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NEWS & ANALYSIS

Institutional Controls or Emperor's Clothes? Long-Term Stewardship of the Nuclear Weapons Complex

by John S. Applegate and Stephen Dycus

Editors'Summary: DOE is responsible for managing as many as 8) geographic sites that are contaminated with long-lived hazardous and radioactive materials. The longevity of these Wastes will require long-term stewardship at these sites in order to protect both human health and the environment. This Article discusses the challenges that DOE faces in developing an effective long-term stewardship program. The authors begin with an overview of DOE's waste management program and a description of its long-lived wastes. They proceed to examine the statutory framework—primarily CERCLA and RCRA—for addressing such wastes. The authors find that the statutes and regulations fail to impose effective restrictions on the future use of contaminated property and do not establish the types of institutions that are necessary to manage long-lived wastes. Next, the authors describe the various waste management options that DOE currently uses or plans to use. They also identify a number of institutional controls that DOE could utilize to restrict future uses at sites holding long-lived wastes. They conclude that existing institutional controls are not likely to be effective over the long term. Therefore, the authors advocate the development of new legal instruments, procedures for current decisionmaking, and stewardship institutions that will ensure the successful long-term management of long-lived wastes.

The U.S. Department of Energy (DOE) is in the midst of a massive program to clean up the toxic and radioactive waste[1] generated by *50* years of designing, manufacturing, and testing nuclear weapons. Mandated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)[2] and the Resource Conservation and Recovery Act (RCRA),[3] DOE's environmental management (EM) program is easily the largest and most complex environmental remediation project in the world. The project is rendered much more difficult by the character of DOE's waste stream, which includes radionuclides that will remain extremely dangerous for thousands or even millions of years.

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DOE's current plans for cleanup of the U.S. nuclear weapons complex rely heavily on "institutional controls" to help meet its long-term stewardship obligations. Such controls are intended to restrict future uses of contaminated or depository sites in order to prevent contact with hazardous wastes or wider dispersal of those wastes into the environment. However, DOE is only just beginning to assess the long-term management implications of such controls.[4]

While long-term management is occasionally mentioned in the relevant statutes and regulations, the practical problems of ensuring lasting protection of human health and the environment remain largely unresolved. The as yet unmet

[1] Unless the context indicates otherwise, this Article uses "waste" broadly to describe unwanted hazardous materials in the wide variety of forms found at DOE sites. because the relevant statutes use several different terms to describe such materials. In this usage, "waste" includes materials that DOE regards as "inventory" because they are not currently in use but have not been declared surplus or waste. *See* OFFICE OF ENVIRONMENTAL MANAGEMENT, US. DOE, TAKING STOCK: A LOOK AT THE OPPORTUNITIES AND CHALLENGES POSED BY INVENTORIES FROM THE COLD WAR ERA 3-12 (DOE/EM *0275)* (1996).

[2] 42 U.S.C. §§9601-9674, ELR STAT. CERCLA §§101-405.

[3] *Id* §§6901-6992k. ELR STAT. RCRA II 1001-1 1012. RCRA and CERCLA apply to federally and privately owned facilities. *Id* 6991f, ELR STAT. RCRA §9007; *id* §9620, ELR STAT. CERCLA §120.

[4] DOE has commissioned several studies of long-term stewardship (including institutional controls, stewardship organizations, and data management), drafted its own overview of the long-term management needs of its sites, and is seeking the advice of its stakeholders on the issue. *See, e.g.,* OAK RIDGE RESERVATION END USE WORKING Group, STAKEHOLDER REPORT ON STEWARDSHIP (1998)

challenge to the legal system is to create instruments and institutions that require (or at least permit) stewardship activities to be continued over an extremely long period of time. It is also critically important to develop ways of incorporating long-term consequences and management needs into present cleanup decisionmaking.

This Article identifies some of the many intersections of long-term stewardship and the law. More importantly, it highlights this serious challenge to DOE's waste management program and, by extension, to all waste management programs that rely on environmental isolation or land use restrictions to address long-lived hazardous and radioactive wastes. The Article begins with an overview of DOE's EM program and a description of its long-lived hazardous wastes. Next, it examines the legal structure for addressing those wastes and their longevity. It then describes the various management options available to DOE and the requirements of each for long-term stewardship. It also chronicles some of the growing evidence that existing strategies for controlling land use will be inadequate to the task. While a detailed prescription or legislative proposal would be premature, the Article concludes with an urgent plea for the development of procedures and institutions capable of protecting future generations from this deadly legacy of the Cold War.

Overview of DOE's EM Program

The federal government spends between *$5* and $6 billion each year on the EM program,[5] and estimates of the total cost of cleaning up the entire weapons complex range from $147 billion[6] to *$350* billion,[7] depending on the scope of work. DOE is responsible for hundreds of waste streams, ranging from traditional industrial wastes, like asbestos and mercury, to extremely radioactive acids, sludges, and spent nuclear fuel rods. Some of the materials at DOE's sites are held as wastes per se (i.e., awaiting disposal), some contaminate environmental media like soil and groundwater, and some are materials in inventory with little likelihood of eventual use.[8] The EM program is responsible for 134 geographic sites.[9] Active remediation was completed by 1997 at 60 of these sites, and 21 relatively small sites have been transferred to the U.S. Army Corps of Engineers.[10] Of the 53 sites remaining, completion dates for 43 range from 1998 to 2008 and 10 extend out as far as *2050.*[11] As many as 81 sites will require active long-term surveillance and monitoring.[12] Many more will employ passive controls on land use.

Many DOE sites with long-lived wastes are located near substantial human populations. The sites that DOE currently expects to require long-term stewardship are shown on the map on the following page. Except at the Yucca Mountain and Waste Isolation Pilot Plant (WIPP) geologic repositories, wastes will not be buried deep in the earth. They will therefore require even greater efforts to keep them effectively isolated over the long term. DOE's and its regulators'reasons for leaving long-lived hazardous wastes at such widely dispersed sites are the familiar combination of cost, the limits of existing treatment technology, transportation and other remediation risks, and the political difficulties of moving waste from state to state. Whatever the reason, DOE's responsibility for most sites will not end with completion of the cleanup activities currently underway.

Longevity also characterizes the wastes themselves. One is accustomed to thinking about radioactive materials in terms of time; half-lives are a familiar part of their description. Many of the radioactive elements and radioisotopes that DOE manages will remain dangerously radioactive for thousands or millions (in the case of uranium-238, billions) of years. DOE must also handle the nonradioactive hazardous wastes that typify private industrial sites. Although the latter materials are not usually thought of in temporal terms, for all practical purposes elements like mercury and minerals like asbestos will last forever. Such long-lived wastes can be stabilized, isolated, or immobilized, but as a practical matter they cannot be destroyed.[13] They will remain in the environment—in more

[5] As a measure of scale, this is twice the annual public and private expenditures on nonfederal Superfund cleanups, and nearly the equivalent of the U.S. Environmental Protection Agency's (EPA's) entire annual budget. KATHERINE N. PROBST & MICHAEL H. McGOVERN, LONG-TERM STEWARDSHIP AND THE NUCLEAR WEAPONS COMPLEX THE CHALLENGE AHEAD viii (Resources for the Future 1998).

[6] OFFICE OF ENVIRONMENTAL MANAGEMENT, U.S. DOE, -ACCELERATING CLEANUP: PATHS TO CLOSURE 2-5(1998) [hereinafter PATHS TO CLOSURE].

[7] OFFICE OF ENVIRONMENTAL MANAGEMENT, U.S. DOE, 1996 BASELINE ENVIRONMENTAL MANAGEMENT REPORT 4-1 to 4-2(1996) [hereinafter BEMR].

[8] There is a continuum from contained waste awaiting disposal to contaminated media. Because contaminated media usually present lower concentrations of the hazardous constituents, higher total volumes of material, and greater dispersion in the environment, they tend to be managed differently from contained waste.

[9] See PATHS TO CLOSURE, supra note 6. at C-3.

[10] Id.

[11] Id, at C-3 to C-9.

[12] *IS* at 2-10.

[13] Some radioactive wastes may be transmuted in a reactor or accelerator into shorter-lived or more stable isotopes, or into nonradioactive elements. Development of a practical process has been under study at DOE for a number of years, although some fear that it might be prohibitively expensive or might even create more dangerous waste than it destroys. *See* Daniel Gibson, *Can Alchemy Solve the Nuclear Waste Problem?* BULL ATOM. scientists, July/Aug. 1991, at 12; KS. SHRADER-FRECHETTE, BURYING UNCERTAINTY RISK AND THE CASE AGAINST GEOLOGICAL DISPOSAL OF NUCLEAR WASTE 234(1993). Ironically, it was the transmutation of uranium to plutonium and

and less stable configurations—indefinitely.[14]

This temporal dimension of hazardous wastes requires the rethinking of the management of Superfund sites. The life cycle of a Superfund site at which hazards remain is pictured in the following diagram, in which the upper line indicates time periods and associated activities at the site, and the lower line identifies the distinct risk profiles across time.[15]

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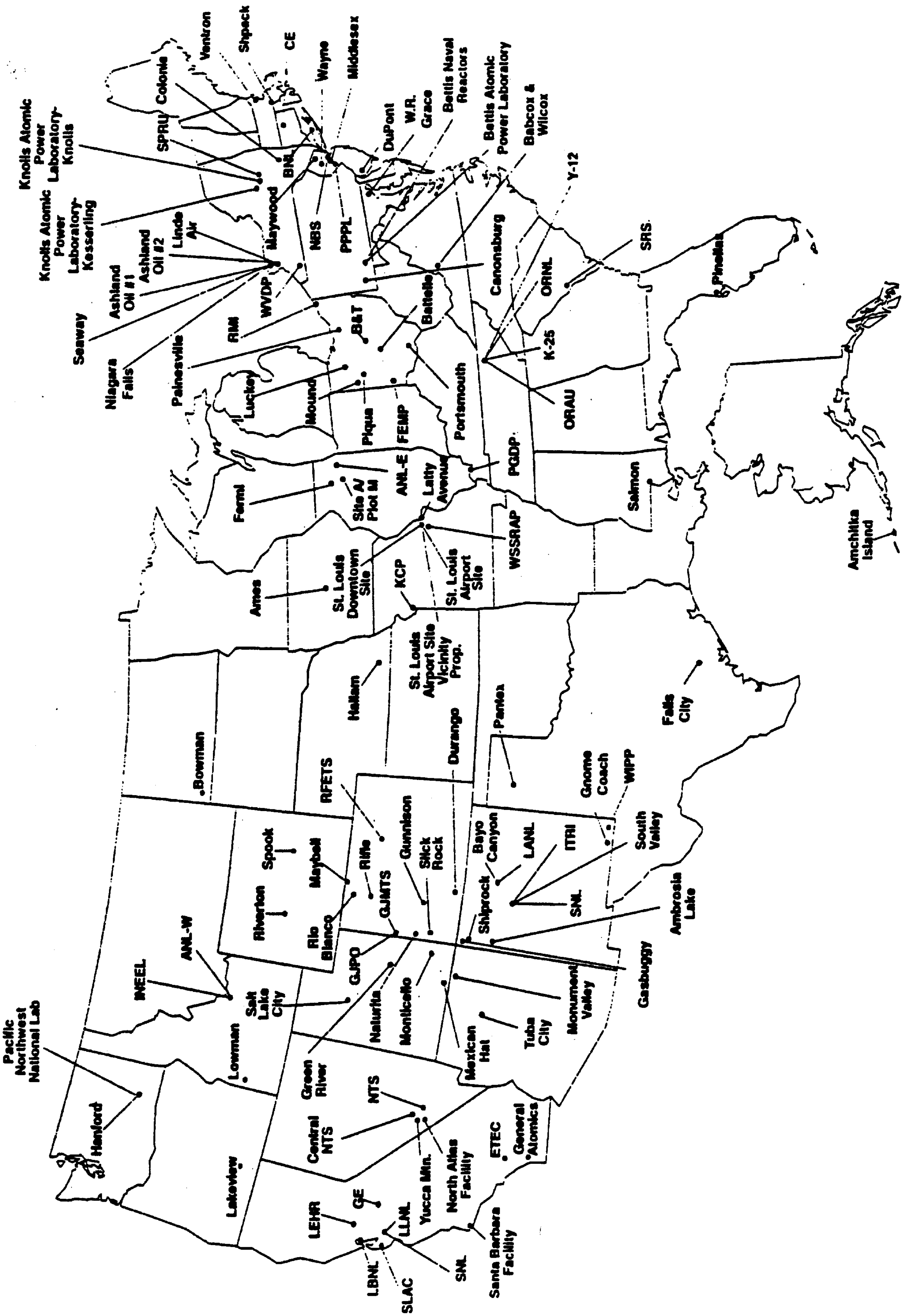
the subsequent separation of plutonium that created DOE's high-level waste, which is arguably its most dangerous waste. OFFICE OF ENVIRONMENTAL MANAGEMENT, U.S. DOE, LINKING LEGACIES: CONNECTING THE COLD WAR NUCLEAR PRODUCTION PROCESSES TO THE ENVIRONMENTAL CONSEQUENCES 171 (1997) [hereinafter LINKING LEGACIES].

[14] *See generally* OFFICE OF TECHNOLOGY ASSESSMENT, SUPERFUND STATELY 226-27 (1985) (criticizing a policy of containing rather than treating hazardous wastes, and suggesting a policy of interim responses to wastes that cannot be treated).

[15] This is a modified version of Figure 2 in John S. Applegate & Ste. then Wesloh, *Short ChangngShon-TermRisk.~A Study of CERCLA Remedy Selection, 15* YALE *J. ON Reg.* (forthcoming 1998).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Bettis Naval Reactors
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Ashland Oil #1
Seaway
Niagara Falls
WVDP
RMI
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Battelle
Canonsburg
ORNL
SRS
Pinellas
K-25
ORAU
Painesville
Luckey
Mound
Piqua
FEMP
Portsmouth
PGDP
Salmon
Fermi
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Latty Avenue
WSSRAP
Amchitka Island
Ames
St. Louis Downtown Site
KCP
St. Louis Airport Site
St. Louis Airport Site Vicinity Prop.
Hallam
Durango
Pantex
Falls City
Bowman
RFETS
Gnome Coach
WIPP
Spook
Maybell
Rifle
Gunnison
Slick Rock
Bayo Canyon
LANL
ITRI
South Valley
Riverton
Rio Blanco
GJMTS
Shiprock
SNL
Ambrosia Lake
ANL-W
INEEL
Salt Lake City
GJPO
Naturita
Monticello
Mexican Hat
Tuba City
Monument Valley
Gasbuggy
Pacific Northwest National Lab
Hanford
Lowman
Green River
NTS
Central NTS
Yucca Mtn.
North Atlas Facility
ETEC
General Atomics
Lakeview
LEHR
GE
LLNL
SNL
Santa Barbara Facility
LBNL
SLAC

Pre-Industrial Use	Uncontrolled Past	Polluted Present	Remediation	Foreseeable Future ("End State")	Long-Term Stewardship
Background Risk/Pristine	*Increasing Risk*	*Baseline Risks*	*Transition Risks*	*Target or Residual Risks*	*Long-Term Risks*

The early phases of the "life cycle" are familiar. A period of "pre-industrial use" existed first. It represents the "background" or naturally occurring risk level that would be achieved by returning a site to a "pristine" or "greenfields" condition. The "uncontrolled past" encompasses the industrial activities that led to the current situation. The "polluted present" reflects the unremediated baseline risk of the site. The "remediation period" covers the cleanup activities themselves, which, ironically, pose their own risks to health and the environment.[16] Completion of remediation activities should achieve a target or residual risk in the "foreseeable future," but will seldom result in the removal of all hazardous materials from a site. The long-term future extends to the time when waste or contamination remaining at a site is no longer hazardous to human health or the environment. "Long-term stewardship"—this Article's concern—includes the activities necessary to maintain protection of human health and the environment from the residual waste at a site.

The problems of long-term management of radioactive waste at the proposed Yucca Mountain and WIPP geologic repositories have been extensively examined elsewhere.[17] In contrast, the management of long-lived wastes at other DOE sites has been almost entirely neglected, even though DOE expects to manage the vast majority of these wastes by placing them in on-site engineered disposal facilities, isolating them in their present locations, or simply leaving them where they are.[18]

The Problem of Long-Lived Wastes

The U.S. nuclear weapons complex had its origins in 1942 as the Manhattan Engineer District of the U.S. Army Corps of Engineers (the Manhattan Project), which produced the atomic bombs dropped on Japanese cities at the end of World War II.[19] With the passage of the Atomic Energy Act of 1946,[20] development and production of nuclear weapons were taken up by the Atomic Energy Commission. That work was transferred to the Energy Research and Development Administration from l975-1977,[21] and then to DOE.[22] Almost all weapons production stopped in 1989, and since that time a large share of the DOE budget has been devoted to cleaning up contamination remaining throughout the weapons complex and to disposing of radioactive wastes.

