THE CHALLENGES AND OPPORTUNITIES OF INSTITUTIONAL CONTROLS FOR LONG-TERM STEWARDSHIP OF THE FORMER DOE WEAPONS COMPLEX

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ABSTRACT

Starting from the premise that we owe the future the power of the knowledge of what it's up against, we define Institutional Controls, explain why they pose a challenge, suggest appropriate time frames for Long-Term Stewardship, propose the institutionalization of an annual mapping as a snapshot of the evolving state of knowledge of the location and risks of residual contamination at legacy sites, and apply recent research in Traditional Ecological Knowledge to suggest Native American Tribes as the right people (the right institutions, since they've been here a long time before us and a long time longer than the planning period) to help the United States Geological Survey manage this mapping. The paper concludes with examples of current and proposed work to develop knowledge and tools to support institutional controls undertaken by the Subsurface Contaminants Focus Area within the DOE Office of Science and Technology.

A DEBT TO THE FUTURE

In the Introduction to its *Draft Long-Term Stewardship Study* (DOE 2000), released for public comment last October, the DOE Office of that name explains the source of stewardship requirements: "Based on existing plans and agreements with regulators and affected parties, EM program cleanups will leave behind residual levels of radioactivity (e.g., buried waste) and other residual hazards at most sites. The challenge facing DOE is how to ensure continued protection of human health and the environment after the cleanup projects are complete."

What do we as a society owe the future in terms of the legacy wastes from nuclear materials and weapons production? One could answer: Nothing, arguing that the future, likely to command more knowledge and capability than ours, should be quite able to look after itself, so that attempts at help from us would be considered, from a far vantage point, as merely quaint. The Department of Energy does not answer in this way. The Department, aiming to reflect the larger society it serves, claims ownership of a responsibility and names it with the word "stewardship." So perhaps a look into the origins of this word will help clarify both the nature of the debt and the means of discharging it.

According to the *American Heritage Dictionary*, "steward" derives from an Indo-European root meaning, "to perceive, watch out for." Etymology thus suggests that we owe future generations the ability to perceive, to know the state of residual contamination at current former weapons complex sites. Since we wish them life and health, we want to prevent, if possible, their stumbling, through ignorance or accident, into what may bring them harm. We owe them the ability—the knowledge and therefore the power—to make informed choices about land and other resources, as inputs to the decision tools of the day. Surprises are the bane of management. We want to institute and institutionalize management strategies to minimize the likelihood of future surprises.

In addition to "steward," important derivatives from this root include *wary*, *aware*, *ward*, *lord*, *warden*, *award*, *reward*, *guard*, *panorama*, and *revere*. *Wary* and *aware* speak directly to understanding and monitoring contaminant fate and transport. *Warden* raises the question of who will have responsibility for seeing to it that appropriate long-term institutional management is set up and maintained. *Award* and *reward* remind us of likely necessity of financial incentives for the care taking managers and doers. *Guard* makes us ask how to prevent people and other creatures from harmful contact with residual contamination. *Panorama* reminds us of the centrality of envisioning, either all at once or in an evolutionary manner, appropriate future land uses for legacy waste sites. Finally, *lord* and *revere* remind us of the religious and philosophical roots, sources, underpinnings of the value structures that derive from various concepts of the human relationship with nature and thus dictate what we watch out for, how we do that watching, and to what ends.

The general thesis of this paper is that DOE should continue and enhance its efforts to include native Americans—by centuries and millennia the most persistent and land-reverent of institutions—in the gathering, interpreting, maintaining, and disseminating of information underpinning institutional controls. The specific recommendation is that, beginning with the already established State and Tribal Government Working Group, DOE find a way to fund, first, tribes, and second, the Department of Interior's United States Geological Survey, to institutionalize an annual mapping of the status of residual contamination at DOE sites. These maps, which essentially respond to the National Research Council's stewardship components four through six given in the next section below, item 3, will tell whoever needs to know how to mark the markers, place the fences, ease the easements, design the signs, drill and forbid the wells, write the deeds, zone the zones.

DEFINING 'INSTITUTIONAL CONTROLS'

Let us begin by examining definitions of "Institutional Controls" given by three institutions—DOE, EPA via the Environmental Law Institute, and the National Research Council—from documents in chronological order.

