

Science and Public Participation: An Analysis of Public Scientific Argument in the Yucca Mountain Controversy

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While they make valuable and significant theoretical moves, new models of public participation in environmental decision making may not help publics navigate within traditional models of public participation. In this essay, the author builds from Kinsella's (2004) concept of public expertise and examines what she calls public scientific argument. Through an examination of the Yucca Mountain site authorization public comment period, the author analyzes how non-scientist citizens attempt to engage in scientific argument in current technocratic models of public participation. This essay not only calls our critical attention to providing practical resources for citizens faced with current technocratic models of public participation but also challenges new models to more fully consider citizen abilities to engage in scientific argument as a form of technical competency.

Keywords: Public Participation in Environmental Decision Making; Rhetoric; Nuclear Communication; Public Expertise; Public Scientific Argument

The controversy over the Yucca Mountain high-level nuclear waste repository began in 1984 when the Department of Energy (DOE) and President Ronald Reagan selected Yucca Mountain in Nevada, the Hanford Complex in Washington, and a location in Deaf Smith County, Texas as the three potential sites for geologic storage of high-level nuclear waste. In 1987, Congress amended the Nuclear Waste Policy Act (NWPA)¹ to direct the DOE's attention to study just one site: Yucca Mountain. This

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amendment is also known as the “Screw Nevada Bill” because opponents argue that Yucca Mountain was chosen for political reasons. At a September 5, 2001 public hearing in Las Vegas, Leana Hildebrand stated, “I believe it’s been a political move. At the time that Yucca Mountain was actually decided upon, Nevada did not have the political strength that it does at this time” (US DOE, 2001a, n.p.).² In the midst of an ongoing controversy over the site, Congress and President George W. Bush officially authorized the Yucca Mountain site in 2002. Between 2002 and June 2008, the DOE prepared an application for a Nuclear Regulatory Commission (NRC) license for the site. The DOE submitted a license application on June 3, 2008 and the NRC now lists the application as docketed. An interview with an NRC official reveals that the NRC usually takes three to four years to evaluate an application.³

To date, Nevada politicians, citizens, Western Shoshone and Southern Paiute leaders, and local and national organizations have engaged in over 20 years of protest and resistance to the Yucca Mountain site. In addition to arguments that the site was chosen for political reasons—pointing out that the site violates a treaty with the Western Shoshone nation and accusing the DOE of an unjust process for citizen input—opponents also argue against the scientific suitability of the site. The fight against the site has not stopped with the submission of the NRC license application. My conversations with several citizen groups and American Indian tribal members suggest that opponents to the Yucca Mountain site are planning to engage in the NRC public participation process by submitting contentions against the site.

Amidst the variety of objections to the Yucca Mountain site, the scientific and technical suitability of the site is an important criterion for selecting a high-level nuclear waste storage repository. Few would deny that we need good science and engineering to design a nuclear waste repository. Accordingly, the scientific and technical suitability of the site is a prominent locus of argumentation. Indeed, many arguments against the site directly or indirectly posit a lack of sound scientific and technical evidence to support the site. Science comes up in two ways in arguments against the site. First, opponents object to the nature of the Yucca Mountain Project (YMP) as a type of “regulatory science,” that is, science produced for policy objectives.⁴ These types of arguments contend that the science supporting the site has been manipulated to fit the policy objective, that regulations have been changed to fit the scientific findings of the DOE, and that independent scientists’ findings cast doubt on the scientific and technical suitability of the Yucca Mountain site. Second, opponents raise specific concerns with the scientific and technical findings of the YMP that form the basis of the federal government’s support of the site. These arguments use independent (i.e., non-DOE), peer-reviewed findings or knowledge of the scientific method to challenge specific aspects of YMP scientific and technical findings. A selection of peer-reviewed scientific articles and a forum on Yucca Mountain highlight several loci of scientific controversy, including the risks of seismic or volcanic activity, groundwater and aquifer contamination, and storage cask design (Apted *et al.*, 2002; Birkholzer *et al.*, 1999; Conner *et al.*, 2000; Ewing & Macfarlane, 2002a; Ewing & Macfarlane, 2002b; Flint *et al.*, 2001; MacFarlane & Ewing, 2006; Macilwain, 2001; Stuckless & Dudley, 2002; von Winterfeldt, 2002; Waltar, 2002;

Wernicke *et al.*, 1998; Zhang, Wu & Houseworth, 2006). Opponents draw on both peer-reviewed independent science and commissioned scientific studies (e.g., the Yucca Mountain Legacy Project⁵) to create arguments against the scientific and technical suitability of the Yucca Mountain site. This essay focuses on the latter form of opposition to the site. It analyzes how participants in the 2001 Yucca Mountain site authorization public comment period attempted to use scientific arguments to contest the authorization of the site.

Three areas of communication research—public participation in environmental decision making, nuclear communication, and science communication—inform my analysis. Scholars of public participation in environmental decision making have exposed numerous flaws in current models of public participation (e.g., Depoe, Delicath & Elsenbeer, 2004). Most currently practiced models of public participation assume a technocratic one-way model of communication. In these models, decision makers are set aside from members of the “public,” a monolithic conception of the public that means anyone who is not a decision maker or expert.⁶ Technocratic models of public participation construct science as the most important form of evidence, the public as a monolithic and passive body (despite the heterogeneity of multiple publics seeking an active role in decision making), and a hierarchical divide between experts and the public (Depoe & Delicath, 2004; Farrell & Goodnight, 1981; Fiorino, 1990; Fischer, 2000; Fisher, 1987; Goodnight, 1982; Katz & Miller, 1996; Ratliff, 1997; Toker, 2002; Waddell, 1990, 1996). Technocratic models of public participation constrain participation and dialogue between publics and decision makers. This essay complicates critiques of the technocratic nature of current models of public participation by attending to science as a necessary topic in public deliberation and as a means to achieve environmental justice in decision making.

Fischer (2000), Kinsella (2004), Wynne (1996), and others have examined how technocratic models of public participation often dismiss the input of citizens because they advance social, political, or value-based arguments that do not fit into the traditional positivist notions of science or expertise and are thus perceived as non-scientific. Fischer (2000) details how current models of decision making value science and expertise to the exclusion of the normative, political and social issues that all citizens can bring to decision making. Fischer and Kinsella both call for new conceptions of public participation that recognize the value of citizen input and local expertise. Fischer calls for a social constructionist view of science that recognizes local knowledge (and the social and political arguments that are currently left out of decision making) as a part of an expanded notion of science. However, few studies have actually examined the particular ways in which members of publics have tried to make traditional scientific arguments. My analysis will demonstrate that citizens are capable of making scientific arguments, thus challenging the perceived dichotomy between scientific experts and “scientifically illiterate” publics. Indeed, as Fischer (2000) notes, publics are often assumed to be ignorant partially because of the problem of “lumping together a wide range of citizens under the category ‘the public’ . . . But there is good reason to believe that significant portions of the citizenry are more intelligent than usually credited” (p. 35).

