Making Imperfect Decisions: Results From Public Workshops on Bioremediation[1]

Amy K. Wolfe[2] and David J. Bjornstad[3]

Abstract

This article addresses how people make decisions in community settings when any option, though beneficial to some people, may cause harm to others. We focus on decisions surrounding field research on, and the use of, a category of bioremediation—using microbes to immobilize below-ground plumes of metal and radionuclide contamination at United States Department of Energy legacy waste sites. As part of a multi-year project, we previously developed a conceptual framework called PACT (Public Acceptability of Controversial Technologies) and analyzed recordings of citizen advisory board meetings at three sites facing subsurface contamination issues. In this paper, we report on a series of quasi-experimental workshops undertaken to test hypotheses about the determinants of societal acceptability of controversial remediation technologies that emerged from our past work.

We found the quasi-experimental approach to be a powerful tool to address questions of this sort. Results indicated that 1) workshop participants readily accepted the role-playing methodology and responded in ways that mirrored actual behavior in decision-making settings; 2) the quasi-experimental design allowed us to structure the activity into systematic "treatments" while leaving the participants' responses unconstrained; 3) the approach yielded systematic differences among treatments, but also displayed differences depending on the decision context interacting with the specific personalities of the participants; 4) participants were generally unfamiliar with the particular technologies involved but reframed issues into analogous terms to which they could apply lessons learned from past experience; and 5) because the approach encouraged participants to impose their own frames of reference and values to the questions they were to answer as a group, many of the results were surprising, yet consistent with the local context and personalities.

Introduction

Start with contaminated subsurface sediment and groundwater. Assume the contaminants may be harmful to anyone having extensive contact with them, but that the chances of contact in the foreseeable future are slim. Also assume that this subsurface contamination has been acknowledged for decades, that the agency generating them first denied responsibility for cleanup, later accepted responsibility, subsequently developed a cleanup-related research program, and finally implemented a variety of specific cleanup actions. Add to this situation a surrounding community that has some degree of past or continuing economic dependence on the agency responsible for both the contamination and the cleanup, the possibility of continued local economic benefit associated with cleanup-related research or cleanup itself, and a desire for a "safe" and "desirable" community that is attractive for current and future residential and economic development. Finally, ask the community to advise the government agency on cleanup options without specifically assigning it a role in the final decision.

In broad outline, this description depicts the situation faced at many United States Department of Energy (DOE) sites, and possibly at numerous other contaminated sites throughout this country and worldwide. DOE sites are termed legacy waste sites because they are part of the so-called legacy of the Cold War. Community members constituent to remediation decisions may be DOE employees, regulators, residents, local business leaders, environmentalists, or virtually any interested or affected party. How will these constituents navigate the complex, ever-changing world of remediation decision making? The work described in this paper sought to reveal how people undertake decisions about new remediation technologies and, through this undertaking, establish the conditions under which alternative options become more or less acceptable.

In the section below, we describe the quasi-experimental methods we used to explore this question, first depicting how our past work led us to take this particular approach, and second describing the specific methodology. Next, we summarize our findings, both those associated with the process of implementing these methods

as well as substantive results. We end with a discussion of the implications of these methods and results for questions of how groups make "imperfect" decisions.

Background: Why We Began to Study the Acceptability of Bioremediation, A Potential Cleanup Option

Our initial foray into the realm of bioremediation decision making began with a research project that asked: What are the determinants of societal acceptability of a particular, yet-to-be-developed, bioremediation strategy? That strategy was the use of genetically engineered microorganisms (GEMs) in remediating subsurface metal and radionuclide contamination, a topic we took to be inherently controversial. The contaminants of most interest—namely the metals mercury and chromium, and the radionuclides uranium, technetium, and plutonium—pose particular challenges to DOE. Although several alternative strategies can be used to deal with these subsurface contaminants, none is problem-free when considering all of the technical, economic, and ecological attributes within the specific community context. For example, when the contamination is concentrated and relatively close to the surface of the ground, it is more feasible to remove than when it is deep, dispersed, or in the groundwater. Contaminant attributes must be factored in, as must groundwater flows, likelihood of exposures to affected populations or ecosystems, and likely future land uses.

