributions. BMF distributions are then calibrated and validated with site-specific contaminant data. At RMA, almost 2000 biota samples representing numerous trophic levels in food webs for five sink species were the basis for calibration and validation of the model. When a BMF distribution is divided into a maximum allowable tissue concentration (developed from literature values), a distribution of probabilistic biota criterion (PBC) is generated. PBCs are then used to quantify risks

EP 200-1-8
15 Feb 96

to biota in the various trophic levels and food webs. Contaminant-specific PBCs are compared to the concentrations of each COC in soil and water to identify exceedances. Finally, exceedances are summed to identify areas where the additive risk for all COCs indicates potential ecological endangerment.

EXAMPLE/DOE

Addison, S.J. Date: 1981. Title: Excess Cancer Risk Estimates from Exposure to Gamma and Radon Daughter Levels in Mesa County, Colorado. Corporate Author: Western Colorado Radiologic Associates; Grand Junction, CO. Pub: CONF-811049; Uranium Mill Tailings Management, Proceedings of the Fourth Symposium, Fort Collins, CO, October 26-27, 1981, 737 pp.; (pp. 169-179) Abstract: Mesa County, Colorado has been a location of concern regarding the carcinogenic effect of chronic exposure to uranium mill tailings. This study utilizes a recent comprehensive report on health effects of low-level radiation to determine individual risks of excess cancer in the Mesa County population. Risks from radiation levels throughout the county are considered, with emphasis placed on sites included in the mill tailings removal project. Evidence indicates only a few, if any, cancers would be induced by the county's increased gamma levels, and these would probably not be discernable at a statistically significant level. However, elevated levels of alpha emitters, which cause irradiation of the bronchial epithelium, could conceivably increase an individual's chance of lung cancer.

EXAMPLE/DOE

Armstrong, A.Q.; Layton, D.W.; Rutz, E.E. Date: 1994. Title: Risk Assessment Applications for Determining Cleanup Limits for Uranium in Treated and Untreated Soils. Corporate Author: Oak Ridge National Laboratory, Oak Ridge, TN; Lawrence Livermore National Laboratory, Livermore, CA; University of Cincinnati, Cincinnati, OH. Pub: CONF-940225; Waste Management '94: Proceedings of a Conference, Tucson, AZ, February 27-March 3, 1994; (11 pp.) Abstract: Uranium-contaminated soils are present at various locations across the United States where uranium was processed for nuclear fuels or atomic weapons. Important issues relative to such contamination include the assessment of potential health risks associated with human exposures to the residual uranium and the determination of safe levels of uranium in soils that have been treated by a given technology. This paper discusses various risk assessment considerations that must be dealt with when developing

cleanup limits for uranium in treated and untreated soils. Key issues addressed include alternative land use scenarios, potential exposure pathways, characterization of the bioavailability of uranium compounds in food and water, a brief overview of health risks associated with uranium and its daughter products as well as a summary of considerations for development of risk-based cleanup limits for uranium in soils.

EXAMPLE/DOE

Avci, H.I.; Biwer, B.M.; Blunt, D.L. Date: 1992, November. Title: Off-Site Population Radiological Dose and Risk Assessment for Potential Airborne Emissions from the Weldon Spring Site. Corporate Author: Argonne National Laboratory, Environmental Assessment and Information Sciences Division, Argonne, IL. Pub: ANL/EAIS/TM-78; 26 pp. Abstract: Radiological doses and health risks to the population around the Weldon Spring site from potential airborne emissions during remedial action at the chemical plant area of the site have been assessed with the Clean Air Act Assessment Package-1988 computer code. Two treatment options are being considered for waste produced by site cleanup activities: chemical stabilization/solidification and vitrification. Over the entire cleanup period of 7 years, the collective dose received by the people who live within 80 km (50 mi) of the site (about 3 million persons) is estimated to be about 34 person-rem for the chemical stabilization/solidification option and 32 person-rem for the vitrification option. By comparison, the same population is expected to receive about 6×10^6 (E+6) person-rem from natural background radiation during that time. If only the population within a reasonable radius of impact is considered (about 10,700 persons live within 5 km of the site), the remedial action activities are estimated to result in about 5 person-rem over the entire cleanup period; the same population is expected to receive about 20,000 person-rem from natural background radiation during that time. Because the doses are low, no cancers or genetic effects are expected to occur among the population around the Weldon Spring site as a result of exposures resulting from potential radioactive releases to the atmosphere during remediation of the chemical plant area.

EXAMPLE/DOE

Bair, W.J. Date: 1983, February. Title: Former Nuclear Site Risk Estimation. Corporate Author: Pacific Northwest Laboratory,

EP 200-1-8
15 Feb 96

Richland, WA. Pub: PNL-4600 (Part 5); Pacific Northwest Laboratory Annual Report for 1982 to the DOE Office of the Assistant Secretary for Environmental Protection, Safety and Emergency Preparedness - Part 5: Environmental and Occupational Protection, Assessment, and Engineering; (p. 13) Abstract: During FY 1982, the project was initiated to estimate health effects at formerly utilized MED/AEC nuclear sites or inactive uranium mill tailing sites. This activity complements radiological survey programs that are also sponsored by the Office of Operational Safety. During FY 1982, the general outlines of the methodology to be used in health effects estimation were developed, and initial estimates were calculated for twelve vicinity properties in the Salt Lake City area.

EXAMPLE/DOE

Barnthouse, L.W.; Bascietto, J.J.; Joseph, T.J.; Bilyard, G.R. Date: 1992, October. Title: A Survey of Ecological Risk Assessment at DOE Facilities. Corporate Author: Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN; U.S. Department of Energy, Washington, DC; U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN; Pacific Northwest Laboratory, Richland, WA. Pub: CONF-921029; Waste Management and Environmental Restoration, Proceedings of the Eighth Annual DOE Model Conference, Oak Ridge, TN, October 18-22, 1992, 228 pp.; (6 pp.) Abstract: A Risk-Based Standards Working Group sponsored by the U.S. Department of Energy (DOE) is studying standard setting and remedial action based on realistic estimates of human health and ecological risks. Little technical guidance has been provided by state and local regulatory bodies about how ecological risk assessments should be performed or what constitutes an adequate assessment. The Superfund Guidance Manual put out by the U.S. Environmental Protection Agency (EPA) in 1989 is targeted at project managers rather than at technical staff. EPA's "Framework for Ecological Risk Assessment" (1992) provides basic definitions and principles for ecological risk assessment, but gives no concrete technical guidance. To develop guidance in this area, the Working Group conducted a survey between March and September 1992 of ecological risk assessment activities at ten major DOE facilities. The survey objectives were to (1) identify new approaches now being used by DOE staff and contractors; (2) record successes and failures of these approaches; (3) identify new technical developments with the potential for general application to many DOE facilities; and (4) identify major data needs, data resources, and methodological deficiencies. This paper describes the survey results.

