# PROFILE

# Multiattribute Utility Analysis as a Framework for Public Participation in Siting a Hazardous Waste Management Facility

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ABSTRACT / In an attempt to facilitate the resolution of contentious environmental problems, public and private organizations are experimenting with collaborative approaches wherein stakeholders participate in the decision-making process. A dilemma for the design of collaborative approaches is the technical complexity of many environmental problems. How can members of the public play a meaningful role in decisions that involve complicated scientific arguments?

This paper describes a public participation exercise in which stakeholders used an approach based on multiattribute utility analysis to select a site for a hazardous waste management facility. The key to success was the ability to separate and address two types of judgments inherent in environmental decisions—technical judgments regarding the likely consequences of alternative choices and value judgments regarding the importance or seriousness of those consequences. The approach enabled technical specialists to communicate the essential technical considerations and allowed stakeholders to establish the value judgments for the decision. Although rarely used in public participation, the multiattribute utility approach appears to provide a useful framework for the collaborative resolution of complex environmental decision problems.

This paper briefly reviews public participation and describes an application based on multiattribute utility analysis (MUA). The approach was used by Sandia National Laboratories (SNL) to involve stakeholders in an important technical decision associated with its environmental restoration (ER) project. SNL is located on Kirtland Air Force Base, immediately south of Albuquerque, New Mexico, USA. The decision was where on the base to locate a corrective action management unit (CAMU), a facility intended to consolidate and store wastes generated by the cleanup of hazardous waste sites. Although rarely applied with stakeholder participation, MUA proved surprisingly effective. It helped reverse initial hostility toward the CAMU, produced consensus over a selected site, and enhanced public trust and understanding of Sandia's ER activities.

KEY WORDS: Multiattribute utility analysis; Public involvement; Collaboration; Dispute resolution; Environmental management

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## Public Participation

Public participation describes the process by which parties affected by or interested in a decision play some role in decision making. Possible roles range from providing decision makers with information and comments to participating in a collaborative process whereby interested parties attempt to reach consensus over a course of action (Selin and Chavez 1995). Two recent government reports emphasize the importance of public participation for successful risk management (CRARM 1996; NRC 1996). In theory, public participation can reduce the time delays and costs associated with controversial decisions, maintain and improve organizational credibility and support, and produce decisions that are more responsive to public preferences and concerns (EEI 1984).

Collaborative approaches, which empower stakeholders to take collective responsibility for decisions, have been advocated for situations where failure to obtain stakeholder acceptance would prevent the successful implementation of the decision (Thomas 1995). Hazardous facility siting, often derailed by public opposition, is a prime candidate for collaborative approaches. Regula-


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tory changes have provided enhanced opportunities, resources, and access points for parties opposed to the siting of hazardous facilities (Regens 1983). Opposition to siting has been attributed to not-in-my-backyard (NIMBY) syndrome, and the general decline of trust in public and private sector institutions (Portney 1991). Research on risk perception suggests that the public frequently attributes greater risks to hazardous facilities than do technical experts (Covello 1983). Frech (1991) observes that even the strategy of choosing sites at existing hazardous waste facilities does not always work.

### Public Participation Methods

Table 1 lists methods for facilitating public participation. The methods are grouped into those for getting information to the public, obtaining information from the public, and exchanging information; public meeting methods; survey methods; and decision-making methods.

Current literature provides relatively little discussion of analytic methods for supporting the key step of decision making. The most widely used analytic methods appear to be the Delphi technique and the nominal group technique. Delphi is a method of using questionnaires to obtain and share opinions in such a way as to minimize dysfunctional effects of group dynamics (e.g., domination by a strong personality). It is most often used to obtain experts' opinions. The nominal group technique is a structured process for generating and ranking ideas. A facilitator attempts to minimize argument and criticism that would otherwise limit creativity. Participants identify and individually rank ideas. The ideas receiving the highest rankings averaged across individuals are identified and discussed.

