VALUE ISSUES AND STAKEHOLDERS' VIEWS IN RADIOACTIVE WASTE MANAGEMENT[a]

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ABSTRACT

We review a study in progress that is examining the role played by ethical and value issues in high-level and low-level radioactive waste management. For each policy issue, we attempt to separate its "value concerns" into three categories, which we call the procedural, distributional, and evidential aspects. These categories refer to concerns about fairness and appropriateness of process, outcomes, and scientific evidence, respectively. For each value concern, we attempt to state the rationale used by key stakeholder groups in justifying their policy positions and to extract the "underlying general principles" (UGP's) that appear to be the basis for the arguments. By examining patterns of UGP's across groups for an issue, and across issues for a group, we hope to explain the patterns of UGP's in terms of more fundamental attributes of stakeholders' "world views" and notions about science and society.

INTRODUCTION

Radioactive wastes present some of society's most complex and vexing choices. Among experts and lay persons, there has been throughgoing disagreement about many significant aspects of radioactive waste management (RWM): how, when, where -- and whether -- to dispose of the waste; who should pay the costs, bear the risks, and reap the benefits involved; and what those costs, risks, and benefits are in the first place. Opinions have been just as divided on what, at least in a democracy, are even more basic issues: who should determine the answers to all of these questions and how should they do so? For one reason or another, a sustained and definitive RWM policy has been an elusive goal for our nation since the beginning of the nuclear age. An atmosphere of contentiousness and mistrust among the interested parties, fed by a long history of policy reversals, delays, false starts, legal and jurisdictional wrangles, and scientific overconfidence, and played out against the background of public concern with nuclear power and weapons issues generally, has dogged society's attempts to come to grips with the radioactive waste management problem.

In the Low Level Radioactive Waste Policy Act of 1980 (LLWPA) and the Nuclear Waste Policy Act of 1982 (NWPA), Congress ratified fragile compromises reached after years of heated debate among the diverse affected interests and attempted to end longstanding impasses over RWM policy. These two remarkable pieces of legislation (and recent amendments to the LLWPA) establish elaborate sets of policies and procedures for making decisions in the future, extending over fifteen years and more, intended to settle the main issues surrounding the fate of high and low-level civilian radioactive wastes. The NWPA, in particular, requires extensive public participation and aims explicitly to anticipate and to accommodate continuing debate and uncertainty over many of the relevant scientific and sociopolitical aspects.

The framers of the NWPA and the LLWPA recognized that implementing either bill would be an extraordinary challenge for our participatory democracy. Even with an implementing agency possessing consummate technical and political skills, the framework established by the act could unravel for many reasons: few people want radioactive wastes in their backyard because of the perceived risks; anticipating developments for fifteen or more years in an unprecedented program with many outstanding technical issues and uncertainties is almost impossible; guaranteeing performance of a geologic waste repository for many thousands of years is a unique regulatory challenge; the credibility of government agencies with the public is low; an so forth. The LLWPA has already had to be amended because of difficulties in getting state governments to be responsible for finding new low-level waste disposal sites.

Several hotly-contested key steps in the implementation of the NWPA and the LLWPA came to a head

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over the past year. The issues were: choosing three western sites for in-depth characterization for the first high-level waste geologic repository; choosing twelve eastern sites for preliminary investigation for the second geologic repository; deciding on the need for, feasibility of, and siting in Tennessee of the proposed Monitored Retrievable Storage (MRS) facility that would repackage commercial spent fuel for later shipment to a repository; and selecting states to host new low-level waste disposal facilities.

The intensity of the controversies, however, may nave exceeded what even the framers of the NWPA anticipated. Not only is there a plethora of lawsuits brought by affected states against the federal agencies, a number of voices in Congress are now saying that the Department of Energy (DOE) corrupted the NPWA and acted politically in deciding to indefinitely postpone development of the second repository. Enough congressmen believed DOE's implementation of the act was flawed to cut the budget and to prohibit site specific activities in fiscal year 1987. In January, the DOE acknowledged that the opening date of the first repository would have to be extended from 1998 to 2003. While DOE aims at proceeding with characterization of the three candidate sites for the first repository and arguing for the MRS, some critics are now saying that the current problems go beyond poor implementation and that the act is itself flawed. After five years, it is quite possible that Congress will decide that the NWPA -- like the LLWPA -- has to be amended.

The complex intertwining of technical, political, legal, and social issues is the hallmark of the RWM issue. The disagreements among the affected stakeholders are fundamentally conflicts over values, dealing with such issues as the fairness and appropriateness of process and outcomes and the appropriate weight and type of scientific evidence needed to justify a societal decision. Values include both principles and interests. Sometimes stakeholders shop around for principles to support their interests, but in many cases the value principles are a fundamental component of the stakeholders' "world views." For scholars, RWM is fertile ground for examining how ethical and value issues influence legislation, regulation, agency decisions, stakeholders' positions, and scientific judgments in environmental risk management.