My focus on the Yucca Mountain controversy also intersects with nuclear communication scholarship. According to Taylor *et al.* (2005, p. 364) the focus of nuclear communication is to examine the “overlapping spheres of organizational and public communication produced in and around the nation’s nuclear-industrial infrastructure.” According to nuclear communication scholar Taylor (2003, p. 288) “nuclear waste represents one of the most complex and highly charged controversies created by postwar society. Perhaps daunted by its technical, legal and political complexities, communication scholars have not widely engaged this topic.” Several essays explore the nature of public participation in nuclear waste siting decisions (e.g., Endres, 2009; Katz & Miller, 1996; Ratliff, 1997). These essays focus more on the rhetorical strategies of decision makers that constrain public participation than on the rhetorical strategies used by public participants in their attempts to be heard. Taylor *et al.* (2005) call for more research into the dynamics of public participation in policy making, particularly shifting our attention to the “micropractices of participants” (p. 382). This essay answers this call by focusing on how public commenters tried to make scientific arguments and thus engage in debate with the DOE in what Kinsella and Mullen (2007) describe as a “paradigmatic site of technocratic authority” (p. 80).

Science communication also informs this essay. Research in science communication includes examination of communication among scientists, between scientists and other groups, and about scientific policies. Rhetoric of science and public understanding of science (PUS) are two areas of science communication to which my essay speaks. Although there are many rhetoricians of science studying the role of science in deliberation (e.g., Ceccarelli, 2001, 2004; Condit, 1990; Farrell & Goodnight, 1981; Fisher, 1987; Gross, 1984; Mitchell, 1995; Reeves, 1997; Waddell, 1990; Weaver, 1997), they tend to examine the rhetoric of politicians and scientific experts speaking to publics instead of examining the ways in which publics use scientific argument. Examination of publics’ attempts to make scientific arguments is crucial if we are to understand the complex roles of public participation and scientific argument in environmental policy deliberation. The rhetoric of science will benefit from expanding its focus to public scientific rhetoric. This expansion engages with the ongoing conversation started by Gaonkar (1993) in the early 1990s about the risks of expanding rhetoric to include the rhetoric of science (see Gross & Keith, 1997). I will return to this in the implications section of the paper.

PUS is focused on models and strategies that decision makers and scientists can use to teach or involve publics in science and science policy. As Brossard and Lewenstein (2008) argue, even though there are multiple models of PUS (i.e., deficit, contextual, lay expertise, and public engagement), all of them operate under an assumption of deficit. In other words, the deficit model assumes that the public has a deficit of scientific understanding or information and that simply filling the empty well will solve the deficit. Agreeing with Gross’ (1994) statement, “the deficit model fails generally as a ground for public understanding and political action” (p. 9), this essay challenges the deficit model by calling for a shift from studying how publics receive scientific information to how publics construct scientific information and arguments.

In this essay, I build from Kinsella's (2004) concept of public expertise and examine what I call *public scientific argument* as a form of public expertise. Through an examination of the Yucca Mountain site authorization public comment period, I analyze how non-scientist members of publics attempt to engage in scientific argument. The essay begins by discussing public expertise and public scientific argument. Then, I turn to an analysis of the Yucca Mountain site authorization public comment period. The essay concludes with the implications of this analysis for public participation in environmental decision making, nuclear communication, and science communication. For public participation, this essay not only calls our critical attention from theorizing new models to providing practical resources for citizens faced with current technocratic models of public participation but also challenges new models to more fully consider citizen abilities to engage in scientific argument as a form of technical competency. Based on my analysis, I will offer specific commentary on the rhetorical strategies of public scientific argument. For nuclear communication, my analysis of the micropractices of participants in the public comment period reveals opportunities for small breakthroughs and strategies of resistance in the current technocratic models of nuclear discourse. For science communication, I explore how a focus on the arguments of non-scientist publics productively expands our notion of the rhetoric of science and provides a critique of the deficit model that is prominent in PUS scholarship.

Public Expertise and Public Scientific Argument

The Yucca Mountain site authorization public comment period exemplifies a technocratic model of public participation in environmental decision making. The NWSA mandates that the DOE administer a site authorization public comment period before submitting a site recommendation to the president. This public comment period is distinct from the National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS) public comment period for Yucca Mountain. One difference is that the NWSA legally mandates that the DOE can only consider scientific and technical arguments from the site authorization public comment period, whereas EIS public comment periods include evaluation of the social and cultural impacts of proposals (even though EIS public comment periods are very science-heavy in practice). In the DOE's announcements of the site authorization public comment period, it explicitly framed it as an opportunity for the DOE to educate "the public" and for "the public" to comment on the scientific and technical documents produced by YMP scientists (US DOE, 2006a; US DOE 2002b,c). These announcements highlight that one purpose of the comment period was to educate, a sign of technocratic and deficit models of public participation already in play (e.g., Katz & Miller, 1996). The second purpose of the site authorization public comment period was to evaluate the scientific and technical suitability of the Yucca Mountain site. However, the technocratic model of decision making creates a catch-22 for citizens who have "come to the table with enough scientific knowledge to make technical comments" but are then disregarded because they are not scientific experts (Ratliff, 1997, p. 372). The

technocratic model defines credentialed scientists as experts and members of the public as non-experts. Critics of the model argue that the common citizen's voice in policy deliberation can easily be overwhelmed, intimidated, co-opted, or silenced (Katz & Miller, 1996; Powell, 1999; Toker, 2004, 2005; Wander, 1976). The technocratic model of public participation in decision making is heavily weighted against citizens, particularly with regard to scientific argument.

There is no doubt that we need new and improved models of public participation in environmental decision making. Much scholarly attention is paid to theorizing, developing, and advocating alternative models of public participation (e.g., Beierle & Cayford, 2002; Depoe *et al.*, 2004; Fischer, 2000; Fiorino, 1990; Kinsella, 2004; Walker & Daniels, 2001, 2004). Walker and Daniels (2004) offer "civic science" as a dialogue between scientific experts, political experts, and citizen experts. They argue, "within a civic science orientation, environmental policy decision making honors traditional knowledge (both indigenous and local) just as it seeks scientific and technical knowledge; voices from non-scientific communities are heard alongside those of scientists" (p. 138). Yet, a civic science model still maintains the assumption that scientific argument is the realm of scientists and non-scientific argument is the realm of publics. While Walker and Daniels seek to create space for multiple voices, diverse types of expertise, and various types of arguments, Kinsella (2004) seeks to break down the divide between public and expert with his concept of public expertise. Public expertise recognizes the extant scientific and technical competencies of citizens as well as their local knowledge and experiences (i.e., popular epidemiology). Kinsella argues, "Re-conceptualizing experience as a public resource, and the relationship between experts and publics as civic dialogue, is essential to overcoming the barrier and to improving the quality of energy and environmental decisions" (Kinsella, 2004, p. 86). Fischer (2000) similarly calls for re-envisioning public participation as a conversation between experts and citizens. Drawing from a social constructionist perspective on science, his model expands the very definition of science to include local knowledge and to acknowledge the inevitable normative judgments that go into scientific research. In this model, experts are viewed as specialized citizens and citizens are viewed as experts in local knowledge. Under this new vision, Fischer argues, "Public debate would still require the participation of experts, but rather than merely analyze and render judgments *per se*, they would interpret complex issues in ways that facilitate citizen learning and empowerment" (p. 259). Walker, Daniels, Kinsella, and Fischer offer new ways of conceiving public participation in environmental decision making that play with the relationship between science, expertise, and public participation.