Radioactive waste was generated at every step in the weapons production process. The mining, milling, and refining of uranium, one of the basic raw materials, created a landscape of tailings piles and other detritus at locations in several states. The uranium ore was refined and formed into metal products at DOE foundries. Some of the uranium was then combined with fluorine to make a highly corrosive gas from which uranium-235 (the fissionable isotope) could be separated. The remainder was fashioned into fuel rods and used in reactors to produce plutonium, the main fuel of most nuclear weapons. Some of the fuel rods now constitute waste that must be disposed of. Others were treated with acids and other chemicals to allow the plutonium and highly enriched uranium in them to be extracted and refined. This chemical process generated more than 85 percent of the radioactivity remaining in weapons complex wastes, and almost all of that is mixed with nonradioactive hazardous materials. Fabrication of the refined materials into actual bomb components produced another stream of radioactive and industrial wastes at several DOE sites.

The industrial processes of refining and machining metals (including radioactive ones) also used common solvents like benzene and toluene, cyanide, petroleum products, and volatile organic compounds. Similarly, the weapons complex used huge amounts of electricity and heat, so polychlorinated biphenyls (PCBs) and asbestos also abound. (At some sites, the buildings themselves were made of transite siding, a mixture of asbestos and cement, which is now contaminated with radioactive dust.) Several nonradioactive toxic metals were used in production, including the familiar Superfund villains chromium, lead, and mercury. Finally, testing of the weapons themselves—nuclear

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[16] *See Id.* (describing nature and extent of transition risks).

[17] *See, e.g.*. James Flynn et al., One Hundred Centuries of Solitude: Redirecting America's High-level Nuclear Waste Policv (1995); NATIONAL RESEARCH COUNCIL, TECHNICAL BASES FOR YUCCA MOUNTAIN STANDARDS (1995) [hereinafter TECHNICAL BASES FOR YUCCA MOUNTAIN STANDARDS]; SHRADER-FRECHETTE, *supra* note 13; NATIONAL RESEARCH COUNCIl.., RETHINKING HIGH-LEVEL RADIOACTIVE WASTE DISPOSAL: A POSITION STATEMENT OF THE BOARD ON RADIOACTIVE WASTE MANAGEMENT (1990); Chris 0. Whipple, *Can Nuclear Waste Be Stored Safely at Yucca Mountain?* Sci. AM.., June 1996, at 72; Kristin Shrader-Frechette, *Risk Estimation and Expert Judgment: The Case of Yucca Mountain,* 3 RISK, SAFETY, HEALTH & ENVT. 283 (1992). For recent developments *see* James Brooke, *Underground Haven, or a Nuclear Hazard? N.Y.* TIMES, Feb. 6, 1997, at A14; Matthew L. Wald, *Doubt Cast on Prime Site as Nuclear Waste Dump,* N.Y. TIMES, June 20,1997, at A12. Broader discussions of the long-term issues posed by nuclear waste may be found in Equity ISSUES IN RADIOACTIVE WASTE MANAGEMENT (Roger E. Kasperson ed., 1983) [hereinafter EQUITY ISSUES], which contains many useful essays on different aspects of the subject, and EDITH BROWN WEISS, IN FAIRNESS TO FUTURE GENERATIONS: INTERNATIONAL EQUITY 169-91 (1989).

[18] See generally Office of Environmental Management, U.S. DOE, Charting the Course: The Future Use Report (DOE/EM 0283) (1996) [hereafter Charting the Course].

[19] The production of nuclear weapons and its environmental legacy are described in detail in LINKING LEGACIES, *supra* note 13; OFFICE OF TECHNOLOGY ASSESSMENT, THE ENVIRONMENTAL LEGACY OF NUCLEAR WEAPONS PRODUCTION (1991); BEMR, *supra* note 7; OFFICE OF ENVIRONMENTAL MANAGEMENT, U.S. DOE, CLOSING THE CIRCLE ON THE SPLITTING OF THE ATOM (1995); *see also* STEPHEN DYCUS, NATIONAL DEFENSE AND THE ENVIRONMENT 80-124 (1996) (reviewing the Cold War legacy of both DOE and the U.S. Department of Defense).

[20] Ch. 724, 60 Stat. 755.

[21] Pub. L. No. 93-438, 88 Stat. 1233 (1974).

[22] Pub. L. No. 95-91, §301, 91 Stat. 565, 577 (1977) (codified as amended at 42 U.S.C. §7151).

detonations in the atmosphere and underground—left soils and groundwater contaminated at sites from Alaska and Hawaii to Mississippi, and especially at the Nevada Test site north of Las Vegas.

These activities have left radioactive and hazardous materials in four general configurations, each of which poses a threat to human health and the environment, and in the case of fissile materials (weapons-grade uranium and plutonium) to national security:

- wastes already regarded as such, from the nuclear weapons production process or from the cleanup of the weapons complex, stored in barrels, tanks, lagoons, pits, boxes, and other containers;
- contaminated soils, surface water, sediments, and groundwater, which resulted from the uncontrolled release of hazardous materials into the ambient environment;
- contaminated structures, such as production buildings and waste storage facilities; and
- usable radioactive materials remaining "in inventory."[23]

The materials of concern in the various configurations fall into several legal or regulatory categories:

- spent nuclear fuel, that is, irradiated reactor fuel rods;[24]
- high-level wastes, mainly derived from the reprocessing of fuel rods or targets to extract plutonium and other fission products;[25]
- transuranic (TRU) wastes, mostly clothing and other items contaminated with plutonium;[26]
- low-level radioactive wastes, some of which, despite the name, are as hazardous as high-level wastes;"[27]
- nonradioactive hazardous waste, the industrial legacy of the nuclear weapons program;[28]
- mixed low-level wastes, low-level radioactive wastes that are combined with chemically hazardous wastes;[29]
- uranium mill tailings, the enormous volumes of broken rock spoil from the mining of uranium ore, which produce radon;[30]
- uranium and thorium production byproducts, also known as 11e.(2) material;[31]
- contaminated soil and water, which represent by far the greatest volume of DOE's wastes.[32]

These categories are subject to overlapping regulation by DOE, the Nuclear Regulatory Commission (NRC), the U.S. Environmental Protection Agency (EPA), and the states. Where there is concurrent authority, typically the NRC specifies design and issues licenses, EPA sets the standards for environmental protection, and owns and builds the physical facilities. This is a recipe for confusion, but for the most part, the regulatory details are not of concern here.[33] Many of

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[23]This particular division follows LINKING LEGACIES, *supra* note 13. *See also* PROBST and McGOVERN, *supra* note 5, at 9-11.

[24]42 U.S.C. § 10101(23); 40 C.F.R. § 191.02(g) (1997) (definition); ***it).*** Pt. 191 (1997) (regulation). DOE considers its spent nuclear fuel a material in inventory, because it can be reprocessed to recover other products; however, commercial spent nuclear fuel is treated as high-level waste, to be disposed of in a geologic repository. 42 U.S.C. 110131 (Yucca Mountain).

[25]42 U.S.C. § 10101(I2XA), (B); 10 C.F.R. *60.2(1998); DOE Order No. 5820.2A (definition); 42 U.S.C. §10131; 40 C.F.R. pt. 191 (1997); 10 C.F.R. pt. 60 (1998) (regulation). It is to be disposed of in a geologic repository.

[26]40 C.F.R. §191.02(i) (definition); *Id*, pts. 191, 194 (1997) (regulation). TRU means an element (or isotope thereof) that is heavier than uranium ("beyond'uranium on the periodic table). This would indude, for example, plutonium and americium. TRU waste is defined in DOE Order No. 5820.2A.

[27]42 U.S.C. §2021b(a); 10 C.F.R §§61 .55.61.2(1998) (definition); 40 C.F.R. Pt. 61(1997) (regulation). Under the Low-Level Radioactive Waste Policy Act, 42 U.S.C. §12021b-2021j, low-level radioactive wastes are radioactive wastes that are not otherwise classified. Because other radioactive wastes are classified isotopically or by source, the remainder are not necessarily less hazardous. Certain isotopes of radium, for example, are technically low-level waste but are extremely radioactive.

[28]42 U.S.C. §6903(5), ELR STAT. RCRA §1004(5); 40 C.F.R. pt. 261 (1997) (definition); 42 U.S.C. §6924, ELR STAT. RCRA §3004; 40C.F.R. pL 264(1997) (regulation). Radioactive wastes are ~peciflca1ly excluded from RCRA's coverage. 42 U.S.C. §6903(27), k2~LR STAT. RCRA §1004(27).

[29]This was defined as a separate category in the Federal Facilities Compliance Act. 42 U.S.C. §6903(41), ELR STAT. RCRA §1004(41). Generally speaking, mixed waste must be treated according to the regulatory requirements for both radioactive *and* hazardous characteristics. *Id.* §6939c(b). ELR STAT. RCRA §3021(b) (requiring mixed waste to meet the same treatment standards as hazardous waste under RCRA §3004(m). in addition to radiologic controls).

[30]Mill tailings are extremely large in volume and relatively low in radioactivity, though they do emit substantial amounts of radon, a daughter product of uranium. 42 U.S.C. §7911(8) (definition). They are regulated under the Uranium Mill Tailings Radiation Control Act (UMTRCA), 42 U.S.C. §§7901-7942; 40 C.F.R. Pt. 192(1997); 10 C~F.R. §40.27 & app. A. (1997).

[31]These are defined and regulated by the Atomic Energy Act, 42 U.S.C. *§2011.5cc it).* §2014(e)(2) (definition); *it).* §2113; IOC.F.R. p1. 61(1998) (regulation).

[32]*Contaminated environmental media are governed by CERCLA,* 42 U.S.C. § 9601(14), ELR Stat. CERCLA §101(14), and the contained-in policy under RCRA. 40 C.F.R. §261.3(a)(2), (c)(1), (d) (1997). See Chemical Waste Management, Inc. v. U.S. EPA, 869 F.2d 1526, 1537-40, 19 ELR 20641, 20646-48 (D.C. Cir. 1989) (upholding EPA's interpretation of 40 C.F.R. §261.3); see also Jeffrey M. Gaba, The Mixture and Derived-From Rules Under RCRA: Once a Hazardous Waste Always a Hazardous Waste?, 21 ELR 10033, 10042 (Jan. 1991) (describing the legal status of the contained-in policy). EPA proposed to codify its contained-in policy in a new 40 C.F.R. p1.269. U.S. EPA, Requirement for Management of Hazardous Contaminated Media, 61 Fed. Rag. 18780 (Apr. 29.1996). Final action is expected in 1998. DOE must manage 79 million cubic meters of soil and 1,800 million cubic meters of water (mainly groundwater). LINKING LEGACIES, *supra* note 13, at 72.

[33]For reasonably accessible overviews of this regulatory structure, see PATRICK 3. ROHAN, *Radioactive Waste*, in 4 ZONING AND LAND USE CONTROLS 25B-l to 25B-61 (1997); Charles H. Montange, *Federal Nuclear Waste Disposal.* 27 NAT. RESOURCES 3. 309

DOE's wastes are extremely long-lived. They include industrial pollutants commonly found in CERCLA remediations, such as heavy metals, that do not break down over time. Of even greater concern for DOE are the many radionuclides in its wastes. The rule of thumb is that radio-active materials are hazardous for about 10 times their half-life;[34] thus, strontium-90, with a half-life of a modest 29 years, poses a significant hazard for nearly 3 centuries.[35] Plutonium-239—a principal product of the nuclear weapons complex, a major item in inventory, a common constituent of TRU waste, and a soil contaminant at Rocky Flats and elsewhere—has a half-life of approximately 24,000 years. Plutonium is one of the most hazardous materials known; inhalation of an almost infinitesimal amount is nearly certain to cause lung cancer. And uranium-238—an alpha-emitting radionuclide, highly dangerous to the lung, and a heavy metal with deleterious effects on the kidney—has a half-life of *4.5 billion* years. Moreover, these materials' decay products are often themselves very dangerous. Uranium decays into radon, which is short-lived and poses a significant lung cancer risk in confined spaces.[36]

The treatment and disposal options for all of these materials are extremely limited. Because they are nearly indestructible, such materials cannot be treated to reduce their toxicity.[37] They can be treated to reduce their volume or their mobility in the environment: Wet material can be dried or mixed with a solidifying agent; dry material can be enclosed in a matrix of concrete, plastic, or glass. A stabilized material is less likely or will take longer to leak out of a disposal facility and into or through the environment, or it will do so in significantly lower concentrations. Even after a stabilized material is disposed of, however, it must be isolated for the entire time that it remains hazardous.

Cleanup *Versus* Remediation: How Dirty Is Clean?

In 1980, Congress enacted sweeping legislation to clean up hazardous materials that had been disposed of and were being released into the environment.[38] In 1986, CERCLA was extended to federally owned facilities that otherwise meet the criteria for coverage.[39] The CERCLA remediation process and environmental standards for federal facilities are generally the same as for private ones, with some changes to permit enforcement against the federal government. RCRA regulates active hazardous waste treatment, storage, and disposal facilities, and it requires the remediation of RCRA-permitted facilities. Such "corrective actions"[40] apply to federally owned facilities as well as to private ones.[41] The use of the terms "cleanup"[42] and "corrective ● action," as opposed to the more tentative "remedial" or "re-sponse" actions,[43] may suggest that the hazardous materials can simply be made to disappear. However, even if all the long-lived material is removed from one site, it will continue to exist at a disposal site (ideally but not necessarily in a more stable and isolated configuration), unless it can be treated to render it no longer hazardous. For long-lived wastes, in other words, CERCLA and RCRA simply establish the terms under which such wastes will remain in the environment.

CERCLA and Its ARARs

CERCLA's criteria for cleanup[44] are a potpourri of congres-sional aspirations and preferences, although EPA has largely succeeded in rationalizing them in its national contingency plan (NCP), the regulatory blueprint for remedy selection.[45] The

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(1987); Karen *Geer, Below Regulatory Concern: The Nuclear Regulatory Commission's Solution for Radioactive Waste Management.* 2 Fordham ENVTL. L. REP. 139 (1991).

[34] PROBST and McGovern, *supra* note 5, at 13. The half-life of a radionuclide is the time in which half of a given amount decays into a "daughter" product. Because the amount of the material remaining after the first half-life has elapsed also decays at the same rate (i.e., one-half will decay over that period of time), much more than two half-lives are required for the substance to disappear. After 7 half-lives, less than 1 percent of the material remains; after 10 half-lives, less than 0.1 percent of the original activity remains. The degree of residual hazard depends, of course, on the initial radioactivity. It should also be noted that the "daughter" product may be more radioactive than the original material.

[35] The shorter the half-life, the greater the radioactivity, because more energy-releasing disintegrations are occurring. Thus, a short-lived radionuclide, as a general rule, is a greater health concern than a long-lived one, because of the intensity of the ionizing radiation it produces. Therefore, a given mass of strontium-90, which is a very great health concern, will continue to be a very great health concern for 290 years, nearly half again the age of the United States. *See* LINKING LEGACIES, *supra* note 13, at 34-35.

[36] *See* U.S. EPA, Standards for Remedial Actions at Inactive Uranium Processing Sites, 48 Fed. Reg. 590, *597* (Jan. 5, 1983) [hereinafter Standards for Remedial Actions] ("tailings will remain hazardous for hundreds of thousands of years").

[37] Many could be diluted, of course, and the nature of radioactivity is such that dilution may be a defensible technique (for example, radon concentrating in basements is remediated by venting to the ambient air, where it disperses). Nevertheless, EPA does not generally regard dilution as an appropriate treatment technique for toxic hazards. *See* 40 C.F.R. §268.3(1997); Chemical Waste Management, Inc. v. U.S. EPA. 976 F.2d 2, 19-20,23 ELR 20024,20032-33 (D.C. Cir. 1992), *ccii. denied,* 507 U.S. 1057 (1993).

[38] Pub. L. No. 96-510, 94 Stat. 2767 (1980).

[39] 42 U.S.C. §9620, ELR Stat. CERCLA §120

[40] *Id.* §§6924(v), 6928(h), 6942(u), 6991b, ELR STAT. RCRA §§3004(v), 3008(h), 4002(u), 9003.

[41] *Id.* §§6903(15), 6961, ELR STAT. RCRA §§1004(15), 6001. The Federal Facility Compliance Act of 1992. Pub. L. No. 102-386, 106 Stat. 1505, confirmed that state RCRA programs are enforceable against the federal government. 42 U.S.C. §6991f(a), ELR STAT. RCRA §9007(a). Even earlier, President Carter declared that federal facilities would comply with all applicable pollution control laws. Exec. Order No. 12088,43 Fed. Reg. 47707 (Oct. 13, 1978).

[42] *See, e.g.,* 42 U.S.C. §9621. ELR STAT. CERCLA §121 (cleanup standards).

[43] *See. e.g., Id.* §9604, ELR STAT. CERCLA §104 (response authorities).

[44] *Id.* §9621(b), (d), ELR STAT. CERCLA §121(b), (d).