Research Methodology

We are in the middle of a study examining the role played by ethical and value issues in radioactive waste management. The goals of our project are: (i) to explore the degree to which ethical and value issues have been explicitly or implicitly taken into account in RWM legislation, regulation, and planning, (ii) to determine the value conflicts that exist among stakeholders, the contradictions and inconsistencies that have occurred in stakeholders' justifying their policy positions with value principles, and the degree to which value principles can be separated from stakeholders' special interests and from technical, economic, and political issues, and (iii) to suggest what these contradictions and value disputes imply for the future course of implementing RWM policy and how certain modifications in current implementation plans might reduce problems that are foreseen, improve communication among affected interests, and regain the consensus on RWM policies over the long time-frame required for their implementation.

Our first step is to delineate systematically all of the key policy issues in high-level and low-level radioactive waste management. For each policy issue, we then attempt to separate its "value concerns" into three categories, which we call the procedural, distributional, and evidential aspects. The procedural aspects refer to who should make what decision for whom and by what process. The distributional aspects refer to what distribution of costs, benefits, and risks is fair to the parties affected and to society as a whole. The evidential aspects refer to what level and type of scientific evidence is sufficient and admissible in making a particular decision for society and to how we should fairly assess and evaluate competing scientific claims. In other words, our categories of "value concerns" are fairness and appropriateness of: process, outcomes, and evidence. Each policy issue has procedural, distributional, and evidential aspects.

For each value concern about a policy issue, we next attempt to state the basic arguments used by key stakeholders -- Congress, federal agencies, the nuclear industry, utilities, environmental groups, state governments, Indian tribes, local communities, etc. -- to justify their policy positions. (We recognize, of course, that no special interest group is monolithic, which often requires us to specify different factions.) If possible, we extract the "underlying general principle" (UGP) that appears to be the basis for a stakeholder's argument.

As an illustration, let us take the distributional "value concern" of who should pay for DOE's program to find a high-level waste repository. An environmentalist's UGP justifying the "one mill per kilowatt-hour" fee on nuclear electricity, which was authorized in the NWPA, might be phrased as "the one who causes a problem should pay for its solution" or "let the polluter pay." An industrialist's UGP justifying the fee would likely have a different connotation, such as "those who benefit from an activity (providing electricity) should bear the costs." (Of course, everyone might not agree on who caused a problem, who benefits from an activity, or how much it should cost to fix it.)

Let us take the above example one step further and examine the issue of how much should the federal government pay for putting defense waste in the civilian repository. The Edison Electric Institute and the National Association of Regulatory Utility Commissioners think that the DOE defense program is not offering to pay its fair share. The public debate is over the methodology used to calculate "fair share," an evidential dispute, rather than over the distributional principle (but it could have been the latter if the DOE defense program had offered to pay only the incremental cost of putting its waste in the repository). In this example, stakeholders' special interests are likely influencing the principles used in the evidential debate.

After specifying policy positions and value principles, we attempt to examine the patterns of UGP's across stakeholder groups for a particular issue, and across issues for a particular group. The final step of the study, which we hope to complete by the end of the year, is to try to explain the patterns of UGP's in terms of more fundamental attributes of different stakeholders' "world views," the type of "goods" involved (health, dollars, etc.), and different notions about science and society.

We have held three meetings with stakeholders involved in particular policy disputes: the MRS in Tennessee, low-level waste disposal in New York, and the high-level waste repository. These meetings of

"Stakeholders Anonymous" have helped us to understand better the positions, interests, and principles of the key groups. (At the repository meeting, it took eight hours for the twenty-five participants individually to give their answers to three questions: (i) what are the problems in implementing the NWPA and their root causes, (ii) what do you think is going to happen over the next year, and (iii) what do you think should happen?) Experienced negotiators say that an understanding of stakeholders' interests is necessary in order to negotiate and to resolve disputes effectively. We are examining the utility of our framework as a way of helping stakeholders to communicate more effectively with each other. In other words, is it worthwhile to understand each other's value principles; will it help stakeholders to reach consensus; or will it just help them to argue more effectively? We believe that the taxonomy of procedural, distributional, and evidential issues and the specification of stakeholders' views in terms of underlying general principles provides at a minimum useful insight.

An Example: Background on the MRS

One of the most important issues resolved by the NWPA was the role of a permanent geologic repository versus that of long-term interim storage for high-level waste and spent fuel. As determined by Congress, the overarching purpose of the act was to establish a schedule for the siting, construction and operation of repositories that would provide reasonable assurance that the public and environment would be reasonably protected from the hazards posed by nuclear waste. The act set a deadline of January 1, 1998, for initial operation of the first geologic repository. The emphasis on a repository was opposed by some influential Congressmen, who favored instead developing long-term monitored storage in engineered facilities above or near the surface; and this type of facility became known as an MRS, which stands for Monitored Retrievable Storage.

The proponents of the MRS argued that there was no need to rush into developing a repository, that we knew how to build an MRS and would be confident in its performance and our ability to take corrective action in the event of any problems, and that the MRS would allow time for new technological developments on permanent waste disposal and allow for the possibility of future reprocessing. Some of the MRS champions were Senators from states that were under active consideration for a repository. The repository proponents argued that the U.S. should find a permanent solution to isolating radioactive waste and not leave the problem to future generations, and that demonstrating a permanent disposal solution to the public was necessary to remove a dark cloud obscuring the future of nuclear power.