The below-ground conditions in which metal and radionuclide contaminants are found at some DOE sites make them extremely difficult to clean up. For example, the contaminants sometimes are found at great depths, sometimes hundreds of feet below ground. Site hydrogeology (how water flows in those geological conditions) may be complex, making it challenging to know or sometimes impossible to predict the rate and extent of contaminant movement below ground over time. Contaminated portions of DOE reservations can be very large. For instance, an estimated 200 square miles of groundwater are contaminated on the Hanford, Washington reservation. These expanses make some existing remediation technologies extraordinarily expensive or otherwise impractical. Also, because of past DOE operations and practices, sites tend to be contaminated by more than one metal or radionuclide, and may also contain other contaminants like solvents.

DOE initiated a basic research program in the late 1990s that sought to provide the scientific underpinnings for eventual strategies that use microorganisms to clean up these contaminants in place. Cleanup for this program centered mainly on using microorganisms for immobilizing contaminants so that plumes would not migrate and adversely affect human or ecological populations or on speeding up the natural breakdown process. Bioremediation has been used successfully for some contaminants, mainly organic compounds that can be transformed into harmless substances. However, that is not the case for the target metals and radionuclides in subsurface environments. Further, while bioremediation cannot transform radionuclides into harmless non-radioactive substances, the hope was that bioremediation could be used to immobilize, for example, by changing the atomic structure of a radionuclide. As an illustration, while uranium VI in the subsurface environment is mobile and potentially can be taken up by plants, animals, and humans, uranium IV is insoluble and not mobile. As the research program developed, DOE decided to exclude GEMs. However, we have continued to consider them in our work on societal acceptability because of their putative potential to generate concern and controversy.

Our work was motivated by two observations. First, an agency staff member responsible for chemical cleanup commented to us that, no matter how much he explained the projects to them, so-called environmentalists never changed their minds. To us, from the outside, it was clear that the environmentalists—especially those representing activist organizations—would not change their minds because their goals had little or nothing to do with the project the staff member was managing. Our question became, is it not reasonable to assume that other parties affected by the cleanup also have goals apart from the cleanup itself, but goals that they express in terms of the cleanup? Second, the agency staff member's response indicated that he

thought that "the public" should be "educated" about the situation, technology, or alternative presented. Like many other specialists, he exhibited the attitude that "if they (the public) only knew, they would agree with us." Again, as outsiders, this line of reasoning appeared to us as narrow. It systematically excluded a range of issues of likely importance to community members, was optimistic in assuming that similar facts lead to similar opinions, and stood in contrast with extant evidence (Evans and Durant 1995; Martin and Tait 1992; Yount and Horton 1992). We queried: Do agency officials reduce the acceptability of projects by offering nonresponsive responses to citizen concerns?

We focused our analysis on cleanup-related decision making, rather than on generalized opinions, values, or preferences. Our reasoning was that decision making forces people to confront and chart a course for navigating through messy and uncomfortable real-world terrain, whereas opinions are often abstract and hypothetical. Messy refers to such elements as uncertainties, incomplete and conflicting information, and different goals (cleanup, economic development, reduction of stigma, cost containment, etc.). Uncomfortable refers to value conflicts, such as choosing among alternatives that may remove contaminants from one location while destroying the local ecosystem (as when all vegetation is removed and bulldozers scrape and remove soil to a depth of several feet) and transporting those wastes to another location, potentially exposing individuals along the transportation corridor and surrounding the waste disposal site.

Within this decision-making context, we were interested in the positions that involved individuals and groups took, and how those positions were adjusted over time in response to interactions, new information, and other changes. We noted an asymmetry in the power of different positions, with a negative position (no GEMs) frequently holding more sway than the positive position (GEMs hold great promise). Therefore, we were particularly interested in those factors that would propel individuals and groups holding non-negative positions into taking strongly negative positions. We included both outcome and process considerations. One affected party might object to a project unless certain features were modified. Others might object because they were excluded from the decision-making process that considered the features. Or, affected parties might simply require an opportunity to express opinions, for example, that the agency was remiss for having created the contamination in the first place.

Our Conceptual Framework: Public Acceptability of Controversial Technologies (PACT)

We began our work by developing a generic, conceptual framework for analyzing issues of social acceptability for technologies deemed "controversial," using GEMs to add concreteness to our efforts (Wolfe and Bjornstad 2002). We did not define "controversial" precisely, but at minimum it was taken to mean that some parties to a technology decision-making process thought the alternatives were less than fully acceptable. We also believed that some technical attributes were lightning rods for controversy. The resulting framework describes the dimensions of acceptability relevant to a dialog among involved constituents (see Figure 1).

