Nuclear Waste Transportation: Case Studies of Identifying Stakeholder Risk Information Needs

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The U.S. Department of Energy (DOE) is responsible for the cleanup of our nation's nuclear legacy, involving complex decisions about how and where to dispose of nuclear waste and how to transport it to its ultimate disposal site. It is widely recognized that a broad range of stakeholders and tribes should be involved in this kind of decision. All too frequently, however, stakeholders and tribes are only invited to participate by commenting on processes and activities that are near completion; they are not included in the problem formulation stages. Moreover, it is often assumed that high levels of complexity and uncertainty prevent meaningful participation by these groups. Considering the types of information that stakeholders and tribes need to be able to participate in the full life cycle of decision making is critical for improving participation and transparency of decision making. Toward this objective, the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) participated in three public processes relating to nuclear waste transportation and disposal in 1997–1998. First, CRESP organized focus groups to identify concerns about nuclear waste transportation. Second, CRESP conducted exit surveys at regional public workshops held by DOE to get input from stakeholders on intersite waste transfer issues. Third, CRESP developed visual tools to synthesize technical information and allow stakeholders and tribes with varying levels of knowledge about nuclear waste to participate in meaningful discussion. In this article we share the results of the CRESP findings, discuss common themes arising from these interactions, and comment on special considerations needed to facilitate stakeholder and tribal participation in similar decision-making processes. ***Key words:*** **environmental information, hazardous waste, risk communication, risk perception, stakeholders.** ***Environ Health Perspect*** **111:263–272 (2003). doi:10.1289/ehp.5203 available via** ***http://dx.doi.org/*** **[Online 31 October 2002]**

Citizens of the United States face many difficult challenges regarding nuclear waste cleanup. Cleanup issues include the large volumes of waste, the toxicity of the waste, potentially severe human and environmental impacts, technical complexity, lack of previous experience, a legacy of secrecy, staggering costs, a history of inequitable practices, and a jumble of intricate federal and state regulations. Many entities, including decision makers; tribal, state, and local government agencies; regulators; citizen groups; and contractors, must be involved in the decision process. Given the complexity of the cleanup, including all these groups is difficult.

In this article we explore ways to determine what information stakeholders, and particularly Native American tribes, need to become involved in nuclear waste cleanup decisions. The term "stakeholder" is defined as parties interested in or affected by U.S. Department of Energy (DOE) cleanup. The term generally includes citizens groups, regulators, DOE managers and contractors, state and local governments, and the general public. Tribal peoples assert that their "government-to-government" relationship with the U.S. government means they do not fall within standard definition of the term "stakeholder." In this article we therefore use "stakeholders and tribes" to refer to these groups.

We focus on several questions: What are the major issues? Who is involved and who is absent from the discussions? What information do people need, and how can it be best presented? What tools and approaches enable stakeholders and tribes to participate in meaningful dialogue with these issues? Considering such questions is critical to improving participation in these complex decisions. Toward this objective, the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) participated in three stakeholder and tribal interactions involving nuclear waste transport. CRESP is a national consortium of university-based researchers operating under a grant from the DOE (for more information, see Boiko et al. 1996; CRESP-II 2001; Goldstein 1998; van Belle et al. 1996).

An important goal for CRESP is to improve the dialogue among decision makers, technical specialists, and interested and affected parties [we use these terms as identified in the National Research Council (NRC) book *Understanding Risk* (NRC 1996)] to create more sustainable, understandable, and acceptable nuclear waste transport decisions. We report the results of these activities here jointly to leverage the lessons learned and challenge the scientific community to develop and evaluate approaches to improve public involvement in the DOE context. In the next section we briefly introduce nuclear waste transport and discuss some of the cleanup challenges, which also apply to many other types of complex decision problems informed by risk assessment approaches. In the third section we summarize each interaction as a mini-case study. In the fourth section we highlight common themes and lessons that have emerged from these interactions. Finally, in the conclusion we make suggestions that may help scientists and managers to develop information stakeholders and tribes need to participate in complex decision-making activities.

Tackling the Challenge of Nuclear Waste Transportation

The DOE is responsible for cleaning up the nuclear weapons production facilities—some 140 sites in 26 states and territories (U.S. DOE 1999). Many of these sites are small, just a few acres in size, while others are quite large; the Idaho National Environmental Engineering Laboratory (INEEL) in southeastern Idaho tops the list at > 900 square miles. This vast former nuclear weapons complex has produced a large amount of waste both in terms of volume (36 million m^3) and radioactivity (1 billion Ci) (U.S. DOE 1997a). The DOE uses the term "waste" generally to refer to "solids or liquids that are radioactive, hazardous or both" (U.S. DOE

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1997a). Waste comes in several forms, including high-level waste, transuranic waste, low-level waste, mixed low-level waste, residues from mining operations called "tailings" or 11e(2) by-product material, hazardous waste, and other waste (Table 1). These definitions are codified in laws such as the Nuclear Waste Policy Act [NWPA (1982)], the Atomic Energy Act [AEA (1954)], the Resource Conservation and Recovery Act [RCRA (1976)], and DOE Order 5820.2A (DOE 1988). Definitions are generally based on the types of processes that produced the waste. Although "high-level waste" generally emits high radiation levels and the severity of its potential impacts are high, "low-level waste" may emit moderate levels of radiation and does not necessarily translate to low risk. These semantics cause some confusion about nuclear waste disposal and transportation among stakeholders and tribes. For a more complete discussion of nuclear waste categories from both military and civilian nuclear activities, see Ahearne (1997).

Cleaning up these wastes generally involves activities to stabilize them by altering physical or chemical properties, by changing the location of wastes, or by erecting some physical or institutional barrier so that wastes are less likely to come in contact with people or the environment (examples of physical and institutional barriers are fences and deed restrictions, respectively). The cleanup activities fall under the purview of the Environmental Management program at the DOE, which has a budget of roughly $6 billion per year (fiscal year 1992–fiscal year 2002) (U.S. DOE 2000, 2002). Some cleanup plans call for transporting nuclear wastes or hazardous materials from one site to another. For example, the current trend for low-level and mixed low-level waste is toward a "regional disposition," in which waste from smaller sites will be consolidated at larger sites (at Hanford in eastern Washington, the Nevada Test Site, the INEEL, Los Alamos National Laboratory in New Mexico, Oak Ridge National Laboratory in Tennessee, and the Savannah River Site in South Carolina) (U.S. DOE 1997b). The rationale behind this is to remove the waste from smaller sites so they can be closed and used for alternative purposes. Other strategies call for long-term storage at special facilities such as the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. WIPP is designed to dispose of transuranic waste and began receiving shipments of waste in March 1999. Another special facility proposed for high-level waste is Yucca Mountain, Nevada. This project is more than a decade behind schedule and may never open due to technical and political obstacles. The National Transportation Program for DOE (DOE 2001a) is responsible for coordinating all nonclassified shipments of hazardous materials, including radioactive and mixed wastes for DOE's Environmental Management program. DOE has also established the Transportation Resource Exchange Service (T-REX) to provide a virtual library of relevant documents. Using T-REX, one can search for and learn about shippers, packaging, routes, tribal issues, regulations, and more (T-REX 2001).