The repository faction prevailed in the NWPA, but MRS proponents got a section in the act requiring DOE to study the need for and feasibility of an MRS and to provide specific designs, cost estimates and three alternative sites for Congressional consideration. The act also gave the potential host state certain rights of consultation with the Department of Energy, and the right to issue a notice of disapproval for the facility that could be overridden only by Congress.

In April 1985, the DOE produced a draft version of its study on the need for and feasibility of the MRS. The agency, however, proposed a facility that had significant differences from the MRS in the NWPA. The proposed MRS would be an integral part of the waste management system. Spent fuel would be shipped from eastern reactors to the MRS for re-packaging and temporary storage, and then shipped to the repository in the west. The MRS was no longer a back-up or alternative to the repository. DOE proposed three sites, all in Tennessee, with the favored site near Oak Ridge.

The DOE argued that the MRS was not absolutely necessary, but that it provided significant advantages: improvements in system development (implementing early a major part of the waste management system independent of uncertainties surrounding the repository); accelerated waste acceptance from utilities (reducing the need for added storage capacity at reactors); improvements in the transportation system (reducing the number of cross-country shipments); and institutional benefits (demonstrating that DOE could work constructively with potential host states). In order to alleviate concerns that the MRS might become a "de facto" permanent facility, DOE also proposed a cap of 15,000 metric tons of storage at the MRS, and later proposed that the MRS would not accept spent fuel until the repository received a construction license from the Nuclear Regulatory Commission (NRC).

The DOE provided $1.4 million to Tennessee for the state to conduct its own independent evaluation of the MRS. Part of these funds went to the affected local communities for their evaluations. The city of Oak Ridge and Roane County set up the Clinch River Task Force, which produced a report stating that the MRS could be safely built and operated and that the community would accept it provided certain conditions were met. The conditions included: a citizen review board that could suspend operations in certain situations; a limit on spent fuel received at the MRS before NRC construction authorization for the repository; payments equal to (and in lieu of) taxes beginning with Congressional authorization of the MRS; purchase of research, development, goods, and services from the community and state to the fullest extent possible; and clean-up of the environmental problems at the Oak Ridge reservation prior to MRS operations. DOE addressed many of these conditions in its revised proposal.

The Governor's Safe Growth Team sponsored studies of the economic impacts of the MRS and the need for, feasibility of, and siting of the MRS. The "need and feasibility" study compared waste management systems with and without the MRS and concluded that the system with the MRS was about $2 billion more expensive and did not reduce transportation impacts over the no-MRS system provided that certain transportation improvements were made. The risks of either system were estimated to be low and comparable. The study also concluded that the preference of one system over another was a judgment about which reasonable people could disagree. Concerning siting, the study concluded that a major reason for DOE's preference for the Oak Ridge site was that the community would be favorably inclined. The economic impacts study concluded that the negative perceptions about the MRS would affect industrial location decisions and tourism in the region. The state also conducted a number of public meetings to solicit citizen views, which were largely negative except for the Oak Ridge community.

The state's actions also included a law suit asserting that the NWPA required that DOE consult with the state before selecting specific MRS sites. DOE claimed that the state's consultation right and authority to issue a "notice of disapproval" apply only after the MRS is authorized by Congress. The lower court agreed with the state and issued an injunction preventing the agency from delivering its MRS proposal to Congress. Subsequently, the Appeals

Court reversed the lower court ruling, but left the injunction in place while the state appeals to the Supreme Court.

In January 1986, the Governor announced his decision to oppose the MRS. He concluded that nuclear waste is Tennessee's problem, too; that the MRS can be operated safely, but that it is unnecessary and therefore a waste of money. Moreover, he concluded that Oak Ridge is exactly the wrong place for it because he felt that it would turn away many more jobs than it could ever attract. The MRS would, he felt, create a negative image for the Oak Ridge-Knoxville corridor, which otherwise has a bright future for attracting high technology companies. Interestingly, he commented that a site in a poor county, such as Morgan County (which is not far from Oak Ridge), might have been more acceptable because there were no jobs to turn away. (Some citizens of Morgan County have subsequently lobbied for siting the MRS there, finding it acceptable provided DOE meets the same conditions set by Oak Ridge and eliminates the county's current indebtedness.)

Because of the injunction and subsequent appeal, the MRS issue is on hold. While a new governor has taken office, it is unlikely that he or the Congressional delegation will be anything but publicly hostile to MRS, reflecting state-wide public opinion. After the legal issues are resolved, the issue will be taken up by Congress. Whether or not Congress will conclude that the MRS is sufficiently needed to take the step of overriding the state's objections is completely unknown at present, but it is clear that the MRS is a high priority for DOE. The MRS issue illustrates many features found in other cases of attempted siting of "unwanted" facilities. Having a local community favor the facility because of perceived economic benefits is not uncommon, but the more frequent situation is for the local community as well as the state to oppose the facility.