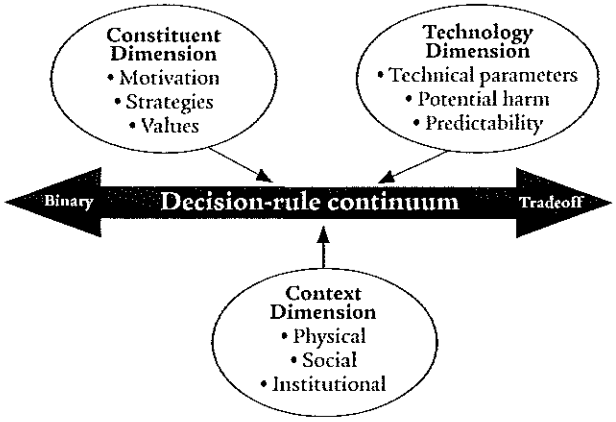
Our framework argued that decision-making dialogs occur across a continuum of decision rules. At one extreme was what we termed binary decision rules, constituting insistence on either acceptance or rejection. We reasoned that these positions were similar in the sense that assuming an inflexible stance militated against a productive dialog to resolve differences. At the other extreme was a decision rule marked by complete negotiability, a kind of indifference in which everything becomes negotiable because there is no stance. Intermediary points describe conditional requirements placed upon a subject technology necessary to achieve acceptability, which we define as a willingness to consider seriously rather than as a particular outcome. Within this context, acceptability describes a condition whereby a technology is considered a viable alternative. This willingness to consider an alternative is separate from the specific issues that influence actual technology deployment, for example, cost considerations; many acceptable technologies never are deployed.

We identified three types of considerations

that would affect the location of parties to the acceptability dialog along the continuum. The first was the attributes of the involved parties, which we divide into goals, motivations, and strategies. Our point here was to emphasize that involved parties may have different goals from the agency as well as different values, and may or may not adopt a strategy of revealing those goals and values accurately or at all.

The second set of considerations was the local context. Local context included physical, institutional, and social attributes, recognizing that current manifestations of local context reflect past interactions and events. Take, for example, a community with a long-standing contamination problem that now is faced with a cleanup decision. The community likely will react differently if the action is deemed critical because the contamination poses an imminent threat (the plume might be moving toward the community's drinking water supply), than if the contamination is deemed relatively benign, but its removal is required by law. Social and economic attributes also are key. A community in an isolated location may view cleanup as a "basic industry" supplying jobs. Institutional aspects might include the forum in which the dialog takes place, the rules governing the dialog, and the standing of individual groups in the decision-making process. Lastly, there is the technology dimension, basically, the attributes of the technology—its costs, technical effectiveness, predictability, history of use in similar settings for similar purposes, associated risks, alternatives to that technology, and so on.

Figure 1. PACT Framework
(PACT = Public Acceptability of Controversial Technologies)



Two Previous Acceptability Analyses, Guided by PACT

Next, we engaged in two analytical efforts. First, we applied PACT to the subject of phytoremediation (using plants to trap or clean up contaminants) in an attempt to determine if the framework provided an efficacious means of ordering the issues pertinent to a decision to use what is presented as a relatively benign technology (Wolfe and Bjornstad 2002). In the course of examining the technology lifecycle, we determined that once plants have absorbed contaminants they may be disposed of using incineration, itself a controversial technology. Further, there may be some volatilization of contaminants taken up by plants, a factor that could discourage the use of phytoremediation near such places as schools, playgrounds, or parks. We concluded that all remediation technologies can become controversial, given the right combination of attributes.

Second, guided by the PACT framework, we collected data from a number of meetings of three DOE Site-Specific Advisory Boards (SSABs). We took this approach to observe continuing remediation-related dialog among multiple parties, where the positions of involved parties—and changes in those positions—could be tracked over time. SSABs are institutionalized, DOE-sanctioned modes of public participation. We targeted our investigation on aspects of the SSAB (or advisory board) mode of participation that could, by themselves, influence the dialog process and its outcome (Wolfe, Bjornstad, and Kerchner. 2003). Two examples of internal SSAB procedures that affect the nature of participation and "outcomes" delivered to DOE are whether or not: (a) to use "round-robins" as a means to air each participant's thoughts (in contrast to situations where a few SSAB members can dominate discussion to the near or total exclusion of other members), and (b) to transmit to DOE dissenting or minority opinions.