EXAMPLE/DOE

Bascietto, J.J. Date: 1992, October. Title: Development of Ecological Risk Assessment - An Historical Perspective. Corporate Author: U.S. Department of Energy, Office of Environmental Guidance, Washington, DC. Pub: CONF-921029; Waste Management and Environmental Restoration, Proceedings of the Eighth Annual DOE Model Conference, Oak Ridge, TN, October 18-22, 1992, 228 pp.; (8 pp.) Abstract: This paper gives the history of the U.S. Environmental Protection Agency's (EPA's) effort to develop a regulatory framework for ecological risk, beginning in the 1980s. This effort arose from the EPA's difficulty in establishing the proper level of ecological risk for the cancellation of two pesticides (diazinon and carbamate carbofuran). Diazinon, which was canceled first in 1990 after a six-year special review by the EPA, was less widely used and less toxic than carbamate carbofuran, which was canceled in 1991 after another six-year special review. EPA's 1992 framework for ecologic risk was the first published consensus document on generic ecological risk assessment principles, and is expected to form the basis for all future EPA ecological risk assessments. Current EPA regulatory framework, based on early ecological risk assessment efforts, is given in another paper in this same conference session.

EXAMPLE/DOE

Biggerstaff, R.L. Date: 1994, June 30. Title: Qualitative Risk Assessment for the 100-KR-4 Groundwater Operable Unit. Corporate Author: Westinghouse Hanford Company, Richland, WA. Pub: WHC-SD-EN-RA-010; 81 pp. Abstract: This report provides the qualitative risk assessment (QRA) for the 100-KR-4 groundwater operable unit at the U.S. Department of Energy's (DOE) Hanford Site in southeastern Washington State. The extent of the groundwater beneath the 100 K Area is defined in the Remedial Investigation/Feasibility Study Work Plan for the 100-KR-4 Operable Unit (DOE-RL 1992a). The QRA is an evaluation of risk using a limited amount of data and a predefined set of human and environmental exposure scenarios and is not intended to replace or be a substitute for a baseline risk assessment.

EXAMPLE/DOE

Brice, D.A.; Archer, J.A.; Greer, J.K. Date: 1990. Title: Establishment of Alternate Clean Up Goals for a RCRA Facility

EP 200-1-8
15 Feb 96

Utilizing Numerical Analysis of Transport Pathways to Evaluate Risk to Human and Environmental Receptors. Corporate Author: Geraghty and Miller, Inc., Oak Ridge, TN; Oak Ridge National Laboratory, Oak Ridge, TN. Pub: CONF-9005149; Aquifer Restoration, Groundwater Monitoring, and Geophysical Methods, Proceedings of the Fourth National Outdoor Action Conference, Las Vegas, NV, May 14-17, 1990, 1333 pp.; (pp. 919-934) Abstract: Achievable cleanup goals were developed for a Resource Conservation and Recovery Act interim status disposal unit and associated Solid Waste Management Units collectively referred to as the S-3 Waste Management Area (S-3 WMA). The unit, now closed and capped, was an unlined disposal pond located at the Oak Ridge Y-12 Plant in Oak Ridge, Tennessee. The area is geologically complex, typified by steeply dipping sedimentary strata of diverse lithology and hydraulic properties. Groundwater was identified as the primary transport pathway because it links the source area to potential points of exposure along the creeks. The transport of four constituents representative of the types of constituents disposed at the ponds during the thirty-three years of use were modeled. Exposure scenarios were developed based upon current conditions for both human and environmental receptors. Plant workers conducting routine sampling or studies of the groundwater or surface water were identified as the most sensitive human receptors. Aquatic biota are the most sensitive environmental receptors. Transport simulations showed that the concentration of these constituents would be naturally attenuated by a factor of 10 or more between the source and the nearest point of exposure. Alternate concentration limits (ACLs) were based on attenuation and allowable levels at the point of exposure. Proposed ACLs have been submitted by the U.S. Department of Energy to the state of Tennessee and the U.S. Environmental Protection Agency for approval.

EXAMPLE/DOE

Cox, N.D.; Atwood, C.L. 1988. Probabilistic Risk Assessment for Greater Confinement Disposal. Oct. 1988. EG and G Idaho, Inc., Idaho Falls, ID Contract number - DOE AC08-89NV10630 Report number DOE/NV/10630-4 (NOTE - Portions of this document are illegible in microfiche products) Abstract: Risks arising from two aspects of disposing radioactive waste at the Nevada Test Site (NTS) are analyzed in this report. The first aspect concerns occupational exposures received during handling and disposal of high-specific-activity low-level waste (HSA-LLW) in augured boreholes used to ensure greater confinement. The second aspect concerns the threat to the public from waste after disposal in

augured boreholes. The risk assessment for HSA-LLW confirms that procedures for, and operations of, future augured borehole disposal sites will provide a safe and effective way to dispose of this type of waste. Augured borehole disposal operations are conducted at minimal, or near minimal, occupational radiation levels for site personnel. Contingency plans to recover from equipment failure are well thought out and, if executed as planned, will keep personnel radiation exposures within tolerable limits. The risk to the public from waste that has been disposed in augured boreholes was identified as a result of tritium seepage from disposal packages. The resulting committed dose equivalents were calculated using conservative assumptions. If one new hole is filled each year, the annual dose equivalent to an individual living full-time near the disposal site is on the order of 0.2 mrem, well below the regulatory limit of 25 mrem. The annual dose equivalent to an average individual is much smaller, approximately 0.001 mrem. The probability of a harmful health effect to either individual is negligible compared to other risks that are encountered in everyday life. 21 refs., 4 figs., 13 tabs.

EXAMPLE/DOE

Devgun, J.S. Date: 1990a, April. Title: Radioactive Risk Assessment for Radioactive Contamination at a Landfill Site. Corporate Author: Argonne National Laboratory, Argonne, IL. Pub: CONF-9004181 (Vol. 1); Remedial Action Under the Environmental Restoration and Waste Management Five-Year Plan, Proceedings of the Department of Energy Remedial Action Program Conference, Albuquerque, NM, April 16-19, 1990, Vol. 1, 656 pp.; (pp. 355-366) Abstract: A limited-scope preliminary assessment of radiological risk has been conducted for a landfill site at the Seaway Industrial Park in Tonawanda, New York, where radioactive residues resulting from past uranium ore processing operations of the Manhattan Engineering District are present. Potential radiation doses to an individual under different scenarios have been predicted using the RESRAD computer code. The assessment provides useful input to the remedial action planning for the site that is currently underway. The results of this preliminary analysis show that the current conditions case for Area A of the landfill site does not meet DOE radiation protection criterion of less than 100 mrem/yr dose to an individual member of the public. After the erosion of the thin cover on Area A in about 150 years, the dose to an individual in the resident/farmer scenario is more than two times the dose limit; for the industrial worker scenario, the dose is about three quarters of the dose limit. Given DOE commitment to as low as reasonably achievable

EP 200-1-8
15 Feb 96

potential dose levels, letting the current conditions remain "as is" in Area A is not a viable alternative in the long term.