Value Concerns and the MRS

As an illustration of our general approach, let us examine some of the value concerns with the MRS. Our study separates the MRS issue into several sub-issues: need, choice of technology, safety, site selection, impacts/compensation, and the federal/state/local consultation process. Each sub-issue has evidential, procedural, and distributional aspects. (The separation into sub-issues and categories of value concerns is not always clear-cut; at times there are overlaps.)

Let us examine the sub-issue of impacts/compensation. The value concerns here are largely distributional, as one might expect, but there are procedural and evidential concerns as well. For the governor of Tennessee, the "stigma" effects associated with the MRS appeared to carry great weight in his decision to oppose the MRS. In other words, he felt that negative perceptions about the MRS could produce real economic (and political) impacts -- by scaring away jobs and tourists -- and that these impacts could not be easily offset. His concern was clearly a distributional one, but evidential concerns were linked as well. (A relevant UGP might be "one should not have to accept a burden for others if adequate compensation for the burden is unavailable and alternative solutions to the problem are possible," which combines concerns about fairness of outcomes with concerns about DOE's evidence on the issue of need for the MRS.)

The nuclear industry and DOE believe that there would be no negative economic effect on a region hosting the MRS; they dispute the evidence upon which the governor's conclusion was based. The conclusion of a "stigma" effect was based in part on inferences from polling -- by believing that tourists and business executives would act as they said in a poll. The resulting deadlock over what evidence to take into consideration regarding the "stigma" effect is one of the value conflicts at the core of the MRS dispute.

Even if socioeconomic impacts could be agreed upon, there are procedural concerns with how compensation should be determined, i.e., who negotiates with whom and who ultimately decides. The Oak Ridge community felt that the MRS would bring tangible economic benefits provided that the federal government accepted the conditions laid down by the community. DOE was willing to meet some, but not all of the conditions. The state was unwilling to talk about compensation since it could have created the impression that the state was willing to negotiate.

Some citizens in Oak Ridge also believed that their community, having benefited in the past from the nuclear enterprise, should be part of the solution to the waste management problem. (A UGP might be "one who benefits from an enterprise has a duty to take the lead in solving its problems.") Some environmentalists argued that the MRS imposed risks on current and future generations that are inherently uncompensable (suggesting a UGP like "some things are not for sale") They felt that citizens who did not cause the problem, such as those who live near the proposed site, should not have to accept the risks. They also opposed the MRS because they thought that it would delay the repository indefinitely, and future generations should not have to solve our waste legacy. Moreover, some environmentalists believed that the nuclear industry and utilities were primarily responsible for the nuclear waste problem; and, therefore, utilities should have to take care of the storage problem until a permanent repository is ready.

One ironic twist was that some utilities and some environmental groups appear to use the same UGP for the distributional issue: "the entity responsible for a problem should bear the burden and cost of solving it." In the case of spent fuel management, the culprit for the utilities is the federal government, which they feel has procrastinated and botched finding a permanent solution. The federal government should, therefore, take spent fuel expeditiously from utilities, i.e., DOE has a moral commitment to begin accepting spent fuel from utilities by 1998, the date set in the act for the opening of the repository. (The legal requirement, however, is to take spent fuel from utilities when the repository is ready.)

Another distributional concern is regional equity, as represented in the NWPA by the plans for the first repository in the west and the second repository in the east. Some observers feel that having an MRS in the east satisfies concerns about regional equity, thereby alleviating the urgency for siting a second repository. Several senators in the west and in Tennessee obviously disagree with this interpretation of equity. Many environmentalists believe that storage at power plants is fairer from a distributional point of view than at a centralized MRS. (Of course, the UGP "everyone should be responsible for their own waste" becomes impractical if decentralization is carried to the extreme, but fairness is another root issue in the MRS siting dispute.")

The issue of federal/state/local consultation embodies a number of strongly held value concerns, primarily procedural ones, as the lawsuit brought by the state makes evident. An interesting procedural concern is a condition laid down by Oak Ridge for taking the MRS. Oak Ridge wanted DOE to allow them to set up a local oversight group with the power to shut down the facility if it were not being operated properly. Several public surveys have found that, in trying to site unwanted facilities, the local community may be more interested in a considerable degree of local control than in purely economic incentives.

Some of the other value issues with siting are evidential. Because the MRS is an engineered facility that can go almost anywhere, the State of Tennessee charged that DOE's selection of three sites in the state was politically motivated and not based on an objective siting methodology. DOE concluded that Oak Ridge was technically acceptable and that it was not unreasonable to include potential community acceptance in the siting decision.

Overall in the case of the MRS, the most important issue for determining a stakeholder's position appears to be either determination of need, primarily an evidential concern, or impacts/compensation, primarily a distributional concern. At the national level, determination of need appears to be the most important issue. DOE perceives that the MRS would demonstrate progress on solving the vexing nuclear waste problem and would allow DOE more control over the system. Utilities who favor the MRS see it as providing a potential backup for spent fuel acceptance, ensuring that the federal government can meet its moral commitment to take spent fuel in 1998. Utilities who quietly oppose the MRS think that the MRS is unnecessary and too costly, and that DOE is likely to fail to get the MRS authorized because of political opposition. These utilities conclude that they individually will have to solve the storage problem until a repository is ready.