Over a several-month period, we used PACT to structure our analyses of hundreds of hours of audio and video tape recordings of SSAB dialogs in full-group meetings (as opposed to smaller, working-group meetings) at Hanford, Washington; Oak Ridge, Tennessee; and Rocky Flats,

Colorado. These tapes allowed us to observe a real-world, formal deliberative process unobtrusively. We wanted to learn how participants tend to present their issues and concerns about remediation options; how they interact; and if or how they shift positions over time. As expected, GEMs were not a topic of discussion. Nevertheless, analyses of these tapes revealed much about the dynamics of one form of public participation with regard to remediation technology acceptability. Our conclusions included the following:

- Technology-oriented decision making need not focus on technologies or their attributes—the amount of time spent discussing specific technologies and their attributes was miniscule.
- Generalized opinions about technologies and technical issues need not transfer to particular cases (opinions about waste disposal generally vs. at a particular facility), and vice versa—these apparent inconsistencies actually may reflect different ways of framing issues.
- Differences in the "same" forms of public participation (SSABs at the three DOE sites studied) significantly influence the nature of the subsequent dialog (reinforcing our previous findings).

Despite the value afforded by unobtrusive observation (via tapes) of constituent groups interacting in actual forums, this method also has several drawbacks. As examples, information of this sort is costly to analyze, much of the dialog may be irrelevant to research goals, and observation does not allow the kind of manipulation necessary to test some important hypotheses.

Therefore, we sought additional data sources to inform our work, specifically through the series of quasi-experimental simulation exercises that we report here. We designed these exercises to gather data about specific hypotheses in a more controlled way than is possible with observation of naturally occurring situations.

Methods: Quasi-Experimental Simulation Exercises

Each workshop was structured into four phases: 1) background information; 2) scenario 1; 3) scenario 2; and 4) de-briefing. We selected participants from the Oak Ridge and Knoxville, Tennessee, vicinity, working through web-based lists of community organizations (chambers of commerce, neighborhood associations, etc.) to identify individuals willing to participate. Our target participants were adults likely to be involved in community decision making, but with no direct connection to local DOE offices or the local DOE complex in Oak Ridge. A number of participants did, however, have a current or previous connection with these operations. Some happened to have worked for other businesses in the region and had previous experience in grappling with non-DOE cleanup issues. We did not seek participants who were technical experts.

Because workshop participants had varied backgrounds, we thought it important to provide them with common background information about the DOE complex, the legacy wastes, and continuing remediation challenges. Background information described DOE legacy wastes, and the challenges associated with remediating subsurface chromium, mercury, plutonium, uranium, and technetium. Information packets also described categories of remediation options, including bioremediation, along with some of the pros and cons associated with each option (in terms of financial costs, technical effectiveness, long-term maintenance and monitoring, impact on landscape, etc.). We deliberately wanted to convey the idea that there are no "perfect" options.

After giving participants time to read and ask questions about the background information, workshops then centered on a sequence of two hypothetical scenarios. The sites and contamination scenarios, though fictitious, were consistent with real-world sites and cleanup-related issues. Scenario 1 focused on the acceptability of four proposed bioremediation *field research* projects, all ultimately targeted at immobilizing subsurface chromium, mercury, plutonium, uranium, and technetium. The proposed experiments were the following:

- Injecting nutrients below ground, in wells, to test whether naturally occurring microorganisms live and multiply as anticipated in the field setting;
- Altering the chemical composition of the below-ground environment (by reducing acidity, removing nitrates, or adding oxygen), to make it more conducive to the growth and multiplication of naturally occurring microorganisms that

could transform contaminants into more stable forms or immobilize contaminants in place;

• Adding naturally occurring microorganisms from another location to the below-ground environment at the field experiment location;

• Testing whether microorganisms genetically engineered to target specific contaminants and to thrive in the below-ground environment function as anticipated.

Participants were given a series of questions to address, and they were told that their product should be a report to the federal agency (called Fedagency in the scenarios) proposing the research that would advise the agency on the acceptability of the four field research alternatives.

After a break, participants were provided with Scenario 2. It was described as taking place several years after Scenario 1 and focused on the acceptability of a proposed *use* of one bioremediation technique, GEMs, for remediation. We deliberately chose GEMs as the deployment option because we thought that option would be likely to spur the greatest controversy and discussion among workshop participants. Again, the group was given a set of questions to consider and told to report to Fedagency about whether it was ready to "go public" with its proposal.

