# INCORPORATING TECHNICAL INFORMATION AND COMMUNITY GOALS INTO RISK MANAGEMENT DECISION RELATED TO GROUNDWATER*

Henry B. F. Hughes**

Cornell University, Ithaca, NY

## ABSTRACT

Effective local groundwater management requires technical information which often must be provided by experts from outside the community who become intervenors. We have found that successfully weaving technical information into the decision making process of a community requires a sensitivity to the perspective of the community. Understanding the community context can allow an intervenor to develop technical information that is relevant to the immediate needs of the community. An effective partnership between the intervenor and key individuals in the community facilitates the development of realistic options, and usually leads to a positive outcome.

KEY WORDS: groundwater contamination, groundwater management, risk management, local government

## INTRODUCTION

Groundwater management is a responsibility which local governments in New York State are beginning to address as a result of the increasing frequency of groundwater contamination incidents. Effective management requires technical information which often must be provided by experts from outside the community. The Water Resources Program at Cornell has been assisting communities through New York State in dealing with water quality issues. Our goal has been to help communities address the issues currently facing them in a manner that will leave them better prepared to face and deal with future water quality problems. We have also sought to develop and improve methods of assisting communities. The issue which we have dealt with most is groundwater protection which is the subject of this paper.

We have found that successfully weaving technical information into the decision making process of a community requires a sensitivity to the perspectives of the community, since every community we have worked with has approached the problems from a slightly different perspective. Groundwater quality is not always of primary importance to a community and, therefore groundwater management competes with other community goals.

This paper identifies three key components of intervention by outside experts in local groundwater management decisions which we have found from experience to be critical to achieving a positive outcome. The first component consists of gaining an understanding of the community's perspective and establishing a constructive relationship with community leaders. The second is to develop technical information which addresses the most important issues of the current situation. The third component is presenting the technical information in the form of options which give the community as much flexibility as possible to choose how groundwater will be managed locally.

The Local Perspective

The goals which a community has set which are not related to groundwater may either compete with or compliment the goals related to groundwater. The goal which most often conflicts with groundwater protection is economic development. In some communities, development is a goal of local officials because more jobs are needed. In several Long Island towns, where rapid development is already occurring, local officials are trying to reduce or control the development pressure for a number of reasons including groundwater protection and open space or farmland preservation.

Where development is already perceived by community leaders as undesirable, groundwater protection is embraced as one of several complimentary goals. However, the communities that seek development along with groundwater protection are much more skeptical of strict land use controls, such as limiting housing densities. If community leaders want both development and good quality groundwater then the information presented to them should help them understand the risks that particular types of development pose to groundwater quality.

Farmland preservation is a goal which may or may not compliment groundwater protection. The nonintensive type of agriculture practiced in many rural areas of New York State is often consistent with maintaining high quality groundwater in underlying aquifers. In these areas farmland preservation and groundwater protection are natural allies. More chemically intensive agriculture can cause serious groundwater contamination meaning that the need for high quality groundwater must compete with agriculture or at least with certain agricultural practices. This is most evident in potato growing areas of Long Island where nitrogen fertilizers and several pesticides have contaminated large quantities of groundwater.

In each community with which we have worked, the past experiences of the community with groundwater and the other goals have influenced the perception of the risk of groundwater contamination from various local activities. In order for us to intervene in a constructive way it was necessary to take the time to understand the specific community and to realize that while we were the experts on groundwater, the leaders of the community were the experts on the community. Helping the community leaders make use of the information we could provide required us to establish a relationship with the leaders so that we could understand their goals and gain their trust. We could then work together to develop a groundwater protection strategy.

Developing Useful Technical Information

The key to developing useful technical information for a community is understanding what questions need to be answered before community leaders can proceed with a groundwater management program. Groundwater and its contaminants are elusive entities from a technical standpoint. This makes it very difficult to answer questions about contaminant health effects or groundwater movement in precise terms. This, in turn, can cause experts to either shy away from hard to answer questions or to invest a lot of money in trying to precisely define one aspect while ignoring others. Both of these pitfalls can render a technical report useless if they cause key questions to be left unanswered. Answers to the technical questions which can not be calculated precisely can be developed and presented in a way that openly shows the uncertainty.