At the state and local level, distributional impacts appear to be crucial. The state perceives that the MRS would cause real economic costs to the region and real political cost to elected officials. (The latter issue is not directly mentioned, but is obviously important.) Compensation for these economic and political costs could not be easily arranged. The perceived economic benefits were key for the Oak Ridge community, but not sufficient by themselves without safeguards such as local oversight. On the same issue of need, the state concluded that storage at reactors was cheaper and viable, making the MRS unnecessary. The Oak Ridge community countered this by stating that the issue of need should be a concern of Congress and not be a concern of either the community or the state.

An interesting feature of the MRS case is that the governor and the Oak Ridge community, as well as the federal government, concluded that the risks were small if the facility and transportation were operated with sufficient care. There was discussion of evidential questions concerning risks of transport (e.g., cask tests) and operation (e.g., relevance of DOE history to promises of future management performance). However, neither the governor nor most Oak Ridge citizens were swayed by environmentalists' claims about risks. In other cases of environmental risk management, including possibly the high-level waste repository and low-level waste disposal, this degree of consensus on acceptable risk may not exist.

Repository Evidential Issues

Evidential issues connected with repository siting are as contentious as with the MRS, but considerably more complex. For example, mathematical models will be used to assess the performance of a geologic repository in terms of estimatead radioactive releases over thousands of years. Models will also be used to assess the performance of certain man-made barriers such as the waste canister. In the licensing hearings there will likely be major disputes over the validity of models and the magnitude of the uncertainties. It is also quite likely that the public in the potential host state, for its acquiesence, will demand that DOE prove that DOE's favored site is the best site in the country, a very demanding burden of proof. As a newspaper in Utah stated in 1981,

> "Neither Utah nor any other state can properly refuse to bear the nuclear waste burden once it has been established to the best of human conditions. However, the honor of making such sacrifice for time without end must confer on the luckless lamb the satisfaction of knowing firsthand that the duty couldn't have been just as well assigned elsewhere. If Utah's veto stew accomplishes that much it will not have been cooked up in vain."

DOE believes that finding an acceptable site is sufficient for receiving an NRC license, and that finding the "best" site is an impossible standard in practice (i.e., the "best" is the enemy of "good").

Evidential issues are already the cause of several lawsuits between the potential host repository states and DOE, concerning the guidelines for selecting sites for characterization, and EPA, concerning its generally applicable standards for high-level waste repositories (one state spokesman claimed that DOE's guidelines would not even exclude Disneyworld). In addition, the methodology used by DOE to select three out of five sites for characterization has come under intense scrutiny. DOE's draft methodology was severly criticized by the Board on Radioactive Waste Management of the National Academy of Sciences (calling it "unsatisfactory, inadequate, undocumented, and biased"). For credibility, DOE opted to revise its methodology and to submit it to NAS review. DOE used what is probably the most extensive application ever of a decision-aiding tool called multiattribute utility analysis. The NAS eventually gave DOE a better grade on its methodology, but the DOE's application of the methodology (particularly in DOE's selection of the fifth-ranked site Hanford) and the credibility of the NAS board have been challenged by the states.

These examples illustrate that much of the public debate over the repository will concern evidential issues, but the distributional issues, as with the MRS, will remain a key consideration for states and local communities. Moreover, the three types of value concerns -- procedural, distributional, and evidential -- may be linked in proposals for resolving the deadlock that exists among stakeholders. For example, Governor Gardner of Washington made a statesmanlike remark in commenting that he would support the repository at Hanford if it can be shown that the site is technically acceptable and the best of the sites under consideration. (Perhaps he is confident that Hanford will not meet this standard.) In his proposal, the evidential and distributional concerns are clearly linked. Moreover, he simultaneously offered a procedural approach -- a national mediation effort -- to end the present stalemate.

Styles of Argument on Evidential Issues

The NWPA has been beset from its inception by charges that decisions concerning the location, technical characteristics, and expected performance of the candidate repository sites have been made on an unduly political rather than a sound technical basis. Utility, federal, state, local, and environmentalist/citizen stakeholders accuse one another of advancing positions that have poor scientific justification, and by large seem to talk past one another in evaluating the repository program.

One of the reasons for this impasse concerning whose or which scientific claims deserve the most credence appears to be found, in part, in the underlying, often conflicting views about science and scientific method held by the various parties, and in the different styles of argument on technical questions favored by the several stakeholders.

These differences of opinion within the scientific community and between scientists and non-scientists frequently appear in three seemingly preeminently technical areas: repository performance (what are the likely long and short-term risks to humans and to the environment, for the relevant hydrogeologic settings, waste package designs, etc.?); repository location (which potential sites offer the best combinations of geology, hydrology, and other criteria?); and repository need (how good are the technical arguments, given in terms of cost, spent-fuel projections, transportation factors, other storage alternatives, etc., for building the first and/or second repositories and MRS to begin with?)

In all three areas, when one looks at the positions of the stakeholders, and the replies of each stakeholder to the positions of the others, the specific points at issue fall into four categories, involving:

(1) Scientific theories and mathematical models of physical phenomena. For example, how reliable are the specific theories and computer codes used to model the relevant complex radiolytic chemical corrosion and macro and micro-hydrological/geological processes affecting radionuclide releases? How sure are we that all significant factors have been included in the theory or model? Do long-term predictions involve special uncertainties? Have alternative theories and models been fairly and adequately considered? How "full- dress" and how long an empirical test program is needed to answer these questions?