[45] The NCP can be found in 4.0 C.F.R. Pt. 300 (1997). Section 300.430 is of most direct relevance to our concerns. For a critical review of the statutory provisions and their regulatory interpretation as they relate to the Superfund life cycle, see Applegate & Wesloh, *supra* note 15.

NCP organizes the statutory commands into three tiers consisting of nine criteria.

The first tier consists of two threshold criteria that must be met in all cases: (1) "overall protection of human health and environment";[46] and (2) compliance with "applicable or relevant and appropriate requirements" (ARARs) of other federal or state laws.[47] Overall protectiveness is measured primarily by achievement of a residual risk within the range of one in ten thousand (1x10-4') to one in one million (1x10-6) excess lifetime individual risk of cancer among members of the public.[48] (Harm to the nonhuman "environment" is also considered, but it tends to be emphasized less, in large part because it is more difficult to measure.) ARARs are often the decisive measure of cleanup levels, however, because they provide clearer operational guidance for specific remedial actions than generic risk levels do.[49] ARARs drawn from RCRA hazardous waste disposal requirements, radioactive waste disposal regulations under the Atomic Energy Act (AEA),[50] and the Safe Drinking Water Act's (SDWA's)[51] standards for groundwater are among the most important and most frequently encountered in DOE's cleanup program. Balancing criteria, the second tier, may be traded off against each other. They include: (3) the long-term effectiveness and the permanence of the remedy;[52] (4) the use of treatment to reduce toxicity, mobility, or volume of contamination,[53] *(5)* short-term effectiveness, that is, the risks of the remedial activities themselves;[54] (6) implementability (i.e., the technical and administrative feasibility) of the remedy;[55] and (7) the capital and operational costs of the remedy.[56] The balancing criteria display a continuing concern for the long-term effects of environmental contamination, and CERCLA itself includes clear preferences for remedies that utilize treatment and maximize long-term efficacy.[57] In fact, the federal facilities section of CERCLA specifically requires that remediation agreements include "arrangements for long-term operation and maintenance" of the relevant facility.[58]

The modifying criteria, the third tier, are: (8) state (governmental) acceptance[59] and (9) community (general public) acceptance.[60] They are of distinctly lesser importance, coming into play only *after* a preferred remedy has been selected.[61]

Even as it applies to long-lived wastes, CERCLA does not anticipate that all hazardous substances will be removed, leaving a site that is totally clean in the sense of returning to a pre-industrial condition or background level of risk. Rather, it permits the continued existence of contaminants at a site, so long as their calculated residual risk does not exceed the stated risk range. The use of a risk-based cleanup standard is important in this context, because one element of risk is exposure: remove or reduce the exposure, and you remove or reduce the risk.[62] Thus, residual contamination that is either so diluted or so isolated that only minimal human (or ecological) contact can be expected presents a relatively low residual risk level, despite the continued existence of the contamination. This is of obvious significance for hazardous materials that cannot be made less hazardous by treatment. Although CERCLA does not place temporal limitations on its mandate to protect human health and the environment, EPA's NCP regards long-term effectiveness as a preference (as opposed to a threshold requirement) that can be outweighed by other considerations, such as cost. Given the enormous expense of the DOE cleanup program and the increased pressure on the federal budget, one can expect an effort to emphasize the cost factor and find alternatives to expensive remedies.

CERCLA's incorporation of other statutes as ARARs does not change the situation significantly. For long-term stewardship purposes, the most important ARARs are the

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[46] 40 C.F.R. §300.430(e)(9Xw)(A) (1997).

[47] *Id.* §300.430(eX9)(iii)(B).

[48] *See itt* §300.430(e)(2XIXAX2).

[49] *See* Alex S. Karlin, *How Long Is Clean? The Temporal Dimension to Protecting Human Health Under Superfund,* 9 NAT. RESOURCES a Eiwr. 7,48(1994); Elizabeth H. Temkin, *Cleaning Up ARARs: Reflections From the Field,* 6 NAT. RESOURCES & ENV. 18,51(1992).

[50] 42 U.S.C. § §201 l-2297g-4. Most ABA authorities are exercised by the NRC and DOE, but several were transferred to EPA when EPA was created in 1970. Proposed EPA regulations for radiation site cleanup were withdrawn in December 1997 after submission to the Office of Management and Budget because of a dispute between EPA and the NRC. EPA has instead issued guidance setting out more protective standards and calling the NRC standards inadequate and inapplicable as ARARs in CERCLA remediations. U.S. EPA, OSWER Directive No.9200.4-18, Establishment of Cleanup Levels for CERCLA Sites With Radioactive Contamination 3 (Aug. 22. 1997). Perhaps ironically, the NRC characterized its recent decommissioning regulations as achieving consistency with EPA's institutional controls practices under CERCLA. NRC, Radiological Criteria for License Termination, 62 Fed. Reg. 39058, 39071 (July 21, 1997) [hereinafter Radiological Criteria].

[51] 42 U.S.C. §§300f to 300j-26, ELR STAT. SDWA §1491.

[52] 40 C.F.R. §300.430(e)(9Xiii)(C).

[53] *Id.* §300.430(eX9)(iii)(D).

[54] *Id* §300.430(eX9Xiii)(E).

[55] *Id* §300.430(eX9)(iii)(F).

[56] *Id* 1300.430(eX9XiiiXG).

[57] CERCLA mirrors the RCRA approach to managing hazardous waste. The RCRA land ban requires treatment to specified standards before disposal. 42 U.S.C. §6924(m), ELR STAT, RCRA §3004(m).

[58] *ld* §9620(eX4)(C), ELR STAT. CERCLA §120(eX4)(C). Similarly, the likelihood that long-term pumping and treating will be necessary is recognized with respect to the transfer of federal property. *Id.* §9620(h)(3)(B), ELR STAT. CERCLA §120(h)(3)(B). RCRA has similar statutory requirements. *See id* §6924(a), ELR STAT. RCRA §3004(a).

[59] 40 C.F.R. §300.430(e)(9Xiii)(H).

[60] *Id* §300.430(eX9)(iii)(1).

[61] John S. Applegate, *Beyond the Usual Suspects: The Use of Citizens Advisory Boards in Environmenal Decisionmaking,* 73 INo. U. 903, 912-13 (1998).

[62] NATIONAL RESEARCH COUNCIL, RISK ASSESSMENT IN THE FEDERAL GOVERNMENT: MANAGING THE PROCESS 19-20 (1983) (explaining that chemical risk is the product of the toxic potency of a chemical and the amount of exposure to it).

SDWA's drinking water standards[63] and RCRA's hazardous waste disposal provisions.[64] The SDWA establishes maximum contaminant levels (MCLs) for many of the chemicals found at DOE sites.[65] The MCLs are set as close to the purely health-based MCL goals as is "feasible," so they do not require zero risk or zero contamination.[66] Despite being specifically mentioned by CERCLA,[67] the use of the SDWA standards has been strongly criticized where the contaminated groundwater is not now and does not appear likely to be actually used for drinking purposes.[68] Achievement of the MCLs often requires extensive pumping and treating of the groundwater, a process that can take years or decades because of the difficulty of extracting the contaminants with existing technology.[69]

RCRA applies to DOE sites both as an ARAR incorporated into CERCLA and on its own with respect to treatment, storage, disposal, and cleanup of hazardous wastes. RCRA authority may be exercised by state regulators enforcing state law through EPA-approved programs in most states.[70] This dual authority can result in overlapping jurisdiction (which the Federal Facilities Compliance Act confirmed)[71] and differing approaches,[72] although in practice legal standards for long-lived waste seldom conflict.

RCRA requires treatment of most hazardous wastes before they can be disposed of on land.[73] Because, by definition, the toxicity of long-lived wastes cannot be reduced, treatment is required to "substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized,"[74] EPA's regulations, upheld by the courts, interpret "minimized" to mean the lowest level achievable by the "best demonstrated available technologies."[75] Treatment is unnecessary only if it can be demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit.., for as long as the wastes remain hazardous."[76] Where this standard cannot be met, RCRA specifies minimum technology requirements, including leachate collection systems and groundwater monitoring, for the landfills in which treated hazardous waste is placed.[77]

While RCRA contemplates stewardship in the form of continued operations at a disposal site after it has been closed, this requirement is limited to a 30-year horizon.[78] For some purposes, such as the no-migration standard for injection wells, EPA uses the very distant horizon of 10,000 years.[79] Likewise, EPA's regulations governing radioactive waste disposal at the

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[63] *See* 42 U.S.C. §300g-l, ELR STAT. SDWA § 1412.

[64] *See id* §6924, ELR STAT. RCRA §3004.

[65] *Id* §300g-1, ELR STAT. SDWA § 1412. These standards apply to groundwater that may be used for drinking purposes. "Sole source aquifers," that is, aquifers that are a "sole or principal drinking water source" for an area, receive special attention under the SDWA. *Id* §§300h-3(e), 300h-6, ELR STAT. SDWA §§ 1424(e), 1427.
For radionuclides, there may be a conflict between EPA's SDWA concentration levels and its UMTRCA groundwater cleanup standards because they are calculated differently. *Compare* National Primary Drinking Water Regulations; Radionuclides, 50 Fed. Reg. 33050 (July 18, 1991) *with* 40 C.F.R. Pt. 192 (1997) (Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings). EPA has implied that the drinking water standards will control in the case of an actual conflict U.S. EPA, Groundwater Standards for Remedial Actions at Inactive Uranium Processing Sites, 60 Fed. Reg. 2854. 2864 (Jan. 11, 1995).

[66] 42 U.S.C. *300g-l(b). ELR STAT. SDWA §1412(b). EPA regards the only "safe" level of a carcinogen to be zero, so for carcinogens the MCL is set as close to zero as is feasible. *See* Natural Resources Defense Council v. U.S. EPA, 824 F.2d 1211. 17 ELR 21100 (D.C. Cir. 1987). The proposed MCL for uranium in groundwater, for example yields an expected risk of one in one hundred thousand (1×10^{-5})individual lifetime risk. 56 Fed Reg 33050 (July 18,1991).

[67] In fact, CERCLA requires compliance with MCL goals "where such goals or criteria are relevant and appropriate under the circumstances." 42 U.S.C. §9621(d)(2)(A), ELR STAT. CERCLA §121(d)(2XA) (requiring consideration of MCL goals). However, where the MCL goal is zero, EPA categorically requires attainment only of the MCL on the ground that zero is unattainable and unverifiable if obtained. 40 C.F.R. 1300.430(e)(2Xi)(C) (1997). This interpretation was upheld in Ohio v. U.S. EPA, 997 R2d 1520, 1529-30. 23 ELR 21157. 21161-62 (D.C. Cir. 1993).

[68] *See, e.g.,* Teinkin, *supra* note 49, at 19.

[69] Some contaminants disperse and so are difficult to locate, some cluster in pockets from which they cannot be extracted, some attach to the gravels through which the aquifer moves and so are carried very slowly, and some do not dissolve in water. *See* Linly Ferris & David Rees, *CERCLA Remedy Selection: Abandoning the Quick Fix Mentality,* 21 Ecowoy L. 0.785,828-39(1994); **NATIONAL RESEARCH** COUNCIL, ALTERNATIVES FOR GROUND WATER CIeanup (1994).

[70] 42 U.S.C. §6926, ELR STAT. RCRA §3006.

[71] *See supra* note 41.

[72] *See* United States v. Colorado, 990 F.2d 1565,23 ELR 20800(10th Cir. 1993), *ccii. denied,* 510 U.S. 1092 (1994).

[73] RCRA's somewhat misleadingly named "land ban" forbids the disposal on land (i.e., in a landfill) of certain *untreated* hazardous wastes. 42 U.S.C. §6924(d)-(g), **(in),** ELR STAT. RCRA §3004(d)-(g), (m).

[74] *Id* §6924(m), ELR **STAT.** RCRA 13004(m).

[75] Chemical Waste Management Inc. v. U.S. EPA, 976 F.2d 2,14-15. 23 ELR 20024,20030 (D.C. Cir. 1992) (upholding requirement of treating characteristic wastes beyond removal of the characteristic); Hazardous Waste Treatment Council v. U.S. EPA. 886 F.2d 355, 361-66, 19 ELR 21398, 2l401-04 (DCCir 1989). EPA's treatment requirements are understood to mean no migration in amounts capable of causing unacceptable risks. Natural Resources Defense Council v. U.S. EPA, 907 F.Zd 1146,1160-62, 20 ELR 21274, 21280.81 (D.C. Cir. 1990).

[76] 42 U.S.C. §6924(d), (e). (g), ELR STAT. RCRA §3004(d), (e), (z).

[77] *Id* §6924(o), (oXl)(A), ELR **STAT.** RCRA §3004(o).

[78] 40 C.F.R. §[264].117(a) (1997). Post-closure care of a RCRA-regulated disposal facility must be described in a plan approved by EPA and incorporated into a permit. *Id* §264.118. Notice of the existence of the site and its contents must be filed with the local zoning authority and recorded with a deed. *Id* §§264.116, 264.119.

[79] *Id* §148.20(a)(l)(i) (1997) (injection of hazardous wastes). EPA's explanation for 10,000 years, U.S. EPA, Underground Injection Control Program, 53 Fed. Reg. 28118, 28125-26 (July 26, 1988), was upheld in Natural *Resources Defense Council,* 907 F.2d at 1158, 20 ELR at 2 1279-80. EPA adopted a potentially longer "as long as the wastes remain hazardous" standard for the no-migration exception for land-disposed wastes. 40 C.F.R. §268.6(a) (1997). It was upheld on other grounds in *Natural Resources Defense Council,* 907 F.2d **at** 1159-63.20 ELR **at** 21280-82.

WIPP geologic repository include a 10,000-year standard.[80] Yet, while this time period is beyond the extreme limit of our predictive abilities and technical capabilities,[81] it is well short of even the *half* lives of many of DOE's radioactive wastes, to say nothing of long-lived nonradioactive hazardous wastes. The NRC, by contrast, adopts a 500-year horizon for low-level waste[82] and a 1,000-year horizon for decommissioned facilities and for uranium mill tailings[83] (both NRC rules are potential ARARs for DOE facilities). The l,000-year horizon is largely aspirational, however, because it is qualified by the term "to the extent reasonably achievable" and by a mandatory minimum of only 200 years.[84]

CERCLA calls for the review of remediated sites every five years if the remedy "results in any hazardous substances, pollutants, or contaminants remaining at the Site."[85] Because of the nature of the wastes that will remain at most DOE sites, such periodic reviews could continue indefinitely. Yet CERCLA neither imposes restrictions on the use of property nor establishes the kinds of institutions that would be required to maintain a surveillance program for the centuries or millennia that some long-lived waste will need to be isolated.[86]

Future Use and Institutional Controls

Remedy selection under CERCLA is currently undergoing a fundamental change. The statute directs that the degree of cleanup ultimately be determined by reference to the level of residual risk at a site in the foreseeable future.[87] The emphasis traditionally has been placed on treatment to destroy the hazardous substance or to reduce toxicity.[88] However, the limitation of that approach has become apparent where long-lived wastes are concerned—in part thanks to experience with the nuclear weapons complex—and attention has focused increasingly on reducing exposure instead.[89] Because exposure is half of the risk equation, exposure control results in lower post-cleanup risks, making it easier to achieve CERCLA's target risk levels.

Exposure control most obviously takes the form of creating barriers between the hazardous material and potential human and ecological receptors. An engineered disposal *fa*cility is supposed to prevent the material and receptors from coming into contact. Natural barriers also may isolate some wastes in, for example, lake sediments, where the superjacent waters shield the contaminated material from most intrusions.

Alternatively, according to the "future use" or risk-based corrective action (RBCA) approach to cleanup,[90] if the uses of land around the waste can be restricted, then potential exposure and hence the expected residual risk level may both be lowered. If the future use of the above-mentioned lake is a wildlife refuge, remedial action may not need to be taken if the contamination is contained in stable sediments. At the other

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[80] 40 C.F.R. §§191.13(a), 191.15(a), 194.2, 194.32 (1997). *See also* Standards for Remedial Actions, *supra* note 36, at 597 (adopting a l,000-year horizon, while acknowledging that "tailings will remain hazardous for hundreds of thousands of years").

[81] Kai Erikson, *Out of Sight, Out of Our Minds,* N.Y. Times, Mar.6, 1994 (Magazine), at 36, 40-41, 50. EPA asserts that some natural processes—geologic, hydrogeologic, and climatic—can be predicted over 10,000 years; in default of any better prediction, **it** assumes that all other site conditions will remain the same over that period. U.S. EPA, Criteria for the Certification and Re-Certification of the WlPP's Compliance With the 40 C.F.R. pi 191 Disposal Regulations, 61 Fed. Reg. 5224,5227-28 (Feb. 9, 1996) [hereinafter Criteria for the Certification and Re-Certification].

[82] 10 C.F.R. §§61.7(a)(2), (b)(5) (1998) (general), 61.52(aX2) (1998) (Class C low-level radioactive waste).