### Limitations of Current Approaches

Public participation is often resisted by organizations involved in hazardous facility siting. Environmental professionals are reluctant to share decision-making responsibility with individuals who lack understanding of key technical considerations. Other frequently expressed concerns are that participants want to focus not on site selection but on whether the facility is needed, that people are unable or unwilling to balance environmental and economic considerations, and that the process inevitably leads to disappointment because of the impossibility of achieving universal happiness with the outcome (Ducsik 1986). Experience confirms that public participation is not a panacea. Guenette (1992) complains that institutionalized participation opens the door "to endless public debate." Frech (1991) notes that "even the best-planned and executed communication programs are often unsuccessful in helping to achieve public acceptance." Thomas (1995) argues that the most serious complaint about a collaborative approach is the distortions it can introduce to public decisions. A review by Wiedemann and Femers (1993) concludes that public participation often backfires, that participation procedures themselves create new conflicts. The fault, they argue, is viewing public participation as the goal, rather than the means—the appropriate goal being to improve the quality of decisions. Decision quality involves both the process by which the decision is reached and the quality of the choice that is made.

### Multiattribute Utility Analysis

Multiattribute utility analysis (MUA) is an analytic approach for making logical decisions when there are multiple objectives (Keeney and Raiffa 1976). Numerous technical requirements must be satisfied to properly apply MUA (Keeney 1980). However, in its simplest form, the basic steps are: (1) identify decision objectives, (2) establish attributes and rating scales for measuring the degree to which options achieve objectives, (3) assess weights and other value judgments specifying the relative importance of achieving the objectives, and (4) combine weights and ratings to obtain an overall measure of the desirability of each option. MUA is deceptively similar to the more common approach of rating alternatives against criteria and then weighting and adding the results. However, unlike rate-and-weight techniques, which have been shown to produce ambiguous and unreliable results (Hobbs 1979), MUA includes procedures to ensure that results are logically sound.

MUA has been applied to siting decisions with favorable peer review (e.g., Merkhofer and Keeney 1987). However, MUA is not widely known outside the decision science community and has only rarely been used as a means for involving the public and other stakeholders in public-policy decisions (Marttunen and Hamalainen 1995, Lathrop and Schiff 1992). Major limitations have been the time and costs required to use MUA. Recently, tools, techniques, and software for facilitating the implementation of MUA have been developed by a team of representatives from SNL, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory as part of a formal priority setting-process known as the laboratory integration and prioritization system (LIPS) (Anderson and others 1994). These advances have increased the potential for applying MUA with public participation.

Table 1. Public participation methods[a]