Yet, while they make valuable and significant theoretical moves, new models of public participation in environmental decision making may not help publics navigate within traditional models of public participation. In other words, it is important to also develop our understanding of how people work within the constraints of current models of public participation. An analysis of how members of publics attempt to engage in scientific argument within the current models will not only inform new models of public participation such as the ones discussed above, but can also yield

practical strategies for publics faced with traditional technocratic venues for participation.

Even though Kinsella argues for a shift in public participation practices, his concept of public expertise is also useful for examining how publics make scientific arguments within the constraints of current technocratic models of public participation. Kinsella and Mullen (2007) identify three forms of public expertise: (1) mobilizing technical competencies; (2) “local knowledge unavailable to most official experts”; and (3) “technical assistance and scientific authority provided to stakeholder groups by external non-governmental organizations sympathetic to their interests” (p. 95). Kinsella’s concept of public expertise assumes that citizens can engage in discussions in the technical sphere (e.g. Goodnight, 1982). “Public expertise, in any of the three forms described above, operates primarily within the scope of Luhmann’s system rationality or Fisher’s rational-world paradigm, vying for authority with alternate technocratic narratives offered by actors such as the Department of Energy” (Kinsella and Mullen, 2007, p. 96). In other words, the concept of public expertise addresses situations of scientific or technical controversy that arise when members of publics enter into the debate.

Public Scientific Argument

Expanding upon public expertise, I delineate and examine *public scientific argument* as a type of technical competency. Kinsella (2004, p. 85) notes, “The ideal form of public expertise is technical competency acquired and used directly by affected citizens.” I define public scientific argument as scientific and technical arguments constructed by non-credentialed, non-scientist members of “the public.”⁷ Public scientific arguments fall into three categories: (1) using scientific data produced by credentialed scientists to support a claim (in this case about the suitability of the site); (2) identifying flaws in the scientific method in order to challenge particular scientific findings; and (3) using one’s own scientific data to make a claim. The first two are the most common forms of public scientific argument in my analysis. Members of publics use their understanding of scientific method and scientific data to engage in discussion of the scientific or technical aspects of a decision. However, some citizen groups have started their own data collection or scientific projects, such as the Healing Ourselves and Mother Earth’s (HOME) Yucca Mountain Legacy Project, to gather baseline groundwater contamination data in the Yucca Mountain region (Viereck, Haddar & Rice, 2006). The Yucca Mountain Legacy Project and others like it draw from members of their organizations with scientific training as well as credentialed scientists who volunteer their time as consultants.

Science plays an important, though problematic role in public deliberation over environmental issues and policies (Killingsworth & Palmer, 1992; Kinsella, 2004; Powell, 1999; Rosenbaum, 2006; Walker & Daniels, 2004). According to Waddell (1990, p. 397) “The audience (public) must be prepared to participate constructively in the scientific and technological controversies that are becoming increasingly crucial in our nation and to our world.” An understanding of scientific information and the

scientific method is important for public participation in deliberation over scientific and environmental policies. Kinsella (2004) suggests, “One important tool for effective citizen participation is technical competency, and in most cases citizens must possess some basic level of technical knowledge to enter the conversation at all” (p. 92).

PUS scholars often study ways to increase scientific literacy among citizens or to increase levels of understanding of scientific concepts and evidence (Miller, 1998; Shen, 1975; Sturgis & Alum, 2004; Zimmerman, 1995). Miller (1998) states, “civic scientific literacy refers to a level of understanding of scientific terms and constructs sufficient to read a daily newspaper or magazine and to understand the essence of competing arguments on a given dispute or controversy” (p. 204). However, these foci still fall within the deficit model that assumes that once the deficit is filled, citizens will adhere to scientists’ findings or arguments (Brossard & Lewenstein, 2008). Instead, I focus on how publics attempt to make their own scientific arguments.

Despite the assumption that most citizens are scientifically illiterate, publics are capable of engaging in scientific arguments (e.g., Condit, 1996; Kinsella, 2004; Lessl, 1989). According to Fischer (2000), “many citizens are much more capable of grappling with the complex technical and normative issues than the conventional wisdom would have us believe” (p. 260). Members of publics do not have to be credentialed scientists to make scientific arguments. As Lessl (1989) notes:

The driving motives of science—rationality, skepticism, and the desire to know—are not the exclusive property of the scientist; they are fundamental qualities of the human creature that happen to be featured in the scientific mindspace. As a means of human identification, the public rhetoric of science must chiefly be concerned with finding the scientists in each man, woman, and child. (p. 193)

This passage indicates the possibility for technical competency. As Kinsella (2004) refers to it, technical competency does not mean that citizens need to “attain the same depth of technical knowledge as specialists”; rather, technical competency involves “a working vocabulary of scientific terms and concepts, and an overall understanding of how technical reasoning operates” (p. 92). Thus, technical competency allows for citizen participation and “prepares them for more successful involvement with particular issues” (p. 93). I argue that an understanding of scientific method and the ability to read scientific journals can help citizens to create public scientific arguments. Technical competency and public scientific argument can empower publics to engage in scientific debate with the communication competency to engage in current models of public participation that call for publics to comment on scientific and technical issues.

Building from the assumption that publics can and should be able to understand scientific argument, scholars have shown examples of publics successfully demonstrating their technical competence (Fabj & Sobnosky, 1995; Hamilton, 2003; Kinsella & Mullen, 2007; Toker, 2002). Kinsella and Mullen’s (2007) analysis reveals how Hanford downwinders engaged in forms of public expertise. Hamilton (2003)

suggests further that members of a public can and do use scientific and technical arguments. In regard to the Fernald radium case, she states, “elements of technical rationality were evident in several of the citizen’s responses” (p. 300). Moreover, in their study of AIDS activists, Fabj and Sobnosky (1995) demonstrate that activists were able to engage in scientific argument with medical researchers toward productive ends. Despite the constraints of current models of public participation, these studies show that publics can use technical competency to engage in public participation processes. Moreover, in the case of Fabj and Sobnosky, publics can influence research and policy through using technical competency as a starting point. Considering that local, political, and social knowledge and expertise are not valued in current technocratic models of decision making, perhaps the only way for publics to gain some traction or have a hope of influence is to begin on the ground of the experts by using public scientific argument to open the door for small pockets of resistance. Over time, these pockets of resistance may lead to the possibility of influencing the scientific debates among experts (Fischer, 2000), influencing policy (Fabj & Sobnosky, 1995), or challenging regulatory science from the bottom up.