[83] 40 C.F.R. §§192.02(a), 192.32(bXi) (1997); 10 C.Fj.. §40.27 & app. A, criterion 6 (1998) (UMTRCA); *see also* 10 C.F.R. §20.1402(d) (1998); Radiological Criteria, *supra* note 50, **at** 39070, 39083 (nuclear facilities generally).

[84] 10 C.F.R. pt 40, app. A, criterion 6(1998); 40 C.FR. §§ 192.02(a), 192.32(b)(i) (1997); *see also* 10 C.F.R. §§60.1 13(aXl)(ii)(A) (1998) (300 years for waste forms and containers in repositories), 61.7(b)(2) (1998) (low-level radioactive waste forms and containers).

[85] 42 U.S.C. §9621(c), ELR STAT. CERCLA §121(c).

[86] *See* U.S. EPA, OSWER Directive No. 9320.2-09, Close Out Procedures for National Priorities List Sites (1995); U.S. EPA, OSWER Directive No. 9355.7-02, Structure and Components of Five-Year Reviews (May 23, 1991) [hereinafter OSWER Directive No. 9355.7-02]; U.S. EPA, OSWER Directive No. 9355.7-02A, Supplemental Five-Year Review Guidance (July 26. 1994); U.S. EPA, OSWER Directive No. 9355.7-03A, Second Supplemental Five-Year Review Guidance (Dec. 21,1995). None of these guidances deals with really long-term hazards. EPA even sets priorities among sites for required five-year reviews because it has insufficient resources to perform them all. *See id* No. 9355.7-02.4.

[87] See42U.S.C. §9621(b), (d), ELR **STAT.** CERCLA §121(b), (d).

[88] *Id*~ §9621(b), ELR STAT. CERCLA §121(b) (preference for treatment). This preference arose from the concern that CERCLA not create a vicious circle of inadequate disposal leading to new Superfund sites. *See* OFFICE **OF** TECHNOLOGY ASSESSMENT, SUPERFUND STRATEGY 75 (1985) (discussing the "turnstile" problem of revisiting sites that were thought to be cleaned up).

[89] Risk reduction through exposure reduction has long been accepted in the context of radiation. However, those who focused on chemical risks (a largely separate group—.-institutionally, the agencies are the NRC and EPA, respectively) considered isolation a second-best option.

[90] Concise statements of the logic of considering future use may be found in ROBERT HERSH ET AL., LINKING LAND USE AND SUPERFUND CLEANUP': UNCHARTED TERRITORY (Resources for the Future 1996); CHARTING THE COURSE, *supra* note 18, at 7-11; BEMR, *supra* note 7, at 6-1 to 6-13; George Wyeth, *Land Use and Cleanups: Beyond the Rhetoric,* 26 ELR 10358 (July 1996); Douglas J. Saino, *Future Use Considerations in the Cleanup of Federal Facilities,* HAZARDOUS MATERIALS CONTROL, May/June 1993. **at** 20. An early appearance of the concept is an Office of Technology Assessment report on Superfund that advocated site classification based on present and future use to determine the level of cleanup required. OFFICE OF TECHNOLOGY ASSESSMENT, SUPERFUND STRATEGY, *supra* note 88, **at** 118-21.

For a discussion of RBCA and the application of future use concepts to RCRA, see James R Rocco & Lesley Hay Wilson. *The Risk-Based Corrective-Action Process, and* BROWNFIELDS: A COMPREHENSIVE GUIDE TO REDEVELOPING CONTAMINATED PROPERTY 250.67 (Todd S. Davis & Kevin D. Margolis eds., 1997) [hereinafter BROWNFIELDS]; Michael L. Gargas & Thomas F. Long, *The Role of Risk Assessment in Redeveloping Brownfields Sites, and* BROWNFIELDS**,** *supra,* at 239; James P. O'Brien, *The Tiered Approach to Corrective Action Objectives and the Site Remediation Program in Illinois,* 27 ELR 10611 (Dec. 1997); Gerald W. Phillips, *Rethinking Restoration: Risk Based Corrective Action and the Future of Economic Regulation,* 16 N. ILL. U. L. REv. 659 (1996).

Strong dissents to the future use approach can be found in Donald A. Brown, *What Is Wrong With the 1990 National Contingency Plan?*, 20 ELR 10371, 10373-74 (Sept. 1990); Jeffrey Spear, *Remedy Selection Under CERCLA and Our Responsibilities to Future Generations.* 2 N.Y.U. ENVL. U. 117(1993).

end of the land use spectrum, agricultural use of a site involves exposure to the farmer through direct dermal contact with soil and groundwater, extended opportunities to in-hale contaminated dust, and occasional ingestion. Residential use has a similar exposure profile, because children play in their yards and adults dig in their gardens. Industrial and commercial uses, however, involve considerably less potential contact, if only because the concrete slab of a building and the asphalt of a parking lot insulate workers from contamination beneath them. The isolation in such situations is not perfect, but, so long as the structure remains in place, it will cut off some routes of exposure. Recreational uses of greenspace involve even less exposure, because most people spend far less time at recreational sites than at work or home, and their activities (apart from sports) typically involve only limited contact with the soil. Finally, a highly restricted land use, in which only trespassers or occasional monitors visit the site, yields a very low exposure profile, though at the price of permanently underutilized land.[91] The assumption of a particular future land use,[92] therefore, has a profound effect on the calculated exposure and hence the risk at a contaminated site.[93]

Future use developed as an alternative to what had been the usual assumption in Superfund risk assessments that a property will have an intensive post-remediation use like agricultural or residential, which requires a level of cleanup sufficient for all eventualities.[94] Advocates of the future use approach argue that, because many Superfund sites are located in industrial areas that have no foreseeable prospect of a use other than industrial or commercial, cleanup activities can be limited accordingly. Cleanup to make an industrial site safe for farming, the thinking goes, is cleanup for its own sake. It is wasteful of resources, and, in an environment of limited resources, it may result in more serious contamination going unremedied.[95] The difference between cleanup levels is substantial: adoption of commercial instead of residential use in one study of U.S. Air Force facilities showed a tenfold difference in acceptable levels of residual contamination.[96] By lowering cleanup costs, the future use approach benefits potentially liable parties (including federal agencies) and in some cases may encourage industrial redevelopment.[97] Many states, eager for this so-called brownfields redevelopment, encourage reliance on assumed future use.[98] Consideration of future land use is also a feature of CERCLA reform proposals and pending reauthorization legislation.[99]

The future use approach to planning for cleanup and disposal of hazardous wastes can only be justified, however, if the future use of the land can be predicted with confidence. This means that the future use approach must be applied prescriptively, not just predictively. Thus, if future uses of the above-mentioned lake were uncertain, one might attempt to close the lake to development to ensure no disturbance of its sediments. The techniques for prescribing and maintaining future uses are known as institutional controls.[100] They include physical barriers, like fences and guards; information transmission, like warnings and public records; and legal controls, like ownership, zoning, and deed restrictions. In-

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[91] See CHARTING THE COURSE, supra note l8, at 13 (describing seven land use categories and associated exposure pathways); John S. Applegate & Douglas J. Sarno, *FUTURESITE: An Environmental Remediation Game-Simulation*, 28 SIMUlATION & GAMING 13. 18 (1997).

[92] Future use for the purposes of calculating risk and remedy selection is not the same as land use planning. Traditional land use planning can be very specific, and it often distinguishes among types of activities within a given category, such as different types of industry. While industrial and commercial uses have similar risk exposure profiles, they have entirely different characteristics for the purposes of zoning. In addition, it is important to remember that future uses are *generalizations;* there are sure to be persons who are exposed at greater or lesser levels than the model predicts.

[93] Consideration of future use is particularly effective at reducing expected risk because the bulk of the risk from hazardous waste sites lies in the future. James T. Hamilton & W. Kip Viscusi, *Human Health Risk Assessments for Superfund*, 21 ECOLOGY L.Q. 573. 600-02, 608-09 (1994).

[94] *See* U.S. **GENERAL** ACCOUNTING OFFICE, GAO/RCED-94-1944. **NUCLEAR CLEANUP:** COMPLETION OF STANDARDS **AND** EFFECTIVENESS OF LAND USE PLANNING ARE UNCERTAIN 13-14(1994) (quoting congressional testimony of EPA Deputy Administrator).

[95] *See* **CLEAN** Sites, **IMPROVING REMEDY SELECTION: AN** Explicit AND INTERACTIVE PROCESS **FOR THE SUPERFUND PROGRAM** 40-41 (1990).

[96] U.S. AIR FORCE ENVIRONMENTAL RESTORATION PRoow., FUTURE USE CONSIDERATIONS IN THE CLEANUP OF AIR FORCE INSTALLATIONS 12 (1992) (report authored by Clean Sites). *See also* Rocco & Wilson, *supra* note 90, at 260-65 (case study); Gargas & Long, *supra* note 90. at 242-45 (case studies).

[97] *See* John S. Applegate, *Risk Assessment, Redevelopment and Environmental Justice: Candidly Evaluating the Brownflelds Bargain*, 13 J. NAT. RESOURCES & ENVTL. L. (forthcoming 1998). DOE explicitly recognizes this benefit for its closing facilities. CHARTING THE COURSE, *supra* note 18, at 9.

[98] *See* BROWNFIELDS, *supra* note 90, at 287-681 (chapters describing state programs); Larry Schnapf, *State-by-State Survey of Brownfield and Voluntary Cleanup Programs*, 28 Env't Rep; (BNA) 2488 (Mar. 27, 1998); ASSOCIATION OF STATE AND TERRITORIAL SOLID WASTE MANAGEMENT OFFICIALS, SURVEY OF STATE INSTITUTIONAL CONTROL MECHANISMS (1997) [hereinafter ASTSWMO].

[99] *SeeS.* 8, 105th Cong. tit. IV, §101 (1998); H.R. 2727, 105th Cong. tit. I, § 104(1997); HR. 3000,105th Cong. tit. I, § 101(1997). Recent proposed amendments to CERCLA addressing land use issues are analyzed m Krista i. Ayers, [may references missing from the DOE PDF]

[100] A variety of institutional controls are described and analyzed in **MARY** R. **ENGLISH** Er **AL, INSTITUTIONAL** CONTROLS **AT SUPER**-FUND Srr~s: A **PRELIMINARY ASSESSMENT OF THEIR EFFICACY AND PUBLIC ACCEPTABILIT** *Potential for Future Use Analysis in Superfund Remediation Programs*, 44 EMORY LI; 1503, 1519-22 (1995); RenaL Steinzor, *The Reauthorization of Superfund: Can the Deal of the Century Be Saved?* 25 ELR 10016 (Jan. 1995); Anne D. Weber. *Institutional Controls An Expedited and Cost-Effective Means for Returning a Superfund Site to Beneficial Use*, 9 J. NAT. RESOURCES & ENVL. L. 461,470-76(1994); NATIONAL COMMISSION ON SUPERFUND, FINAL CONSENSUS REPORT OF THE NATIONAL COMMISSION ON SUPERFUND (Keystone Center & Vermont Law School 1994). **Y** 21-31 (Joint Institute for Energy & Environment 1997); **HERSH ST AL.,** *supra* note 90, at 65-94; John Pendergrass, *Use of institutional Controls as Part of a Superfluid Remedy: Lessons From Other Programs*, 26 ELR 10109 (Mar. 1996); Wyeth *supra* note 90; Susan C. Borinsky, *The Use of InstitutionalControls in Superfund and Similar State Laws* 7 Fordham ENVT'L. U. 1, 14-19(1995); David F. Coursen, *institutional Controls atSuperfund Sites*, 23 EUR 10279 (May 1993); Weber, *supra* note 99; Ayers, *supra* note 99, at 1523-1538; Em Sheridan, *How Clean Is Clean: Standards for Remedial Actions at the Hazardous Waste Sites Under CERCLA*, 6 **STAN.** ENvm. U. 9~ 34 (1986-1987).

stitutional controls are important to ensure that predictions for the *foreseeable* future actually come to pass. But they are absolutely essential to prescribing land use conditions in the *long-term* future, as to which accurate prediction is extremely dubious.[101] Institutional controls, in other words, are the *sine qua non* for reliance on future use, and so the legitimacy of future use depends on the availability and efficacy of appropriate institutional controls. Conversely, if institutional controls are ineffective over the long term, then they must either not be relied on, or systems must be in place to respond when they fail.

EPA has come to embrace future use as part of a broad trend toward exposure-based risk control.[102] A *1995* directive to regional offices from EPA's Office of Solid Waste and Emergency Response (OSWER) declares that "[r]easonably anticipated future use of the land at NPL [national priorities list] sites is an important consideration in determining the appropriate extent of remediation."[103] EPA officials are directed to discuss such uses with local land use planners and other officials, and with the public, as early as possible in the remedial investigation/feasibility study (RI/FS) process, because those uses will affect exposure pathways to be evaluated in the "baseline risk assessment."[104] This information is supposed to allow the development of "practicable and cost-effective remedial alternatives."[105] Future uses of a particular tract may be predicted by considering, inter alia, its current uses, local zoning laws, location of transportation and public utilities, historical development patterns, U.S. Census Bureau projections, cultural factors, the location of dangerous or environmentally sensitive geographical features, and environmental justice concerns.[106] Advice from the public is supposed to make such predictions more reliable.[107]

Consistent with its future use policy, EPA also recognizes institutional controls as a legitimate part of a remedial plan:[108]

> In appropriate site situations, treatment of the principal threats posed by a site, with priority placed on treating waste that is liquid, highly toxic or highly mobile, will be combined with engineering controls (such as containment) and institutional controls, as appropriate, for treatment of residuals and untreated waste.[109]

Many CERCLA records of decision now rely on institutional controls to achieve the calculated residual risk levels.[110] "Water use and deed restrictions" are specifically mentioned as potential components of a completed remedy.[111] CERCLA § 120 provides that when contaminated federal lands are conveyed or leased to a nonfederal owner, the instrument of transfer must include "necessary restrictions on the use of the property to ensure the protection of human health and the

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[101] DOE recognizes the inseparability of future use and institutional controls, but has little to say about the nature of the institutional controls. See CHARTING **THE** COURSE, *supra* note 18, **at** 10. 16,22; *see also* Radiological Criteria, *supra* note 50, **at** 39069-71.39083 (acknowledging the difficulty of predicting the distant future); Criteria for the Certification and Re-Certification, *supra* nbte 81, at 5227-28 Expressing confidence only in predictions of certain natural processes).

[102] Because, as noted above, radiological risk management has traditionally been based on exposure rather than toxicity, the NRC relies heavily on future use and institutional controls in its safety standards for decommissioned facilities. 10 C.F.R. §120.1401-20.1404 (1998); Radiological Criteria. *supra* note 50, at 39069-70, 39083.

[103] U.S. EPA, OSWER Directive No. 9355.7-04, Land Use in the CERCLA Remedy Selection Process 3 (May 25, 1995) (summanzed **at** 60 Fed. Reg. 29595 (June 5, 1995). According to the directive, the same considerations should apply in planning RCRA corrective actions. Virtually all states allow consideration of future use in their own cleanup programs. ASTSWMO, *supra* note 98, at 7-9.

[104] OSWER Directive No. 9355-04, supra note 103, at 3.

[105] Id, at 6.

[106] Id, at 5.

[107] "Where there is substantial agreement among local residents and land use planning agencies, owners, and developers, EPA can rely with a great deal of certainty on the future land use already anticipated for the site." But where future land use is "highly uncertain, a range of the reasonably likely future land uses should be considered in developing remedial action objectives." In such a case, "it may be useful to compare the potential risks associated with several land use scenarios to estimate the impact on human health and the environment should the land use unexpectedly change." *IS* at 6-7.

DOE has issued detailed guidance or developing relevant data and involving stakeholders m this process. **OFFICE OF ENVIRONMENTAL** MANAGEMENT, U.S. DOE, FORGING THE MISSING LINK: A RESOURCE DOCUMENT FOR FOR IDENTIFYING FUTURE USE OPTIONS (Final Draft 1994). A public process for doing this was successfully implemented at the very large Hanford site in southeastern Washington, HANFORD FUTURE USES WORKING GROUP, **THE** FUTURE OF **HANFORD: USES AND** CLEANUP (Dec. 1992), and the relatively small Fernald site in southwestern Ohio, **FERNALD CITIZENS TASK FORCE, RECOMMENDATIONS ON REMEDIATION** LEVELS, WASTE DISPOSITION, PRIORITIES, AND FUTURE USE (July 1995) [hereinafter FERNALD **CITIZENS TASK FORCE].** *See also* US. DEPARTMENT of **DEFENSE,** A GUIDE TO ESTABLISHING INSITITUTIONAL CON**TROLS AT MILITARY INSTALLATIONS** (Feb. 1998).

[108] According to the NCP, EPA 'expect, to use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants.'40 C.F.R. §300.430(a)(lxiij) (1997). The D.C. Circuit found that institutional controls were not *per se* violative of CERCLA. Ohio v. U.S. EPA, 997 R2d 1520, 1536-37, 1546-47,23 ELR 21 157, 21171 (D.C. Cir. 1993).