1. DOE's *From Cleanup to Stewardship*, October 1999. In this founding document for DOE's Long-Term Stewardship program, "institutional controls" (pp. D-4,5) are "Non-engineering measures, usually, but not always, legal controls—intended to affect human activities in such a way as to prevent or reduce exposure to hazardous substances. Institutional controls include, but are not necessarily limited to: land and resource (e.g., water) use and deed restrictions; well-drilling prohibitions; building permits and well use

advisories and deed notices; other legally enforceable measures. However, they are distinct from physical engineering measures such as treatment and containment systems."

2. Environmental Law Institute's *Protecting Public Health at Superfund Sites: Can Institutional Controls Meet the Challenges?,* ELI, 2000, p. 93: "Legal and administrative mechanisms designed to prevent exposure to contamination left on site after remediation. Examples of institutional controls include: notices in property records, restrictions on the use of property recorded on the deed, conservation easements, zoning, groundwater restrictions, soil testing and removal requirements, and public information tools—such as educational campaigns—designed to increase awareness of site risks." This definition importantly adds "information tools" to the picture.

3. The National Research Council's definition, in *Long-Term Institutional Management of U. S. Department of Energy Legacy Waste Sites* (National Academy Press, 2000), p. 163, mostly recapitulates DOE's original definition: "Restrictions on land access or use through such devices as easements, deed notification, zoning, permits, fences, signs, government ownership, and leases; also, legal measures to ensure continued access to privatized sites for the purpose of monitoring and, if necessary, further remediation."

In this report, "institutional controls" figure as just one of the eight components of "stewardship"; but indeed the requirements for institutional control depend at any given time on most or all of the other components; we therefore give all eight here:

"'Stewardship'—Activities that will be required to manage potentially harmful residual contamination left on site after cessation of remediation efforts, including:

- maintaining contaminant isolation and measures to monitor the migration and attenuation or evolution of residual contaminants;
- institutional controls;
- conducting oversight and, if necessary, enforcement;
- gathering, storing, and retrieving information about residual contaminants and conditions on site, as well as about changing off-site conditions that may affect or be affected by residual contaminants;
- disseminating information about the site and related use restrictions;
- periodically reevaluating how well the total protective system is working;
- evaluating of new technological options to reduce or eliminate residual contaminants or to monitor and prevent migration of isolated contaminants; and
- supporting research and development aimed at improving basic understanding of both the physical and sociopolitical character of site environments and the fate, transport, and effects of residual site contaminants."

4. Finally, DOE's *Draft Long-Term Stewardship Study*, October 2000, p. 115, essentially recapitulates the definition in *From Cleanup to Stewardship*: "Non-engineering measures—usually, but not always, legal controls—intended to affect human activities in such a way as to prevent or reduce exposure to hazardous substances." Examples (p. 43)

include "easement, deed notification, deed restriction, lease, covenant, permit, zoning, sign, fence."

These definitions point up both the opportunity and the challenge of institutional controls. The opportunity is to be of service to future generations. The challenge is to institute the right controls for now and to devise a process that will institute the right controls for the future, based on the systematic acquisition and dissemination of the best possible understanding of what one is up against and must look out for. Institutional controls depend for their effectiveness on the understanding of the risks they are designed to minimize and protect against. And the persistence of institutional controls depends on the persistence and robustness of the institutions that maintain them.

HOW LONG IS LONG?

We recall the acronyms—NIMTO, NIMPL, NOPE—bandied about in the Department in response, in 1989 and 1990, to the date of 2018, the original end date in the Department's first *Five-Year Plan* for the then "Environmental Restoration and Waste Management" program. The date of 2018 was chosen at the suggestion and request of the STGWG, because it was then the farthest-out milestone in the Hanford Tri-Party Agreement. The so-called "30-year cleanup goal" to which the Department then committed itself (Note: committed itself to the *goal*, not to the *cleanup*) was considered safe for the agreeing officials because it was "Not In My Term of Office" and, for most people, "Not In My Professional Lifetime." The final acronym, for "Not On Planet Earth," is the one to fight against by choosing both a goal and a timeframe for the goal that can reasonably withstand such a melancholy fate. The goal of cleanup, meaning restoration of all sites for unrestricted use, though championed bravely and largely without irony a decade ago, is now seen to have been ill founded, because we have neither the resources nor the scientific and technical capability to achieve it. Many inside the Department and out also believe that stewardship, not cleanup, is the intelligent, low-risk course—that, once we destroy, stabilize, contain, and remove what we more or less easily now can, the best next step is to let and to help natural processes do the rest, while we watch to make sure, site by site and case by case, and with interested parties looking over the Department's shoulders, that they're right. This whole idea could change, of course, over decades or centuries, as we learn more, and everyone who writes about stewardship agrees with the principle that nothing we do now should foreclose technical or administrative options that might become advantageous in the future.