Opposition to the transportation of nuclear waste can be intense. For many years, researchers have found that the public has a higher fear of radiation risks than other types of risks (Mills and Neuhauser 1998; Slovic et al. 1979, 1991a). For example, as early as 1978, lay audiences (League of Women Voters members and students) perceived nuclear power to be involuntary, delayed, unknown, uncontrollable, unfamiliar, potentially catastrophic, dreaded, and severe—all the extremes of the factors thought to contribute to perceived risk (Fischhoff et al. 1978). In addition, the Yucca Mountain project in Nevada has faced heavy opposition from a variety of sources (Slovic 1991; Slovic et al. 1991a, 1991b). According to several surveys, the specific problem of waste transportation is also problematic. A survey of Oregon residents about transporting nuclear waste using the state highway system found that public concerns about health and safety issues were high, while confidence and trust in public officials were low (MacGregor et al. 1994). An Idaho survey indicated that there may be a particular concern about using trucks to transport nuclear waste (McBeth and Oakes 1996). A survey of neighborhoods adjacent to a radioactively contaminated site (Feldman and Hanahan 1996) found that more respondents favored off-site management of wastes than on-site management, but noted that

> written comments indicated a concern with exporting or transferring the problem elsewhere, ensuring the careful transport of contaminated soil while avoiding contamination of additional sites through transport.

Table 1. Waste definitions in the DOE complex.

Waste category	Definition	Total volume (m^3)	Total radioactivity (million curies)
High-level waste	Highly radioactive waste resulting from the chemical processing of SNF and irradiated target assemblies (DOE 1988, 1997a; NWPA 1982)	380,000	960
TRU waste	Contains alpha-emitting TRU elements with half-lives > 20 years whose combined activity level is at least 100 nCi/g of waste at the time of assay (DOE 1988, 1997a)	220,000	4
Low-level waste	Composed of all radioactive waste not classified as high-level waste, TRU waste, SNF, or natural uranium and thorium by-product material defined under section 11e(2) of the Atomic Energy Act (DOE 1997)	3,300,000	50
11e(2) By-product material	The DOE's term for the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material (i.e., uranium or thorium) content (DOE 1997a)	32,000,000	National figures not available but can exceed 1,000 pCi/g
Mixed low-level waste	Contains both hazardous waste subject to the RCRA (1976), and source, special nuclear, or by-product material subject to the Atomic Energy Act (DOE 1997a)	146,000	Likely to be < 2.4
Hazardous wastes	Defined under the RCRA, its implementing regulations in 40CFR260–279, and corresponding state regulations. A material is a hazardous waste under the RCRA only if it meets the definition of a solid waste; a solid waste is considered hazardous if it is either listed in the regulations as a hazardous waste or exhibits a characteristic of corosivity, ignitabilty, reactivity, or toxicity (DOE 1997a)	Information not available	Not radioactive
Other waste	Some DOE waste does not fit into one of the previously defined categories because of its chemical and radiologic composition [e.g., PCBs and PCBs mixed with radioactive waste that are subject to the TSCA but are not also subject to the RCRA, asbestos, and 11e(2) waste mixed with hazardous waste subject to the RCRA] (DOE 1997a)	79,000	Not radioactive

Abbreviations: NWPA, Nuclear Waste Policy Act; PCBs, polychlorinated biphenyls; RCRA, Resource Conservation and Recovery Act; SNF, spent nuclear fuel; TRU, transuranic; TSCA, Toxic Susbstance Control Act. Adapted from U.S. DOE (1997a).

Finally, nearly all the site-specific advisory boards (SSABs) and citizen advisory boards (CABs), official committees that advise the DOE on nuclear waste cleanup issues in general, have provided official advice and comments to DOE radioactive waste transportation. Transportation issues are clearly important for the SSABs, who are arguably the most involved and active groups in site decision making. [Information about the SSABs is available on the Internet (DOE 2001b).]

The DOE recognized in the early 1990s that its nuclear waste cleanup strategy required a high level of public involvement. Issuing the first in a series of requests, then Assistant Secretary for Environmental Management Thomas P. Grumbly asked the National Academy of Sciences to evaluate the feasibility and desirability of using risk assessment as a means to build enough consensus among its stakeholders to make lasting decisions about DOE cleanup. The subsequent report, *Building Consensus Through Risk Assessment and Management of the Department of Energy's Environmental Remediation Program* (NRC 1994), recommended that stakeholders be included in dialogue about cleanup from the beginning. A process to implement this recommendation was initiated in 1994 with a *Plutonium Roundtable* (League of Women Voters of Washington 1997) in the Pacific Northwest. The roundtable occurred during several evenings in Seattle and Richland, Washington (the latter being near the Hanford Nuclear Reservation). It brought together a broad array of stakeholders and tribes, as well as the Russian Atomic Energy Deputy Minister and staff. Participants addressed disarmament of the nuclear stockpile as well as cleanup of contaminated sites. A major recommendation from the workshop advocated that DOE stakeholders and tribes develop a process to generate debate about long-term cleanup and disarmament strategies on a national scale.

Building on these recommendations, the National League of Women Voters entered into a cooperative agreement with the DOE to facilitate the National Dialogue on Nuclear Material and Waste Disposition in 1996. The project was designed as a national initiative to elicit stakeholder values and develop principles to help guide DOE decision making regarding its nuclear and toxic materials legacy, particularly waste transportation issues. Pending decisions about DOE-managed material and waste at sites around the country affect not only the areas in which those sites are located, but also whole regions and communities along transportation corridors. Therefore, the goal of the national dialogue was to engage affected citizens to develop a strategic and more equitable national policy for management and disposition of nuclear material and waste. The national dialogue process began with a series of regional pilot field workshops, followed by subnational forums to formulate public values and principles surrounding the transportation and disposal of nuclear materials, including plutonium, spent nuclear fuel, and transuranic waste. A national forum on this topic was originally envisioned by the League of Women Voters, but was never implemented by the DOE (League of Women Voters Education Fund 1998). Four regional pilot workshops were developed as educational, public dialogues among diverse stakeholders, tribes, and decision makers.