[109] 40 C.F.R. §300.430(a)(l)(uiXC) The regulation indicates that in fashioning a cleanup remedy, one or more alternatives should be considered that

> involve little or no treatment, but provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances *...* through engineering controls, for example, containment, and, as necessary, institutional controls **...** to assure continued effectiveness of the response action.

Id. §300.430(e)(3Xii).
Virtually all states with cleanup programs allow reliance on institutional controls, although in many cases the controls themselves are voluntary, even those that must be in place to achieve cleanup levels. ASTSWMO, *supra* note 98. at 10-14.

[110] A survey of states showed that institutional controls were incorporated into records of decision in 33 of 42 states responding to the survey. ASTSWMO, *supra* note 98, at 74.

[111] 40 C.F.R. §300.430(a)(lXiii)(D).

environment."[112]

In evaluating alternative remedies, EPA must consider the "adequacy and reliability of controls such as containment systems, and institutional controls," the "type and quantity of residuals that will remain following treatment," and cost, including annual operation and maintenance costs."[113] Where an aquifer is contaminated, "[rapid restoration may also be appropriate where the institutional controls to prevent the utilization of contaminated groundwater for drinking water purposes are not clearly effective or reliable."[114] According to the NCP,

> the use of institutional controls shall not substitute for active response measures (e.g., treatment and/or containment of source material, restoration of groundwaters to their beneficial uses) as the sole remedy unless such active measures are determined not to be practicable, based on the balancing of trade-offs among alternatives that is conducted during the selection of a remedy.[115]

The D.C. Circuit has emphasized that EPA's discretion under this regulation is limited: "[Any remedy relying on institutional controls must meet the threshold requirement of protectiveness."[116] In sum, CERCLA's threshold criterion of protecting human health and the environment can be satisfied only if genuinely reliable institutional controls are available to ensure that an inappropriate use will not be made of the site.

Future use is of special interest to DOE.[117] It holds the potential for reducing the amounts of contaminated soil and water that the legal standards require to be treated, for permitting on-site disposal or in-situ isolation of waste materials (thus avoiding the economic and political costs of transportation), and for achieving a protective remedy where permanent, total cleanup technologies do not exist.[118] While cost alone cannot justify a nonprotective remedy,[119] it can provide a powerful incentive to reassess assumptions that go into the calculation of the residual risk level, including assumptions about future use. In addition, much DOE property is attractive for redevelopment because an industrial infrastructure already exists (i.e., transportation, utilities, etc.), and there is an understandable desire to ease the economic impact of the closure of sites on surrounding communities.[120] Moreover, for some wastes, cleanup to unrestricted use standards is technically impossible or is likely to cause more environmental harm than it avoids.[121] The. detonation cavities at the Nevada Test Site, for instance, are too deep and too radioactive to be remedied with current technologies. At such sites, restrictions on future land uses are inevitable.[122]

EPA's *1995* OSWER directive would appear to validate DOE's plans to accomplish its cleanup of the nuclear weapons complex by leaving some contamination in place and some waste on-site, based on a prediction and/or prescription of limited land uses.[123] However, while DOE can undoubtedly control the *foreseeable* future of sites it owns, its reliance on institutional controls to achieve its *long-term* stewardship goals may not be justified. The history of such controls is checkered at best. It is frequently observed that Love Canal, which provided the original impetus for the Superfund program, was a case of failed institutional controls.[124] What, then, must be done to protect present and future generations from DOE's residual wastes?

The Long-Term Management of Long-Lived Waste

If long-lived wastes are not managed for the long term, they will manage themselves. The question, therefore, is not whether to manage them, but *how* they will be managed, and, in particular, whether the management techniques are effective over the long term. We begin this section with a description of waste configuration options available to DOE, each of which is either currently in use or planned somewhere in the nuclear

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[112] 42 U.S.C. §9620(h)(3)(C)(ii)(l) ELR STAT. CERCLA § l20(h)(3XC)(ii)(~).

[113] 40 C.F.R. §[30]0.430(eX9)(CXI).(2) (D)(5), and (G)(2); *see* 42 U.S.C. §9621(b), ELR **STAT.** CERCLA §121(b).

[114] U.S. EPA, National Oil and Hazardous Substances Pollution Contingency Plan, 55 Fed. Reg. 8666, 8732 (Mar. 8, 1990). on the balancing of trade-offs among alternatives that is conducted during the selection of a remedy.

[115] 40 C.F.R. 1300.430(a)(l)(iii)(D).

[116] Ohio v.U.S.EPA,997F.2d 1520, 1537 23ELR21l57 2l165(DC Cir. 1993).

[117] *See* CHARTING **THE COURSE,** *supra* note 18, at7-l I (referring to it as "a critical factor in DOE decisions").

[118] In fact, DOE estimated in 1996 that it would cost only(!) $11 billion more to clean up the entire weapons complex to residential/agricultural levels than to clean it up for industrial use (excluding areas targeted for waste disposal and those for which suitable cleanup technology is not available) BEMR, *supra* note 7, at 6-9 to 6-10. This relatively small difference—$166 billion versus $155 billion—is attributable in part to the remoteness of most DOE sites from existing populations and to the large expense of achieving even industrial levels at most sites.

[119] *See* Ohio v. U.S. EPA, 997 F.2d at 1531, 1533.23 ELR at 21163 ("Although cost cannot be used to justify the selection of a remedy that is not protective of human health and the environment, it can be considered in selecting from options that are adequately protective.").

[120] This was the purpose of CERFA, Pub. L. No. 102426. 106 Stat. 2174 §2(1)-(3) (1992) (codified at 42 U.S.C. §9620(h), ELR **STAT.**CERCLA 1120(h)).

[121] The NRC gives a similar rationale for allowing restricted future uses at decommissioned commercial nuclear facilities. Radiological Criteria, *supra* note 50, at 39069.

[122] This rationale for considering future use has been noted outside DOE context, as well. *See* Coursen, *supra* note 100, at 12079; Samuel I. Gutter, *SDWA Standards: A Frai 'newo,* for Groundwater Cleanup,* NAT. RESOURCES A ENV'T, Spring 1989, at 3, 47.

[123] DOE has cited the directive for this purpose. ***See*** CHARTING THE COURSE, *supra* note 18. at 8.

[124] *See* **HERSH et al**., *supra* note 90, at 65-68; PROBST & McGOVERN, *supra* note 5, at 28. Probst and McGovern also note that cemeteries have a very mixed record of long-term care. *Id. at33;see also* HERSH *et al., supra* note 90, at 39-64 (reporting case studies).

weapons complex.[125]

Waste Configurations for Long-Term Management

To generate cost estimates for its accelerated cleanup plan, DOE and its regulators have had to define for each site the "end state" (foreseeable future) that is to be achieved by active remediation.[126] Even when the foreseeable future condition is reached, nearly all sites will be left with some accessible contamination in soil, groundwater, or surface water at levels considered safe only on the basis of a limited land use. All except the smallest sites also plan some kind of disposal facility. A range of management options is addressed here in the order of more to less secure isolation techniques.[127] The choice of waste configuration determines long-term stewardship requirements and hence the costs and effectiveness of waste management.

Disposal Facility. A dedicated disposal facility, other than a geologic repository,[128] is intended both to prevent the waste inside from escaping and to prevent external agents—humans, precipitation, plants, burrowing animals—from intruding. Such an engineered facility typically involves the use of synthetic or natural (plastic or clay, respectively) liners between the waste and the soil on which it sits, synthetic or natural caps over the waste, and a leachate collection system to capture any water that makes it through cap, waste, and liner and in the process becomes contaminated with the waste. Facilities of this kind—though some lack liners and others rely on waste containers *inside* the facility—are in place, under construction, or planned at many production (waste-generating) sites, and at locations like the Nevada Test Site, which are destined to be importers of DOE waste. Commercial disposal facilities also receive low-level and nonradioactive wastes from DOE sites.[129]

There is no inherent difference between waste disposal facilities at generating sites and those at remote dedicated disposal sites. The hydrogeology of a site, its proximity to present and projected populations, and the risks and costs of transporting wastes are the dominant considerations in choosing between on-site and off-site disposal. As a general rule, however, dedicated waste disposal sites have been established more recently; thus, they use better isolation technologies and are better sited with respect to hydrogeology and population. Regardless of location, these facilities are designed to require less monitoring activity, and they do not anticipate retrieval of the contents at any time in the future.

A disposal facility must be fenced off (literally or otherwise) to prevent intrusion, and it must be marked to prevent inadvertent human intrusion if the fencing fails. Monitoring and surveillance would help to ensure its continuing integrity; however, because a disposal facility is intended to last essentially forever, there is little incentive to provide such oversight. A disposal facility is designed to be left alone.

Active Isolation in Place. Active isolation in place differs from disposal in that contaminants are not collected and moved before being abandoned in the environment It is most appropriately used for contaminated soil, as an alternative to excavation, although it is also used for old waste disposal areas. The most common form is "capping in place," that is, placing an impermeable barrier on top of the waste or contamination to stop or retard water from entering the material and carrying the waste farther into adjacent soil, surface water, or groundwater. A dike or slurry wall adjacent to and downgradient of the waste is sometimes employed.[130] Like engineered disposal facilities, however, this process depends on structures that are subject to deterioration over time even with careful maintenance, or to disturbance by human activity. Hence, monitoring and surveillance are even more important with active isolation in place than at disposal facilities.

Passive Isolation in Place. Passive isolation in place is another way of saying minimal remedial action. Such a response may be justified where contamination is extremely inaccessible or its removal would cause more harm than good. At the Nevada Test Site, the explosion chambers from underground testing are filled with extremely radioactive material, but they are buried as much as 2,400 feet below the surface.[131] The excavation of contaminaled wetlands sediments at the Savannah River site would effectively destroy an area that, left undisturbed, provides excellent habitat for a wide variety of wildlife.[132] Closer cases include contaminated material located under buildings or roads, where the structure acts in effect as an engineered cap.[133] Ultimately, it is hoped that natural attenuation will sufficiently dilute the material to eliminate any threat.

One particular drawback of passive isolation is that it may only function for as long as adjacent land uses remain essentially the same. At the Nevada Test site, for example, drilling for water downgradient of the sources of contamination could result in human exposure to the contaminants. It may also be important to control activities on the contaminated site. If

[125] The predicted end states and the management options at individual sites are summarized in PATHS TO CLOSURE, *supra* note 6, 3-3 to 3-49 & app. E.

[126] PATHS TO CLOSURE, *supra* note 6, at ES4, 1-6 to 1-7 (defining "completion" and "end state"). DOE engaged in a similar exercise previously for the purpose of estimating necessary remediation activities. CHARTING THE COURSE, *supra* note 18.

[127] The discussion of waste configurations draws from PATHS TO Closer, *supra* note 6; BEMR. *supra* note 7; and PROBST & McGOVERN, *supra* note 5, at 11-14.

[128] We have excluded from our analysis the storage or disposal of weapons-usable material and the high-level wastes destined for geologic repositories, because they implicate a different, though overlapping, set of environmental concerns.

[129] *E.g.,* the Envirocare facility in Clive, Utah.

[130] Yet another technique, "in situ vitrification," uses electrodes placed on either side of the contaminated soil to heat and turn it into a glass-like material. The vitrified result is highly resistant to leaching of contaminants. Vitrification may be a very difficult technology to implement, however, because it depends on a soil composition that lends itself to glassmaking.

[131] 2 NEVADA RISK ASSESSMENT/MANAGEMENT PROJECT, PRELIMINARY RISK ASSESSMENT FOR DOE SITES IN NEVADA 8 (1996).

[132] ***See*** Dycus, *supra* note 19. at 112-13.

[133] Some of the risks are described in ELI, INSTITUTIONAL CONTROLS CASE STUDY: GRAND JUNCTION (Draft 1998) (hereinafter GRAND JUNCTION].

existing buildings and structures are relied on to isolate contamination, those buildings and roadways must be maintained indefinitely. Even under the best of circumstances, however, waste is likely to migrate from both passive and active isolation configurations.

Leaving Contaminants Accessible to Humans. Some residual contamination will be deliberately left accessible to human contact. Where the contamination has been caused by airborne deposition of hazardous materials or infiltration of groundwater, the resulting concentrations of the contaminant in soil and groundwater decrease as the distance from the source increases along the plume of contamination, eventually to the point that they disappear or merge into background (naturally occurring) levels. The concentration gradient translates into a risk gradient, with risk decreasing as the concentration of contaminants decreases. The gradient thus presents the familiar problem in risk regulation of finding a place to draw the line: at what point along the gradient does the risk posed by the contaminant decrease to an "acceptable" level?[134] Risk, however, depends not only on the intrinsic hazard of the contaminant but also on the degree of exposure to it. Therefore, if exposure is reduced, risk will be reduced even if the amount of the contaminant remains the same. If the use of contaminated land is such that relatively little contact with the soil occurs (as in the wildlife use of lakes with contaminated sediments), then the risk at that point is reduced *pro tanto.* For this reason, it is plausible to leave in place contaminated soil and groundwater that is readily accessible to the public, if one assumes that the soil or groundwater will not be used, or at least not used very much.[135] But this assumption must be grounded in effective controls to limit use.

Monitored Retrievable Storage. Monitored retrievable storage (MRS) is most often discussed as an alternative to a geologic repository.[136] The idea is to provide a temporary way-station ("storage" in RCRA parlance, as opposed to "disposal")[137] for wastes for which the permanent disposal is at this time either technologically infeasible or insufficiently reliable. The waste would be placed in secure containers that can be transferred to a better storage or more reliable disposal site when one becomes available. Without calling it MRS, DOE is considering temporary storage at the Fernald site in Ohio for radium-rich uranium ores that now sit in decaying silos, and at Rocky Flats in Colorado or the Savannah River site in South Carolina for excess plutonium that impedes progress on other aspects of the cleanups there. MRS requires, as its name suggests, close monitoring, as well as placement in a location that isolates storage vessels from human or environmental contact. Because it is an interim waste configuration, awaiting a safer arrangement, access to the facility must be strictly controlled with barriers and, probably, guards. An MRS facility, in other words, is an ongoing operation involving a more or less continuous human presence.

Pump and Treat. Pumping and treating groundwater can be used to contain a plume of contamination in or to remove contaminants from an aquifer. As a waste management technique, it is like MRS in that it anticipates active management over a long period of time, though unlike MRS the time period is a matter of decades (at most) and not centuries. In one sense, it fits into the period of active remediation, but in practice it often will take far longer than remedial excavation and construction activities.[138] The extraction of contaminants from groundwater is an especially time-consuming process when the contaminants do not dissolve evenly in the water or they adhere to the sands and gravel of the aquifer.

DOE's Waste Management Options. Several important points can be drawn from this survey of DOE's waste management options. First, management of long-lived hazards consists not of destroying them (by our definition, they are practically indestructible), but of moving them from a less secure configuration to a more secure one. Thus, the long-term weaknesses of even the most secure management techniques cannot be avoided, but they may be postponed for a while. *All* disposal techniques for long-lived materials have in common an intergenerational impact: some amount of activity will be required to maintain the effectiveness of the technique over the long term, and that activity will be the responsibility of the future generations who inherit the waste.

Second, some type of long-term stewardship program is unavoidable, because of the long-lived nature of DOE's wastes. Any use of containment requires stewardship. Therefore, the question is not whether long-term stewardship is a good or a bad thing; rather, the key questions are what kind of stewardship do we want, how can we maximize its effectiveness, and what are the consequences of a failure of controls.

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[134] For a discussion of the problem of setting acceptable risk levels under these conditions, see JohnS. Applegate, *The Perils of Unreasonable Risk: Information, Regulatory Policy, and Toxic Substances Control,* 91 COLuM. L. REv. 261, 272-76 (1991).

[135] *See. e.g.,* ELI, INSTITUTIONAL. CONTROLS **CASE** STUDY: **MOUND** PLANT (Draft 1998) [hereinafter MOUND] (describing in detail DOE plans to leave contaminants in place at one site based on an assumption of limited use).

[136] For advocacy of dry cask or MRS of high-level waste, see James Flynn at al., Overcoming Tunnel Vision. Redirecting the U.S. High-*Level Nuclear Waste Program,* ENVIRONMENT, Apr. 1997. at6, 27-29; ARJUN MAKHIJANI & SCOTT SALESKA, HIGH-LEVEL DOLLARS, LOW-LEVEL SENSE 105-08, 125-26(1992). For a contrary view, see Luther J. Carter, *Its Time to Lay This Waste to Rest,* **BULL. ATOM.** SCIENTISTS, Jan Feb. 1997, at 13; ***see*** Whipple, *supra* note 17, at 72. Adoption of the MRS option is specifically permitted by the Nuclear Waste Policy Act, 42 U.S.C. 110161.