(2) Analytical tools and methodologies. For example, how trustworthy are the results of the various probabilistic risk assessments, systems engineering studies, multi-attribute utility analyses, and statistical tools used in screening potential sites and estimating total system risks? Are any problems ones of correct application of the methods, or are there questions of their soundness in principle?

(3) Regulatory standards. For example, should radiation exposure limits be set with respect to background radiation, prevailing risks of modern life, exposures that would occur otherwise (had the uranium generating the nuclear power never been mined, or had coal plants been used to provide the same amount of power)? Should standards be set for individual and population exposures, for annual and lifetime exposures, for exposures from the total system and its components? How should high-level waste be defined? What period of time should leak standards be based upon?

(4) Human factors. For example, what assurances do psychology, human reliability studies, and industry experience provide concerning the effects of human actions, broadly taken to include deliberate or accidental intrusion into the repository, repository employee errors and problem-solving, management laxness in quality control, monitoring, and employee training functions?

Each stakeholder group also appears to have predominant argument styles, which can be gleaned from stakeholder literature, interviews, and workshops. Four styles have been identified:

(A) Some stakeholders prefer to make their cases (be it for or against the claims and decisions of the repository program) primarily in terms of substantive scientific points directly involved in each particular case. Examples: "the lab tests of waste package corrosion were conducted in an unrealistically high-oxygen environment," "increasing the temperature is a legitimate way to simulate long-term behavior of the waste package," "the environmental studies failed to discover readily available historical reports of earthquakes in the area," "the WAPPA and REPRISK models of waste package behavior and radionuclide migration contain the following simplifications," "the plate-tectonics theory is established beyond reasonable doubt," "the report does consider all credible regimes of behavior for the bentonite overpack," etc. We refer to this as the topical argument style.

(B) A second, or "procedural" argument style, while still focusing on the particular repository-related technical claims under discussion, emphasizes questions of scientific procedure. Examples: "the state did not have enough time to conduct an adequate peer review," "this study was never peer reviewed," "the peer reviewers were biased or improperly chosen," "alternative, less orthodox scientific theories of the phenomena in question were not given a fair hearing, or were denied research funds," "the PRA is too complex to check out in a reasonable period of time," "the data was based on poor controls and inadmissible statistical procedures," etc.

(C) A third, or "analogical," style relies on substantial empirical evidence concerning the track record (both successes and failures) of science and engineering in dealing with similar problems in other areas (including non-NWPA high-level waste programs, low-level wastes, nuclear power, chemical wastes, and even strikingly unrelated fields of science and technology). Examples: "the geohydrological model used for WIPP, as is now recognized, failed to take account of the karst geology, so how can we believe DOE's claim that, say, the Richton Dome modeling is valid," "the consultant made a major error in its ranking of sites for the Southeast low-level radwaste compact, so why should we trust the current high-level rankings prepared by another consultant," "why should we rely on current claims regarding source terms, environmental migration and dispersion, etc., in light of the unexpected plume skipping at Chernobyl, unexpected failure of soils to bind certain radionuclides, unexpected recent discoveries in source term chemistry, etc.," "they were wrong about the Shuttle, about continental drift, and could be wrong about repositories, too," "the experience of the aircraft industry shows that an excellent quality assurance program can be maintained over decades," "the NAS has flipflopped four times in its successive reports on chlorofluorocarbons in the atmosphere, yet each time the conclusions were presented with the same confidence DOE exhibits on the repositories," "people poohpoohed the scientific problems in landing on the moon, but the

program succeeded in spite of the skeptics." In other words, this argument style concentrates not upon the direct scientific evidence per se, but on evidence concerning the success rate and time frames with which technically similar (and dissimilar) scientific fields handle evidence, and theory.

(D) A final, "philosophical," argument style appeals to general theoretical and procedural arguments that do not depend on the particulars of the repository scientific claim at issue. Examples: "even though this report was peer reviewed, this is not enough, because peer review itself is open to several challenges (e.g., because consensus in science often is the result not of conclusive evidence but of sociological bandwagon effects)," "studies of expert opinion and risk estimation show that experts often place unwarrantedly high confidence in their claims, overestimating the supporting evidence and underestimating the possibility of surprises," "science is an error-correcting enterprise, but the time frame for recognizing and correcting mistakes is much longer than of the NWPA," "whatever its flaws, reliance on scientific experts is the best guarantee of truth humans have," "sure it's only a theory, but this is no weakness -- a good, powerful theory is the very goal of each field of science," etc.