Involving the public in waste transportation decisions is clearly a good idea, but the technical complexities of the material are still assumed to be a barrier to meaningful participation (Feldman and Hanahan 1996; Probst and Lowe 2000). Many researchers and decision makers believe that average citizens simply cannot understand or discuss nuclear waste transport issues, radiation hazards, or regulatory requirements. In fact, there are documented examples where lay people have grappled with highly complex issues and have been able to affect meaningful change (see, e.g., Kleinman 2000). Kaplan (2000) recounted the early history of citizen participation activities at the DOE Hanford site and strongly disputed the notion that citizens cannot handle complexity. In addition, Bonano et al. (2000) showed that stakeholders can work with experts on highly technical DOE cleanup decisions to formulate recommendations. Common to these examples is a concerted effort to provide participants with at least some degree of specialized knowledge, information, or training. The challenge for scientists is to abandon their assumptions and think more systematically about questions such as, what information do participants need to engage in the process, who is participating currently in waste cleanup dialogues, and, perhaps more important, who is missing from the discussion? Finally, how can scientists present information in ways that foster participation? We believe that we face a major challenge in getting people to engage in iterative dialogue about defining and addressing nuclear waste transportation and cleanup issues. How can we develop accessible resources for stakeholders and tribes so that their valuable input can contribute to decision processes and outcomes? These questions are explored in the sections below.

Stakeholder Information Needs: Three Case Studies

We used a case study evaluation design to synthesize the results from these three interactions because the how and why orientation of our research questions is well-suited to case studies (Yin 1994). For this study, we used a mixture of quantitative and qualitative data collection techniques including focus groups, intake surveys, and literature reviews. Our analysis techniques included content analysis and descriptive statistics. Several themes and lessons emerged from a synthesis of the three cases. Looking at the studies together strengthens the impact of our findings and allows for broader generalization.

Community focus groups. CRESP worked with Decision Research (Eugene, OR) to conduct focus groups to help identify local concerns related to nuclear waste transportation. (Decision Research has a wealth of expertise in the field of risk perception and extensive research experience on nuclear issues, particularly transportation; see, e.g., Decision Research 2002; Flynn et al. 1997; MacGregor et al. 1994; Slovic 1991). The purpose of the focus groups was to gain better insight into the issues of concern to various stakeholder groups. We wanted to work with stakeholders and tribes to understand their priorities and concerns about transporting waste. Specifically, we hoped to gain insight into the factors that led people to have a particular set of opinions about this issue. In addition, we wanted to determine what information stakeholders need to understand waste transportation issues and contribute meaningfully to cleanup decision processes. Our overall objective was to facilitate meaningful stakeholder input into these decisions by understanding some of these processes and perspectives.

Focus groups are small, facilitated group interviews that, in our case, followed an open ended-interview format (Patton 1990). Focus groups are often used as part of an exploratory research protocol to identify questions of interest for further inquiry. Although sample size is small, in-depth group discussions provide an opportunity for participants to give opinions and hear those of others. This allows researchers and participants to think about their views in the context of others' views. Our intention was to scope out the issues with participants of differing job descriptions, employment, geographic location, and familiarity with the topic.

Facilitators from Decision Research developed a script of key questions that should be covered during the discussion to aid in the consistency of discussion across focus groups. The script was built from issues defined in scientific literature and from experience working with nuclear waste transportation issues. During each focus group session, two facilitators shared responsibilities: one managed the group discussion, probing participants for concerns about nuclear waste transportation, and another recorded comments. Facilitators developed a summary of each group and then synthesized a common list of ideas and concerns. A follow-up group, made up of at least one participant from each group, was convened to review the major themes.

Four topical areas were investigated: ecological risks, human health risks, regulator and public agency concerns, and stakeholder and emergency response concerns (Table 2). Each focus group contained between 4 and 12 participants. Three focus groups were held in the Seattle area of western Washington, and three were held in the tri-cities area of eastern Washington, near the Hanford site. The focus groups were held in autumn 1997 and winter 1998. CRESP outreach coordinators identified focus group participants. Most knew of CRESP and represented groups with whom the project has had regular involvement. However, some participants, especially the public-at-large focus groups, were unfamiliar with the CRESP project. The participants in these public-at-large groups were invited specifically for their diversity of interests and backgrounds.

Examples of specific concerns that emerged from the discussions are also provided in Table 2. Despite differences in perspective between the focus groups and between individual participants, many common themes emerged. Concerns over the following issues were raised in several groups:

- Economic impacts or negative image of the tri-cities resulting from a proposed increase in the number of waste shipments to and from Hanford
- How waste form and packaging specifications affect accident scenarios
- The adequacy of safety preparation and emergency response capabilities along transportation corridors
- Potential impacts to human and environmental health resulting from a potential accident
- Fairness and equity of decisions calling for the consolidation of waste to a few major sites (many focus group participants, particularly those in the public-at-large groups, questioned whether there was sufficient justification to move wastes between sites, or if it were less risky to just leave the waste alone)
- Whether transportation of nuclear waste could be done safely, including whether drivers are adequately trained and if there are strict protocols for packaging and tracking shipments
- Lack of trust in and credibility of the DOE, concern that the DOE will not always make the most prudent choices, a general consensus that decisions made at more local government levels would be viewed with greater trust. This perception highlights the continuing need for transparency in, and stakeholder access to, DOE decision making and points to the need to partner with local officials both to generate the best information and ensure credibility.

Some differences among the groups were also evident. One of the clearest differences was the varied information base that even specialized participants—experts in various fields—brought to the discussion. Expertise tended to be focused on specific aspects of the issue and did not necessarily include knowledge across multiple aspects. Although there were important information gaps in all groups, in the public-at-large groups in particular there was a lack of knowledge of the kind and amount of waste currently being shipped through the community, as well as a lack of knowledge about differences between the kinds of waste being discussed, including those differences directly related to potential health threats.