Congress is currently considering legislation to establish an interim MRS facility at the entrance to the proposed Yucca Mountain repository. The House passed its version of the bill in October 1997 with enough votes to overturn a promised presidential veto. H.R. 1270, 105th Cong. (1997). While the Senate bill was passed in 1997, it lacked a sufficient margin to overturn a veto. 5. 104, 105th Cong. (1997); Patricia Ware, *DOE Says Contracts With Utilities Address Delays in Waste Storage Programs,* Daily Env' t Rep. (BNA). Feb. 5. 1998, at A-3.

[137] 42 U.S.C. *6903(3), (33), ELR STAT. RCR.A *1004(3), (33).

[138] To enable prompt reuse of contaminated property, CERCLA permits transfer of federal property after remedial action "has been taken," but pumping and treating is still ongoing. *ld.**9620(b)(3)(B)-(C), ELR **STAT.** CERCLA * 120(h)(3)(B)-(C). Likewise, DOE's accelerated cleanup plan includes pumping and treating among the residual activities that may occur at a site that is considered "closed." PATHS TO CLOSURE, *supra* note 6, at 18-19. The NCP, on the other hand, does not regard a cleanup as "complete" until drinking water standards have been met. 40 C.F.R.*300.435(0(3) (1997).

Third, for a given type and concentration of hazardous waste, there may be an inverse relationship between the security of the configuration and the intensity of the residual stewardship activities that must be carried out. A disposal facility needs less "babysitting" than accessible waste, for example, because it can rely more on the design characteristics of the facility and less on continuous control of human activity and natural processes on or near the site.

Finally, the management options and their long-term weaknesses are not limited to DOE's cleanup program. DOE does not have a monopoly on long-lived hazardous wastes. The NRC regulates cleanup of radionucides at decommissioned civilian nuclear power generating plants and other licensed facilities.[139] Heavy metals like lead, mercury, and chromium are common constituents of privately owned Superfund and RCRA corrective action sites. Moreover, as pressure increases, to undertake less thorough remediation to speed up brownfields redevelopment, the private long-term stewardship problem will far outstrip DOE's. DOE's sites, while vast, are relatively few in number, and most are quite well known. There are, by contrast, nearly one-half million private industrial sites at which some waste or contamination may remain indefinitely.[140]

The Qualities of a Long-Term Stewardship Program

Before turning to the legal complexities of a long-term stewardship program, it will be useful to consider the characteristics that would enable such a program to manage long-lived waste effectively. These qualities provide both the goals of an appropriate legal regime and the standards against which existing and future legal structures can be evaluated.[141]

Transparency. Above all, long-term dangers to public health and the environment must not be ignored in the rush to dispose of hazardous wastes as cheaply as possible or to restore contaminated sites to productive uses. The risks must be fully and openly evaluated, and affected parties must be invited to participate in management decisions. Transparency will also facilitate the accountability of decisionmakers.

Life-Cycle Accounting. Although decisions about cleanup and waste management, post-remediation activities, and long-term stewardship will be implemented at different times, they are strongly interrelated. Thus, postremediation activities will be affected by and should influence current cleanup planning, while the success of long-term stewardship will depend on the level to which contaminated sites are cleaned up and on advance preparations at disposal sites. To the extent possible, decisions about all three activities should be made at the same time.[142]

Decisionmakers should also count all the costs, present and future, associated with their actions.[143] Short-term savings from leaving contaminants in place must be balanced against the costs of monitoring and maintenance for as long as the contaminants remain dangerous. Land restricted to specified uses will contribute less to the local economy in taxes and development potential. Provision must be made for the enforcement of restrictions and for emergency responses if controls fail, and despite every precaution, there will always be some residual risk of future harm, which must somehow be calculated and considered.

Documentation. Information about the nature and location of contaminants remaining at each site, as well as a complete record of cleanup and disposal decisions, should be widely disseminated, carefully archived, and made readily accessible in the future. Cleanup at some DOE sites today is complicated enormously by past failures, for example, to record the contents of high-level waste storage tanks, to map the locations of landfills, or to inform state authorities and neighboring landowners about unpermitted releases.

Identification of Stewards. Responsibility for administration of any stewardship program must be assigned to a specific entity.[144] In addition, provision must be made for a succession of replacements when the original steward retires, is dismissed, or ceases to exist. Each steward in turn must function openly and be publicly accountable for its actions. It also must have the legal authority, bureaucratic structure, and financial support needed to discharge its duties.

Enforceability. Land use restrictions and other controls must be legally enforceable for as long as they are needed.[145] To facilitate enforcement, responsible government bodies and interested parties must have access to information about conditions at each site. In the spirit of the citizen suit provisions of many environmental laws, compliance will be enhanced if site conditions are widely publicized and if any member of the public has standing to compel enforcement.

Redundancy. Because the consequences of failure to contain DOE's process wastes or to prevent human contact with them could be very grave, and because of the inherent difficulty in predicting the efficacy of control measures over hundreds or thousands of years, we must adopt several such measures with overlapping functions at each site. If one institutional controls fails, others should be available to take its place.[146]

Public Involvement. Members of the public, local governments, and state and tribal regulators should be fully informed and given an opportunity to participate in planning for cleanup or disposal at each site. These parties have interests uniquely affected by the decisions, and they may have a special sensitivity to the needs of future generations, to whom they are related by place, history, and perhaps family. Their understanding of local conditions may well improve the quality

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139 PROBST & McGOVERN, *supra* note 5, at 46.

140 *See* Todd 5. Davis & Kevin D. Margolis, *Defining the Brownfields Problem, in* BROWNFIELDS, *supra* note 90, at 6.

141 Similar goals are set out in Pendergrass. *supra* note 100, at 10121-23; ORR **REPORT,** *supra* note 4, at 3-15. A set of implementing strategies, focusing on the needs of future generations, may be found in WEISS, *supra* note 17, at 169-91.

142 *See* MOUND, *supra* note 135 (reuse and cleanup decisions are being made prior to the identification and development of institutional controls).

143 ***See*** BEMR. *supra* note 7, at 3-i to 3-3.

144 ***See*** PioasT & McGovnN, *supra* note 5, at 37-38.

145 Practical difficulties of enforcement are described in HERSH **ET *AL.,*** *supra* note 90, at 88-92; Pendergrass, *supra* note 100.

146 See Pendergrass, supra note 100, at 10120.

of the decisions.[147] Public education about the dangers associated with each site will also promote the long-term enforcement of institutional controls.

Sustainability. Aside from sheer luck, future generations will be protected from hazardous wastes only by engineering measures or institutional controls that remain effective. Simply writing controls into records of decision (RODs) will not suffice. Unless a stewardship technique can be expected to work for as long as the wastes remain dangerous, it must be regarded as experimental and labeled accordingly.

Sustainability also requires a secure source of funding. The maintenance and protection of sites holding hazardous wastes must be financed for as long as the contents are hazardous. If provision for these payments cannot be made now, for example, by the creation of a trust fund, then we must be candid about the fact that the economic burden is being shifted to future generations.

Flexibility and Responsiveness. It is possible that future generations will develop technologies to complete the cleanup of contaminated sites at less cost, or that they will find a way to utilize the wastes for, say, the generation of electricity. They may determine that risks to human health and the environment from these wastes are greater—or less—than we perceive today. Our children and grandchildren may be better equipped than we are to respond to the effects of future climate changes, armed conflicts, political realignments, and population movements, simply because they are closer in time to the events. One way to anticipate what we cannot foresee is to adopt a long-term stewardship program that continually reinvents itself. Such a program would be subject to ongoing evaluation and adjustment based on new discoveries and changing priorities.

Every plan that relies on institutional controls must include an analysis of the probable consequences if those controls fail. An emergency response must be described in sufficient detail to allow the steward to engage in contingency planning and maintain needed logistical support for as long as the controls remain in effect.

The Law and Long-Term Stewardship

Stewardship Options Under Current Law

Because the conditions at a site cannot be predicted very far into the future, they must be prescribed. Effective institutional controls are, therefore, central to a program of long-term stewardship. Where land use must be restricted following a CERCLA cleanup, EPA insists,

> Institutional controls will play a key role in ensuring long-term protectiveness and should be evaluated and implemented with the same degree of care as is given to other elements of the remedy. In developing remedial alternatives that include institutional controls, EPA should determine: the type of institutional control to be used, the existence of the authority to implement the institutional control, and the appropriate authority's resolve and ability to implement the institutional control.[148]

Deed restrictions, deed notices, and local government land use controls are mentioned as options.[149] Nevertheless, in a recent study of plans for the geologic repository at Yucca Mountain, a National Academy of Sciences panel expressed skepticism about the long-term effectiveness of such measures:

> We might expect some degree of certainty of institutions, and hence of the potential for active institutional controls, into the future, but there is no basis in experience for such an assumption beyond a time scale of centuries... Passive controls, too, may be of limited duration, requiring future generations to renew them.[150]

In this section, a variety of physical measures, institutional controls, and institutions that might be used with different waste configurations to provide the necessary long-term protection of human health and the environment are considered.[151] Current law requires some to be implemented in connection with disposal of radioactive waste.[152] Some have already been employed in CERCLA remediations[153] or in other settings.[154] The challenge here is to identify those elements that, individually or in combination, could be used by DOE to fashion a coherent stewardship program with the characteristics described in the previous section, and to indicate changes in existing laws that would enable the development of such a program.

Active Institutional Controls

Active institutional controls require an ongoing affirmative effort by some agency. They include continued government control of sites containing wastes, inspections, maintenance, access controls, groundwater pump-and-treat operations, enforcement of land use restrictions, permitting, and preservation of archives. Such active controls can be effective in protecting human health and the environment so long as they are continued, that is, until a political decision is made to abandon them or to stop paying for them. Yet, EPA regulations for the geologic repositories and uranium mill tailings, which

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[147] The reasons for active public participation are surveyed in Applegate, supra note 61, at at 921-26.

[148] OSWER Directive No. 9355.7-04, *supra* note 103, at 9-10.

[149] ***Id.*** at 10.

[150] TECHNICAL BASES FOR YUCCA MOUNTAIN STANDARDS, ***supra*** note17, at 105-08.

[151] ***See*** *supra* sources cited in note 100.

[152] ***See, e.g.,*** 10 C.F.R. §161.44, 61.59(b) (1998); 40 C.F.R. §1191.14(a), 194.41(b) (1997).

[153] EPA has already used deed notices, covenants, conservation easements, and zoning restrictions, as well as fencing, warning signs, and monitoring, in an effort to control future use at a number of Superfund sites. However, these measures are rarely described in detail in RODs. Their application has been uncoordinated, standardless, and controversial. *See* HERSH ET AL., *supra* note 90, at 39-64; Borinsky, *supra* note 100, at 12; Ayers, *supra* note 99, at 1516-1518, 1529-1530; Weber, *supra* note 99. at 469; GRAND **JUNCTION, *supra* n**ote 133; MOUND, ***supra*** note 135.

[154] ***See*** Pendergrass, *supra* note 100, at 10113-20 (describing, among other things, protections for sole source aquifers and wellhead areas under the SDWA, programs to prevent development in floodplains and earthquake zones, and operation of the National Historic Preservation Act).

contain the most dangerous and voluminous wastes, respectively, permit reliance on active controls for no more than 100 years after disposal.[155] Passive controls may provide a backstop, since they are intended to continue operating over an extended period of time, perhaps indefinitely, without further expenditure or effort on anybody's part. For this reason, active and passive controls are sometimes used together.

Continuing Government Ownership. Government ownership is an obvious option for DOE sites, reflecting as it does the federal government's continuing legal and moral responsibility for the environmental condition of the nuclear weapons complex. Ownership brings with it the right to control activities on the site and the right to access for inspection, monitoring, and repair, but, of course, no guarantee that those rights will be exercised or even that the federal site manager from time to time will be aware of the danger when it authorizes the use or conveyance of the site.

Human disturbance could be minimized by posting guards and alarm systems at a site, as DOE now does to protect inventories of weapons-grade materials, although the expense of such measures is very high and unlikely to be supportable over long periods. Without such elaborate protections, private parties could, either deliberately or inadvertently, and without the knowledge or consent of the government, use the site in ways that would expose them to harm or allow dispersal of the wastes. The fact that their actions were unauthorized would not make those actions less dangerous; indeed, the contrary is more likely. The risk would be reduced if the public were fully informed about the dangers and could assist in the detection and suppression of violations. Members of the public might be even more helpful if they had a direct stake—unrelated to the environmental hazard—in preserving a restricted use, such as a park.

Transfer of a site containing dangerous wastes from one government agency to another presents additional risks. For example, if current efforts to abolish DOE are successful, it is not clear that the agency successor to DOE's land holdings would have the expertise, organizational structure, or resources to provide needed protection for hazardous wastes, or that that activity would be consistent with the new agency's ongoing mission.[156] Indeed, the problem of long-term stewardship is sufficiently novel that it is hard to think of any extant institution with direct experience and expertise.

Congressional tolerance for holding a large inventory of land for no purpose other than to restrict its use is problematic. Such holdings are expensive to maintain, and they are contrary to the general congressional desire to dispose of surplus property.[157] Congress has, however, directed that title to privately held uranium mill tailings and low-level radioactive waste and the land holding them are to be transferred to the federal or a state government.[158] The required transfer does not include "vicinity" properties where no tailings have been used for building materials or for fill.

Leasing, rather than outright transfer, of contaminated sites could allow the government to exercise direct continuing oversight. Restrictions on use may be written into leases,[159] but if they are not aggressively enforced by the government, others affected by violations may not do so. Leases with terms long enough to encourage capital inves merit in site improvements—typically 50 or 99 years—.ini over time be neglected by federal managers.[160]

Monitoring and Reporting. If any hazardous substances will remain at a site after remediation is completed, CERCLA requires review of the remedial action at least ever five years to ensure that human health and the environment are still being protected.[161] Any additional cleanup needed must be carried out at the same time.[162] The results of the reviews and any further remedial actions must be reported to Congress."[163] RCRA also calls for a "thorough inspection" at one- or two-year intervals of facilities used for the treatment, storage, or disposal of hazardous waste[164] while they are active.[165] Periodic reviews will permit the testing of containment structures and institutional controls. Depending or the setting, site inspections might include ground and surface water sampling,[166] and monitoring for radon emissions. If it is discovered that a disposal tumulus is being used as a dirt bike track (as has occurred), or that a gravel pit has been excavated on the site, use restrictions can be enforced. If weather has eroded a clay cap or burrowing animals have made holes in it, repairs can be made. Advances in cleanup technology may permit additional remediation. Publication of the results of monitoring could help to keep the public informed about dangerous conditions at the site. Unfortunately, under current law, several years could elapse between the failure of a control and its detection. On the other hand, the periodic reviews and inspections apparently will have to be carried out indefinitely at most CERCLA sites, unless the statutory mandate is changed or funding is cutoff, since CERCLA does not include a time limit. Although the annual cost of surveillance and monitoring is small compared to active remediation, it is far from clear that future generations will find the political resolve to continue those payments forever.

Affirmative Easements. CERCLA provides that when remediated federal lands are conveyed or leased to a nonfederal

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[155] 40 C.F.R. §1191.14(a), 194.41(b). The NRC has a similar requirement, not permitting reliance on active controls after transfer of ownership. 10 C.F.R. §61.59.

[156] See generally PROBST & McGOVERN, supra note 5, at 37-47 (discussing potential "stewardship implementers").

[157] See 42 U.S.C. §9620(h),ELR STAT. CERCLA § 120(h) (CERFA).

[158] *Id.* §§7914(f), 10171(b); 10 C.F.R. §§40.27(a), 61.59(a) (1998).

[159] ***See, e.g.,*** MOUND, *supra* note 135, at 20-22 (leases of contaminated properties requiring DOE approval of physical alterations, changes in uses, or subleases).

[160] Long-term leases are contemplated by CERCLA. ***See*** 42 U.S.C §9620(h)(3)(B), (5), ELR STAT. CERCLA 1120(hX3)(B). (5).

[161] *id.* §9621(c), ELR STAT. CERCLA §121(c); 40 C.F.R §300.430(IX4Xu) (1997).

[162] 42 U.S.C. §9621(c), ELR STAT. CERCLA §121(c).

[163] ***Id.***

[164] *Id.* §6927(c)-(e), ELR STAT. RCRA §3007(c)-(e).

[165] The inspection provisions are presumably subject to the general 30 year horizon on closed RCRA facilities. ***See*** *supra* text accompanying note 78.

[166] ***See GRAND*** **JUNCTION,** ***supra*** **note** 133, at 16.

owner, the document of transfer must include an easement permitting the government to reenter the site to monitor compliance with use restrictions and perform any necessary additional cleanup or repairs.[167] Access also may be required for many years to complete a groundwater pump-and-treat project. In some states such an "easement in gross' could not be transferred to a nonfederal steward.[168] So long as it remains in federal ownership, however, it presumably will not be subject to loss by state statutes of limitation or common-law prescription, or abandonment, even if it is not exercised for a long period of time.[169] But only the federal government would be entitled to exercise it.