Our research design included three separate exercises, each of which was conducted twice, for a total of six workshops. Participants in each workshop were divided into two or three subgroups. Variations within and among workshops and subgroups, illustrated by the following examples (see Figure 2), helped us address specific hypotheses about differences in acceptability:

• **Workshop 1**—participants were given local versus non-local advisory board roles;

• **Workshop 2**—site size and complexity varied; and

• **Workshop 3**—forcing conditions and pressures to remediate differed (economic development pressure, encroaching human health impacts, and regulatory deadlines).

For four of the six workshops, participants were assigned roles that corresponded to interest groups affected by real cleanup situations. These roles included 1) owner of property adjacent to contaminated site, 2) president of the League of Women Voters local chapter, 3) head of the Chamber of Commerce, 4) leader of a fictitious local environmental activist group called Friends for a Safe Environment, 5) retired scientist, and 6) minister. Participants were given information packets that described their goals and motivations. Two examples of the role-related information provided to participants follow:

Figure 2. Research Design Manipulated Variables within and across Simulation Exercises

	Exercise 1	Exercise 2	Exercise 3
Subgroups	3	3	4
Advisory board members	1 national, 2 local	all local	all local
Assigned roles	1 group	all groups	all groups
Contaminant location	• non specific • your community	• isolated, rural community in your vicinity • in the midst of your town	• outskirts of your community
Question	local vs. non-local	site context	forcing condition

***President, local chapter of the League of Women Voters*:**
As the president of the local chapter of the League of Women Voters, your main goals are to assure that decisions are fully informed and that local community members have both the opportunity and the materials necessary to acquire relevant information. You strongly oppose measures that may shut down the flow of information. You do not join this advisory group with already formulated opinions about, preferences for, or antagonism toward particular cleanup-related activities or options.

***Leader, local environmental organization*:**
You lead a local environmental organization called Friends for a Safe Environment (FASE). FASE has a long history of challenging Fedagency. Years ago, your group challenged the agency to acknowledge and take responsibility for its contamination problems. FASE has challenged the findings of many worker and community health studies. The group has pushed hard for total cleanup at the complex, no matter the costs. It has criticized Fedagency on many cleanup-related issues, such as foot-dragging on environmental cleanup and favoring lower-cost cleanup

solutions to what FASE would consider genuine cleanup. FASE position papers highlight Fedagency's ethical and legal responsibility to protect the health and well-being of workers and local citizens as well as the need for environmental protection and restoration.

As its leader, your goal is to represent and promote FASE's main interests—the protection of human health and the environment. FASE strongly supports activities that allow or achieve true cleanup and strongly opposes alternatives that the group thinks may lead to non-solutions.

The simulation exercises were intended to provide rich qualitative data that would further the knowledge about particular aspects of bioremediation acceptability. They were not intended to provide statistically valid results about which to generalize.

Results: Analogies, Issues, and Conditions that Influence Acceptability

Although there was considerable variation among groups in the manner of their interactions and their specific responses, we are able to draw a number of conclusions. As to role assignment, we found that without roles, the participants viewed themselves as adopting the values and goals they attributed to Fedagency. In contrast, once assigned roles, participants exhibited quite different values and goals. The distinction between groups with assigned roles versus those without assigned roles was so strong in the first workshop, we decided to assign roles in all subsequent workshops. Roles seemed to provide participants with an anchor—with the stakes they held in the decision-making process. This observation may be indicative of the difficulty in anticipating acceptability issues from the general populace, as opposed to affected and involved parties.

With regard to proposed bioremediation field research activities, for instance, participants generally ranked the alternatives from most to least acceptable, as follows: inject nutrients (for example, glucose or acetate); alter subsurface chemistry (such as to change pH, add oxygen, remove nitrate); introduce non-native organisms; and introduce GEMs. This ordering largely was consistent across groups, though some groups found the suite of options much more acceptable than other groups. However, there were notable exceptions to this ordering, which seem to be influenced by the kinds of analogies or allusions members of different subgroups used as they reframed issues. We were struck by the apparent power of these analogies to anchor discussions and to influence participants' descriptions of their reasoning. For example, some subgroups ranked as least acceptable the introduction of non-native organisms. A number of these groups referred to this proposed research project as "the kudzu alternative." Kudzu is a well-known invasive plant species in the eastern Tennessee region, where the workshops were held. It was originally introduced to control erosion along TVA waterways, but was found to cover landscapes aggressively if unchecked. Some of the groups that pursued this line of reasoning also identified a number of invasive plant and animal species that may or may not be important locally. Members of these groups expressed concerns that non-native microorganisms could have similar invasive effects.