Returning now to our precise topic, we note four candidates for the answer to this question. The first is 70 years, given by the current end date for the responsibilities of DOE-EM's Office of Project Completion. The second, 300 years, comes from the National Research Council's report, cited earlier, as a suggestion based on the reduction in the risks posed by radioactive cesium and strontium by a factor of a thousand. The third candidate, 1,000 years, weighs in from DOE Order 435.1, regarding the performance of low-level waste landfill covers, although the strategy here is repair and replace, not set it and forget it. The final candidate is tens to hundreds of thousands of years, if the aim is to reduce by orders of magnitude the risks posed by uranium and plutonium.

Let us not pretend to plan for, say, 10,000 years. Ice ages occur in such timeframes. Even 300 years could be excessive, depending on, say, some apparently high-probability global warming scenarios. Waste Management 2301 could well be held in the semi-tropical paradise of present day Manitoba, Americans having by then packed up and joined the forests and food crops in their march to the north. I personally hope somebody remembers to preserve the Arizona Inn's recipe for chicken salad, and how to put the patina on Li'l Abner's steaks and ribs. If those aren't part of stewardship, I say, with of course no official U. S. government backing, forget it.

The question is more than academic, given that in the federal government, for most activities, two years is a long time. When the EM program began, in August 1989, some of its civil servants tried, without success, to persuade Congress to fund its activities through a no-year mechanism like DERA—the Defense Environmental Restoration Account—which funded, and may still fund, DOD's Environmental Restoration Program. Such a mechanism allows an agency to do real planning and to make real promises. Absent such funding, everything is up for grabs each year. In its *Draft Long-Term Stewardship Study*, pp. 87-88, DOE notes the advantages and disadvantages of four kinds of funding vehicles—annual congressional appropriations, a long-term stewardship trust or escrow fund or funds, fees from DOE commercial activities/sales of assets, and public-private partnerships. The appropriate choice may not be one of these alone but rather a changing proportion of each, plus others yet to be brought forward. Who knows? Bill Gates could fund the whole darned thing. He's already given and promised a lot—hundreds of millions—to libraries, which will have to be key players in providing and maintaining access to institutional control-related information.

THE IMPORTANCE OF TRADITIONAL ECOLOGICAL KNOWLEDGE

Or maybe, instead of one or several mega-mogul angels, we'll have thousands, hundreds of thousands, or millions of volunteers—regular folks, people who live near former DOE sites and understand and care enough about the local situation to be stewards for the inherent reward of preserving life and ways of life. In the executive summary of its EPA document mentioned earlier, ELI (p. iii) says, "Unless there is improvement in the use of institutional controls, it is likely that such controls will continue to fail at some sites and that eventually one or more of these failures will cause people to be exposed to and possibly harmed by residual hazardous substances." (Note that the variety of contaminants at the four sites chosen as case studies does not include radionuclides.) Thus their ELI's recommendation is for Inter-Governmental Coordination on behalf of long-term efficacy. The governments to focus on would be federal, state, and tribal. Three hundred years from now we might or might not have a federal government. State governments are more likely; but tribal governments, considering they've mostly been around for thousands of years, look like a good bet for continuity. And the current partnership between STGWG and the National Conference of State Legislatures sounds like best bet going.

Given these thoughts, it came as timely and fortuitous that during the preparation of this paper, the prestigious journal, *Ecological Applications*, devoted more than 80 pages of its October 2000 issue to invited feature articles on the topic of Traditional Ecological Knowledge. In "Rediscovery of Traditional Ecological Knowledge as Adaptive Management," Berkes, Colding, and Folke, observe that "Interest in Traditional Ecological Knowledge [TEK]—possessed by people outside Western science, knowledge that often becomes encoded in rituals and in the cultural practices of everyday life—has been growing in recent years, partly due to a recognition that such knowledge can contribute to the conservation of biodiversity, rare species, protected areas, ecological processes, and to sustainable resource use in general." For our purposes, TEK may hold a key to the management and 'institutionalization' of the institutional controls that must underpin an informed and sustained program of stewardship of DOE's legacy waste sites.