Some may argue that a focus on publics using scientific information only reifies the primacy of scientific reason and deflects attention from significant social, political, and vernacular arguments. Indeed, exclusive reliance on scientific proof will divert attention from other important social, economic, or pathos-based considerations in what Gross (1984) refers to as “the failure of technical knowledge to resolve social, ethical, or political dilemmas” (p. 406). The implication of such arguments is not that science is useless, but that we need to find new ways to integrate scientific, social, and cultural arguments into public deliberation. Fischer (2000), Kinsella (2004), and others do this by theorizing new models and approaches to public participation. However, we also need to discover ways to better understand citizen abilities to engage in scientific argument. Studying public scientific argument involves challenging the privileged status afforded to scientific argument in policy making while also recognizing citizen abilities to engage in scientific argumentation.

In order to better understand the ways in which publics attempt to engage in scientific argument, I offer a rhetorical criticism of some of the scientific arguments made during the Yucca Mountain site authorization public comment period. As Toker (2002) suggests, “Through criticism we can identify the specific rhetorical strategies that people actually use” (p. 79). Understanding specific rhetorical strategies is important for further refining our understanding of the relationship between science and policy making. Criticism of this type has both theoretical and practical contributions. A focus on public scientific arguments expands traditional notions of science as linked to expertise and has implications for how we think about models of public participation. Practically, it offers people on the ground strategies for engaging in public participation. Studying public scientific argument is intended to critically analyze the way that publics uses science in public deliberation and to discover rhetorical and argumentative strategies that allow citizens to engage in deliberation in contemporary constrained models of public participation without falling into the trap of reifying or fully legitimating these approaches.

Public Scientific Arguments in the Yucca Mountain Controversy

In preparation for making a site authorization decision, the DOE released scientific and technical reports and a draft EIS which were to be used by the Secretary of Energy to make a site authorization recommendation. These documents make the initial case for the Yucca Mountain site and provide resources for other proponents of the site to build their arguments. Concurrent with the release of these documents, the DOE announced a period in which it would accept public comments and hold public hearings about the scientific and technical suitability of the site. The public comment period lasted from May to December 2001 and resulted in 5250 public comments, taking the form of a statement made at one of the 66 public hearings throughout Nevada, a statement to a court reporter at the Yucca Mountain Information Center, an e-mail message, or a written comment sent via post. An archive of public comments is available at the Yucca Mountain information center and on the web (US DOE, 2006b). Following the public comment period, the DOE produced a document that summarizes and responds to the public comments (US DOE, 2002a).

From the corpus of public comments, I focus on those comments that make arguments about the scientific and technical grounding for the Yucca Mountain site. Science plays a prominent role in both opponent and proponent arguments about the site, but I focus only on the scientific arguments against the site. Public attempts to use scientific arguments to challenge the scientific suitability of the Yucca Mountain site vary widely; they resemble and invoke the scientific arguments found in peer-reviewed science journals to different degrees. However, I only analyze the arguments that fit into my definition of public scientific argument, that is, those that draw from scientific findings of credentialed scientists (mostly by citing peer-reviewed scientific articles), that challenge the scientific method of YMP science, or that draw from one's own scientific data to make a claim. In order to understand how public scientific arguments interact with the DOE's justification for the Yucca Mountain site and the current model of public participation in environmental decision making, I also examine the DOE's official response to public arguments, the DOE's scientific and technical documents, and Secretary Abraham's site authorization report (Abraham, 2002; US DOE, 2002a,b,c). To be aware of the loci of scientific controversy over the Yucca Mountain site, I also examine relevant peer-reviewed scientific articles. Together, these texts provide significant insight into how publics tried to make scientific arguments and how the DOE both constrained and responded to these arguments. The remainder of this section will discuss two specific strategies that emerged from my analysis.

Citing Peer-Reviewed Scientific Data

Some public participants made scientific arguments that cited peer-reviewed scientific research to support their claims about the unsuitability of the Yucca Mountain site. In a public comment letter written on September 18, 2001, Buob (2001) stated, "While the geological characteristics of the Yucca Mountain area

should have disqualified the site long ago, the DOE has managed to twist, stretch, and ignore data to make the shoe fit . . . (discusses seismology) . . . The area is also clearly volcanic as it is clearly noticeable from the lava cones seen from atop Yucca Mountain. Global positioning satellite studies (published in *Science Magazine* (sic) '98) have shown that the crust at Yucca Mountain is expanding westward" (p. 2). This argument challenges the YMP's findings on volcanism. Buob's statement suggests that the geological, specifically volcanic, characteristics of the area make the Yucca Mountain site unsuitable for high-level nuclear waste storage. Then, he goes further by citing a peer-reviewed article in *Science* that reports on the authors' analysis of earth crust movements and concludes that there is a higher than normal chance of volcanic activity during the period of the Yucca Mountain site's projected use (Wernicke *et al.*, 1998). Wernicke *et al.* argue that the area is "experiencing an epoch of anomalously rapid strain accumulation" which could increase the risk of volcanic hazards (§ 19).

I am categorizing Buob's comment as the first type of public scientific argument, the use of peer-reviewed scientific data to support a claim. While the first part of the passage addresses a challenge to regulatory science, the second part of the passage makes an argument about the risks of volcanism for the Yucca Mountain site. This use of the Wernicke *et al.* study is consistent with the conclusions of the study and is consistent with the concept of technical competency. Buob's letter uses a basic level of understanding of a geologic process described in a peer-reviewed scientific article to support a challenge to the DOE's findings on the risk of volcanic activity. His use of this article to challenge the suitability of the site reveals an understanding that the Yucca Mountain site relies on geologic stability to keep the nuclear waste contained and that a higher than normal risk of volcanic activity could jeopardize the safe containment of radiation from nuclear waste. Some might question the level of technical competency in Buob's response, but recall Kinsella's (2004) argument that technical competency does not mean that citizens have the same level of knowledge of experts but it does mean that citizens have the basic ability to engage in an otherwise esoteric scientific topic. As I will argue in the next paragraph, Buob's use of public scientific argument elicited a different type of response from the DOE than the usual dismissal.