As another example, subgroups considered the proposed field research project that would alter subsurface chemistry in two broad ways. One set of subgroups explicitly saw this proposed field research project as analogous to gardening, where it is common to alter soil pH. These subgroups tended to consider this field research alternative as benign. Others, however, deemed the same alternative relatively unacceptable. In these subgroups, discussion centered on the introduction of chemicals to the subsurface, implying that chemicals should be avoided.

Participants also used other kinds analogies relating to recent or local events. One example was a train derailment that occurred in the months preceding our workshops, spurring a local evacuation because of a sulfuric acid release. Another example was a contaminated industrial site located in Knoxville, Tennessee. In both cases, the participants mentioning these cases used them to raise potential concerns such as faulty flow of information, accountability, (lack of) results or problem resolution, and issues of trust/distrust of government.

We also found that the kinds of issues raised

regarding proposed bioremediation field research tended to differ from those for proposed deployment. These differences are summarized in Table 1. In general, discussion focused more on technical issues in scenario 1 than scenario 2. Participants queried each other about the types and characteristics of various organisms and the technical merits of each alternative field research endeavor when discussing scenario 1. In these deliberations, they also considered such attributes as the potential safety/harm of each alternative and costs for the different kinds of field experiments. Some groups were concerned about the duration of the experiments, though that issue was not raised in the two groups in which no roles were assigned. While this result could be a matter of chance, it also could be related to the influence that holding stakes in outcomes may play in remediation decision making—a testable hypothesis. Finally, some groups questioned the need or desirability of conducting more research instead of taking action to clean up the site.

Table 1. Issues Raised Tended to Differ for Proposed Bioremediation Field Research Versus proposed use.

Research	Application
• Safety	• Research conferred some legitimacy
• Technical components	• Long-term consequences
• Cost of experiments	• Long-term "stewardship"
• Duration (for role-players)	• Distrust of government and research results tied to government
• Research versus cleanup	

In contrast, deployment-related discussions associated with scenario 2 tended not to delve into technical issues, costs, or safety. Rather, these discussions typically started with process issues deriving from the disparity between Fedagency's choice (to use GEMS) and the advisory group's previous recommendation (typically ranking GEMS least acceptable). Some groups reasoned that the research that occurred between the time of scenario 1 and scenario 2 must have shown that GEMs were the best alternative, indicating that the research conferred legitimacy on an otherwise less-than-desirable choice. Other groups, however, expressed irritation that Fedagency disregarded their previous input and wondered why they should provide additional advice "for the agency to ignore." In that same vein, participants in several groups expressed a distrust of government and the results of government-sponsored research.

Deployment-related discussions also centered on the long term. Participants were concerned about the potential long-term consequences of deploying GEMs and their effectiveness over the extremely long time periods necessary for radioactive contaminants. Several participants raised long-term institutional issues, wondering whether funding levels or monitoring would be sustained over time and whether there had been any contingency planning, should the remediation strategy prove ineffective or be found to cause other problems. Our scenario indicated that GEMs likely would require continuing, periodic so-called feeding to maintain their effectiveness, as opposed to creating a self-sustaining system. This piece of information led some participants to suggest that immobilization or containment is an impermanent solution. Taken together, this suite of concerns led some participants to state that total acceptability may not be possible, though some were willing to take a chance to recommend that Fedagency proceed with GEMs.

A critical part of our investigation centered on the conditions under which various field research or deployment options might become acceptable. Items that participants suggested could enhance the acceptability of field research alternatives are as follows. They include prior laboratory-based research; publications in peer-reviewed literature, although a few participants distrusted the selection of peers to review literature; locating the field experiments away from residential areas; and monitoring the experiments. Elements that could enhance the acceptability of deploying GEMs included monitoring, particularly by independent parties, and long-term stewardship; assuring safety should there be unintended consequences or re-mobilization; plans for dealing with contingencies; proven effectiveness at cleaning up, as opposed to immobilization; more research conducted on a larger scale, with a broader focus, and undertaken for a longer period of time; and speed for a quicker remediation process.