There were several gaps in information or understanding that were specifically identified by participants. These included risks associated with different transportation modes (such as truck, rail, or barge); risks and failure rates associated with different types of packaging, including the form of the waste being transported (solid, liquid, or gas), and whether it was mixed with solids or formed into bricks; current protocols for handling wastes, including training standards for truck drivers; current volumes and types of waste shipped to and from Hanford; decision-making power (e.g., several agencies have authority to make decisions regarding transportation issues: the DOE, the U.S. Department of Transportation, state departments of transportation, state patrols, and/or other emergency responders); clarification about what transportation decisions have already been made and which are still pending, and at what point in the process was, or will, stakeholder input be sought and used; and the criteria for selecting general transportation strategies and specific modes and routes.

The focus group discussions emphasized the need for communication between the DOE and people affected by and interested in its policies and practices. Stakeholders and tribes need information about the decisions the DOE is making and why they are being made. In turn, the DOE needs information about stakeholder and tribal concerns, priorities, alternatives, and their origins before it can

Table 2. Focus groups: participant's organizations and examples of specific concerns.

Focus group	Participant's organizations	Specific concerns (examples)
Ecological risk group (*n* = 6)	Pacific Northwest National Laboratory, CRESP Ecological Task Group, Washington Department of Ecology, private consultant working on environmental health issues	Biodiversity and the presence of sensitive ecosystems or species need to be included in DOE decision-making criteria Ecological impact of roadway construction and maintenance need to be adequately considered
Human health risk group (*n* = 6)	Oregon State University, U.S. EPA Region 10, University of Washington School of Medicine, private physician working with the Hanford Health Information Network, CRESP researcher	Need for better education to promote lay understanding of the differences between uncertainty and variability in data to help raise public understanding of risk Need for scientists to better understand long-term health effects of low-level radiation exposures via air, water, and soil
Regulator group (*n* = 5)	Washington Department of Ecology, Oregon Office of Energy Nuclear Waste Transfer Program, U.S. EPA Region 10, INEEL Oversight Program, U.S. Department of Transportation	Transportation represents the lowest risk in comparison to waste storage and handling Do not move wastes unless you have a very good reason Need for the worst case scenarios to be treated credibly and seriously
Public-at-large group 1 (*n* = 6)	First response fire unit, Tri-City Industrial Development, CRESP, Disarmament Coalition, Yakama Indian Nation	Emergency response infrastructure is inadequate and underfunded Need for better and more comprehensive emergency response training, especially in rural areas and within tribal communities Need for better, more timely, notification and general information about nuclear waste transport
Public-at-large group 2 (*n* = 12)	Engineer, two realtors, two staff members of a nonprofit human service organization, a homemaker, two small business owners, a court reporter, an environmental educator, a city planning director, and the owner of a local mortgage company	
Follow-up overview group (*n* = 4)	Four participants from previous groups were reconvened to review outcomes	

make effective and enduring decisions. Stakeholders and tribes must have access to information; they must know what information they need, where to get it, and what it means, and their access to that information must be practical and unencumbered. Likewise, DOE decision makers need to understand what information they need from stakeholders and tribes and where to get it. The DOE's access to information from interested parties must be practical and unencumbered, as well. In summary, these focus groups have suggested some of the ideas that need further attention, but they also raise many questions, such as how best to provide the information, who needs it, when, and in what format.

Regional nuclear waste transportation workshops: participant surveys. Pilot workshops were held during the summer and fall of 1997 in four regions across the United States. The Washington League of Women Voters and the Washington Physicians for Social Responsibility hosted the pilot workshops in the Pacific Northwest. The workshops were held in Richland, Spokane, and Seattle, Washington, and in Portland, Oregon. They drew more than 400 participants who gathered to discuss issues related to nuclear material and waste, including storage, treatment, worker and public health and safety, transportation, and disposal technologies.

Workshops were divided into three main components. The first segment provided an opportunity for participants to collect background information and handouts, view graphic displays and videos, and engage in informal discussions with resource people who were on hand from various sites, tribes, and interest groups. The second segment consisted of presentations by a panel of "resource people" from various sites. During the final segment, small groups of 8–10 participants were convened to voice concerns and formulate values and underlying principles that the DOE should apply when making decisions. Facilitators at each table recorded the concerns, values, and principles raised during the discussion. The small groups then reconvened in a large group for an open-microphone discussion of the key points raised by each of the small tables.

A workshop report by the League of Women Voters of Washington (1997) includes a summation of the values and principles developed among participants in the Pacific Northwest, the results of a survey on substantive waste storage and disposal issues, and an evaluation of the workshop process itself. The initial reports on the regional pilot workshops were designed to help the DOE decide whether the national dialogue should proceed at the subnational and national level.

In addition, CRESP conducted an intake survey for participants at the four northwest regional field workshops. Survey questions focused on two main themes: demographics and outreach methods. The first theme pertained to demographic characteristics of the workshop participants including sex, age, race/ethnicity, highest level of education, occupation, class of worker, household annual income, and place of residence. The second theme included questions designed to ascertain how participants found out about the workshop, the timeliness of outreach efforts, and which outreach methods were most effective. Participants were also asked to identify stakeholder groups that were missing from the public workshop process.

The intake survey was made available to workshop participants after the meeting concluded but was not mandatory. Because it was one of three different surveys that were circulated at the workshops, we were not surprised that fewer than half of the participants (201 of 426; 47%) responded (Figure 1). Response rates varied by workshop: roughly 50% of the Seattle and Spokane participants returned the forms, while almost 60% of the Richland participants and only 26% of Portland participants returned forms. Of the 201 surveys received, 15% came from the Portland workshop, 25% from the Richland workshop, 19% from the Spokane workshop, and 41% from the Seattle workshop.

Demographic data from the combined survey responses were compared to Washington and Oregon census data from 1990. We found that workshop participants differed from the average population in respect to age, race/ethnicity, education level, and income (Figure 2). Underrepresented populations included persons < 30 years of age, native Spanish speakers, persons without a college degree, and persons living in households with an annual income < $40,000. Overrepresented groups included persons > 40 years of age, persons of Native American or other (biracial/mixed) heritage, persons with college or professional degrees, and persons living in households making > $55,000/ year. When asked who was missing from the workshop, respondents repeatedly indicated that "the general public," "elected officials" (decision makers), and "people of color" should be included in the workshops. These results suggest that future outreach and communication activities should be targeted to improve representation of underrepresented groups.