Roughly speaking, each major stakeholder group -- DOE, NRC, EPA, the states, Indian tribes, city officials, Senators and Congressmen, local residents' groups, local and national environmental groups, and utilities -- exhibits a characteristic argument style (although the favored style may shift, depending on whether the stakeholder is evaluating repository performance, location, or need.) All four styles are used by both supporters and critics of the repository program. Furthermore, each argument style can garner strong empirical and theoretical arguments in its favor; none of the styles is irrational or "anti-science." Indeed, implicit in each stakeholder's position, and mode of justification for that position, is a philosophy of science -- i.e., one of several possible theories one may plausibly advance concerning the nature of scientific truth, scientific method, and scientific institutions, both ideally and in practice. With isolated exceptions, stakeholders can defend their case on the technical aspects of repository performance, location, and need with empirical and theoretical arguments that are rational and plausible (if never decisively compelling) in light of its tacit philosophy of science.

In particular, two views of the nature of science appear to underly the stakeholders' stands on evidential matters. One view assumes that, typically and on the whole, at least in the frontier areas relevant to geologic disposal: (a) science produces answers and reduces uncertainties, (b) consensus is normal and desirable in science, (c) peer review and other self-regulatory mechanisms are adequate, (d) science is mainly driven by evidence (facts, data), which can clearly be distinguished from theories, and (e) scientific knowledge is established on a relatively fast time scale (e.g., fast enough to demonstrate, in time for the final repository to open on schedule, "reasonable assurance" that it will meet the regulatory criteria).

The second view of science holds that: (a) scientific research generates as many questions as answers (so that we should expect significant surprises in the repository testing and research program), (b) pluralism of theories, research programs, and methods is normal and desirable in good science (so that consensus may be a sign of hasty thinking or bandwagon effects) (c) peer review is too prone to political manipulation and scientific orthodoxy, (d) science is primarily driven by theory and assumptions, which also affect the selections, nature, and interpretation of evidence, and (e) science proceeds more slowly than the repository program appears to assume.

In this way the differences of opinion on scientific aspects of the high-level radioactive waste repository program can be traced to different underlying ideas about science and scientific method and to different styles of argument. These ideas and styles appear to affect one's views as to: what claims (or scientists) are technically credible; the likelihood that "independent" review panels will agree with those associated with the federal government; the identification and significance of scientific and engineering uncertainties; and the time needed to resolve these uncertainties. This occurs in all four of the repository evidential issue areas mentioned earlier (theories, analytical tools, regulations, and human factors). Indeed, the controversies over repository evidential issues reveal a great deal of confusion as to the meaning of phrases like "technically credible," "resolve uncertainties," "verify or validate a theory or model," "technically sound," "technically flawed," "reasonable assurance," etc. This confusion appears to reflect a further confusion as to the relative roles of "objective" and "judgmental or evaluational" factors in science.

There are several practical suggestions for improving the quality of the discussions among stakeholder groups on evidential issues. One is for each stakeholder to strive to discover and to understand its own underlying argument styles and assumptions about science (and about the role of science in a democratic society). This is actually much easier than it may seem; each style of argument can be successfully characterized by means of a familiar, vivid catch phrase or image. Another suggestion is for each stakeholder to realize that it sometimes appeals simultaneously to inconsistent assumptions on the same issue, and that it sometimes appeals to one assumption on one issue and to conflicting assumptions on other issues. In general, every stakeholder's position is less substantial than it seems to the stakeholder advancing it, and more substantial than it seems to the stakeholders opposing it. A third suggestion is to incorporate the first two suggestions in actual negotiation and conflict resolution situations (consultation and cooperation programs, multiattribute decision panels, etc.). This may prove quite helpful in reducing the amount (and volume) of cross-purposes talk on repository scientific questions.

Differing World Views of Stakeholders

It is possible to characterize some of the fundamental elements of each stakeholder's "world view" as a way of understanding why the various stakeholders have such diverse positions on RWM issues. By this we mean that the stakeholders not only disagree over numerous technical and scientific theories and procedures, they also differ as to what the basic problem is in each case. With such a differing starting point, it is no wonder that the various solutions put forward vary widely.

It is at this point that many technical and scientific people find themselves becoming increasingly frustrated, as they are barraged by what appears to them as a host of non-scientific objections. Of course, from the layperson's point of view, there is a similar frustration as engineers and technicians

stubbornly discuss profound value issues in narrowly technical terms.

This study has found that beneath the disputes over distributional, procedural, and evidential issues, there are relatively durable points of view which tend to be held by the various stakeholders. We call these their "world views" and will briefly profile several examples.

First: Time Frame

National officials - typically short: two to four years (i.e, the next election). Occasionally they are aware of making decisions whose effects will reach far into the future.

State and local officials - typically very short (i.e., the next few months, or until the next election, the next meeting of the state legislature, etc.).

Indian nations - typically very long term: the past 10,000 years and the next 10,000 years.

Business community - typically short (i.e., five years; reinforced by current tax laws, business theory, etc.) On the other hand, "growth" as a principle of management is a commitment to medium range thinking.

Utilities - typically middle range (i.e., the next five to forty years, dictated by plant-life expectancy, longevity of existing hardware, etc.)

Environmentalists - typically very long-term (i.e., the next 50 to 1,000 years, using the extremely long time-frames of geology and botany).

Result: the differing time frame causes each stakeholder to go at each of the major RWM proposals differently; to ask different kinds of questions, to value different kinds of benefits, and to be wary of different kinds of costs.