How does it work? To oversimplify, indigenous peoples know the signs of healthy land, water, plants, and animals and have encoded this knowledge in their everyday language, customs, and rituals. They have had to perceive and deeply embed such knowledge in order to survive and thrive for a long, long time. What Western science learns and measures through instruments, indigenous people know through the instrumentality of their senses and their history. Laser-induced fluorescence imaging is one promising way to monitor the health of an aquifer based on contaminant uptake by plants. Indigenous stewards are another. Western science and indigenous stewards together make an unbeatable pair. Each has much to teach the other.

Listen, for example, to this. In "Indigenous knowledge and resource management systems in the Canadian subarctic," in Berkes, *et al.*, eds., *Linking Social and Ecological Systems*, Cambridge University Press, 1998, pp. 98-128, Berkes (p. 109) writes, "Perhaps the most notable feature of present-day beaver management in the James Bay area is the territorial system. The community hunting area of Chisasibi is divided into 40 'traplines' or hunting territories, representing traditional family areas and formalized by the government into a resource management system. Each territory is occupied seasonally by a hunting group, usually consisting of two or three nuclear families, and led by a 'beaver boss' or a steward, as Feit prefers to call them. The steward is a senior hunter who acts as leader for the group, and who is part of the collective leadership provided by the Chisasibi Cree Trappers Association (CTA). He (and it is usually a he) oversees that all the codes and rules for proper hunting, not just for beaver but for all resources, are carried out. The steward acts as a 'gatekeeper' for the area and controls access; any persons who wish to hunt or fish in an area are expected to obtain permission from him.

"He also keeps a mental inventory of resources and harvests in his area. It is not unusual for a steward to have a mental map of all the beaver colonies in an area of several hundred square kilometres, and a good idea about the numbers and age composition of the beaver in each. By integrating the knowledge from past hunts with trends in abundance, a hunter can set his objectives for the next season. However, these objectives are flexible. If there are no animals where there should have been plenty, the hunter quickly adjusts his expectations."

By the way, beaver is only one resource the Cree watch carefully. Berkes notes that "Based on ethnohistorical information and current practice, James Bay Cree hunters seem to be simultaneously managing beaver populations on a 4-6 year scale, lake fish on a 5-10 year scale, and caribou on a 80-100 year scale." Can DOE do without such a genre of devotion and expertise? I think not. It's a matter of a cultural imperative that we Westerners do not generally possess. Berkes, Colding, and Folke (2000) observe that "…[A]n essential component for traditional knowledge and practice for ecologically sustainable outcomes is a worldview that provides appropriate environmental ethics. The pervasive cosmology of traditional societies may be characterized as a 'community of beings' worldview in which humans are part of an interactive set of living things…. Cultural values such as respect (for humans as well as for nature), sharing, generosity, reciprocity, patience, and humility characterize a diversity of systems of traditional knowledge and practice, including those of American aboriginal groups…"(1259, with some adjectives from Folke, Fikret, Birket and Colding, "Ecological practices and social mechanisms for building resilience and sustainability," in Berkes, *et al*., eds., *Linking Social and Ecological Systems*, Cambridge University Press, 1998, p. 418). These values don't immediately jump out as characterizing non-aboriginal Americans.

It is therefore heartening to find the following description on EM's Tribal Programs/Special Initiatives web page (http://www.em.doe.gov/public/tribal/initiatives.html#specinit2):

"Tribal "*Oral Histories*" Project
The Department is working in partnership with several Tribes to capture the stories of native peoples as they were impacted by the development of the nuclear arsenal and the subsequent cleanup of the weapons complex. The project is intended to yield additional information about the sites to assist the Environmental Management program in its remediation activities. Additionally, the Tribal "Oral Histories" project is bringing to light the wisdom and knowledge of Tribal elders and members in a way that furthers the Department's understanding about the significance of Tribal culture and the Indian Tribes' inherent relationship with the environment. Furthermore, the project will increase Tribal members' understanding of the nuclear age and the challenges faced by the Department in addressing the cleanup of its sites."

This activity is as important as the support of "an innovative program at the Santa Fe Indian School, which encourages Tribal youth to consider careers in scientific and technical areas of environmental protection. In a community-based approach, students learn hands-on environmental monitoring and analytical skills. They work with Pueblo environmental program staff in water and wildlife monitoring as well as cultural resource protection activities. What the students learn in the classroom is applied in field work important to the Department's clean-up activities." I hope this project is connected to the Oral Histories Project; of paramount importance is that Department scientists not only teach their knowledge and methods but that they also learn from traditional Tribal knowledge.