| | Method | Description / primary purpose |
|---|---|---|
| Getting information to the public | Advertisement | Allows organization to control message content and reach large audience. Usually used to describe projects, announce meetings, etc. |
| | Bill stuffer | Economical means for notifying service users of specific events or ongoing programs. |
| | Briefing book | Describes project roles and key project facts. Often used to help internal staff respond to questions. |
| | Brochure | Provides large amounts of information at relatively low cost. Good format for pictures and other graphics. |
| | Contest / event | Stimulates interest in a topic and creates publicity. Often used as prelude to meetings / workshops. |
| | Door hanger | Provides information to a high fraction of residents in a limited geographic area. |
| | Exhibit / display | Conveys information through imagery. Usually set up in highly visible locations—e.g., libraries, malls, city hall. |
| | Fact sheet | Handouts for public meetings, open houses, and other events. |
| | Field office | Located in a highly visible part of the community and staffed with people able to answer questions. |
| | Focus group | Market research technique. Facilitator guides in-depth exploration of opinions of small group. |
| | Information ''hot'' line | Single telephone number that people can call to ask questions or make comments. |
| | Information repository | Provides comprehensive materials pertaining to a project. The level of detail ranges from fact sheets to research reports. |
| | Legal notice | Used to comply with legal requirements for public notification. |
| | Newsletter | Provides information over time. Typically used to inform stakeholders about project status and upcoming events. |
| | Newspaper insert | Targets information to selected geographic areas. Often includes response forms to solicit public comment. |
| | News release | Written, video, or audio statements of newsworthy information provided for news media by senior figure or spokesperson. |
| | Panel | Collection of experts or leaders who interact in front of an audience. Often used to stimulate interest at meetings. |
| | Public service announcement | Short announcements provided by radio and television stations as condition of keeping their licenses. Can be used to obtain free publicity. |
| | Radio talk show | Interactive format for conveying answers to commonly asked questions. |
| | Storefront, trailer, or street kiosk | Provides highly visible means for sharing project information. |
| | Training program | Educates participants on complex topics. |
| Getting information from the public | Interactive polling | Involves voting on a hand-held computer module. Typically used at meetings to obtain immediate responses to statements or proposals. |
| | Interview | Flexible one-on-one discussion that allows in-depth exploration of a subject. Often used to collect complex or controversial data. |
| | Newspaper coupon / survey | Solicits input from the public. |
| | Poll | Conducted by trained interviewers who ask each person same questions in same order. Allows for statistical analysis of responses. |
| | Public comment period | Often required for permitting. Typically announced with legal advertisement. |
| | Questionnaire | Written questions answered and self-recorded by respondents. Often used to obtain large amounts of information from subjects. |
| Exchanging information | Advisory group | Small group of representatives of various interests or fields of expertise. Established to advise decision makers on on-going basis. |
| | Computer-based teleconferencing | Permits communication among geographically dispersed participants. |
| | Dialogue | Form of conference designed primarily to build relationships. Often held in retreat setting. |
| | Door-to-door canvassing | For use in small area that will be directly affected. Used to demonstrate commitment and provide interaction through personal contact. |
| | Task force | Advisory group with a specific task to accomplish. Usually dissolved at task completion. |
| Meetings | Charrette | A prolonged meeting among all stakeholders that continues until agreement is reached. |
| | Coffee klatch | Small group meeting held in a private home. Used to break down antagonism and stereotypes. |
| | Conference | Formal meeting wherein technical experts or representatives of various interests make presentations. |
| | Large group meeting | Used to present proposals, general information. Provides public a chance to vent, but usually not interactive. |
| | Open house | Allows onsite observation of project. Creates visual impact and open atmosphere. |
| | Public hearing | Large, formal public meeting with format typically dictated by regulatory process. Typically used to obtain public comment on draft plans. |
| | Small group meeting | Presents detailed data or clarifies points of concern to a specific group of stakeholders. |
| Surveys | Mail | Useful for obtaining inputs from general public, e.g., personal preferences and demographic data. |
| | Telephone | Used in place of and to supplement mail surveys to obtain a higher response rate. |
| | Personal | Used with smaller sample size and to collect more complex data. |
| Decision making | Arbitration | Binding or non-binding choice by neutral third party. |
| | Decision analysis | Involves building decision tree model representing alternatives and possible future scenarios. |
| | Delphi technique | Market research technique allowing for anonymous exchange of opinions. |
| | Mediation | Panel of representatives of various interests reaches consensus with help of neutral third-party mediator. |
| | Multiattribute utility analysis | Formal technique for evaluating options using multiple criteria. |
| | Nominal group technique (NGT) | Used to identify and rank goals, activities, or criteria. |

[a]Adapted from EEI (1984), AWWA (1995).

## Using MUA to Select a CAMU Site

When the concept of a CAMU was first proposed for SNL, it was widely derided as unacceptable to the public. State regulators were especially discouraging in their comments. Stakeholder collaboration was proposed as a potential means for securing necessary stakeholder buy-in.

The application began with the formation of a CAMU working group, a group of 20 individuals willing to attend two, one-day meetings to evaluate and rank alternative sites for the CAMU. Group members were self-selected from existing stakeholder organizations, including the Department of Energy (DOE), the DOE Citizen Advisory Board, the New Mexico State Environment Department (NMED), the Environmental Protection Agency (EPA), SNL, and the public at large. Group members were told that participation would not be interpreted as an indication of acceptance of the CAMU concept.

Of the nine public participants, seven were women, one was African American, and two were Hispanic. Occupations varied, but nearly all were active in their communities. Ages ranged from early 20s to late 60s, and education ranged from high school only to master's degrees. Except for the SNL representatives and regulators, members of the group had little experience or understanding of CAMU siting issues, and many had little or no applicable technical training.