EXAMPLE/DOE

Devgun, J.S. Date: 1990b. Title: Radiological Risk Assessment of a Radioactively Contaminated Site. Corporate Author: Argonne National Laboratory, Argonne, IL. Pub: CONF-900210 (Vol. 1); Waste Management '90: Working Towards a Cleaner Environment - Waste Processing, Transportation, Storage and Disposal, Technical Programs and Public Education - Overview and General Waste Management, R.G. Post (ed.), Proceedings of a Conference, Tucson, AZ, Feb. 25-Mar. 1, 1990, Vol. 1, 813 pp.; (pp. 513-518) Abstract: A limited-scope preliminary assessment of radiological risk has been conducted at a radioactively contaminated site located in the southeastern part of the city of Oak Ridge, Tennessee. The Elza Gate site was used by the Manhattan Engineering District in the early 1940s as a storage area for uranium ore and ore-processing residues. Five warehouses with concrete pad floors were used for storing such materials. None of the original structures remain, but the concrete pads upon which the warehouses were built are still in place. The site is currently being developed for use as an industrial park. The radiological risk assessment is based on the available preliminary radiological characterization data for the site and will provide useful input to the remedial action planning for the site.

EXAMPLE/DOE

Doctor, P.G.; Eslinger, P.W.; Elwood, D.M.; Engel, D.W.; Freshley, M.D.; Liebetrau, A.M.; Reimus, P.W.; Strenge, D.L.; Tanner, J.E.; Van Luik, A.E. Date: 1992, May. Title: An Example of Postclosure Risk Assessment Using the Potential Yucca Mountain Site. Corporate Author: Pacific Northwest Laboratory, Richland, WA. Pub: PNL-8081; 299 pp. Abstract: The risk analysis described in this document was performed for the U.S. Department of Energy's Office of Civilian Radioactive Waste Management over a 2-year time period ending in June 1988. The objective of Pacific Northwest Laboratory's (PNL's) task was to demonstrate an integrated, though preliminary, modeling approach for estimating the postclosure risk associated with a geologic repository for the disposal of high-level nuclear waste. The modeling study used published characterization data for the proposed candidate site at Yucca Mountain, Nevada, along with existing models and computer codes available at that time. Some of the site data and conceptual models reported in the Site

Characterization Plan published in December 1988, however, were not yet available when PNL conducted the modeling studies.

EXAMPLE/DOE

Duke, C.S.; Martin, J.F.; Gray, S.I. Date: 1991. Title: Ecological Risk Assessment for the DOE Fernald Facility. Corporate Author: Advanced Sciences, Inc., Idaho Falls, ID. Pub: CONF-910270 (Vol. 2); Waste Management '91: Working Towards a Cleaner Environment, R.G. Post (ed.), Proceedings of the Symposium, Tucson, AZ, February 24-28, 1991, Vol. 2, 815 pp.; (pp. 149-156) Abstract: Ecological risk assessment is an integral part of the CERCLA process for remediating hazardous waste sites, and of NEPA requirements for evaluating the environmental impacts of major federal actions. Ecological risk assessments in NEPA impact analyses and CERCLA Baseline Risk Assessments can serve in turn as the bases for CERCLA-required Preliminary Natural Resources Surveys and Natural Resources Damage Assessments (PNRS/NRDA). These documents attempt to directly assess the value of lost or damaged natural resources as the basis for a court award of monetary damages against the responsible parties. PNRS/NRDA is a significant issue for hazardous waste sites under the control of government agencies, because they are the designated trustees for the natural resources at their facilities. A variety of studies support ecological risk assessment for a CERCLA/NEPA investigation being conducted at the Department of Energy's Feed Materials Production Center (FMPC) near Fernald, Ohio. These include radionuclide analyses of vegetation and aquatic organisms; threatened and endangered species surveys; toxicity tests of soils, sediments, and effluent; wetlands delineation; and surveys of aquatic invertebrate communities. Preliminary results suggest that the FMPC does not have a major ecological impact on the surrounding area, that wetlands are limited in extent, and that endangered species are not present. The breadth of ecological studies at Fernald, a 1050 acre site without extensive wetlands or critical habitats, illustrates the potential importance of ecological risk assessment and PNRS/NRDA to larger and more complex sites.

EXAMPLE/DOE

Duke, C.S.; Meyers-Schone, L.; Glum, S.R.; Quaid, W. Date: 1991, September. Title: An Assessment of Baseline Ecological Risks at the Fernald Environmental Management Project, Fernald, Ohio. Corporate Author: Advanced Sciences, Inc., Ross, OH. Pub: CONF-910981; Environmental Remediation '91: Cleaning Up the Environment for the

EP 200-1-8
15 Feb 96

21st Century, D.E. Wood (ed.), Proceedings of a Conference, Pasco, WA, September 8-11, 1991, 970 pp.; (pp. 861-869) Abstract: The Fernald Environmental Management Project (FEMP), formerly the Feed Materials Production Center (FMPC), is a Department of Energy (DOE) facility located near Cincinnati, Ohio, which produced pure uranium metals from the early 1950s until 1989. DOE is currently conducting a Remedial Investigation/Feasibility Study (RI/FS) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), in order to remediate environmental impacts at the site. DOE is also preparing an environmental impact statement under the National Environmental Protection Act (NEPA) to evaluate environmental impacts of proposed remedial actions. Both CERCLA and NEPA require evaluation of ecological risks of baseline conditions and proposed remedial actions. A preliminary assessment of ecological risks examined the potential effects of FEMP contaminants in one operable unit (OU) at the site: OU5, Environmental Media. Radionuclides of potential concern in OU5 soils include uranium, cesium, radium, strontium, technetium, and thorium. Chemicals detected in terrestrial organisms include aluminum, arsenic, barium, cadmium, lead, mercury, vanadium, and zinc, as well as radionuclides. Chemicals of potential concern in surface water include a variety of metals as well as uranium and technetium. Radionuclides in OU5 do not appear to pose a hazard to terrestrial organisms. Estimated radiation doses to aquatic organisms continually exposed to the maximum uranium concentrations observed in on-property drainages ranged from 40 to 4000 rad per year. However, off-property radionuclide concentrations are very low, and it is unlikely that organisms in streams adjacent to the FEMP are exposed to toxic levels. Maximum arsenic levels in vegetation collected from the FEMP are consistent with values reported in the literature to be toxic to certain plants. However, signs of stress have not been observed in vegetation on, or adjacent to, the FEMP. Similarly, arsenic levels in plants and animals collected from the FEMP could be toxic to terrestrial mammals under worst-case conditions, but toxicity has not been observed in the field. Current and planned sampling of soils will clarify whether nonradioactive constituents constitute a hazard to terrestrial organisms at the FEMP. The maximum concentrations of aluminum observed in OU5 surface waters are comparable to those reported to cause chronic-to-acute effects in aquatic organisms. However, macroinvertebrate communities in streams adjacent to the FEMP do not exhibit any adverse effects of exposure to FEMP constituents. This preliminary assessment suggests that present ecological risks of the FEMP are low and likely to be associated primarily with nonradiological effects. However, long-term

ecological risks could be substantial if containment systems fail or wastes are penetrated by plants or burrowing animals.