Direct Federal Regulation of Nonfederal Lands. A permitting program could provide direct supervision of future uses at former DOE sites. Neither CERCLA nor RCRA currently provides for such a program explicitly, although authority for one might be found in the requirement that any deed from the government must reserve access to perform any remedial or corrective action needed in the future.[170] However, a permit program administered by the same steward responsible for other institutional controls would probably encounter opposition from local land use authorities.

Records Preservation. One indispensable component of a stewardship program is the generation, preservation, and retrieval of accurate information about the location and characteristics of dangerous wastes.[171] Logically, those data include all the environmental information collected in the RI/FS at a contaminated site, program planning documents, and the ROD, along with new information from periodic reviews and additional remediation. Some relevant data can be found currently in the Federal Agency Hazardous Waste Compliance Docket,[172] maintained by EPA, which shows the nature, amount, and toxicity of hazardous wastes at every site on which a federal agency has ever stored, treated, or disposed of such wastes. The NCP also requires establishment of local data repositories,[173] at least during the cleanup planning process. However, CERCLA currently requires such records to be preserved for no more than 50 years.[174]

Archives for data about DOE sites must have several special qualities reflecting the peculiarly grave and enduring hazards of nuclear weapons production residues. They must, first and foremost, be durable. To guard against loss from war, accident, or natural disaster, they must be replicated in several locations where they will be readily accessible. They must be preserved in physical forms that will resist deterioration. Over the long term, film and electronic records have advantages and disadvantages relative to ink on paper.[175] Whatever their form, the records must be housed in dry, secure structures. The creation, maintenance, and operation of a suitable archive over a long period of time will be very expensive, and no existing law provides for such an archive.[176]

Equally important, these records must be able to communicate clearly to distant generations, who may not speak or even be familiar with any language in use today.[177] One response to the inevitable evolution of language and culture would be to require the review, updating, and translation of all data in the archive at intervals of, say, 50 years. Even so, some meaning would be lost, increasing the risk to future generations.

Publicity. Active controls should include a public education program designed to transform the location and danger of contaminated sites, as well as the existence of restrictions on the use of those sites, into "legend," that is, make them part of the popular culture surrounding each site. Frequent republication of this information would reduce the likelihood of inadvertent intrusions, enhance accountability, and facilitate enforcement by citizens or the government. Such efforts would, however, undoubtedly encounter strong resistance from communities and neighbors who are understandably reluctant to jeopardize property values by calling attention to nearby hazards.[178] In any case, aside from CERCLA's provision for

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[167] 42 U.S.C. §9620(h)(3)(A)(iii), (b)(3)(CXii), (h)(4)(D)(ii), ELR STAT. CERCLA § 120(h)(3)(A)(iii), Ch)(3)(C)(ii), (h)(4)(D)(ii). Federal officials are also authorized to enter and inspect any site at which a hazardous substance was generated, stored, treated, disposed of, or released. *Id.* §6927, ELR STAT. RCRA §3007; *id.* §9604(e), ELR STAT. CERCLA § 104(e).

[168] ***See*** ROGER A. CUNNINGHAM ET AL., LAW **OF** PROPERTY 461 (2d ed. 1993).

[169] ***See*** North Dakota v. United States, 460 U.S. 300, 318-20 (1983); United States v. Insley, 130 U.S. 263, 266 (1889).

[170] ***See*** *supra* text accompanying note 166. The NRC reportedly has considered licensing sites contaminated with uranium mill tailings. GRAND JUNCTION, *supra* note 133, at 17.

[171] ICF Kaiser Consulting Group is preparing a comprehensive report for DOE on managing data for long-term stewardship. It is expected to cover stewardship data needs; current requirements and practices for data retention; gaps in the present systems and their consequences; and some potential solutions for data generation, data preservation, future access to information, and the characteristics of a stewardship entity.

[172] ***See*** 42 U.S.C. §9620(c), ELR **STAT.** CERCLA § 120(c) (requiring EPA to establish the docket and make it available for public inspection).

[173] 40 C.F.R. §300.430(c)(2)(Lii) (1997).

[174] 42 U.S.C. §9603(d), ELR STAT. CERCLA § 103(d).

[175] *See* Stephen Manes, Time and Technology Threaten Digital Archives, N.Y. TIMES, Apr. 7,1998, at C4; PRODST & McGOVERN, *supra* note 5, at 29. The ICF Kaiser report will address these issues in detail. *See supra* note 171.

[176] The problem is illustrated by DOE's plan to turn over records of 10,000 properties contaminated with uranium mill tailings to the state of Colorado. State officials worry that the Colorado legislature will not provide funding needed to preserve the records and make them available to the public for even 30 years. GRAND JUNCTION, ***supra*** note 133, at 14; ***see also*** MOUND, ***supra*** **note** 135, at 29-30.

[177] ***See*** Erikson, ***supra*** note 81, also (discussing difficulties of communicating over long periods of time).

[178] At the Fernald site, the community insisted on barriers, institutional controls, and "clear marking" to prevent intrusion into the planned on-site disposal facility, but also sought "unobtrusive.., natural barriers to soften the visual impact." FERNALD CITIZENS TASK FORCE, *supra* note 107, at 4548. ***See also*** GRAND JUNCTION, *supra* note 133, at *15*, 17 (documenting resistance of real estate and financial institutions to annotation of land records).

reports to Congress of periodic remediation reviews,[179] no current law includes such a publicity requirement.

Research and Development. The discovery of new ways to treat or dispose of long-lived hazards may eventually lead to better cleanup of the DOE complex. Some forms of waste management, such as leaving it in accessible locations, are amenable to new technologies that arise because the waste can be retrieved. Other forms, such as geologic disposal. would resist such technologies because (ironically) they are so effective in isolating the waste from deliberate human intervention. Still others, notably MRS, are predicated on the appearance of new ways to handle waste material. Once the initial phase of active cleanup of the DOE weapons complex is completed, however, there may be little enthusiasm for additional spending on research and development.[180]

Emergency Planning. Although under current law EPA has authority to respond to an actual or threatened release of hazardous substances that presents an "imminent and substantial" danger to health or the environment, even from a "closed" hazardous waste site,[181] stewardship plans for each site should provide for population protection and quick remediation if controls fail. EPA's 1995 land use directive indicates that

> where there is some uncertainty regarding the anticipated future land use, it may be useful to compare the potential risks associated with several land use scenarios to estimate the impact on human health and the environment should the land use unexpectedly change. The magnitude of such potential impacts may be an important consideration in determining whether and how institutional controls should be used to restrict future uses.[182]

Planners also must consider the potential failure of controls to contain contaminants or exclude intruders.

The Emergency Planning and Community Right-To Know Act (EPCRA)[183] requires at least some DOE facilities engaged in RCRA or CERCLA cleanups to work with state and local officials to develop detailed plans for emergency responses to accidental releases of hazardous substances.[184] But EPA regulations do not require planning for releases of radionucides, unless state or local planners elect to include them.[185] EPA regulations also do not explicitly address coverage of closed facilities, and no DOE facility appears to have drawn up emergency plans for disposal facilities or sites where cleanup is "complete."

Liability. Because DOE is always liable for its hazardous waste, even after it has transferred contaminated property to someone else,[186] may be tempting to view after-the-fact cleanup as a stewardship option, at least for materials that are presently in a fairly stable configuration. This might be regarded as active stewardship of last resort. It is active be-cause it requires some future entity to undertake whatever remediation is required, as well as to pay for injuries resulting from earlier failures to clean up more thoroughly.[187] It is a last resort because it does nothing in itself to prevent the release or migration of long-lived hazardous materials. Such an approach flies in the face of the preventive goals of environmental law. It also effectively saddles our descendants with a "mortgage" of indeterminate dimensions.

Passive institutional Controls

The problem with active institutional controls is that they require a steward's affirmative action to maintain their efficacy. Further, there is good reason to doubt our ability and willingness to sustain such activities continuously over long periods of time:

> We know [of] no historical examples of societies successfully maintaining active care of decentralized materials through public institutions for periods extending to many hundreds of thousands of years. We have concluded that primary reliance on passive measures is preferable, since their long-term performance can be projected with more assurance than that of measures which rely on institutions and continued expenditures for active maintenance.[188]

Passive controls may in theory last forever, either because they need no active agency to maintain them, or because in some instances they can be maintained by private entities with a continuing interest in their efficacy. In view of the serious consequences of even a single failure with respect to DOE wastes, however, we must resolve major uncertainties concerning the probable longevity of human-engineered structures and the long-term efficacy of land use restrictions.

Physical Barriers, Containment Structures, and Markers. One way to limit access to dangerous materials is to place them in a remote location, such as the middle of a desert or deep underground. The relative isolation of the Nevada Test Site

[179] 42 U.S.C. §9621(c), ELR STAT. CERCI.A § 121(c).

[180] Spending for what DOE calls "science and technology development" is projected at 6 percent of the total EM budget (or about $12 billion) between 1996 and 2030. DOE hopes that savings from new discoveries will exceed research expenditures over the same period. BEMR, *supra* note~ 7, at 3-19,4-29, app. F. But no provision is made for research funding farther into the future.

[181] 42 U.S.C. §6973(a), ELR STAT. RCRA §7003(a); id. §§9604(a)(l), 9606 **,** ELR **STAT.** CERCLA §§104(a)(1), 106.

[182] OSWER Directive No. 9355.7-04, *supra* note 103, at 6-7.

[183] 42 U.S.C. §§11001-11050, ELR STAT. EPCRA §§301-330.

[184] *See* Exec. Order No. 12856,58 Fed. Reg. 41981 (Aug. 3, 1993) (directing federal facilities to comply with EPCRA).

[185] ***See generally*** 40 C.F.R. Pt. 355 (1997). Nevertheless, accidental releases of radionuclides must be reported to state and local emergency planning officials, as well as to the National Response Center. 42 U.S.C. ***§9603(a),*** ELR **STAT.** CERCLA § 103(a); *id.* §1 1004(aX3), ELR STAT. EPCRA §304(a)(3). Routine releases and transfers of radionuclides are not reported on the Toxics Release Inventory under EPCRA §313, however. ***See*** 40 C.F.R. 1372.65 (1997).

[186] 42 U.S.C. 19620(hXBXii). ELR STAT. CERCLA §120(hXBXii).

[187] *Sec* Thomas 3. Laveile, ***The Future "Superfund" Sites: A Price for the Next Generation,*** 10 UCLA J. ENVTL. L a POL'Y 283,285-91(1992).

[188] Standards for Remedial Actions, ***supra*** note 36, at 597.

made it an attractive choice for nuclear weapons testing, and, along with neighboring Yucca Mountain, it remains attractive to DOE and Congress for disposal of radioactive wastes. Similarly, buffer zones around disposal cells at other sites are intended to keep people at a distance. Barriers, such as fences, may discourage intruders for decades or even centuries. Other engineered structures are designed to contain contaminants in soil or groundwater, or to isolate wastes in repositories. These include the natural and synthetic caps and liners described above, concrete sarcophagi for disposal cells, and curtain drains to direct water flows away from wastes. Each of these physical structures must be used in conjunction with other institutional controls to prevent its disturbance.

As a measure of the "long-term effectiveness and permanence" required by the NCP,[189] these physical barriers and containments must perform for as long as the wastes remain dangerous. Yet, our experience to date raises serious doubts about their reliability.[190] The ancient Egyptians used two forms of isolation to protect their royal tombs and the vast treasures they contained.[191] The pyramids at Giza and Saqqara (c. 2650-2500 B.C.) announced the presence of the tombs prominently (to say the least), and relied on the massiveness of their construction to thwart grave robbers. The tombs of the Valley of the Kings (beginning c. 1550 B.C.), in contrast, were structurally modest and were deliberately hidden in an isolated valley. Both the pyramids and the Valley of the Kings were guarded and attended by religious establishments. Despite the obvious ingenuity of the Egyptian builders, the provision for surveillance, and the survival (in name at least) of the Egyptian monarchy into the Roman era under the Ptolemys, neither technique was at all effective, even in the near term. While it is unlikely (and for good reason) that future generations will search for DOE waste with Howard Carter's. persistence in searching for Tutankhamen's tomb, the Egyptians'efforts to isolate the mummies of their deified kings and queens is a cautionary tale for us, their descendants.[192] Ultimately, of course, even Tutankhamen's lost tomb yielded to Carter's intrusion, although it had lain undisturbed for only 3,200 years—one *tenth* of the half-life of plutonium and one *hundredth* of the period during which it remains hazardous. Modern construction methods and materials might extend the life of structures at DOE sites, but we must expect that those structures will need to be repaired or replaced long before the wastes they enclose cease to pose a threat.

Warning signs could help prevent inadvertent intrusions, at least for a while.[193] They might also discourage activities, such as well drilling, that could jeopardize the integrity of containment structures. Needless to say, signs will also need to be repaired or replaced over time.[194] Over the long run, they will also have to be modified at intervals in order to communicate with future generations, whose language and knowledge base may be quite different from ours.[195]

Deed Notices. CERCLA requires that every deed for the transfer of government property contain information about the storage, release, or disposal of any hazardous substances on the land, as well as a description of any remedial actions taken.[196] Similarly, closure of a RCRA-permitted hazardous waste disposal facility requires the recording of a notice in local deed records to warn prospective purchasers of the property that it was used to manage hazardous wastes and that its future use is restricted.[197]

Future transferees of former DOE lands must, in short, rely on each state's system of deed records to learn of any residual hazards.[198] That reliance may be misplaced. Even if the recording system is maintained indefinitely, a deed containing the critical information may not be recorded by the original transferee, or it may be recorded prematurely or delayed, so that it appears out of the chain of title; it may be indexed incorrectly, or filed in the wrong place, so that it cannot be found by a future purchaser; the property may be described inaccurately, so that it cannot be located physically; the deed record or the index may be destroyed; a subsequent transferee by inter vivos gift, will, or inheritance may never consult the deed records; a prospective purchaser may not bother to search the records, or, having searched, may fail to find the government's deed (a problem that will be exacerbated by the growing number of public records that must be searched).

Reliance on the deed records also may be frustrated by policies in every state that place a particular stress on the appearance or recent history of a site. Once contaminated land has passed into private ownership, anyone may acquire a new original title to it by adverse possession after a relatively short time. Even though federal use restrictions presumably would endure,[199] it is not likely that the new owner or its successors would ever search earlier deed records.

In many states abbreviated title searches are rewarded either

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[189] 40 C.F.R. §300.430(eX9Xiii)(C) (1997).

[190] A National Academy of Sciences Study of the proposed geologic repository at Yucca Mountain concluded: "(It is not possible to make scientifically supportable predictions of the probability that a repository's engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years." U.S. EPA, Environmental Radiation Protection Standards for Yucca Mountain. NV, 60 Fed. Reg. 47172, 47174 (Sept lip 1995).

[191] See Howard Carter & A.C. Mace, THE DISCOVERY OF THE TOMB OF TUTANKHAMEN 50-62 (1923, reprinted 1977).

[192] ***See ii***

[193] It is also possible that warning signs would *attract* intrusion by the curious or by those uncertain of their meaning.

[194] Even this level of care cannot be a foregone conclusion. At the Oak Ridge Reservation in Tennessee, DOE decided not to excavate all of the mercury-contaminated sediments of the East Fork Poplar Creek, because to do so would have destroyed one of the important natural resources of Oak Ridge. To limit public access to the sediments, signs were posted in 1983 along its course, warning against fishing and water contact More signs were added in 1992. By 1998, however, it was difficult to find a record of the location of the signs to enable their presence to be confirmed; many of the signs were missing or damaged; and DOE and the state of Tennessee could not agree among themselves who had the responsibility for repairing the signs when the problem was brought to their attention. ***See*** ORR **REPORT,** *supra* note 4, at C-4 to C-S.

[195] Erikson. *supra* note 81. at 36, 40-41, 50.

[196] 42 U.S.C. §9620(h)(3)(A)(i), ELR STAT. CERCLA §120(h)(3XAXi).

[197] 40 C.F.R. §264.119 (1997).

[198] State deed record systems are described generally in CUNNINGHAM ET AL., *supra* note 168, at 823-54.

[199] ***See*** North Dakota v. United States, 460 U.S. 300,318-20,13 ELR 20312, 20317 (1983).

by statute or by customary practice.[200] Thus, as a matter of local custom, attorneys in some jurisdictions search back in a chain of title no more than 40 or 50 years (or in some instances beyond the specified period only until they locate an apparently regular deed) in order to determine that a seller has "marketable title." This practice is codified in at least 20 states. Some of these "marketability" statutes provide that earlier ownership interests or deed restrictions are extinguished if they are not rerecorded at regular intervals.[201] If information about use restrictions or hazardous conditions is not included in every succeeding deed, or if the land is not conveyed by deed often enough, the information may be lost after only a few decades.