### Candidate Sites

To provide siting options, EPA and SNL criteria for CAMU siting were used to screen an initial list of 156 potential siting locations at Kirtland Air Force Base down to five feasible options (SNL 1995). Figure 1 shows the locations of the five candidate sites labeled 18, 74, 107, 240, and 241.

### Initial Meeting

At the first meeting, a facilitator who was an expert in MUA led participants through the process of identifying objectives for the site-selection decision. The question was, ''What does a good CAMU site need to do?'' All group members participated. After an hour of discussion, it was agreed that the selected site needs to: (1) protect public and worker health and safety, (2) minimize adverse impacts to the natural environment, (3) meet the necessary technical and regulatory requirements to enable the site to serve as a CAMU, and (4) ensure effective and efficient use of resources, including land, money, and time. These objectives were displayed for the group as a hierarchy of site-selection criteria (Figure 2).

Next, discussion was directed towards identifying site characteristics and other factors that influence how well sites perform against the criteria. The facilitator posed questions such as, ''What determines the level of risk to the public from the CAMU?'' Given the technical nature of this topic, SNL participants dominated these discussions.

A computer program with the capability to construct and display influence diagrams (ADA Decision Systems 1995) was used to document the identified factors and their relationships. Influence diagrams graphically display the influences among factors relevant to a decision, and they are useful for selecting the attributes and rating scales for MUA (Merkhofer 1990). Participants first agreed on the factors influencing each criterion and then identified the factor or factors judged to be the most useful site discriminators. While technical specialists developed the diagrams, nontechnical participants provided suggestions and quickly understood the logic represented by the influence diagrams.

Figure 3 provides an example of one of the influence diagrams, for the criterion related to public health and safety. The asterisk by the factor labeled ''distance to existing communities'' indicates that distance (measured in miles) was agreed to be a useful discriminator for the public health criterion. Due to the similar geological and hydrological characteristics of the candidate sites, the other factors shown in the diagram were agreed by participants not to differ significantly from site to site.

Between the first and second meetings, 1-to-5 rating scales were developed for each of seven factors identified as useful discriminators. In each case, the middle level 3 was defined as the average for the sites, levels 1 and 5 were specified to encompass the range of possibilities, and the levels were defined to represent approximately equal (value) increments of performance. For example, the scale for distance was based on the distance (in miles) between the site and the nearest public community. Level 3 was defined as the average (4 miles), levels 2 and 1 were specified as above average (5 miles and 6 miles, respectively), and levels 4 and 5 were specified as below average (3 miles and 2 miles, respectively). The scales, together with scoring instructions, were provided to the SNL technical participants, who used the scales to rate each site.

### Second Meeting

At the second meeting, participants toured the candidate sites. After returning to the meeting room, the rating scales were presented to and accepted by the group. SNL participants explained the reasoning that