EXAMPLE/DOE

Ebinger, M.H.; Hansen, W.R. Date: 1994, April 29. Title: Depleted Uranium Human Health Risk Assessment, Jefferson Proving Ground, Indiana. Corporate Author: Los Alamos National Laboratory, Los Alamos, NM. Pub: LA-UR-94-1809; 77 pp. Abstract: The risk to human health from fragments of depleted uranium (DU) at Jefferson Proving Ground (JPG) was estimated using two types of ecosystem pathway models. A steady-state, model of the JPG area was developed to examine the effects of DU in soils, water, and vegetation on deer that were hunted and consumed by humans. The RESRAD code was also used to estimate the effects of farming the impact area and consuming the products derived from the farm. The steady-state model showed that minimal doses to humans are expected from consumption of deer that inhabit the impact area. Median values for doses to humans range from about 1 mrem (plus or minus 2.4) to 0.04 mrem (plus or minus 0.13) and translate to less than $1 \times 10(E+[-6])$ detriments (excess cancers) in the population. Monte Carlo simulation of the steady-state model was used to derive the probability distributions from which the median values were drawn. Sensitivity analyses of the steady-state model showed that the amount of DU in airborne dust and, therefore, the amount of DU on the vegetation surface, controlled the amount of DU ingested by deer and by humans. Human doses from the RESRAD estimates ranged from less than 1 mrem/y to about 6.5 mrem/y in a hunting scenario and subsistence farming scenario, respectively. The human doses exceeded the 100 mrem/y dose limit when drinking water for the farming scenario was obtained from the on-site aquifer that was presumably contaminated with DU. The two farming scenarios were unrealistic land uses because the additional risk to humans due to unexploded ordnance in the impact area was not figured into the risk estimate. The doses estimated with RESRAD translated to less than $1 \times 10(E+[-6])$ detriments to about $1 \times 10(E+[-3])$ detriments. The higher risks were associated only with the farming scenario in which drinking water was obtained on-site.

EXAMPLE/DOE

Fingleton, D.J.; MacDonell, M.M.; Haroun, L.A.; Ozkaynak, H.; Butler, D.A.; Xue, J. Date: 1991, September. Title: Assessing Exposures and Risks in Heterogeneously Contaminated Areas: A Simulation Approach. Corporate Author: Argonne National Laboratory,

EP 200-1-8
15 Feb 96

Argonne, IL; Harvard University, Cambridge, MA. Pub: CONF-910981; Environmental Remediation '91: Cleaning Up the Environment for the 21st Century, D.E. Wood (ed.), Proceedings of a Conference, Pasco, WA, September 8-11, 1991, 970 pp.; (pp. 871-876) Abstract: The U.S. Department of Energy (DOE) is responsible for cleanup activities at a number of facilities under its Environmental Restoration and Waste Management Program (EM), including the Weldon Spring Site in Missouri. The major goals of the EM program are (1) to eliminate potential hazards to human health and the environment that come from contamination at these sites and (2) to make surplus real property available for other uses. The assessment of baseline health risks and ecological impacts that may come from a contaminated site is an important component of the remedial investigation/feasibility study (RI/FS) process, which is required at all Superfund sites. This paper describes one phase of the baseline assessment through the example of the characterization of human health risks associated with exposure to chemical contaminants in air and on interior building surfaces in a contaminated structure on the Weldon Spring Site. The model combines data on human activity patterns in a particular microenvironment within a building, a 60 meter by 110 meter one-story cinderblock structure, with data on contaminant concentrations in that microenvironment to calculate personal exposure profiles and risks within the building. The results of the building assessment are presented as probability distribution functions and cumulative distribution functions, which show the variability and uncertainty in the risk estimates.

EXAMPLE/DOE

Friant, S.L. Date: 1992, October. Title: Ecological Risk Assessment for Radionuclides - A Case Study. Corporate Author: Pacific Northwest Laboratory, Richland, WA. Pub: CONF-921029; Waste Management and Environmental Restoration, Proceedings of the Eighth Annual DOE Model Conference, Oak Ridge, TN, October 18-22, 1992, 228 pp.; (6 pp.) Abstract: Since 1943, production activities at the Hanford Site have entailed the discharge of effluents to the Columbia River, which runs through the northern portion of the site and borders it on the east. DOE Order 5400.5, the one published standard for the protection of ecological resources from exposure to radioactive material, stipulates that the interim dose limit for native aquatic organisms "shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways." This study was undertaken to determine whether the ecological risk paradigm for hazardous chemicals developed by

the Environmental Protection Agency is applicable to organism exposure to radionuclides. The paper is a brief description of the assessment.

EXAMPLE/DOE

Haroun, L.A.; Peterson, J.M.; MacDonell, M.M.; Fingleton, D.J.; McCracken, S.H. Date: 1990, April. Title: Risk Assessment at the Weldon Spring Site: Lessons Learned. Corporate Author: Argonne National Laboratory, Argonne, IL. Pub: CONF-9004181 (Vol. 1); Remedial Action Under the Environmental Restoration and Waste Management Five-Year Plan, Proceedings of the Department of Energy Remedial Action Program Conference, Albuquerque, NM, April 16-19, 1990, Vol. 1, 656 pp.; (pp. 331-354) Abstract: Several health-risk assessments have been prepared for the Weldon Spring Site Remedial Action Project, including (1) the quarry and site water treatment plant engineering evaluation/cost analyses; (2) the quarry baseline risk evaluation; (3) the quarry feasibility study; (4) the site baseline risk assessment; and (5) the site feasibility study. This presentation covers five general topics: (a) specific health risk assessments for the Weldon Spring Site, including their scope and methodology; (b) objectives of the health risk assessment; (c) lessons learned to date; (d) emerging issues in health risk assessment for U.S. Department of Energy Superfund sites; and (e) an ecological assessment.