The DOE's response to this argument takes it seriously and challenges the scientific methodology of the Wernicke *et al.* study. The DOE *Comment Summary Document* (US DOE, 2002a) does not respond to each individual comment but instead categorizes similar comments under a "comment summary" heading and then provides a "response." The *Comment Summary Document* categorizes Buob's comment as: "Members of the public raised issues associated with the high regional stress field characteristics of the Yucca Mountain region as described by Wernicke *et al.* and the seismic and volcanic (or magmatic) effects that a high regional stress field could have on a repository at Yucca Mountain" (US DOE, 2002a, section 4.3.3). The comment summary is followed by the response. The DOE states that the methodology of the Wernicke *et al.* study is flawed because they only used two of 14 GPS monitoring stations and did not control for a recent earthquake. They continue

by comparing the Wernicke *et al.* study to new a US Geological Survey (USGS) study that used a “the larger number of stations, [a] longer survey period (1983–1998), and the removal of the effects of the June 1992 Little Skull Mountain earthquake” to conclude that “the strain rate in the Yucca Mountain region is significantly less (by an order of magnitude) than the rate reported by Wernicke *et al.*” (US DOE, 2002a, section 4.3.3). This response not only challenges Wernicke *et al.*'s methodology (i.e., they only used two of the 14 measuring stations and did not correct for the recent earthquake) but offers a new study that supports the DOE's argument that the rate of crustal movement is lower than that predicted in Wernicke *et al.*'s study.

Unlike the typical dismissal of public comments, this response takes seriously the challenge presented in Buob's comment. Instead of referring back to the findings already presented by the DOE in the documents released before the public comment period or dismissing the argument, the DOE's response takes the challenge seriously enough to offer a new study that responds to the challenge. This is a slight but important distinction. While most of the responses I read in the *Comment Summary Document*, offer very general non-responsive responses to public comments, this response actually introduces new information to counter the public comment. Of course, it would be unlikely for the DOE to concede and agree with a public commenter in their response. However, I argue that the DOE's response demonstrates engagement in debate over scientific findings with a member of “the public.” Although this was not a real-time interaction between Buob and YMP scientists (the *Comment Summary Document* was released one year after the public comment period), the response directly addresses Buob's argument. Even though the DOE still got the final word because there was not an opportunity to respond to the DOE's responses, this example does show that a scientific argument made by a commenter was taken seriously enough to merit a specific and direct response. While being taken seriously may only represent a small victory in a process where the DOE viewed public participation as something to be checked off a list as opposed to a genuine opportunity for input, this example reveals the potential for inserting fissures and resistance into current models of public participation.

In another example, several public comments address a disagreement between NRC commissioned scientists⁸ and YMP scientists on the probability and effects of volcanic activity. Two comments refer to an article from *Nature* (Macilwain, 2001) that summarizes the findings of NRC scientists (i.e., Conner *et al.*, 2000). In a public comment letter received on October 16, 2001, Levin (2001, p. 1) states, “as *Nature* has recently pointed out, it is most likely that the Department of Energy is ‘seriously underestimating the risk presented’ at the site by volcanoes (see issue of August 30, 2001, p. 850).” A September 30, 2001 public comment by Bohannan (2001, pp. 1–2) states, “The British Journal *Nature* says, ‘(The Nuclear Regulatory Commission) thinks that the Department of Energy, which is responsible for getting the repository built, is seriously underestimating the risk presented by volcanoes’ (August 30, 2001, p. 850).” Both comments present a public scientific argument that uses a peer-reviewed article to support a challenge to the site. They argue against the Yucca

Mountain site by citing an article in *Nature* that summarizes the disagreement between the DOE and NRC over volcanism (Macilwain, 2001).

The DOE characterizes these two comments under the summary comment category: “An issue has been raised by the public that there is disagreement between the DOE and the NRC staff on the risks from volcanic events” (US DOE, 2002a, section 4.3.3). The response indicates that the DOE also took this argument seriously:

The resolution of opinions between the DOE and NRC on potential volcanism at Yucca Mountain falls into two broad areas: the probabilistic estimate of volcanic disruption of a repository and the consequences of such a disruption . . . Both of these issues have been the subjects of discussion between the DOE and the staff of the NRC during technical meetings. The NRC staff has expressed confidence that the DOE’s proposed approach to the topics, together with any licensing process, should result in satisfactory resolution of the topics. (US DOE, 2002a, section 4.3.3)

Again, this response engages in quasi-dialogue with Levine and Bohannon’s comments because it at least directly responds to their argument. The DOE response recognizes the NRC scientific findings as a potential challenge to its findings about volcanism and it explains that it has worked with the NRC to address the differences in findings. The acknowledgement of the argument shows some hope that technical competency, specifically public scientific argument, gains the attention of the DOE in different ways than a standard dismissal of public comments.

However, the DOE’s response still exposes a fundamental flaw in current technocratic models of public participation in decision making: the bifurcation between citizens and experts. There is a direct response, but it seems to imply a “just trust us, we know what we’re doing and we’ve talked to the NRC” response. This response legitimates forging ahead with the original plan by responding but then casting aside the commenter’s argument. These examples of public scientific argument cannot dismantle and break down a fundamentally flawed model of participation, but they show that one way in which citizens can engage in scientific argument is to understand and draw from peer-reviewed scientific studies. Although the DOE did not back down on its position, it did acknowledge and respond to these arguments, which, as I will show in the next section, is not always the case.

Raising Questions

A second way in which public commenters attempted to engage in scientific argument was through asking questions that attempt to challenge the scientific method or findings of DOE studies. Many challenges to the DOE’s scientific and technical reports came in the form of questions. Although these questions implicitly challenge the scientific method or scientific findings of the YMP, I will argue that they are a weak form of public scientific argument as compared to citing scientific data. Raising a question is a particular communicative form in which someone brings something up as a relevant issue to be discussed, though a direct answer is not always given or expected (Bilmes, 2001; Leichter & Black, 2003). Raising a question,

although it usually follows the syntactical form of a question, does not have to appear in the form of a question. Toker's (2002) analysis of Lisa Crawford's rhetoric in the Fernald nuclear weapons facility public meetings suggests that Crawford strategically raised questions during a face-to-face meeting with decision makers and scientists as a form of the comic frame (à la Kenneth Burke). Toker argues that despite her technical competency, Crawford asked seemingly ignorant questions as a means of disrupting the public meeting and forming an identification with fellow public participants. Toker's articulation of using questions as a form of the comic is situational; she shows how raising questions in the Fernald public meeting context worked successfully in a face-to-face setting to disrupt the meeting and help the speaker identify with public participants. However, the strategy of raising questions may be less successful in a process of public participation that does not allow for direct real-time dialogue and discussion. In the public hearings held during the Yucca mountain site authorization public comment period, there was no time for questions and answers, just timed public comments to which the DOE responded after the fact.