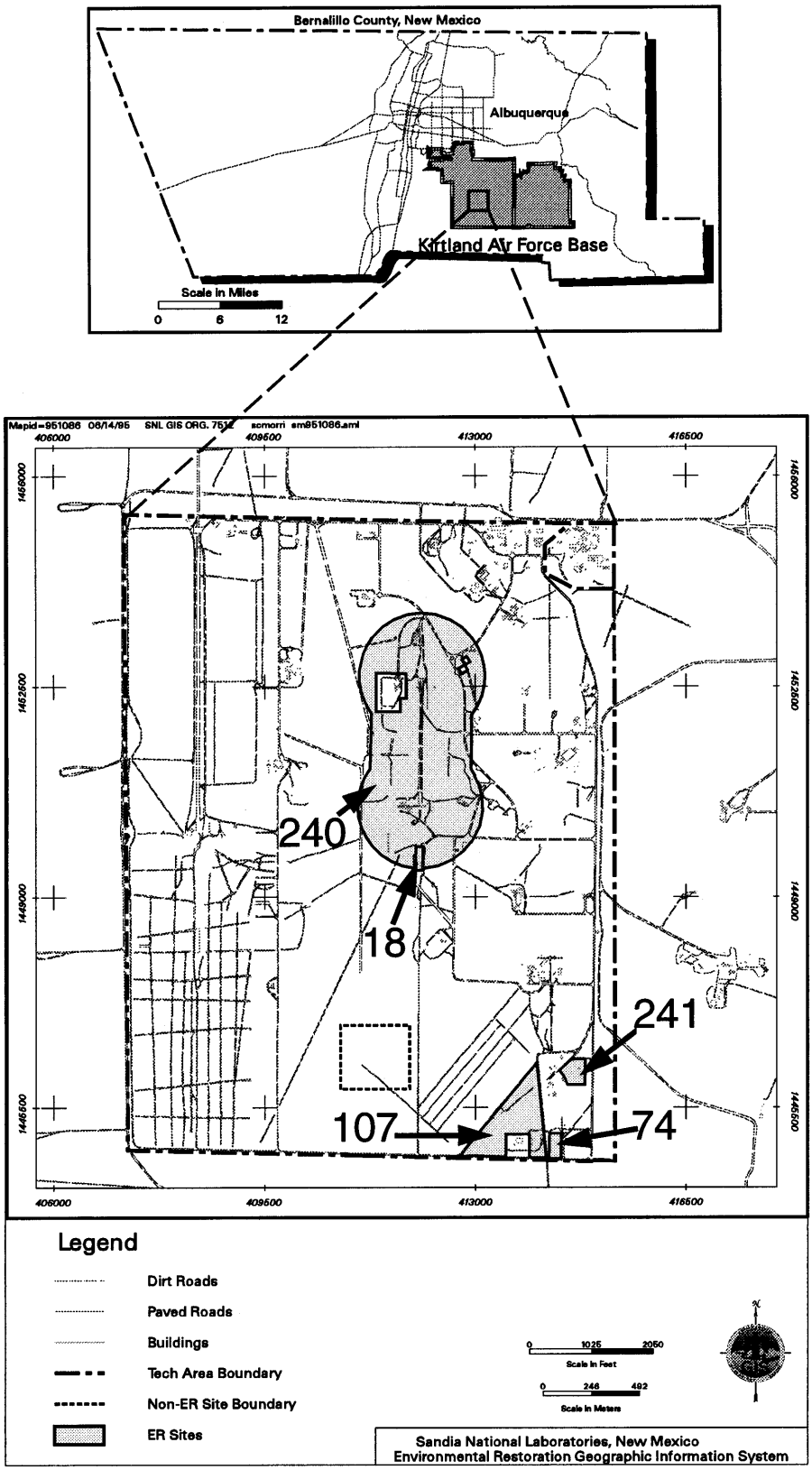


**Figure 1.** Candidate sites.

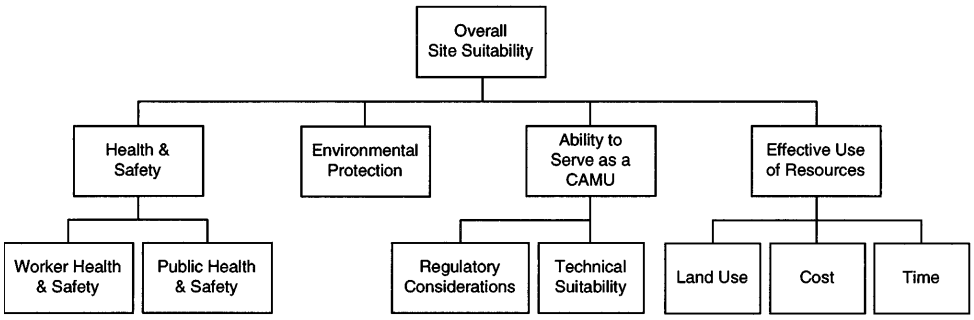


**Figure 2.** Hierarchy of criteria.

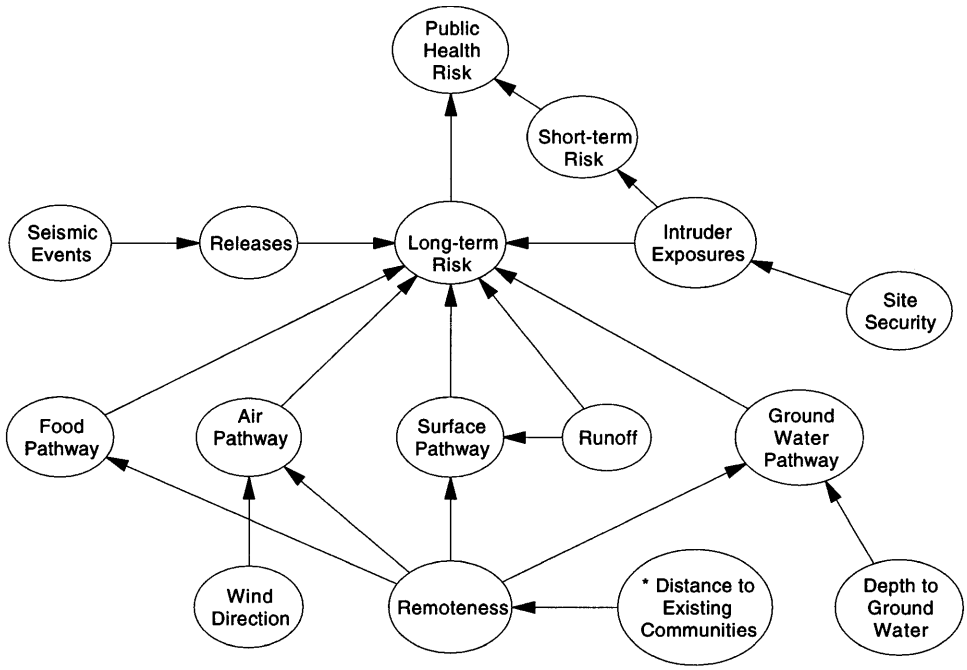


**Figure 3.** Influence diagram for public health.

each had used to score the sites on the rating scales. After a question-and-answer period, the external stakeholders individually scored the sites, using the same scales but applying their own judgments.

Weights were used to combine the ratings on the various factors into an overall measure of performance. Weights were assessed from participants using a technique that ensures consistency between the weights and the ranges of possibilities expressed in the rating scales (von Winterfeldt and Edwards 1986). Neither weights nor ratings were averaged across individuals. This was to ensure that differences in opinion over the rankings could be traced to differences in ratings, which reflect technical judgments, or differences in weights, which reflect value judgments. The distinction was regarded by participants as important. Although some stakeholders acknowledged that their ratings might be less valid due to their limited technical expertise, all felt that their value judgments were at least as valid as those provided by technical specialists. One stakeholder commented that he anticipated major disagreements between the rankings obtained from the technical specialists and stakeholders, based on differences