MAPPING THE STATE OF KNOWLEDGE OF RESIDUAL CONTAMINATION

We suggested earlier that, since stewardship and institutional controls require the ability to perceive and understand what is to be watched out for, we can partly discharge our debt to the future by institutionalizing, as we have institutionalized the Nuclear Weapons Stockpile Memorandum, an annual mapping of residual contamination at DOE stewardship program sites. Information is the reduction of uncertainty. The maps would be based on the best available science, which should improve from year to year, thus decreasing uncertainty about the nature, location, fate and transport, and synergistic and antagonistic toxicity and health effects of contaminants in combination. But the maps would also indicate areas (geographical and otherwise) of uncertainty, puzzles yet to be solved. The maps would show the location of remediation systems and tools and either indicate how they were working, or point to a source for real-time monitoring information, or both. Backup documentation would show ownership of sites or parts of sites and would provide names, addresses, and phone numbers for federal, state, and local points of contact for various site-related activities. Annual results would be published and stored redundantly—on the web, in Federal Depository Libraries, in State Libraries, in DOE and DOI Headquarters as long as they last. Each annual version would be saved in the latest version of the appropriate software. The first principle problem solving is, "First define the problem." This is what we have in mind. Such a program would help avoid the "Oops!" syndrome—discovering after the fact that you're breaking ground for a new facility in the middle of Native American remains in Washington State; or that you've built a development of McMansions over a buried arsenal in Northwest Washington, D.C.

The mapping would be a joint undertaking of the Department of Interior's United States Geological Survey, at the appropriate regional and state levels, and of the appropriate Indian Nation(s) and Tribal organizations, including but not limited to what is now the State and Tribal Government Working Group, and which is funded by DOE though the National Conference of State Legislatures. And if we want an acronym, we could try STEWARD: State and Tribal Extended Waste Attenuation and Residue Delineation.

Thinking there might already be such a program, I sent USGS a note last October asking, "Does USGS maintain a map showing the zones of radiologically and chemically contaminated areas around former DOE Weapons Complex and related sites? Or if you don't, do you know anybody who does?"

A prompt and helpful reply informed me that "the USGS does not have a systematic program for developing such site maps, although maps of selected locations may have been generated. We have no list of such maps. There may be reports (some containing maps) on selected sites such as the online report Ground-Water Flow Study in the Vicinity of the Savannah River Site, South Carolina and Georgia, which may be read at [a long internet address]." I was also directed to "reports generated in the USGS Toxic Substances Hydrology Program."

Entering the address for the SRS Ground-Water Study, I found a helpful 1995 fact sheet, which explained that "Because of the highly complex nature of ground-water flow in the SRS region, the DOE in 1991 requested that the U.S. Geological Survey (USGS) conduct a study to define ground-water flow and stream-aquifer relations in the Savannah River basin in the vicinity of SRS. Other participants in the 6-year study include the Georgia Department of Natural Resources, Clemson University, and the University of Georgia. A committee consisting of representatives from SRS and Georgia and South Carolina State agencies provides technical oversight. The major objective of the study is to quantitatively describe ground-water flow in the vicinity of the SRS and the Savannah River, including evaluation of stream-aquifer relations, to determine whether trans-river flow is occurring. Effects of selected hypothetical pumping scenarios on the potential for trans-river flow also are being evaluated. The study is being implemented in two phases.

"Phase I of the study, completed in 1994, defined the geologic, hydrologic, and water-quality conditions in the SRS area through field investigations, test drilling, data analysis, and ground-water flow modeling (Clarke 1992).

"Analysis of water sampled from 14 test wells and 2 existing municipal wells indicate that the water is within the U.S. Environmental Protection Agency (USEPA) primary drinking-water standards (1993) having no detectable concentrations of contaminants in the deeply buried aquifers. Concentrations of tritium below the USEPA maximum contaminant level of 20,000 parts per liter (U.S. Environmental Protection Agency, 1993) were detected in one 100-foot deep well in northern Burke County, Ga. (Clarke and others, 1994). The source and extent of tritium concentrations in shallow ground water in Georgia were reported by Summerour and others (1994).