Public participants raised questions about multiple aspects of the scientific and technical suitability of the YMP, including the seismic qualities of the region, volcanism, hydrology, storage cask design, and radiation standards. Frankel (2001, p. 1), in a public comment letter sent on October 4, 2001 asks, "The region was shaped by volcanic activity. Is there no risk of future volcanic activity for the next several millennia? These facts (on volcanism) are well known and documented in government reports made by the DOE, GAO, and the State of Nevada." On face value, this may not seem to be a scientific argument. However, Frankel's question acts as a rhetorical question in that it makes an argument through the implied or expected answer to the question. After asking her rhetorical question, Frankel makes her implied argument by citing two technical reports (McKay *et al.*, 2000; US GAO, 2001) that answer her question. The reports reveal uncertainties in the scientific method and findings of the YMP regarding the risk of future volcanic disruption of the storage facility (US DOE, 2002c). Frankel's question about the risk of volcanic activity, viewed in conjunction with the GAO and Nevada reports, can be interpreted as an implicit argument that there will be a risk of future volcanic activity. Of course, I cannot know Frankel's level of understanding of volcanism, but her comment does fit within the first type of public scientific argument because she makes an argument based on citing peer-reviewed scientific data.

The DOE categorized Frankel's argument under the following summary comment: "Members of the public raised issues that past volcanic activity was evident in the Yucca Mountain area and that there was 'recent' volcanism nearby. Several commenters *believed* the small volcanoes in the area are still 'active.' All of these comments *questioned* the viability of the repository in a *perceived* active-volcanic setting" (italics added, US DOE, 2002a, section 4.3.3). It is noteworthy that this summary, unlike the ones quoted in the previous section, uses words like "believed," "questioned," and "perceived" to suggest that the comments are not based on scientific facts but on beliefs and perceptions. The DOE response begins by indicating that "The presence of past volcanism and the existence of small, extinct basaltic

volcanoes, the youngest of which is 80,000 years old, does not make the site unsuitable for long-term waste disposal” (US DOE, 2002a, section 4.3.3). The response then cites specific parts of the technical documents that they released prior to the public comment period such as “Section 1.3.2.2 of the S&ER Rev. 1 (Yucca Mountain Scientific and Engineering Report),” “Section 4 of the YMSD (Yucca Mountain Site Description),” and “Section 4.3.2.1 of the S&ER Rev. 1” (US DOE, 2002a, section 4.3.3). The DOE’s response concludes by stating, “*The DOE considers the information on geology, geologic hazards, and the effects of these hazards on the repository has been adequately described and analyzed in the reports cited above . . . The DOE concludes that past volcanism in the Yucca Mountain region is well-characterized and indicates a very low probability of future volcanic disruption of a repository* (emphasis added, US DOE, 2002a, section 4.3.3).

The DOE’s answer simply refers back to its own studies and reports to argue that there is a low probability of volcanic activity in the future. It answers Frankel’s question about whether there is risk, but do not respond to the argument she made that there is risk. The DOE responds as though Frankel’s question is an information-seeking question and “teaches” her the answer. This type of response is in line with a technocratic model of decision making that assumes that the goal of the process is to educate the public instead of considering their feedback.

However, as Frankel indicates, contemporaneous reports by the GAO, the State of Nevada, and peer-reviewed scientific journal articles do call into question the YMP findings. The State of Nevada Office for Nuclear Projects (McKay *et al.*, 2000, p. 8) report states, “although considered as a low probability of occurrence (of volcanic activity), the consequences would be severe.” Moreover, the US GAO (2001) report states, “the Board (Nuclear Waste Technical Review Board) observed that the DOE had not presented a clear and persuasive rationale for going forward with a site recommendation before resolving the important issue of the potential consequences to the repository from volcanic activity” (see also Nuclear Waste Technical Review Board, 2002, p. 13). In addition to these reports, several peer-reviewed articles in scientific journals indicate the uncertainties with the YMP’s understanding of the effects of volcanism (Conner & Hill, 1995; Conner *et al.*, 2000; Ewing & Macfarlane, 2002a; Macilwain, 2001; Smith, 2002; Wernicke *et al.*, 1998; Woods *et al.*, 2002). Indeed, Conner *et al.* (2000) argue that the likelihood of volcanism is higher than the DOE estimates. The Conner *et al.* findings come from a more complex model than the one used by the YMP scientists (Macilwain, 2001). Would the DOE’s response have been different if Frankel had not asked a question and instead made a direct scientific argument citing one or more of these peer-reviewed articles?

Essentially, the challenges raised in the two reports that Frankel cites are shut down by the DOE’s response. Although, it may seem that Frankel’s argument is treated the same way as the arguments I identified in the previous section, there is an important difference between this and the examples in the section on citing peer-reviewed scientific findings. In this example, the DOE does not directly respond to the reports Frankel cited but instead responded to Frankel’s question. In the previous examples, the DOE may have still tried to disregard the arguments but they at least engaged

in debate with the articles cited by public commenters. When people cited specific studies, they got more direct answers. The strategy of raising questions is a weak form of public scientific argument that does not force the DOE to respond, but allows it to merely refer back to its findings. It does not force dialogue and debate, however stilted they may be in current models of public participation.

Another example of the question raising strategy comes from a comment made by Jane Feldman, from the Toiyabe Chapter of Sierra Club, at a public hearing in Las Vegas:

One of the most serious issues that has been raised by the scientific work at Yucca Mountain is ground water contamination. The hydraulic relationships between the lower carbonate aquifer and the volcanic units and the alluvian (sic) units beneath and down gradient of the aquifer are poorly understood. Will there be contamination in the Amargosa River? Will that contamination spread to other aquifers? Without clear answers to these questions, locating the nation's high-level waste in irretrievable underground tunnels in the Nevada Desert is unacceptable. (US DOE, 2001b, p. 2)

Feldman does not offer an outright scientific counterargument to the DOE's assertion that groundwater contamination from the site is not a significant risk, but instead raises the issue as one needing more research. In point of fact, there were several research studies out at the time that do challenge the DOE's conclusions (Birkholzer *et al.*, 1999; Flint *et al.*, 2001; Shrader-Frechette, 1993).

Feldman's comment appears in the following comment summary category: "Members of the public have raised the issue of scientific uncertainty about the exact locations of the groundwater flow boundaries. They *believe* no one really knows where the groundwater is going" (US DOE, 2002a, section 4.3.5). The DOE's specific response here is similar to its response to Frankel's question; it only refers to the YMP reports in which Feldman could find the answer to her question, but does not address her vague reference to scientific findings that disagree with the YMP findings. The *Comment Summary Document* (US DOE, 2002a) states:

As described in Section 4.2.9 of the S&ER Rev. 1 (Yucca Mountain Science and Engineering Report), the DOE has conducted an extensive program to characterize the direction and nature of groundwater movement and likely transport pathways from the Yucca Mountain site . . . Although some uncertainty exists, the DOE considers that groundwater flow paths have been sufficiently determined in the groundwater flow system beneath and downgradient (i.e., in the direction of groundwater flow) from Yucca Mountain to identify the transport pathways for any radionuclides released from a repository at Yucca Mountain. (US DOE, 2002a, section 4.3.5)

So, again, the DOE responds to this issue by stating where the questions are answered in its technical documents, thus effectively shutting down the raised issue. Because this research was released prior to the public comment period and because the public comment period is framed as a way for citizens to *respond* to DOE scientific and technical research, the DOE's response implies that if the speakers had just looked at the documents, they would have gotten their answer. When public

comments do not specifically and explicitly reference the DOE's documents or findings, the DOE can simply reference these documents and does not have to defend a challenge to its scientific findings.