Covenants and Equitable Servitudes. Covenants and equitable servitudes (sometimes called "deed restrictions") are promises by a landowner to do or refrain from doing something that concerns the land.[202] A homeowner's covenant to use a city lot only for a single-family residence is a familiar example. CERCLA directs the insertion of such a restriction in deeds or leases of federal lands that are not yet cleaned up to a level that would permit unrestricted use.[203] The conveyance must contain assurances that "provide for any necessary restrictions on the use of the property to ensure the protection of human health and the environment."[204] At one site contaminated with a variety of radionucides, for example, DOE proposes to employ deed restrictions that limit future uses to industrial activities, that prohibit drilling or excavation; and that specifically forbid residential uses, child care facilities, non-adult schools, and farms.[205]

State laws concerning the enforcement of these restrictions have become maddeningly complex, as courts have struggled to reconcile their traditional hostility toward land use restrictions with the need for modern urban planning. Moreover, the rules vary widely from state to state, and they are currently the target of vigorous reform efforts.[206] Without clarifying legislation, various doctrinal stumbling blocks could hamper enforcement of restrictions by stewards other than the federal government.[207] For example, in some states, only a nearby landowner can force compliance.[208] Enforcement might not be possible against the lessee of a transferee or against anyone who lacks notice of the restriction or who can mount various equitable defenses. In any event, members of the public would not have standing to enforce such a restriction.

Negative Easements. A negative easement operates to disable a landowner from using property in a particular way or from using it in other than a specified way.[209] In a conveyance of contaminated land to a private owner, for example, DOE might reserve the right to prevent the purchaser or its successors from excavating on the site. Such easements would not, in general, have been enforceable at common law and might not be enforceable today by a nonfederal steward.[210] While almost every state now has legislation authorizing the creation of "conservation easements," these statutory easements may not be suited for restrictions on farming, well drilling, or certain other inappropriate activities.[211] Whether the government holding a negative easement could be compelled by a nongovernment party to enforce it, through an action in the nature of mandamus, is unclear. What is clear is that no one other than the owner of an easement is entitled to enforce it directly.

Reversionary Interests. A deed conveying DOE land to a nongovernment transferee might make continued ownership dependent on the observance of stated conditions, such as refraining from residential occupancy. Thus, transfer of a fee simple determinable or fee simple on condition subsequent would leave the government with a possibility of reverter or right of reentry, respectively, revesting title in the government or allowing it to recover the property if the condition were broken.[212] Such defeasible fee interests have been unattractive to developers, and only grudgingly enforced by courts, because they operate as forfeitures.[213] They are not likely to be popular with purchasers of former DOE lands, or more reliable than the easements and restrictions described above in avoiding inappropriate uses of those lands.

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[200] ***See*** **CUNNINGHAM ET AL,** *supra* note 168, at 854-61.

[201] Some state statutes provide that the interests of the United States will not be extinguished. ***See, e.g.,*** RI. GEN. LAWS §34-13.1-7(1995).

[202] ***See*** *generally* CUNNINGHAM ET AL., *supra* note 168, at 466-504.

[203] 42 U.S.C. §9620(h)(3)(C), ELR **STAT.** CERCLA § 120(h)(3XC).

[204] *Id.* §9620(h)(3)(C)(ii)(I), ELR **STAT.** CERCLA §120(h)(3)(C)(ii)(J).

[205] ***See*** **MOUND,** *supra* note 135, at 24-31.

[206] ***See,*** *e.g..* Susan F. French, *Servitude: Reform and the New Restatement of Property: Creation Doctrines and Structural Simplification,* 73 CORNELL L. REV. 928 (1988); Susan F. French, *Toward a Modern Law of Servitudes: Reweaving the Ancient Strands,* 555. CALL.REV. 1261 (1982); RESTATEMENT (Third) OF PROPERTY (SERVITUDES) (Tentative Draft No. 4, 1994).

[207] Federal rights based on CERCLA authority presumably would be unaffected by such state rules. *See* North Dakota v. United States, 460 U.S. 300, 318-20, 13 ELR 20312, 20317 (1983).

[208] See. e.g.,CUNNINGHAM ET AL., supra note 168, at 490-91.See ii at 440.

[209] See id. At 440.

[210] At common law, only easements for access to air or light, or to ensure lateral or subjacent support or the flow of water, were recognized. The list of permissible negative easements has been expanded in many states by legislation or by judicial decision. ***See id.*** at 440-41.

[211] *See John L.* Hollingshead, *Conservation Easements: A Flexible Tool for Land Preservation,* 3 ENVTL. LAW. 319(1997); see also Ayers, supra note 99, at 1529-31. A number of state statutes have been modeled on the UNIFORM CONSERVATION EASEMENT ACT, 12 U.LA. 170 (1996).

[212] ***See generally*** CUNNINGHAM ET AL., supra note 168, at 35-59.

[213] ***See*** kLat54.

Zoning. Local land use regulations might at first blush seem like a promising way to prevent inappropriate uses. Yet, zoning and related ordinances are enacted and enforced by local governments in accordance with state, not federal, enabling statutes. They vary enormously in almost every particular from one jurisdiction to the next.[214] Local political pressures for development may make it easy to repeal the restrictions on a given site, without additional cleanup or even consideration of the environmental implications, or may make it difficult to enforce existing restrictions. The same may be said for groundwater classification programs in place in most states.[215] In any event, local government officials are not bound by private or federal government land use restrictions, and they certainly cannot be expected to condition their actions on—or even take notice of—such restrictions.[216]

Procedures and Institutions

DOE's long-lived wastes and its necessary reliance on institutional controls demand the prompt creation of an effective long-term stewardship program and the establishment of new or existing institutions to carry out stewardship functions. The legal system must therefore develop, in addition to legal instruments for exercising long-term control, procedures for current decisionmaking and institutions that are capable of implementing the controls and responding to new conditions.

Decisionmaking for the Long Term. Present decisionmaking for the long term requires no more than the elements of good public decisionmaking for other purposes, except that the problem of prediction is greatly magnified. The decisionmaker must be well informed, open to information and opinions from many quarters, especially those affected by the decision,[217] and willing to ask hard questions and take a hard look at the options presented. For decisions affecting many future generations, this is more easily said than done, in three particular respects.

First, the requisite information about the future condition of the site and its stewardship needs is typically sparse, and there is little hope of improving it substantially. In deciding how much reliance to place on particular institutional controls, the decisionmaker should understand what is known (and not known) about the toxicity and mobility of the waste in the long-term future; what is known (and not known) about future use of the surrounding area and the ability to control it; what is known (and not known) about the long-term performance of storage or disposal configurations; and what is known (and not known) about the movement of the waste materials in the environment. Together, these data will provide some idea of the present and future risks of the waste. Life-cycle accounting should be applied to costs, as well. What are the long-term costs of management options that protect only in the short-term? What are the short-term costs of management options that protect for the long term? Are the short-term costs of long-term protection affordable, and, if not, should the decisionmaker (like homeowners with mortgages) accept higher long-term costs?

Second, decisions that depend on the application of political and social values and that affect members of the public and their descendants must, in a democratic society, be reached through an open, transparent process. Ultimate decisionmaking responsibility, of course, rests with the legally constituted authority, but its deliberations should not only permit but also encourage broad public participation. Interested members of the public must have access to relevant information, an opportunity to provide relevant information,[218] and a forum to express their views on these questions.[219] The NRC originally proposed a citizens advisory board procedure for reaching decisions to allow restricted land uses at decommissioned facilities.[220] However, its final rules require little more than notice to the affected public,[221] because the NRC concluded, in the face of heavy industry opposition to the enhanced procedure, that greater "flexibility" was desirable.[222]

Third, the decisionmaking process must face up to the question of intergenerational equity posed by long-lived waste. Should we accept higher long-term costs because the short-term costs of long-term protection are too expensive? A recent report by the National Academy of Public Administration posited four principles of intergenerational equity: (1) trusteeship of present generations for future generations; (2) sustainability of future quality of life; (3) obligation of each generation to address immediate harms to itself; and (4) precaution in avoiding catastrophic or irreversible harm.[223] These principles should be integral to present-day waste management decisions that affect the future. They ask today's citizens to balance their own needs against those of individuals

[214]***See*** *generally iS* at 543-648.

[215]***See*** Pendergrass, *supra* note 100, at 10121.

[216]Notice of the closure of a RCRA-regulated disposal facility and information about its contents must be filed with the local zoning anthoriry, if any. 40 C.F.R. §264.119(a) (1997). There is no requirement, however, that the local zoning authority act on that information.

[217]Most of those affected by the decision are not alive yet., so the decisionmaker must find ways to take account of their needs. ***See*** WEISS. *supra* note 17,at120-26 (suggesting the appointment of a "guardian ad litem"), Daniel A. Farber & Paul A. Hemmersbaugh, ***The Shadow*** *of the Future: Discount Rates, Later Generations, and the Environment, 46* VAND. L. REv. 267,293 (1993) (emphasizing the need to consider future generations so that current decisions will be sustained over the long term).

[218]The report on the East Fork Poplar Creek signage, ***see supra*** note 194, was prepared by an individual citizen for a citizens advisory board at the Oak Ridge Reservation. It suggests that institutions like the End Use Working Group can provide a valuable public forum for obtaining useful information concerning the efficacy of institutional controls and for debating the consequences of those findings for cleanup decisions.

[219]Proposed characteristics of such a process are set out in NATIONAL ACADEMY OF PUBLIC ADMINISTRATION, DECIDING FOR THE FUTURE: BALANCING RISKS, COSTS, AND BENEFITS FAIRLY ACROSS GENERATIONS 8(1997) [hereinafter NAPA]; Applegate, *supra* note 61. at 95 1-56; Roger E. Kasperson, *Social Issues in Radioactive Waste Management: The National Experience, in* EQUITY ISSUES, *supra* note 17, at 55-60.

[220]NRC, Radiological Criteria for Decommissioning, 59 Fed. Reg. 43200, 43213-14, 43222 (Aug. 22, 1994).

[221]10 C.F.R. §20.1405(1998).

[222]Radiological Criteria, *supra* note 50. at 39076-79.

[223]NAPA, *supra* note 219, at 9-13; ***see*** WEISS, ***supra*** note 17. at 34-45 (developing principles of conservation of options for the future, conservation of quality of resources, and conservation of access to the resource legacy from the past).

not yet in existence, whose needs, wants, and circumstances may be very different from our own. (Imagine the needs, wants, and circumstances of Americans of just a century ago; technologically at least, they lived in a different world.) Law and legal formulas cannot fully resolve the dilemma created by the unavoidable uncertainty about future conditions, but the law may help to create procedures that will permit the fair and democratic resolution of these questions now and in the future.

Stewardship Institutions. One of the most important current decisions is the selection and empowerment of a stewardship institution to carry forward the work of waste management. Each of the waste configurations described earlier requires the designation of a steward that has the authority and capacity to perform the necessary stewardship activities and the flexibility to adjust to changing physical, legal, and political conditions.[224] The identity of the institution and the scope of its responsibilities must be determined first. Should it be a national, state, or local entity? Public or private? Should we try to create a priesthood devoted to guarding these wastes and protecting humankind from them?[225] Should DOE be responsible for its own waste, or should another (new or existing) institution take over when active remediation is complete? Should a new institution be responsible for federal sites or for all sites that contain long-lived waste? No matter how these questions are ultimately answered, the institution and its successors must have the ability to perform stewardship functions far into the future, including: site monitoring and management; execution of active institutional controls and enforcement of passive ones; information generation, preservation, and communication; and research and development.[226]

Long-term stewardship may be improved by empowering affected citizens to perform stewardship functions or to see that the designated steward does so.[227] Derivative or citizen suits, in which individuals can either enforce the rights of the steward or can force the steward to enforce its own rights, could be an important check on a gradual decline in vigilance. Such suits depend on citizens having access to information that hazardous waste is present and that it is no longer safely managed. However, because such records and ongoing monitoring results are primarily the steward's responsibility, it is only in fairly egregious cases that citizen enforcement is very likely to occur. Citizen empowerment nevertheless, a valuable backstop or redundancy in institutional stewardship arrangements.

An institutional steward needs sufficient and stable funding. A viable long-term stewardship institution requires the very opposite of the variable, always threatened annual funding that characterizes DOE's (and many other federal agencies') current budget picture. It is conceivable that a trust fund would last a couple of hundred years or so (assuming that Congress would be willing to commit the many billions needed up front),[228] but for real longevity a self-sustaining institution is clearly necessary.

It is nearly impossible to imagine an institution capable of caring for nuclear wastes for as long as they will remain dangerous, but the experience of two familiar European institutions, the Roman Catholic Church and the British monarchy, may be instructive. They have remained recognizable, distinct organizations for, respectively, nearly two thousand and more than nine hundred years. Over long periods of time, each institution has performed a relatively continuous set of functions, has raised money to perform those functions, has withstood enormous internal and external changes, has successfully called on generations of followers for tangible and intangible support, has transmitted knowledge about itself over generations, and has adapted to new circumstances while maintaining a core identity. This is precisely what a long-term stewardship institution must achieve.

How did church and throne do it? Both institutions established and nurtured a relationship with their followers. Whether based on power, legal status, or religious belief, the relationship is reciprocal: the institution protects and cares for its members (gives value, to put it bluntly), and the membership in return supports it materially and with its confidence.[229] Such a relationship (or expectation of it) is not only essential in the near term to obtain the political will to create a long-lived institution, but it is even more important in the long run to assure the continuing existence and efficacy of the institution.

The great long-term challenge for the institution designated to manage this nation's nuclear weapons wastes will be to establish similar relationships of dependency and trust, persuading future generations that the institution's services still give value to them. Above all, the institution must be able to "reinvent" itself[230]—as church and throne have done—to recognize new issues, to pass along new generations, to find new ways to address hazardous wastes, and, ultimately, to survive. We in the current generation will be judged by the imagination and dedication demonstrated in creating a stewardship institution with these qualities.

Conclusion

It now appears that most of the contaminated sites in the nuclear weapons complex will not be cleaned up to levels that will permit unrestricted use. Institutional controls have been incorporated into cleanup agreements at individual DOE sites on a case-by-case basis, but without detailed understanding of

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[224] A recent Resources for the Future report explores the issues of institution-creating in some detail. PROBST & McGOVERN, ***supra*** note 5

[225] Lest this sound too much like an Indiana Jones adventure, the Knights of Malta have functioned since the Crusades **in** 1099 as a provider of humanitarian services. The Hospitallers are both a military and religious order, and they continue to enjoy some aspects of national sovereignty.

[226] ***See*** PROBST & McGOVERN, ***supra*** note 5. at 25-31.

[227] SeekLat36,44.

[228] Banking and money are old, but the economic and legal arrangements that underpin current banking and monetary systems are so relatively new that there is no experience to suggest that traditional investments would be valuable in their present form for centuries. Unfortunately, DOE is unlikely to be given assets with a longer track record, like gold. DOE has one long-term asset aplenty—land—but the environmental condition of that land places its value in doubt.

[229] ***See*** Todd R. LaPorte & Ann Keller, ***Assuring Institutional*** *Constancy: Requisite for Managing Long-Lived Hazards,* 56 Pub.. ADMIN. REV., 535.536(1996) (emphasizing the importance of keeping commitments).

[230] The NAPA report speaks of an iterative process, involving a "rolling present'for decisions affecting future generations. NAPA, *supra* note 219. at 11.

the long-term risks and costs that they entail. As we have seen, existing institutional control techniques are unlikely to be effective for very long. The complexity and expense of a stewardship program, together with the uncertainty of predicting conditions in the very distant future, present an unprecedented challenge not only to DOE but to all entities and localities where long-lived waste is present.

DOE is just beginning to develop a coherent long-term stewardship program. As a first step, DOE must forth-rightly recognize the risks and costs—or its uncertainty about them—that its present actions pose for future generations. Next, it must define the functions of an effective long-term stewardship program. Such an institution must be capable of performing essential stewardship activities that can be reviewed at regular intervals and adjusted as needed to account for program failures, developments in science and technology, and other variables that cannot now be foreseen. It must, in other words, operate somewhat like the U.S. government, constantly reexamining and reinventing itself according to democratic principles within a broad constitutional framework—or perhaps like a species that evolves over thousands of years, maintaining some characteristics and changing others, all the while (thanks to the remorseless demands of natural selection) occupying a useful niche in its ecosystem. Finally, the process for selecting specific stewardship goals and strategies must be entirely public, not only to reflect the interests of persons most directly affected now and in the future, but also to improve the quality of critical decisions and the accountability of decisionmakers.

An effective program of such far-reaching consequence cannot be invented overnight. It is going to take careful research and thoughtful deliberation, and we can only guess at the form that it will eventually take. DOE is to be commended for beginning serious work on the problem, but the ongoing reliance on unproven institutional controls is reminiscent of the story of the emperor's new clothes. However much we want to believe that such controls will be effective for as long as they are needed, and no matter how widely accepted their use in other settings has become, the result will be danger and hardship to future generations if our confidence turns out to be misplaced. DOE must continue and broaden its efforts, and it must enlist the support of all who are responsible for the generation and remediation of the long-lived hazards in our environment.