"During phase II, a more focused site-specific data collection program near the Savannah River will be implemented using geologic and water-quality data from phase I. Based on data and flow-model simulations conducted during phase I, the area having the greatest potential for trans-river flow is near the Burke-Screven County, Ga., line south of the SRS. To provide better definition of ground-water flow conditions in this area, several wells are planned at a cluster site during phase II. Calibration of the ground-water flow model from prepumping to modern-day (1992) conditions is to be completed. Model simulation of hypothetical pumping scenarios that might induce trans-river flow are planned. *Upon completion of phase II, a long-term network is planned to monitor ground-water levels and water-quality data near the Savannah River."* (italics mine)

I learned from an e-mail exchange with the USGS author, J. S. Clarke, that the study had concluded in 1997, and when I asked what, if anything, was still going on, he replied that "the USGS is not involved in gw sampling in the SRS vicinity; we do monitor ground-water levels at a site across from the site in the Savannah River floodplain in Burke County."

Mr. Clarke concluded, "I do know that Westinghouse SRC has incorporated wells constructed as part of our study into an areal ground water quality network that is sampled several times per year," and he gave me a contact name and phone number, where I have left a message. I am impressed by the responsiveness of the USGS. They appear to have a culture that stresses service. This is a good sign, and it reinforces my sense that they are a good bet for this activity.

NATIVE AMERICAN PARTICIPATION IN STEWARDSHIP MAPPING EFFORT

The *Draft Long-Term Stewardship Study*, 7.3, notes that "Although DOE sites can take many steps now toward improving information management practices, a more systematic approach may be needed to coordinate and focus efforts throughout the DOE complex. The necessary framework would include an organization, or a network of organizations, which would have the authority, mission, and funding to identify, preserve, and provide access to information critical to long-term stewardship. There are three general options for developing such a framework: dispersed, concentrated, and hybrid (see Exhibit 7-2)."

In the hybrid option, which we assume to be the likeliest of the three, "some information management responsibilities would be concentrated in a single entity; others would be dispersed among multiple, site-specific entities. Intermediate in terms of flexibility, efficiency, and the need to maintain coordination. A single entity could maintain overall responsibility for managing system (e.g., ensuring standards and protocols are followed; updating technologies). Other entities could be responsible for specific types of information (e.g., local governments could manage real estate records)."

The Study then notes other "federal agencies [that] have established institutional frameworks for managing stewardship information," including the Nuclear Regulatory Commission, The Bureau of Land Management, and The National Park Service's Geologic Resources Department." We suggest that DOE explicitly put into its policy options hopper the inclusion, in major management roles, of the USGS and the State and Tribal Government Working Group.

At the present time, DOE-EM's office of Intergovernmental and Public Accountability funds Agreements-in-Principle with nine Tribal organizations: the Yakama, in Washington State; the Confederated Tribes of the Umatilla Indian Reservation, in Washington and Oregon; the Seneca Indian Nation, in New York State; the Shoshone-Bannock and Nez Perce Tribes, in Idaho; the Navajo Nation, in Arizona; and, in New Mexico, the Pueblos of Isleta, Santa Clara, and San Ildefonso. The funding, approximately $6 million a year, pays for attendance at STGWG and other meetings; for cultural resources activities; and for air, water, and soil monitoring activities, and for checking the results of others' monitoring activities.

The DOE Draft LTS Study, in Chapter 7, Information Management, notes the applicable scoping comment from STGWG in the February 1999 report of its Stewardship Committee, *Closure for the Seventh Generation*: "DOE should establish mechanisms for the collection, retrieval and storage of site data and information necessary for stewardship and historic preservation purposes." Well, as the young people are saying these days, "Duh!" Who should be in the lead in such activities, or at least in partnership for the lead? As an American nation, of natives and non-natives, we should give ourselves and our posterity the best of Western science and technology *and* the best of thousands of years of indigenous Traditional Ecological Knowledge and Wisdom.

The challenge of institutional controls for long-term stewardship is a matter of attempting to shape appropriate behavior for a distant future—which is challenging because we don't know (a) just how distant this future may be; (b) what, year by decade by century, will define "appropriate behavior"; or (c) how to shape this behavior even if we knew what it should be. The distinction between the *stability* and the *resiliency* of an ecosystem may provide a useful analogical answer to this problem.