in weights. In particular, he questioned the relatively low weight assigned by technical specialists to the distance of the site from communities and argued that his weights represented a ‘‘less arrogant’’ level of confidence in the CAMU.

Table 2. CAMU site selection summary of overall performance[a]

| Site | Averages of all weights and all scores | Averages of technical weights and all scores | Averages of technical weights and technical scores | Averages of external stakeholder weights and all scores | Averages of external stakeholder weights and external stakeholder scores |
|---|---|---|---|---|---|
| 18 | 90 | 90 | **89** | 90 | 90 |
| 74 | 83 | 83 | 82 | 84 | 83 |
| 107 | **91** | **91** | **89** | **91** | **91** |
| 240 | 89 | 88 | 87 | 89 | 89 |
| 241 | 88 | 88 | 88 | 88 | 87 |

[a]Overall performance is expressed on a scale normalized such that a site scoring middle values (3s) on all scales would receive 80 points and a site scoring as high as possible on all scales (5s) would receive 100 points. Highest score in each category is boldfaced.

### Results

The results of the prioritizations for the various participants were surprisingly similar. As shown in Table 2, regardless of how the ratings and weights were combined, the resulting site ranking remained the same. Site 74, a chemical waste landfill, was clearly an inferior site. The other four candidates were closely matched, and site 107 was a narrow, but consistent, winner.