EXAMPLE/DOE

Hook, L.A.; Gentry, M.J.; Shaakir-Ali, J.A.; Faulkner, M.A. Date: 1992, June. Title: Development of an Integrated Data Base for the Screening-Level Risk Assessment for the Clinch River Resource Conservation and Recovery Act Facility Investigation. Corporate Author: Science Applications International Corporation, Oak Ridge, TN; Oak Ridge National Laboratory, Oak Ridge, TN. Pub: CONF-9002111; Data Analysis and Interpretation for Environmental Surveillance, Proceedings of a Conference, Lexington, KY, February 5-7, 1990, 149 pp.; (pp. 35-36) Abstract: The Oak Ridge Reservation (ORR) includes three U.S. Department of Energy (DOE) facilities where radioactive and hazardous substances have been handled since 1942. Surface waters beyond the boundary of the ORR, including portions of the Clinch and Tennessee rivers, have received contaminants as a result of past operations and waste management practices. Thus, the U.S. Environmental Protection Agency (EPA), under the provisions of the Resource Conservation and Recovery Act (RCRA), requires that a Clinch River RCRA Facility Investigation

EP 200-1-8
15 Feb 96

(CRRFI) be conducted. The CRRFI is being implemented in a phased approach to (1) define the nature and extent of off-site contamination, (2) quantify risk to human health and the environment, and (3) identify and evaluate the remedial action alternatives. One of the first tasks was to perform screening-level risk analyses for human and aquatic organism exposure pathways, based on existing data. Thus, there was a need to identify, compile, and integrate selected data into a single consistent data base for use by the investigators performing the risk assessments. The data required were recent maximum and mean values of water quality parameters and of contaminant concentrations in sediment, water, fish, and other biota (e.g., vegetation). The study area was divided into manageable units or reaches for the risk assessment, based on proximity to known contaminant release points from DOE facilities and other potential sources of pollution in the area. The major sources of data included Oak Ridge Task Force results, DOE ORR Environmental Surveillance Reports, results of several intensive sediment sampling activities, and Tennessee Valley Authority data retrieved from the EPA's STORET system. No one study or program had sufficient data to meet the risk assessment requirements for any given reach. The structured process by which data files were quality checked and manipulated into a common SAS data base structure are discussed.

EXAMPLE/DOE

JEG. 1993a, September. Title: Baseline Risk Assessment of Groundwater Contamination at the Uranium Mill Tailings Site Near Shiprock, New Mexico. Corporate Author: Jacobs Engineering Group, Inc., Albuquerque, NM. Pub: DOE/AL/62350-48D; 171 pp. Abstract: This report evaluates potential impact to public health or the environment resulting from groundwater contamination at the former uranium mill processing site near Shiprock, New Mexico. The tailings and other contaminated material at this site were placed in a disposal cell on the site in 1986 by the U.S. Department of Energy's (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project. Currently, the UMTRA Project is evaluating groundwater contamination. This risk assessment is the first document specific to this site for the Groundwater Project. This risk assessment follows the approach outlined by the U.S. Environmental Protection Agency (EPA). The first step is to evaluate groundwater data collected from monitor wells at the site. Evaluation of these data showed that the main contaminants in the floodplain groundwater are arsenic, magnesium, manganese, nitrate, sodium, sulfate, and uranium. The complete list of contaminants associated with the

terrace groundwater could not be determined due to the lack of the background groundwater quality data. However, uranium, nitrate, and sulfate are evaluated since these chemicals are clearly associated with uranium processing and are highly elevated compared to regional waters. It also could not be determined if the groundwater occurring in the terrace is a usable water resource, since it appears to have originated largely from past milling operations. The next step in the risk assessment is to estimate how much of these contaminants people would be exposed to if a drinking well were installed in the contaminated groundwater or if there were exposure to surface expressions of contaminated water. Potential exposures to surface water include incidental contact with contaminated water or sediments by children playing on the floodplain and consumption of meat and milk from domestic animals grazed and watered on the floodplain.

EXAMPLE/DOE

JEG. 1993b, September. Title: Baseline Risk Assessment for Groundwater Contamination at the Uranium Mill Tailings Site Near Monument Valley, Arizona. Corporate Author: Jacobs Engineering Group, Inc., Albuquerque, NM. Pub: DOE/AL/62350-43D; 127 pp. Abstract: This baseline risk assessment evaluates potential impact to public health or the environment resulting from groundwater contamination at the former uranium mill processing site near Monument Valley, Arizona. The tailings and other contaminated material at this site are being relocated and stabilized in a disposal cell at Mexican Hat, Utah, through the U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project. The tailings removal is planned for completion by spring 1994. After the tailings are removed, groundwater contamination at the site will continue to be evaluated. This risk assessment is the first document specific to this site for the Groundwater Project. It will be used to assist in determining what remedial action is needed for contaminated groundwater at the site.

EXAMPLE/DOE

Kluesner, D.; Nawar, M.; Mauro, J.J. Date: 1992, March. Title: Baseline Risk Assessment of the Maxey Flats Disposal Site. Corporate Author: U.S. Environmental Protection Agency, Region IV, Atlanta, GA; U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC; Cohen (S.) and Associates, Inc., McLean, VA . Pub: CONF-920307 (Vol. 2); Waste Management '92: Working Towards a Cleaner Environment, R.G. Post (ed.), Proceedings

EP 200-1-8
15 Feb 96

of a Symposium, Tucson, AZ, March 1-5, 1992, Vol. 2, 820 pp.; (pp. 1435-1440) Abstract: The Maxey Flats Disposal Site (MFDS), located in Morehead, Kentucky, operated as a low-level radioactive waste disposal site from 1963 to 1977, when operations ceased due to the determination that leachate was migrating through the subsurface geology. In 1986, the site was listed on the National Priorities List to be addressed under the Superfund program. On April 1, 1991, the Maxey Flats Steering Committee file with U.S. Environmental Protection Agency (EPA) Region IV the MFDS Feasibility Study (FS) in accordance with the Administrative Order by Consent (USEPA Docket No. 87-08-C) entered into by the EPA and consenting members of the steering committee. During the preparation of the FS, a number of technical and regulatory issues were raised and resolved with regard to the Applicable or Relevant and Appropriate Requirements (ARARs) for the site and the performance of a Baseline Risk Assessment. Accordingly, the MFDS docket establishes EPA precedence that may be applicable to other Superfund sites contaminated with radioactive materials. The purpose of this paper is to (1) describe EPA requirements regarding ARARs pertaining to the remediation of the MFDS, and (2) to summarize the radiation exposure scenarios and assumptions used by the EPA to evaluate the baseline risks associated with the MFDS. It is intended that the regulatory interpretations and experience gained in preparing the MFDS remedial investigation/feasibility study reports will help to facilitate the remediation of other Superfund sites containing radioactive materials.