The workshops were advertised through several different mechanisms. These were designed to target stakeholders who were actively involved in nuclear cleanup issues, as well as citizens who were not previously involved in nuclear cleanup issues (Hemmings 1998). To inform the active stakeholder community, invitations were mailed directly to affected Hanford Tribes, the Nuclear Disarmament Coalition, Hanford Advisory Board members, local elected officials, League of Women Voters members, Washington Department of Ecology mailing list subscribers, and various organizations; press packets were distributed to local media; and announcements were placed in routine DOE-Hanford mailings and electronic bulletin boards. To reach members of the public not already involved, invitations were sent to minority community leaders and organizations, advertisements were placed in local newspapers and radio, op-ed (opinion-editorial) pieces were written for Seattle newspapers, and the workshop steering committee made personal phone calls to contacts in Latino and African-American communities.

Most survey respondents heard about the workshops 2–6 weeks in advance and were satisfied with that time frame. They reported learning about the workshops from direct mailings (30%), specific organizations (including workplace postings; 24%) friends or relatives (17%), and the DOE public involvement calendar (12%; Table 3). There were important differences between what communications were expected to be effective and how participants actually heard about the workshops. For example, only 5% learned about the meeting through the newspaper or on the radio, but most respondents (40%) reported that newspapers or radio announcements were the best means of advertising similar events. These findings suggest that perceptions of effective communication methods may be quite different from methods that are actually effective.

The pilot workshops were clearly more visible than routine public involvement activities typically conducted by the DOE (Hemmings 1998). Despite the vigorous approach to outreach, intended to draw in members of the previously inactive public, > 90% of the survey respondents identified themselves as belonging

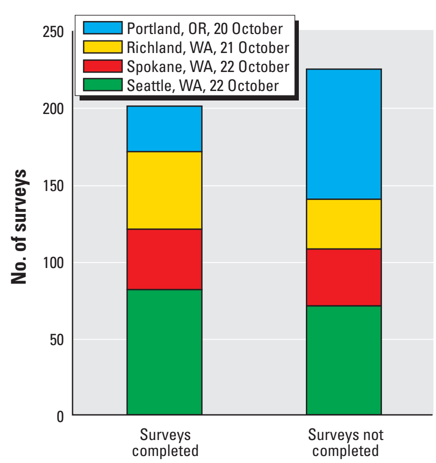


Figure 1. Composition of surveys distributed at regional pilot workshops on nuclear material and waste in 1997 (n = 426 participants).

to an existing stakeholder group. This seems to be a typical finding for DOE public involvement activities. We are unaware of empirical studies that show how few members of the public participate in public meetings on behalf of themselves only (as opposed to an organization for whom they volunteer or that pays them to be there). However, based on our experiences, it is rare to see someone from the public stand up at a public meeting and make a comment. For example, in the entire 36-month history of the Hanford Openness Workshops, not a single person took advantage of the public comment period to make a statement (Kern 1998, 1999).

There were many positive aspects of the regional nuclear waste transportation workshops, such as encouraging participants to interact with technical specialists in small groups, providing an opportunity for participants to build one-on-one relationships, allowing a range of perspectives to be expressed, addressing the big picture by looking at the interactions among all the sites in the complex (not just one site in isolation from others), and using trained facilitators. As an independent, credible institution, the direction and involvement of the League of Women Voters gave the workshops a certain level of legitimacy. However, participants were given little specific information about risks. For example, there was no discussion of how different cleanup alternatives require different trade-offs in terms of risks to workers, the public or the environment (i.e., that cleanup designed to reduce future risks to the general public often translates to increased risks to workers and the environment in the near term—due to the cleanup activities themselves). Moreover, participants "lacked sufficient information to fully understand the impacts of accepting vast new quantities of hazardous materials at a given site" (Hemmings 1998, p. 23). Specifically, participants wanted more information about transportation modes, the likelihood and consequences of major highway accidents, waste packaging information, route-specific guidelines, and local emergency response.

Developing and evaluating visual tools to aid complex discussion. In June 1998, the League of Women Voters organized a second round of dialogue with stakeholders on transportation issues called the Inter-site Discussion on Nuclear Material and Waste. Discussions took place at San Diego State University in San Diego, California, and at Loyola University in Chicago, Illinois, for 2.5 days each. The workshop design differed from the one originally proposed by the League of Women Voters, but the DOE decision makers and those affected by decisions were brought together to discuss intersite waste transportation issues (League of Women Voters Education Fund 1998). A variety of interactive formats (small group presentations, one-on-one discussions, break-out activities, and plenary sessions) were combined in an unprecedented way to create a common learning experience and an exchange of perspectives. Results reported here were compiled from the League of Women Voters final workshop report (League of Women Voters Education Fund 1998), our notes taken during the workshops, and discussions with other observers and participants at the workshops.

For one workshop exercise, CRESP worked with Toby Michelina of Global Environmental Strategies, Inc. (Albany, NY) to prepare an interactive display of nuclear waste for workshop participants (Figure 3). The display used Lego blocks (Lego Company, Billund, Denmark) to represent the type and volume of waste stored at various sites across the United States. Different colored blocks represented the different waste types, and each dot on the blocks represented a certain volume of waste in cubic meters or metric tons (Figure 3). The Legos were placed on a large base map of the United States (5 feet × 4 feet). The map included state outlines, waste site locations, waste repository locations, Native American Indian reservations, and transportation routes (highways and railway lines to be used).

Table 3. Expected method compared to actual communication methods for workshop advertising.

	Percentage of respondents who	
Method	Expected this method to be most effective	Learned of event in this way
Newspaper	25	4
Radio advertisement	15	1
Direct mail announcement	14	30
TV advertisement	10	1
Through a specific organization	7	24
DOE public involvement calendar	1	12
Friend or relative	0	17