Site 107, an area once used for testing explosives, was a relatively remote site that did reasonably well on all criteria. It had not previously been perceived by the technical specialists as a clear favorite, perhaps because it was the only one of the five sites with contamination levels sufficiently low that it might potentially qualify under regulatory requirements for no further action (NFA). Since it demonstrates progress, qualifying a site for NFA is regarded within the cleanup program as a desirable outcome. The logic of the analysis showed that this was not a sufficient consideration to dismiss the site for use as a CAMU.

When asked to comment on the results, each participant stated that the numerical rankings matched his or her personal, intuitive site rankings. A unanimous opinion was expressed that site 107 was indeed the preferred choice. Participants also expressed enthusiasm for the process. Comments included, ''I really felt as though we did a thorough job,'' ''What we did was common sense,'' and ''Sandia should use this approach more often.''

## CAMU Working Group Report

The working group formally recommended site 107 for the CAMU, and the recommendation was approved by the Citizen Advisory Board. The group's charter was subsequently extended, and the same MUA-based approach was then used to evaluate alternative strategies for operating the CAMU. In its final report, the group stated:

> As citizens, we were pleased that government employees . . . reached out to the community early in the process. As far as we are able to determine, Sandia has never asked for public input on a complex project like CAMU at such an early stage.
>
> We believe we have made a difference. . . . We steered the site selection process away from a site at the chemical waste landfill (CWL) to a nearby site (Site 107). Although the CWL site may have been technically desirable, Site 107 seemed to us to better satisfy our values and concerns.
>
> Given a better understanding of storage, treatment, and disposal operations and options available to this project, which we have gained over these months of study and discussion, we concur that Sandia can safely operate a complete CAMU facility. This concurrence is not without reservation, however. We believe that proper safety procedures and environmental monitoring are critical to a complete CAMU operation [CAMU Working Group 1996].

## Summary and Conclusions

The success of the MUA approach can be explained in part through reference to conclusions and advice from previous research. From their review of past studies, Wiedemann and Femers (1993) argue that empowerment of participants is crucial for the acceptance of the public participation process. Empowerment, they explain, means not only power sharing and free access to information, but also the transfer of technical competency to the public. The Edison Electric Institute Public Participation Manual (EEI 1984) discusses the value of working together and seeking agreement on a decision-making rule, ''If people cannot come to a decision on a course of action, they may nevertheless be able to agree on a method by which a decision can be made.'' Wiltshire (1986) points to the value of promoting a sense of responsibility for solving the problem and the appeal of logical procedures. Trimble (1988), a consultant to citizen organizations, argues that the most important elements of public

participation are education of the public, honest understandable communication, meaningful involvement, respect for the participants, and an attitude of ''we're partners.''

The MUA approach achieved these goals. It provided a framework that differentiated available options, identified relevant technical considerations, clarified essential value judgments, and efficiently communicated these elements among stakeholders. It enabled stakeholders to participate effectively, even though they had limited understanding of technical details. By involving stakeholders in the design of the decision model, a sense of ownership and confidence in the process was produced.

In addition, the approach was successful because:

- It was simple and readily understandable to participants. It made sense.
- It focused discussion on the issues that really mattered. Although it identified areas of disagreement, it demonstrated broad agreement over a course of action.
- It provided participants with a meaningful and important role in the decision process.

There are many other potential application areas for the MUA approach, such as siting power plants and prisons, choosing an approach for remediating a hazardous waste site, deciding how to expand a waste water treatment facility, and prioritizing investments that compete for community resources. However, many more case studies are needed to more fully evaluate its advantages and disadvantages. Key research questions include the effectiveness of MUA in instances where rankings differ across participants, determining whether the approach can be used for larger groups of participants, and ascertaining whether the simplifications necessary for quick applications introduce serious errors for the identification of preferred alternatives.

Admittedly, one success does not prove the general usefulness of the approach. Success, in this case, was obviously aided by the fact that rankings were insensitive to weightings. However, it is clear that logic can be a powerful force for consensus. By using a logical, structured framework for analyzing decision options, stakeholder involvement can be an investment with considerable benefits.

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