EXAMPLE/DOE

Marks, S.; Cross, F.T.; Denham, D.H.; Kennedy, W.E.; Stenner, R.D. Date: 1985, August. Title: Risk Assessment in the DOE Assurance Program for Remedial Action. Corporate Author: Pacific Northwest Laboratory, Richland, WA. Pub: PNL-5541; 98 pp. Abstract: This report provides information obtained during performance of several risk assessment tasks in support of the Assurance Program for Remedial Action (ARPA) sponsored by the DOE's Office of Operational Safety. It presents a method for the estimation of projected health effects at properties in the vicinity of uranium mill tailings piles due to transported tailings or emissions from the piles. Because radon and radon daughter exposure is identified as the principal factor contributing to health effects at such properties, the basis for estimating lung cancer risk as a result of such exposure is discussed in detail. Modeling of health risk due to a secondary pathway, ingestion of contaminated, home-grown food products, is also discussed since it is a potentially important

additional source of exposure in certain geographic locations. Risk assessment methods used in various mill tailings reports are reviewed. The protocols for radiological surveys conducted in DOE-sponsored remedial action programs are critically reviewed with respect to their relevance to the needs of health risk estimation. The relevance of risk assessment to the ARPA program is discussed briefly.

EXAMPLE/DOE

Morris, S.C.; Rowe, M.D.; Holtzman, S.; Meinhold, A.F. Date: 1993, May. Title: National Radiation Exposures and Risks Caused by Implementing EPA's Proposed Revised National Primary Drinking Water Regulations. Corporate Author: Brookhaven National Laboratory, Upton, NY. Pub: BNL-49162; 53 pp. Abstract: This report estimates risks to workers and the public associated with treatment processes and associated waste products mandated under proposed regulations of radium, radon, and uranium in drinking water. Three scenarios were examined: (1) all wastes flushed to the sanitary sewer; (2) all wastes disposed on land; (3) similar to (2) but radon removal by granulated activated carbon rather than packed tower aeration. Risks considered included accidental injury and cancer. Worker risks for both scenarios I and II were estimated to be 0.025 and 0.01 deaths per year of operation for radium-226 and radium-228, respectively. Worker risks for uranium were estimated to be 0.13 deaths/year of operation for scenario I and 0.5 deaths/year of operation for scenario II. Worker risks for radon removal were estimated to be 1.7 deaths/year of operation for scenario I and 2.2 deaths/year of operation for scenario II. Risks to the public for scenarios I and II for radium-226 were 4×10^{-4} and for radium-228 were 9×10^{-5} deaths/year of operation. Risks to the public for scenarios I and II for uranium were 7.3×10^{-2} and 2×10^{-4} , respectively. Risks to the public for scenario I and II for radon were 24 deaths/year of operation and for scenario III were nil. Public risks were quantified only for people exposed during a year of operation. For example, effects of public exposures in future years via groundwater contamination associated with landfill of treatment waste were not considered.

EXAMPLE/DOE

Oezkaynak, H.; Xue, J.; Butler, D.A.; Haroun, L.A.; MacDonell, M.M.; Fingleton, D.J. Date: 1991. Title: Addressing Data Heterogeneity: Lessons Learned from a Multimedia Risk Assessment. Corporate Author: Harvard University, Cambridge, MA; Argonne

EP 200-1-8
15 Feb 96

National Laboratory, Argonne, IL. Pub: ANL/CP-71902; CONF-910659; Proceedings of the 84th Annual Air and Waste Management Association Meeting and Exhibition, Vancouver, British Columbia, Canada, June 16-21, 1991; (27 pp.) Abstract: Cleanup activities are being conducted by the U.S. DOE at a former chemical plant site, the Weldon Spring Site (inactive for more than 20 years). The Army produced nitroaromatic explosives at the 220-acre site during the 1940s, and radioactive materials of the uranium and thorium series were processed there by DOE's predecessor agency during the 1950s and 1960s. Chemical and radioactive contaminants are present in soil, surface water, sediment, and groundwater at the site as a result of both past releases and disposal activities and subsequent contaminant migration. Samples have been collected from these media over a number of years under both DOE's environmental monitoring program and the site characterization program of the Superfund process. Results of samples analyses are compiled in a computerized data base, and these data are being evaluated for potential exposure pathways currently present at the site or that may be present in the future, in order to estimate possible adverse impacts to human health and the environment in the absence of cleanup. This paper discusses the methodology used to address associated tasks and the lessons learned during the assessment process. Statistical issues and recommended future directions for dealing with technical aspects of this project and with similar multimedia risk assessment projects are addressed in the final discussion.

EXAMPLE/DOE

Regens, J.L.; White, L.; Albers, B.J.; Purdy, C. Date: 1994. Title: Geomatic Techniques for Assessing Ecological and Health Risk at U.S. Department of Energy Facilities. Corporate Author: Tulane University Medical Center, New Orleans, LA; U.S. Department of Energy, Washington, DC. Pub: Report; 6 pp. Abstract: Hazardous substances, including radionuclides, heavy metals, and chlorinated hydrocarbons, pose unique challenges in terms of environmental restoration and waste management, especially in aquatic environments. When stored, used or disposed of improperly, hazardous materials can contaminate an array of environmental receptors ranging from soils, sediments, groundwater, to surface water. Depending on the specific hazardous substance and site attributes, assessing ecological and health risk as a basis for environmental restoration and waste management can be a complex, problematic activity. This is particularly true for the major Defense Programs facilities managed by the U.S. Department of

Energy (DOE). The Environmental Restoration program of DOE was initiated in 1987 to consolidate and coordinate those regulatory activities designed to identify and remediate sites at installations contaminated with radioactive, chemical or mixed wastes. To supply the tools necessary for defining, describing and characterizing the nature of contaminants within the DOE complex and identifying alternative post-remediation land use options, DOE has implemented a program for the research and development of spatial data technologies to aid in assessing ecological and health risk.

EXAMPLE/DOE

USDOE. 1987. Environmental Analysis of Closure Options for Waste Sites at the Savannah River Plant. Savannah River Lab., Aiken, SC. U.S. Department of Energy, Washington, DC. Conference proceeding - Annual low-level radioactive waste management program conference, Denver, CO, USA, 25 Aug 1987. Abstract- Previously acceptable waste management practices (e.g., the use of unlined seepage basins) for discarding of wastes from nuclear materials production has resulted in occasional cases of groundwater contamination beneath some disposal sites, mainly in water-table aquifers. Groundwater contaminants include volatile organic compounds, heavy metals, radionuclides, and other chemicals. The closure of active and inactive waste sites that have received hazardous and/or low-level radioactive materials at the Savannah River Plant (SRP) is planned as part of an overall program to protect groundwater quality. DOE developed and submitted to Congress a groundwater protection plan for SRP. This initial plan and subsequent revisions provide the basis for closure of SRP waste sites to comply with applicable groundwater protection requirements. An environmental analysis of the closure options for the criteria waste sites that have received hazardous and/or low-level radioactive wastes was conducted to provide technical support. The several parts of this environmental analysis include description of geohydrologic conditions; determination of waste inventories; definition of closure options; modeling of environmental pathways; assessment of risk; and analysis of project costs. Each of these components of the overall analysis is described in turn in the following paragraphs. Production operations at SRP have generated a variety of solid, hazardous, and low-level radioactive waste materials. Several locations onplant have been used as waste disposal sites for solid and liquid wastes. Seventy-six individual waste sites at 45 distinct geographical locations on SRP have received hazardous, low-level radioactive, or mixed wastes. These waste sites can be

EP 200-1-8
15 Feb 96

categorized into 26 groupings according to the function of the waste disposed. 15 refs., 6 figs., 5 tabs.