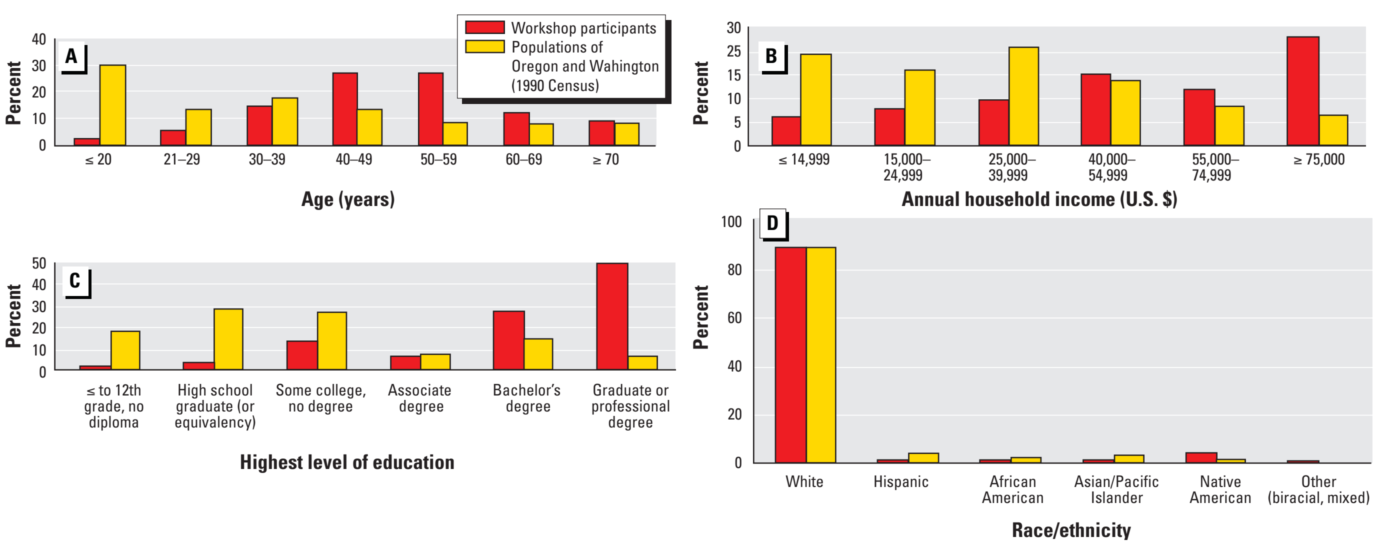
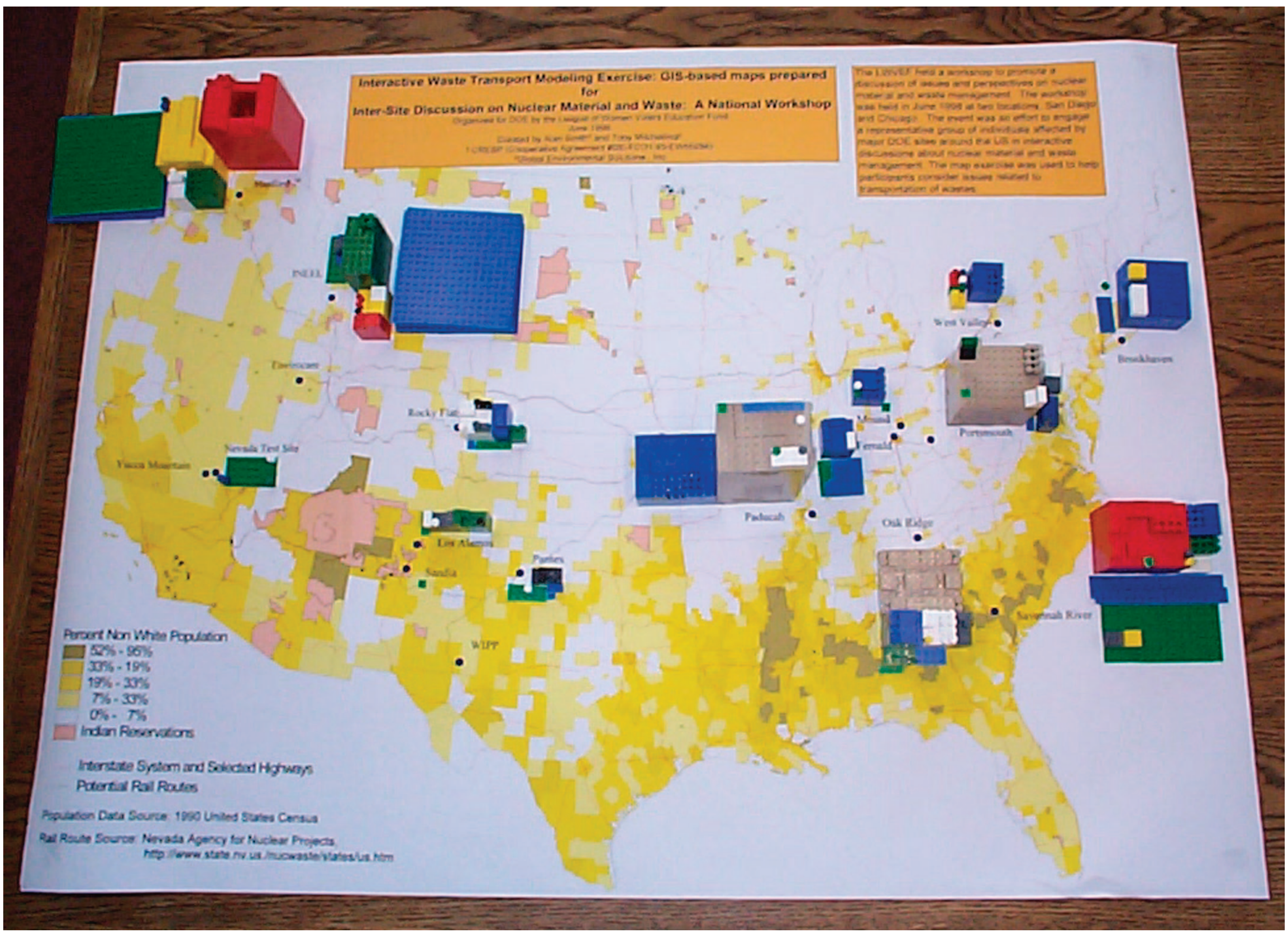


Figure 2. Combined participant demographics of the four regional pilot workshops on nuclear material and waste as compared to 1990 Census data for Washington and Oregon. (*A*) Age. (*B*) Annual household income. (*C*) Highest level of education received. (*D*) Race/ethnicity. Because the survey participants were not a random sample, the statistical significance of the difference could not be determined. Instead the proportion of workshop participants within each demographic category were compared with the proportions from the combined population totals for Oregon and Washington. Differences were noted here if the observed data differed from the expected mean [based on 1990 Census (U.S. Census Bureau 1990)] by at least two standard deviations.

Because workshop organizers were interested in environmental justice issues, the map also showed minority population statistics (percent nonwhite from the 1990 Census). Workshop participants used this Lego map to consider risk–risk trade-offs related to waste disposition and transportation decisions. Participants engaged in a small-group exercise in which they chose final disposition of the waste streams, chose transportation routes and modes (rail or truck), and simulated movements of wastes from one site to another with toy cars.