My analysis shows two (among many other) strategies of public scientific argument: citing peer-reviewed scientific data and raising questions. I chose to discuss these two strategies in the essay because they provide a means to compare the audience reception of each strategy and make some generalizations about the types of strategies that may work better than others for publics faced with traditional models of public participation. If one of the goals of people who submitted public comments is to influence the DOE not to authorize the Yucca Mountain site, the first strategy—citing scientific data—seems more desirable because it at least elicited a direct response from the DOE as opposed to eliciting mere references back to YMP scientific and technical documents. While raising questions can serve multiple rhetorical purposes, raising questions in a non-face-to-face context like the Yucca Mountain public comment period allowed the DOE to avoid debate and engagement with public comments. Instead of raising questions, public commenters should directly challenge the scientific results of the decision makers' science by citing peer-reviewed scientific findings and articulating why those results make the site unsuitable.

Implications

This essay is one step in describing how citizens attempt to make scientific arguments in public deliberation, specifically public participation in environmental decision making. As Kinsella (2004) notes, technical competency is an important part of his concept of public expertise. My analysis expands Kinsella's concept by positioning public scientific argument as a form of technical competency. In addition to demonstrating that some members of the public have the technical competency to make public scientific arguments, my analysis also highlights the importance of rhetorical and argumentative strategies for deploying public scientific arguments. In other words, technical competency must also include strategies for presenting arguments. On a practical level, enacting public expertise may require both scientific and technical competence and rhetorical competence. Further study should be done to develop our understanding of the rhetorical strategies of public scientific argument and public expertise.

It is worth noting the implications of this essay for the other two aspects of public expertise—local knowledge and technical assistance from external organizations. In the case of the Yucca Mountain site authorization public comment period, local knowledge was generally ignored by the DOE in its responses to public comments. This is not surprising, considering that the public comment period conformed to a traditional technocratic model of public participation in which non-scientific information is not valued. In this context it is worth mentioning that, in my analysis, I also found several arguments about volcanism, seismology, and transportation of nuclear waste casks that were based on observation, local knowledge and experience of place. I did not include these arguments in my analysis

because they do not fit my definition of public scientific argument. However, they would fit with Kinsella's (2004) second strategy of public expertise, providing local expertise and knowledge that is unavailable to experts. Still, it is significant to note that the DOE's responses to these local knowledge arguments closely resembled its responses to the scientific questions raised by participants in the public comment period. Thus, although new models of public participation in environmental decision making must find ways to incorporate local knowledge (as well as cultural knowledge, social and ethical considerations, and pathos-based arguments), most current models of public comment periods are not a good venue for incorporating these types of arguments; local knowledge will not be considered in current technocratic models.

Building technical competency and engaging in public scientific argument provides the best hope for publics to engage in current models of public participation. As my analysis shows, there is a difference in the way the DOE responded to public scientific arguments that cited peer-reviewed scientific data as opposed to raising questions and making vague references to scientific data; the DOE actually engaged in debate over scientific data. This difference reveals a potential site of resistance for publics faced with current technocratic models of decision making. Moreover, as Toker (2002) suggests, technical competency can create identification with scientists and decision makers and lead to better interactions, dialogue, and maybe even a space for local knowledge in the future.

The final aspect of public expertise is assistance from external scientists or organizations. Although Kinsella (2004) suggests that this is the least desirable form of public expertise, I argue that technical and scientific assistance is crucial to help build technical competency in publics. At a time when scientific literacy is lacking in a large portion of the non-scientist members of the public (Miller, 1998), many activists and citizens simply do not have the skills to understand scientific and technical arguments. Organizations and scientists can help by providing scientific information and education that is not linked with the decision-making process. It is not the role of the public participation processes to educate and inform publics, but to provide a venue for dialogue and input into the decision. Outside of this venue, scientists and organizations can and should help publics increase their technical competencies so that they can start making public scientific arguments. Kinsella (2004) notes, "with appropriate support from specialists, members of the public can develop technical competencies adequate for substantive participation" (p. 95). In addition to assistance from scientists, organizations can play an important role in building technical competency. Bazerman's (2001) study of the Greater St. Louis Citizens' Committee for Nuclear Information reveals how important a non-profit organization can be in helping members of publics wade through and understand complex scientific information, in this case through "a speakers' bureau, encouraging the release and dissemination of government and other information, spreading available information through its own publication, and verifying information through its own scientific advisory committee" (p. 273). Indeed, there are several organizations that help to disseminate scientific information about the YMP and other nuclear issues. These include HOME, the Institute for

Energy and Environmental Research (IEER), and the Nevada Nuclear Waste Task Force. These and similar efforts can help build technical competency among publics to prepare them to engage in public scientific argument.

Public Participation in Environmental Decision Making

Some may argue that because of the way that the public hearings are conceived by the DOE as a means for further educating the public, the arguments of the opponents of the site probably never had a chance of persuading the Secretary of Energy. Indeed, some go so far as to assert that the Yucca Mountain site authorization public comment period is ultimately a guise of deliberation (Endres, 2005). Although this essay focuses on the ways in which publics attempted to make scientific arguments, the analysis of DOE responses to these arguments certainly bolsters the case for developing new dialogic and inclusive models of public participation. However, as we develop theory and new models, we must not focus solely on public arguments as local and cultural knowledge to the extent that we don't consider the ability of citizens to gain and use technical competency to make the more traditional scientific arguments that are valued in current models. We must not fall into the trap of continuing to uphold the view of technocratic models that public arguments are always non-scientific. We must also develop models on the assumption that publics can develop technical competency and make public scientific arguments. Waddell (1990) contends that even scientists in public deliberation draw from both scientific data and pathos to make their arguments. Similarly, we need models that recognize that publics can draw from local knowledge, pathos, and scientific data to make their claims. These new models would explore the complex interrelations between scientific data, cultural and local knowledge, social and ethical issues, and other forms of data needed to make policy. Considering and refining the concepts of public expertise and public scientific argument provide a significant means with which to develop these new models.

Practically, my findings show that raising questions as a strategy of public scientific argument can undermine the goal of challenging DOE science because the strategy allows the DOE to respond with informative answers that show "it has been studied," and to reiterate its own conclusions. Questions keep the hearing process framed as a venue for the one-way transfer of information and education to the public. When faced with traditional models of public participation in environmental decision making that demand scientific argument, public participants need to provide strong, direct, and researched scientific arguments that challenge the DOE's reports. Arguments with support, as opposed to questions that merely raise issues, would create the expectation that the DOE must respond by defending its science. The strategy of citing scientific data worked to some small degree in forcing the DOE to meaningfully respond to challenges to the scientific suitability of the Yucca Mountain site. These arguments may not have fundamentally changed the model of public participation, but they represent a small victory for opponents seeking to have a voice in the public participation process.