EXAMPLE/DOE

USDOE. 1990, November. Title: Baseline Risk Assessment for Groundwater Contamination at the Uranium Mill Tailings Site, Gunnison, Colorado. Corporate Author: U.S. Department of Energy, Albuquerque Operations Office, Uranium Mill Tailings Remedial Action Project Office, Albuquerque, NM. Pub: DOE/UMTRA-050127-0000; 72 pp. Abstract: The Gunnison Baseline Risk Assessment for Groundwater Contamination at the Uranium Mill Tailings Site was performed to determine if long-term use of groundwater from domestic wells near the site has a potential for adverse health effects. The risk assessment was based on the results of sampling domestic wells during 1989-1990. A risk assessment evaluates health risks by comparing the amount of a contaminant taken in by a person with the amount of the contaminant that may be toxic. The Gunnison Risk Assessment used high intake values to estimate the maximum levels a person might be exposed to. The results of the risk assessment are divided into cancer (carcinogenic) risks and non-carcinogenic risks. Five key contaminants were evaluated for adverse health risks: uranium, manganese, lead, antimony, and cadmium. Due to the potential health risks and the unavoidable uncertainties associated with limited groundwater and toxicity data, it is prudent public health policy to provide a permanent alternate water supply. Additionally, providing a permanent alternate water supply is cost-effective compared to long-term routine monitoring.

EXAMPLE/DOE

USDOE. 1994a, April. Title: Baseline Risk Assessment of Groundwater Contamination at the Uranium Mill Tailings Site Near Gunnison, Colorado. Corporate Author: . Pub: DOE/AL/62350-57D-Rev.1; 157 pp. Abstract: This report evaluates potential impacts to public health or the environment resulting from groundwater contamination at the former uranium mill processing site. The tailings and other contaminated material at this site are being placed in an off-site disposal cell by the U.S. Department of Energy's (DOE's) Uranium Mill Tailings Remedial Action (UMTRA) Project. Currently, the UMTRA Project is evaluating groundwater contamination. This is the second risk assessment of groundwater contamination at this site. The first risk assessment was performed primarily to evaluate existing domestic wells to determine the potential for immediate human

health and environmental impacts. This risk assessment evaluates the most contaminated groundwater that flows beneath the processing site towards the Gunnison River. The monitor wells that have consistently shown the highest concentration of most contaminants are used in this risk assessment. This risk assessment will be used in conjunction with additional activities and documents to assist in determining what remedial action is needed for contaminated groundwater at the site after the tailings are relocated. This risk assessment follows an approach outlined by the U.S. Environmental Protection Agency (EPA). The first step is to evaluate groundwater data collected from monitor wells at the site. Evaluation of these data showed that the main contaminants in the groundwater are cadmium, cobalt, iron, manganese, sulfate, uranium, and some of the products of radioactive decay of uranium.

EXAMPLE/DOE

USDOE. 1994b, June. Title: Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Site Near Tuba City, Arizona. Corporate Author: . Pub: DOE/AL/62350-31F; 138 pp. Abstract: This document evaluates potential public health or environmental impacts resulting from ground water contamination at the former uranium mill site. The tailings and other contaminated material at this site were placed in a disposal cell on the site in 1990 by the DOE Uranium Mill Tailings Remedial Action (UMTRA) Project. The second phase of the UMTRA Project is to evaluate ground water contamination. This risk assessment is the first site-specific document under the Ground Water Project. It will help determine what remedial actions are necessary for contaminated ground water at the site.

EXAMPLE/DOE

USDOE. 1994c, April. Title: Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Site Near Shiprock, New Mexico. Corporate Author: . Pub: DOE/AL/62350-48F-Rev.1; 175 pp. Abstract: This baseline risk assessment at the former uranium mill tailings site near Shiprock, New Mexico, evaluates the potential impact to public health or the environment resulting from ground water contamination at the former uranium mill processing site. The tailings and other contaminated material at this site were placed in an on-site disposal cell in 1986 through the U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project. Currently, the UMTRA Project is evaluating ground water contamination. This risk

EP 200-1-8
15 Feb 96

assessment is the first document specific to this site for the Ground Water Project. There are no domestic or drinking water wells in the contaminated ground water of the two distinct ground water units: the contaminated ground water in the San Juan River floodplain alluvium below the site and the contaminated ground water in the terrace alluvium area where the disposal cell is located. Because no one is drinking the affected ground water, there are currently no health or environmental risks directly associated with the contaminated ground water. However, there is a potential for humans, domestic animals, and wildlife to be exposed to surface expressions of ground water in the seeps and pools in the area of the San Juan River floodplain below the site. For these reasons, this risk assessment evaluates potential exposure to contaminated surface water and seeps as well as potential future use of contaminated ground water.

EXAMPLE/DOE

USDOE/ORNL. 1992, September. Title: Preliminary Risk Assessment Report for Waste Area Grouping 1 at Oak Ridge National Laboratory, Oak Ridge, Tennessee. Corporate Author: Oak Ridge National Laboratory, Oak Ridge, TN. Pub: DOE/OR-1044&D1; ORNL/ER-132&D1; ORNL/ER/Sub/87-99053/60; 321 pp. Abstract: This Preliminary Risk Assessment Report (PRAR) presents the results of the preliminary human health evaluation (PHHE), preliminary environmental evaluation (EE), and hazard screening index (HSI) calculations for the Oak Ridge National Laboratory (ORNL) Waste Area Grouping (WAG) 1. The PHHE and EE analyze the risk to human health and the environment, respectively, from WAG 1 as a whole. The HSI prioritizes operable units on the basis of relative hazards to human health. The PRAR was prepared as part of the Phase 1 remedial investigation for WAG 1 under the ORNL Environmental Restoration program.