The League of Women Voters summarized participant evaluations and facilitator assessments in their report to the Secretary of Energy (League of Women Voters Education Fund 1998). Participants evaluated all major segments of the workshop (Figure 4). Sixty-six percent rated the map exercise favorably, only 9% rated it unfavorably, and it had the highest percentage of favorable ratings of all the different workshop segments. In addition, open-ended questions were asked about the most (and least) helpful aspect of the workshop. Out of 139 responses, 20 specifically mentioned the Lego map as the most helpful aspect, and none cited it as the least helpful. [The Lego map was the second most frequent response in the "most helpful" aspect question. The most frequent response category (n = 57) included comments praising the opportunity to engage with a broad spectrum of ideas.] Participants and observers found that the Lego map was an effective way for participants to conceptualize the types of waste streams involved, visualize the volume and magnitude of the waste to be disposed, understand the limited route alternatives (road vs. rail), and discuss concerns of specific demographic groups that live along transportation corridors. Participants reported that the three-dimensional Legos provided a more concrete way to understand the volume of waste and its distribution among the sites, allowing them to simulate management decisions about intersite transfer more realistically. The Lego map exercise enabled participants to discuss risk-related trade-offs, routes, and other complex issues amongst themselves and with technical advisors. In so



Percent nonwhite population
- 52–95
- 33–52
- 19–33
- 7–19
- 0–7
- Indian reservations
- Interstate system and selected highways
- Potential rail routes

Lego color	Material/waste	Volume conversion
Red	High-level waste	1 dot = 250 m^3
Green	Transuranic waste	1 dot = 250 m^3
Blue	Low-level waste	1 dot = 250 m^3
White	Mixed waste	1 dot = 250 m^3
Black	Plutonium	1 dot = 5 metric tons
Yellow	Spent nuclear fuel	1 dot = 5 metric tons
Gray	Highly enriched uranium	1 dot = 5 metric tons
Tan	Depleted uranium hexafluoride	1 dot = 250 m^3
Light green	Contaminated solid media	1 dot = 10,000 m^3
Dark blue	Contaminated liquid	1 dot = 2,000,000 m^3

Figure 3. Photograph of the Lego map, an interactive display of nuclear waste for workshop participants. Lego blocks indicating waste types and volumes were overlaid on a U.S. map showing repository locations, transportation routes, Native American Indian reservations, and population statistics from the 1990 Census (U.S. Census Bureau 1990).

doing, the Lego map served as a new form of risk communication tool. Overall, participants in the map exercise felt that the Lego map was more inviting, dynamic, and accessible to lay people than simple maps, data tables, and charts.

During the map exercise, observers noticed that participants were open to a wide range of options and alternatives so as to address the waste transportation problem fairly. Participants seemed surprised at how often the proposed transportation routes routed nuclear waste through areas of high nonwhite populations. Although this was a simulation exercise and not an actual decision-making procedure, this open-mindedness refutes the prevailing belief among many scientists that stakeholders and tribes automatically assume a NIMBY (not-in-my-backyard) stance. The interactions support claims by Kaplan (2000) and Bonano (2000) that, with enhanced technical support, stakeholders and tribes can indeed understand complex issues that arise in risk-related decision processes and remain open to a wide range of solutions.

The Lego map display has, by far, been the most popular and requested risk communication device that CRESP has contributed to. It was presented not only at the National Equity Dialogue workshops in San Diego and Chicago but also at several scientific meetings (Hanford Health of the Site and the Society for Risk Analysis), in discussions with advisory boards at the Hanford, Fernald (Cincinnati, OH), and Sandia (Albuquerque, NM) sites, and in classrooms at the University of Washington. The success of using Lego blocks as colorful tools to illustrate waste class and volume was attributable to their use in a manner that aided visualization without trivializing the difficult decisions at hand.

Common themes and lessons. Several common themes and lessons have emerged from these three examples. First, scientists need to work with stakeholders and tribes to develop creative methods to make complex information accessible to the lay public. The Lego map is a good example of how simple objects can be used to represent complex ideas. It also demonstrates how visualizing spatial dimensions of complex problems can contribute to a broader understanding of those problems. Increasingly, researchers and decision makers are turning to geographic information tools, ranging from simple maps to intricate Geographic Information Systems (GIS), for environmental problem solving (McMaster et al. 1997; Nyerges et al. 1997a, 1997b; Tim 1995). Not only can GIS packages be informative for public participation (Jankowski and Nyerges 2001), but certain GIS features such as three-dimensional visualization techniques (e.g., the 3D-Analyst extension for ESRI's Arc\View GIS package; Environmental Systems Research Institute, Redlands, CA) can also provide new perspectives on old problems such as worker radiation exposure (Hedley et al. 1999). We are not advocating tool development as an end in itself; the objective should be more effective and representative stakeholder and tribal participation. Toward that end, researchers should not only continue to explore creative applications but also evaluate their contributions to public participation processes. To date, relatively few studies that evaluate the effectiveness of geographic information tools on public participation processes have been conducted, and this is a significant area for future research. Nyerges et al. (2002) provide suggestions for developing research strategies in this area.

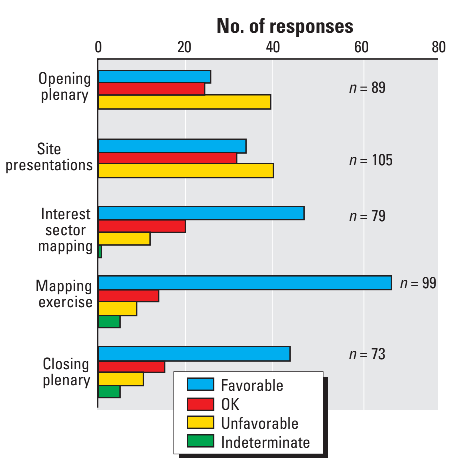


Figure 4. Ratings of major workshop segments from the League of Women Voters intersite workshop (League of Women Voters Educational Fund 1998).

Second, underrepresented groups may require specialized communication efforts to ensure participation. The underrepresentation of Spanish-speaking populations in DOE stakeholder contexts has been previously documented but remains largely unsolved (Boiko et al. 1996). As members of an educational institution, we believe reaching younger people through classroom interactions and service learning opportunities are ways we can work with the community to get youth and young adults involved in complex issues. Through the Institute for Risk Analysis and Risk Communication at the University of Washington and CRESP, we have participated in several initiatives intended to reach underrepresented populations. For example, on several occasions, CRESP has worked with tribes to address tribal risk information needs and concerns. A workshop was held at the University of Washington (Seattle, WA) in 1995 to discuss opportunities for collaboration (CRESP 1996), a Tribal Risk Roundtable was held at the Wildhorse Resort (near Pendleton, OR) in 1998 (Risk Roundtable Steering Committee 1998), and a Tribal Openness Workshop (Spokane, WA) was held in June 1999 as a component of the Hanford Openness Workshops (Kern 1998, 1999). In addition, the Center for Child Environmental Health Risks Research at the University of Washington is working to define children's susceptibility to pesticides by working with farm worker families in the Yakima Valley, a major agricultural area in Washington State (University of Washington 2001). The community intervention portion of the project works to break the pathway by which agricultural pesticides are transferred from work to home. Special bilingual outreach materials have been developed for school-based presentations and a coloring book for children. Efforts to define and meet information needs of specific groups should continue to be a priority for the academic research community.