Nuclear Communication

One subset of nuclear communication scholarship identifies the “characteristic practices by which officials managed stakeholders” including the deployment of scientific authority (Taylor *et al.*, 2005, p. 373). In response to Taylor *et al.*'s (2005) call for more research into how participants engage with officials and decision makers in the nuclear production process, this essay reveals how public participants tried to make scientific arguments and engage in debate with the DOE. As I mentioned above, the strategies of public scientific argument I identify are not revolutionary acts that transformed the system. But, they do describe the *in situ* practices of participants and reveal an opportunity for small breakthroughs in a public comment process that tends to disregard public comments.

This essay increases our understanding of strategies of resistance to nuclear policies. Taylor *et al.* (2005) call for research that “clarifies how affected groups may successfully self-organize to emerge as effective counterpublics, developing and using multipronged, multimodal opposition to engage the complexities of nuclear weapons production and its persistent culture of secrecy” (p. 383). My analysis contributes a piece toward understanding this puzzle. Public scientific argument is one potential method of resistance. It complements the many other methods in which Yucca Mountain opponents are and have been engaged, such as lawsuits (Ensign, 2004; *Nuclear Energy Institute, Inc. v. Environmental Protection Agency*; Rogers, 2005; Western Shoshone National Council, 2005), changing the NHPA to allow permanent on-site storage (Werner, 2004, 2005), and protests (Kuletz, 1998; Rogers, 2002). However, despite these other forms of resistance, participation in official decision-making processes remains an important part of opposition to Yucca Mountain. My conversations with several American Indian tribal representatives, citizen groups, and individuals opposed to the Yucca Mountain site reveal that they are focused on preparing contentions to submit to the NRC for consideration in its licensing decision. Understanding the role of public scientific argument in the site authorization public hearing process can help as opponents engage in other official processes of public participation. Because “all aspects of the global nuclear apparatus are connected” (Taylor & Kinsella, 2007, p. 2), examination of the role of public scientific argument in the Yucca Mountain site authorization public comment period is useful to a general understanding of the micro-practices of resistance to the nuclear production complex.

Science Communication

Finally, this essay contributes to theory in science communication. Both the rhetoric of science and PUS tend to focus on the rhetorical strategies of scientists and politicians, often in the context of issues of scientific controversy in the technical or public sphere. The rhetoric of science will benefit from a shift in focus to an examination of scientific arguments made by non-credentialed scientists. This expands the very definition of the rhetoric of science in productive ways to include

public scientific argument. Despite Gaonkar's (1993) argument about the risks of expanding rhetoric to include the rhetoric of science, we must continue to challenge the ways that science is demarcated in public controversies (Taylor, 1996). In line with Kinsella (2004) and Fischer's (2000) advocacy of expanding our notion of science to include local expertise, my analysis calls for the rhetoric of science not to abandon analysis of credentialed scientists, but to add non-credentialed scientists making scientific argument into the mix. My analysis also pushes PUS scholars to move away the deficit model that underlies most scholarship (Brossard & Lewenstein, 2008). A recognition that publics are attempting and, in some cases, succeeding in making scientific arguments can enhance PUS by encouraging more research into the ways publics engage in scientific debate.

Conclusion

We are in the midst a nuclear waste crisis. As long as we continue to use nuclear technologies, we will be faced with decisions about how and where to store nuclear waste. Although this essay focuses on discourses regarding high-level nuclear waste, there are also controversies over other forms of radioactive waste such as uranium tailings, low-level wastes, and contaminated weapons production sites. Decisions about where to store radioactive waste will always be difficult and controversial. Yet, currently these decisions are primarily being made by the federal government with only minimal opportunity for input by participants in public comment periods. To address the nuclear waste crisis, we must discover ways to create more just processes of public participation in environmental decision making. To do this, we must not only develop new models of public participation that meaningfully involve stakeholders in the process, but also investigate how participants can engage in current flawed models of public participation. Considering the Yucca Mountain site, perhaps, the best bet for engaging in the public participation process is to fight the decision makers on their own ground by making better scientific arguments. Perhaps, then, public scientific arguments can open the way for bringing cultural, social, and political issues into the debate. Or, at least, public scientific arguments can hold regulatory scientists accountable for their findings. This is particularly important in light of the recent discovery that members of the USGS falsified hydrological scientific findings that were used in the DOE's documents in support of the Yucca Mountain site because, as stated in an email message, "science by peer pressure is dangerous but sometime (sic) it is necessary" (Yucca probe focuses on possibly faked data, 2005). In the upcoming NRC licensing decision, the scientific and technical suitability of the site remains the primary criterion for awarding a license for the Yucca Mountain High-Level Nuclear Waste Repository to begin accepting waste. As public opponents of the site develop contentions, public scientific argument can be an important tool. Ultimately, this essay does not (and cannot) solve the problems in nuclear waste siting decisions. Yet, it is a step in the endeavor and calls for more critical examination of the processes, including the communicative processes, of nuclear waste siting decisions.

Notes

- [1] The NWPA provides the legal framework for selecting a site for geologic disposal of high-level nuclear waste in the USA.
- [2] This public hearing was run by the Department of Energy as part of the public comment period on the site authorization decision. The public comment period preceded the site authorization decision in 2002.
- [3] This interview was part of the Nuclear Technology in the Great Basin Oral History Project at the University of Utah.
- [4] See MacFarlane (2003) for a discussion of regulatory science.
- [5] The Yucca Mountain Legacy Project includes citizens, chemists, and hydrologists in monitoring groundwater contamination in the Yucca Mountain region. It released a report in 2006 establishing a baseline of groundwater contamination in the region (Viereck, Hadder & Rice, 2006).
- [6] Although I do not adhere to the notion of a monolithic public, most current technocratic models of public participation use the term “public” to subsume anyone who participates in the public comment or public-hearing process. This monolithic conception of the public fails to recognize the multiple publics/counterpublics that are involved in public participation processes. The use of a monolithic conception of the public is a rhetorical strategy that reifies the division between public/expert that Fischer (2000) and Kinsella (2004) explain in detail. Although I will not further explore this topic in the essay, and I will not specifically delineate all of the different publics/counterpublics that participated in the public comment period, I will use the term publics or citizens throughout the remainder of the essay when referring to participants in the public comment period.
- [7] I define public in the context of public participation in environmental decision making (albeit a simple conception of the public). In public participation venues, a public is called forth by the design of the process; anyone who is not a decision maker or expert is defined as a part of the public. In the case of the Yucca Mountain site authorization decision, the DOE automatically defined anyone who participated in the public comment period as the public. However, because this broad definition of public could include some credentialed scientists (and some did submit comments), I narrow my definition to non-credentialed non-scientists.
- [8] The NRC established an independent center for review of the Yucca Mountain Project called the Center for Nuclear Waste Regulatory Analyses.

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