Second: Primary Obligation

National officials - a balance between concerns for home constituency and the welfare of the whole country.

Indian nations - primary obligation to Earth and Sky as ultimate religous realities; to humans as part of the Biosphere.

State and local officials - more focused on the welfare of the state or local community.

Business community - each business is primarily obligated to itself and its survival; profit is the "bottom line."

Utilities - typically obligated to promote the welfare of the utility company and rate-paying area.

Environmentalists - typically feel primary obligation for welfare of humans within the wider natural habitat, including all other life forms, from the distant past into the far distant future. This leads them to be concerned for consequences over extremely long-range and wide-spread scope.

Third: View of Science, Technology, and Society (STS)

National officials - tend to see STS as mutually interactive and reinforcing, aware of stresses and strains, but basically optimistic regarding technology's role in American society.

Indian nations - profoundly distrustful of science and technology of industrial society.

State and local officials - typically same as national officials, except when ultra-large scale technologies cause severe social trauma in their area (e.g., Bohpal), then more likely to be critical of "modern industrial technology"

Business community - typically optimistic about the interaction of technology and society, science viewed as a having flaws but still bright hope of the future.

Utilities - tend to be optimistic about technology, yet also tend to be caught in ten to fifty-year time lag, until older technology wears out and can economically be replaced by new. The RWM problems present utilities with a whole series of extremely difficult choices, given the widely varying reactor designs and multitude of NRC regulations concerning them, but the most serious problem of all remains one of acquiring a "mind set" appropriate to nuclear technology.

Environmentalists - tend to be very pessimistic regarding the relationship between highly centralized "big science" and society. They tend to emphasize one-sidedly the list of catastrophies arising from incompetent, poorly planned and irresponsible use of modern technology.

Fourth: Fair Distribution of Benefits/Liabilities

National officials - tend to seek ways of distributing benefits and liabilities of RWM across states and groups. Perceived fairness is understood to be crucial in the long-term solution to RWM proposals.

Indian nations - tend to view no compensation as adequate to offset the injuries and insults already perpetrated against the sacred space they inhabit. Any discussion is always conducted under protest.

State and local officials - tend to find ways to maximize local benefits and minimize local liabilities, at the expense of neighboring states/cities.

Business community - tends to view benefits and liabilities in mechanical, that is purely monetary, profit/loss categories, within an organization-centered perspective.

Utilities - tend to approach the question of fair distribution of benefits and liabilities with a double standard: the benefits are distributed to the rate-payers in the immediate present (in the form of electricity, gas, etc.), while the liabilities tend to be loaded onto future generations in the form of long-term debt, waste management schemes, etc.

Environmentalists - tend to down-play the present realization of benefits, and emphasize all kinds of liabilities both in the present and into the long-term future. Against this sort of moral calculus, the technology in question (whatever it may be) always appears to be a bad bargain, with the result that environmentalists tend to give the impression that they are opposed to all modern industrial technology.

These and other fundamental elements of the world views of the major stakeholders such as their attitude toward nature, concept of the highest good, preferred

approach to social problems, and so on, comprise the deep-structure differences that cause so much disagreement about each of the RWM issues. It is clear that these fundamental elements, moreover, are appropriate to each stakeholder, that is, essential to each stakeholder's essential concerns and necessary to accomplish its unique endeavors. Hence it is futile to think of any of them simply abandoning these diverse world views.

In the face of these profound differences in world views, there is no logical or quantifiable mechanism that will automatically bridge the gaps between them. The best way to cope with this situation, given our nation's commitment to democratic processes, is to adhere to full and frank negotiation, respecting the needs and interests of all of the legally constituted stakeholders. After all, it is not necessary that we must all agree with one another's values, we only need to agree on a particular solution and try to understand each other's values. And agreement on particular solutions will occur if and only if each stakeholder is persuaded that most of its concerns and interests and values will be accommodated. That will only begin to happen if and when various stakeholders decide they want to cooperate.

How long will it take for cooperation to "break out" in the current context of confusion, suspicion, and resentment among stakeholders? An optimistic model for predicting cooperation is game theory built upon the Iterated Prisoner's Paradox, recently set forth by Robert Axelrod in The Evolution of Cooperation. This theory states that, in a context of long-term interaction by parties pursuing their own self-group interest and in the absence of any central control, an initial period of backstabbing/cooperation will lead eventually to long-term, stable cooperation. The central interaction is very simple: "Tit-for-Tat." You do back to your opponent what he just did to you. If he attacked, you attack. If he cooperated, you cooperate. As simple as that. This approach is elegant in its simplicity: a clear, recognizable strategy that is robust and long lasting. If only five percent of a field of players are using this rule, eventually it will dominate the whole field. It will even work in micro-organisms having very short memory, low intelligence, and no foresight, which may have some bearing on the RWM problem.

Conclusion

While our research project examining ethical and value issues in radioactive waste management is not complete, we believe that the taxonomy of procedural, evidential, and distributional issues and the specification of stakeholders' views in terms of underlying general principles provides useful insight. We hope that our framework will also help stakeholders to communicate more effectively with each other and contribute to the eventual resolution of this important sociotechnical problem.