Third, multiple approaches and iterative processes are needed to ensure that dialogue includes technological, stakeholder and tribal expertise. There are several barriers to authentic (King et al. 1998) participation in complex issues such as nuclear waste transportation. For example, in a recent survey (Mercer 1999), stakeholders from the mailing list of the INEEL were asked to rank their top three reasons for not attending public meetings about INEEL. The most common reason for not participating was being too busy, but more than half said that they let citizens groups or legislators represent them. Other important factors were not knowing enough, feeling that other issues were more important, that there were better ways to influence INEEL, and that INEEL meetings were not informative. Looking more broadly, Probst and Lowe (2000) explored the national indifference to DOE cleanup issues in a major report from Resources for the Future. The authors noted that people are simply not aware of or interested in DOE cleanup because the issues are extremely complicated, the geographic concentration of the problems and relative isolation of the sites have left them invisible to most of the public, and the cleanup budget is a "small fish" in the "big pond" of defense spending.

It is beyond the scope of this article to list all characteristics and recommendations for successful public involvement activities. Indeed, no single approach to stakeholder or public involvement is appropriate; multiple involvement mechanisms are needed to reach different types of audiences. All of our case studies indicate that breaking into small group discussions can help build the meaningful and lasting relationships that foster deeper understanding, especially when a range of different perspectives are represented. But successful interactions take time. Participants need time to learn, interact with experts, discuss options, weigh trade-offs, and make recommendations. Thus, it is critical to develop iterative processes that build on past relationships and knowledge that has been gained but also leaves room to incorporate emerging information and new voices. Other important considerations include establishing commitment from the responsible agency to use the results of activity, determining the appropriate level of interaction, engaging elected officials, working with key community group leaders early and often, holding meetings at a variety of times and locations, and so on. Good public involvement resources include the International Association of Public Participation (IAP2 2002), which charts public participation in terms of increasing levels of impact—from informing to consulting, involving, and collaborating all the way to empowering—each with its own objective; the U.S. Environmental Protection Agency's (EPA's) stakeholder website (U.S. EPA 2002); and *Fairness and Competence in Citizen Participation: Evaluating Models for Environmental Discourse* (Renn et al. 1995).

In addition, there is much to learn from new models of participation that indicate nonexperts can be meaningfully involved in highly complex and technical decisions. For example, following an example from Denmark, the Loka Institute convened a citizens panel on telecommunications policy in 1997 (Sclove 2000). Fifteen lay participants were recruited for three weekend workshops. The first two provided background material, and at the third, participants heard testimony from a variety of experts, government representatives and other stakeholders. By the end of the weekend, the participants developed several specific recommendations about regulating Internet and telecommunications policy. According to Sclove (2000),

> [It] was the first time in modern U.S. history that a diverse group of everyday citizens … gathered to learn and deliberate on a scientific or technological topic of this breadth or complexity.

Other examples of innovative stakeholder involvement approaches at Hanford include the Hanford Openness Workshops (Kern 1998, 1999) and the Columbia River Comprehensive Impact Assessment process (CRCIA Management Team and Pacific Northwest National Laboratories 1998) and associated stakeholder involvement relating to long-term stewardship. Public meetings are but one in a suite of public/stakeholder participation options. Increasingly, Internet activities are providing a supplemental venue for engaging the public. Examples include the U.S. EPA's recent Internet Dialogue (U.S. EPA 2002), Argonne National Laboratories electronic environmental impact statement (2002), and a pilot project called the Decision Mapping System (Drew 2002). Although we have come a long way in improving Arnstein's (1969) "ladder of citizen participation," much research in these areas is still needed.

Fourth, the need for transparent decision processes and outcomes has emerged from all three case studies. To be transparent, those who are interested in a decision must understand what is being done, and why (Drew and Nyerges. In press). Transparency is particularly important in the context of nuclear waste cleanup and transport, because nuclear materials persist in the environment for very long periods of time (Applegate 1995) and because people are generally fearful of nuclear waste (Slovic et al. 1991a). Another important aspect of transparency involves institutional capacity, consistency, and longevity. In order for processes to be transparent to, understood by, and engaging to stakeholders and tribes, these groups must have faith that process A will lead to decision B, which results in action C, consistently over time. One of the continuing and most problematic challenges for the DOE and its stakeholders continues to be the ever-changing decision-making framework. This is especially true for this arena over other governmental processes because of the inherently long-term timeline of the issues in question. Because nuclear waste disposition and transportation issues operate over a long time scale (decades), they easily eclipse the political and institutional time frame (4–6 years). The dissolution of the national dialogue discussions is a prime case in point. Although it is not entirely clear why DOE failed to continue the national dialogue workshops as planned by the League of Women Voters, a change in the DOE leadership during this period was probably a significant factor. Over time, the continuity provided by stakeholders and tribes may be the only stable knowledge base available for complex sites like Hanford. A knowledgeable and engaged citizenry is, therefore, vital, but it will not be achieved without greater transparency and understanding of both the decision processes as well as the technical issues.

Conclusion

In this article we have described three interactions with stakeholders and tribes on the topic of nuclear waste transportation. We found that stakeholders and tribes are willing to engage in these issues, but they generally believe that they need access to more technical information to be effective participants in the decision-making processes. Meaningful involvement requires that decision processes and technical information be transparent and accessible to a wide range of potential participants. We also found that participants need technical resources to participate in the dialogue, but the format of those resources is a topic for future research. Moreover, participants engaged well when presented with an opportunity to interact with technical experts in small group settings. Clearly, creative tools that present information in a way that can be easily grasped (such as the Lego map) should be developed. Other tools that help participants visualize impacts, uncertainties, and trade-offs are also needed. We thus extend a challenge to the academic community: that we work with stakeholder and tribal groups to develop programs that provide the technical resources needed for meaningful citizen participation in these complex decisions.

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