EXAMPLE/DOE

Yu, C.; Cheng, J.J.; Wallo III, A. Date: 1991, September. Title: Effect of Radon Dose on Cleanup Criteria and Using RESRAD for Chemical Risk Assessment. Corporate Author: Argonne National Laboratory, Environmental Assessment and Information Sciences Division, Argonne, IL. Pub: CONF-910981; Environmental Remediation '91: Cleaning Up the Environment for the 21st Century, D.E. Wood (ed.), Proceedings of a Conference, Pasco, WA, September 8-11, 1991, 970 pp.; (pp. 833-837) Abstract: The U.S. Department of Energy has used RESRAD, a pathway analysis program developed at

Argonne National Laboratory, in conjunction with the as-low-as-reasonably achievable (ALARA) principle to develop site-specific residual radioactive material guidelines (cleanup criteria) for radionuclides in soils at many sites. This study examines the effects of the radon pathway, recently added to the RESRAD program, on the calculation of uranium, radium, and thorium cleanup criteria. The results show that the derived uranium guidelines will not be affected by radon ingrowth considerations. The effect of radon on radium and thorium generic guidelines are more significant, but the model does indicate that at the generic soil limits used for radium and thorium, the indoor radon decay-product concentrations would be below the 0.02 working level standard. This study also examines the feasibility of applying RESRAD to chemical risk assessment. The results show that RESRAD can perform risk assessment of toxic chemicals after simple modifications. Expansion of the RESRAD database to include chemical compounds will increase its capability to handle chemical risk assessments.

EXAMPLE/EPA

Bernhardt, D.E.; Sandquist, G.M.; Bluck, W.V.; Jensen, L.; Meldgin, N. Date: 1987. Title: Remediation/Risk Assessment of Thorium Contaminated Sites in West Chicago. Corporate Author: Rogers & Associates Engineering Corporation, Salt Lake City, UT; CH2M Hill, Salt Lake City, UT; U.S. Environmental Protection Agency, Chicago, IL. Pub: CONF-870705; Proceedings of the Health Physics Society 32nd Annual Meeting, Salt Lake City, UT, July 5-9, 1987; Health Physics 52(Suppl. 1):S13 Abstract: Monazite ore processing operations were conducted at the Rare Earths Facility (REF) in West Chicago, Illinois, from the 1930's to 1973. The facility, which was owned and operated by several corporations, is presently owned by Kerr-McGee Chemical Corporation. Tens of thousands of cubic meters of radioactive waste materials from processing monazite ore were removed from the REF site and widely distributed to various locations in the West Chicago area. Studies and investigations have been conducted to identify these locations and determine the levels of contamination. The U.S. Environmental Protection Agency (EPA), the U.S. Nuclear Regulatory Commission (NRC), and the City of West Chicago studies have identified two major sites containing about 10,000 cubic meters each of thorium residuals; over 100 residential or commercial properties in West Chicago contaminated with the thorium residuals; a contaminated river and creek; and other contaminated properties in the West Chicago area. The two major sites are the West Chicago Sewage Treatment Plant and Reed-Keppler

EP 200-1-8
15 Feb 96

Park (West Chicago City park). The EPA placed these off-site contaminated areas on the proposed National Priorities List (NPL) for remediation. Subsequently, many of the sites have been remediated by Kerr-McGee. The paper focuses on the Remedial Investigation field studies and risk assessments performed by EPA, and mitigations performed by Kerr-McGee at the sites and the criteria for performing the actions.

EXAMPLE/EPA

Morris, S.C.; Rowe, M.D.; Holtzman, S.; Meinhold, A.F. Date: 1993, May. Title: National Radiation Exposures and Risks Caused by Implementing EPA's Proposed Revised National Primary Drinking Water Regulations. Corporate Author: Brookhaven National Laboratory, Upton, NY. Pub: BNL-49162; 53 pp. Abstract: This report estimates the risks to workers and the public that are associated with the treatment processes and their associated waste products that would be mandated under proposed regulations of radium, radon, and uranium in drinking water. Three scenarios were examined: (1) all wastes flushed to the sanitary sewer; (2) all wastes disposed on land; (3) similar to (2) but radon removal by granulated activated carbon rather than packed tower aeration. Risks considered included accidental injury and cancer. Worker risks for both scenarios I and II were estimated to be 0.025 and 0.01 deaths per year of operation for radium-226 and radium-228, respectively. Worker risks for uranium were estimated to be 0.13 deaths/year of operation for scenario I and 0.5 deaths/year of operation for scenario II. Worker risks for radon removal were estimated to be 1.7 deaths/year of operation for scenario I and 2.2 deaths/year of operation for scenario II. Risks to the public for scenarios I and II for radium-226 were $4 \times 10(E-4)$ and for radium-228 were $9 \times 10(E-5)$ deaths/year of operation. Risks to the public for scenarios I and II for uranium were $7.3 \times 10(E-2)$ and $2 \times 10(E-4)$, respectively. Risks to the public for scenario I and II for radon were 24 deaths/year of operation and for scenario III were nil. Public risks were quantified only for people exposed during a year of operation. For example, effects of public exposures in future years via groundwater contamination associated with landfill of treatment waste were not considered.

GENERAL/Commercial

AWMA. 1989. Proceedings - 82nd A&WMA Annual Meeting. 1989. Air & Waste Management Assoc, Pittsburgh, PA. Conference Proceedings - 82nd A&WMA Annual Meeting Anaheim, CA. 1989 Jun 25-30 v 4 1989.

Publ by Air & Waste Management Assoc, Pittsburgh, PA. Abstract- This conference proceedings contain 69 papers presented at the Air and Waste Management Annual Meeting in June 1989. Topics covered include: Handling, Licencing, Minimizing, siting and development of hazardous and mixed waste, Atmospheric Emissions from accidental releases and their modelling and health hazards, emergency response, public awareness, risk communication programs and issues related to these communications, Risk Assessment and uncertainty analysis, Health risk assessment for specific chemicals, Transportation of Toxic and hazardous materials, Environmental Impairment Liability Insurance and issues related to it, Alternative fuels, and then impact on the environment, Air Pollution Analysis, measurement techniques and instrumentation.

GENERAL/Commercial

CDM. 1985. Title: Application of Quantitative Risk Assessment to Remedial Measures Evaluation at Abandoned Sites. Corporate Author: Camp, Dresser and McGee, Boston, MA. Publication: Hazardous Wastes and Environmental Emergencies, Proceedings of a National Conference, Cincinnati, OH, May 14-16, 1985. (pp 234-238).

GENERAL/EPA

ICF, Inc. 1986. Risk Assessment Information Directory. EPA Contract No. 69-01-7090.

GENERAL/Other

FCCSET. 1992. Risk Assessment: A survey of characteristics, applications, and methods used by federal agencies for engineered systems. Federal Coordinating Council for Science, Engineering, and Technology. Ad Hoc Working Group on Risk Assessment. Nov. 1992.

METHODOLOGY/Commercial

Dove, F.H.; Marshall, T.C.; Seiler, F.A. Date: 1991, September. Title: Baseline Risk Assessment Methodology for Mixed Waste. Corporate Author: International Technology Corporation, Albuquerque, NM. Pub: CONF-910981; Environmental Remediation '91: Cleaning Up the Environment for the 21st Century, D.E. Wood (ed.),