Other observations we made about this set of

workshops suggest additional avenues for future research. Even in the short-term, artificial environment we created through these scenarios, groups seemed to mirror the decision-making behavior of real-world advisory groups. In some cases, there were dominating personalities to whom others seemed to defer either by choice, when the individual was charismatic, or not, when the individual was dictatorial. In other cases, group members explicitly sought each individual's input, sometimes voting and presenting the majority response and other times presenting all opinions. It would be interesting to explore whether, or the extent to which, group dynamics affect the nature of the issues raised by advisory groups.

We previously noted that many participants reframed issues through the use of analogies. Participants also seemed to rely on their own expertise, whether we viewed that expertise as relevant or the information they provided as technically accurate. Frequently, participants appeared to separate themselves from the public, so to speak, in their role as an advisory group members. It was not uncommon for participants to refer to what the public or community might think, as if they played a role separate from that of the public at large. Moreover, participants reflected on how responses might vary in different kinds of communities, pointing to Oak Ridge (home of DOE's large, economically important Oak Ridge Reservation that was originally created as part of the Manhattan Project) versus surrounding communities versus other locations across the nation.

Concluding Discussion

We provided workshop participants with difficult decisions. The situations were complicated, with role-playing participants assigned goals and values that conflicted with those of other participants. The options offered had both pluses and in some cases substantial minuses. In their capacity as members of citizen advisory groups for the purposes of these workshops, participants were able to fulfill their charge, though groups did so in a variety of ways.

Overall, we confirmed our observations from DOE Site-Specific Advisory Board meetings that technology attributes influence, but do not determine, acceptability. This finding is particularly striking because the quasi-experimental workshops deliberately were designed to force technology-related discussions and decisions, unlike the SSAB meetings that typically touched on a diverse set of topics and lacked the same focus on technology decisions. One implication of this finding is that perceived technological effectiveness may be defined quite differently between technology sponsors and community members, producing situations in which dialog inadvertently inflames instead of elucidates. The context of potential application, rather than technology attributes, appears to be the key determinant of acceptability. Further, participants' stakes, and their role-defined goals, appear to alter the nature of the decision-making dialog.

Our work demonstrates the importance of focusing on decision-making processes, rather than on individual components of decision making. Viewing decision making primarily through the lens of single components, such as technology attributes, degree of (technical) knowledge held by participants, and ethical concerns too easily fails to benefit from the understanding that emerges by considering these components as part of a system and in juxtaposition to one another.

Our work also demonstrates that decisions about scientific or technological matters are better framed as *social* decisions than as scientific or technical decisions. This conclusion is not exceptional for an audience of anthropologists, but it tends to be jarring for members of agency, regulatory, or scientific and technical communities who frame this kind of decision making as *science-* or *risk-based* as opposed to *science-* or *risk-informed*. Thus, the body of literature emerged that, in essence, began by asking why people so often reject technologies when their risks were so low (Starr 1969; Slovic, Fischhoff, and Lichtenstein 1979, 1982) and, over time, looked to other elements that could play a dominating influence such as values and mental models (Axelrod 1994; Keeney 1992; Kempton, Boster, and Hartley 1995; Morgan et al. 2001; Stern and Dietz 1994). Regardless of the status that science and scientists enjoy in society, ordinary members of society typically do not normally delegate decision-making responsibility to such scientists.

Moreover, while technical details and scientific uncertainties may condition decision dialogs, items of contention in decision dialogs typically are not issues of technical or scientific understanding. We believe that scientific or technical education, while a cornerstone for effective participation in a demographic society, is a necessary, but far from sufficient, condition for issue resolution. O

Notes

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2. Amy K. Wolfe received her Ph.D. in anthropology from the University of Pennsylvania in 1986. She is the leader of the Society-Technology Interactions Group, Environmental Sciences Division, Oak Ridge National Laboratory, Bethel Valley Road, P.O. Box 2008, Oak Ridge, Tennessee (TN) 37831-6038 USA. She may also be contacted by e-mail at **wolfeak@ornl.gov** and by telephone at 865-574-5944.

3. David J. Bjornstad received his Ph.D. in economics from Syracuse University in 1973. He is part of the Society-Technology Interactions Group, Environmental Sciences Division, Oak Ridge National Laboratory, Bethel Valley Road, P.O. Box 2008, Oak Ridge, Tennessee (TN) Oak Ridge, TN 37831-6036 USA. He may be reached also at **bjornstaddj@ornl.gov** by e-mail and at 865-574-5152 by telephone.

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