"By the 1970s, ecologists abandoned the idea that the stability of ecosystems was a function of their complexity. The new perceptions were summarized at the first international congress of ecology in the Netherlands. Moreover, Holling observed that there was confusion about terminology and he defined with precision the terms 'resiliency' and 'stability.' Resiliency determines the persistence of relationships within a system and is defined as the ability to absorb changes in state variables (such as populations, species, or nutrients), driving variables (such as inputs of water or sunlight), and parameters (such as temperature), and still persist. Stability was defined as the ability of an ecosystem to return to a steady-state condition after a disturbance. Stability increases with the speed of return and the reduction in fluctuation. Thus, an ecosystem could be unstable but resilient if it persisted after disturbance but failed to return to a pre-disturbance state"(957). (From A. E. Lugo, "Management of Tropical Biodiversity," *Ecological Applications*, 5(4), 1995, pp. 956-961.)

The importance of this distinction for our purposes comes later in the article: "…[W]e must avoid the common pitfall of traditional management philosophy…. [M]anagement from a stability point of view emphasizes steady states, the maintenance of a predictable world, and the harvest of nature's excess production with as little fluctuation as possible. In contrast, management from a resiliency point of view emphasizes the need to keep options open, to view events in a regional rather than a local context, and to emphasize heterogeneity. *By focusing on resiliency, management does not require a precise capacity to predict the future, but only a qualitative capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take*"(959, emphasis mine).

In the words of Mac Chapin, in "Losing the way of the Great Father," *New Scientist*, Vol. 131, 10 August 1991, pp. 40-44, "Where tradition remains strong, people see no need to preserve esoteric knowledge; the people simply practise their culture." Combining modern and traditional ways of looking, knowing, and evaluating, and institutionalizing that combination now, we may avoid some (not all) failures over the next seven and more generations. We can accept the traditional concept of the future as behind us, because we cannot see it, and of the past, which we can see, as before us. We may yet get ahead by letting an informed past take a greater role as guide.

INSTITUTIONAL CONTROLS-RELATED ACTIVITIES OF THE SUBSURFACE CONTAMINANTS FOCUS AREA

Although formal responsibility for stewardship plans and activities within DOE is lodged with organizations at DOE Headquarters, at the Idaho National Engineering and Environmental Laboratory, and at the Grand Junction Project Office, the Subsurface Contaminants Focus Area, by the very nature of its concerns, has a mission to support stewardship success. SCFA's work packages support projects related to five strategic activities: Identify, Contain, Remediate, Remove, Validate. The last, Validate, refers to long-term monitoring associated with the other four activities. Monitoring must assure that characterization identified (or did not identify) the problem fully and accurately. Then, monitoring must measure the extent to which containment systems isolate contaminants from the biosphere; the extent to which remediation systems actually destroyed contaminants; and the extent to which source terms said to have been removed actually were removed. In short, validation activities allow interested and affected parties inside and outside the program to check up on what, at any given moment, is what.

Technologies and systems to do this checking up are fundamental to the information gathering and sharing underlying the quality of institutional controls. And, at least in terms of Western approaches, we are far from knowing or being able to do enough. Thus, SCFA is blessing efforts of the Environmental Management Science Program to study the fate and transport of contaminants in the subsurface.

Projects with names like the following are part of SCFA's planned and actual near-term future:

- Field Verification of Monitored Natural Attenuation using Marker Technology
- Alternative Landfill Cover Demonstration (at Sandia National Laboratory)
- Development of Perfluorocarbon Tracer Technology
- Hanford Vadose Zone Fate and Transport Test Facility
- In Situ Systems for Long-Term Monitoring
- Electrical Methods for Evaluating & Monitoring Geomembrane Caps
- Data Organization and Long-Term Stewardship Information Management
- Validation of Remediation Technology in Vadose/Saturated Zones
- Robust Site Hazard Warning Systems for DOE Sites Prototype at Rocky Flats

Finally, on December 15, 2000, the National Energy Technology Laboratory (NETL) published a Program Research and Development Announcement (PRDA) No. DE-RA26-01NT40891 for "Development of Innovative and Improved Technologies for Subsurface Contaminants," with a submissions closing date of January 23, 2001. The three research areas anticipated in this PRDA are: (1) characterizing, monitoring, modeling, and analysis, (2) separations and reactive treatments in the subsurface, and (3) validation, verification, and long-term monitoring of contaminants and treatment. Awards under this solicitation will further enhance the Department's chances of real progress toward the goals of its stewardship mission.

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