A question that many communities start with when they address groundwater management is: "Where does the water in our well or wells come from?" The community needs to know where precipitation water infiltrates the land surface and flows toward their well. This area of land, referred to as a recharge area, is very difficult to locate precisely and the price for locating it increases rapidly with precision. However, if groundwater is to be protected the community must answer this question with a precision which it feels comfortable defending.

On Long Island, deep flow recharge areas were identified during a regional study as the most important recharge areas for drinking water. Undeveloped tracts of land in these deep flow recharge areas became natural candidates for areas to protect. In more rural areas there often are not detailed hydrologic studies available, and it was necessary for us to develop estimates of the location of the important recharge areas for public wells in these communities.

One community started with a more basic question which was something like: "Can groundwater contamination happen to our wells?" Many of the members of the town planning board were not familiar with the numerous incidents of groundwater contamination which were highly publicized in other parts of the state. Hence, they were not aware of the risks that their currently high quality groundwater faced. This made it important for us to develop information which could help them envision the types of contamination which they were vulnerable to. This was done by developing hypothetical case studies which showed, in detail, what could happen to their water as a result of a particular development in the recharge area for their wells. The case studies covered contamination from residential development, intensified agricultural activity and underground gasoline storage. Such hypothetical case studies were not necessary on Long Island or in other areas where public officials had been reading about groundwater contamination in their newspapers for years.

Once it has been established that risks do exist and that a particular recharge area is to be the focus of management program, it is necessary to relate particular management actions to levels of risk of contamination from various contaminants. The two classes of groundwater contaminants which we have dealt with most are nitrate and synthetic organic chemicals since these are by far the most common contaminants causing public well closings in New York State.

Nitrate is the simpler example to discuss from a risk management stand point. New York State has had an official nitrate standard for drinking water for a long time. The maximum allowable concentration of nitrate in drinking water in New York State is 10 milligrams per liter (mg/l). Also, nitrate loadings from various land uses are due largely to sewage, animal waste and nitrogen fertilizers. These loadings are predictable, and hence it is possible to determine with reasonable accuracy what land uses can be allowed in a recharge area to be compatible with a chosen planning criterion.

In order to ensure that the concentration of any contaminant is below the standard more than half the time, the average concentration of the contaminant must be less than the standard. Since concentrations vary, this means that a planning criterion must be less than the health standard by an amount that guarantees meeting the health standard a high percentage of the time. This is particularly true of groundwater where relatively little mixing takes place. Porter (1982) evaluated the relationship between the mean concentration of nitrate found in a set of groundwater samples in Nassau County and the percentage of the samples which violated the 10 mg/l nitrate standard. He found that if the average nitrate concentration in an area was 6 mg/l then 10% of the samples from that area had nitrate concentrations exceeding 10 mg/l. In order to achieve better than 90% compliance with the 10 mg/l standard in an area characteristic of Nassau County, an average concentration of less then 6 mg/l would be required. A higher percentage of compliance would require a lower average.

Several Long Island towns adopted unofficial planning criteria for nitrate which reflected their respective philosophies and current situations. In the eastern Long Island towns which are still largely undeveloped there was considerable sentiment for a policy of nondegradation toward the high quality groundwater. Accordingly, planners there used a nitrate criterion of 2 mg/l as a basis for zoning ordinances in recharge areas. The 2 mg/l criterion would ensure a very high percentage of compliance with the 10 mg/l standard, and it had a history of use for protecting similar areas in New Jersey (Hughes and Porter, 1983). It did allow for some development.

A more heavily developed western Long Island town, with which we worked, felt that a 6 mg/l criterion was adequate for the areas they were trying to protect. This higher criterion reflects a number of differences between the western and eastern towns. Development pressures are much higher in western Long Island, there is less public pressure for nondegradation of groundwater and there is less emphasis on maintaining open space.

We helped the towns develop zoning ordinances to ensure that new residential developments would be consistent with their nitrate criteria. The ordinances limited the density of housing and the size of fertilized lawns.

The synthetic organic chemicals we were concerned about did not have official standards, but the State Health Department uses guidelines of 50 micrograms per liter (ug/l) for a single organic, or 100 ug/l combined concentrations if more than one synthetic organic is present, for closing water supply wells. For certain proven carcinogens such as benzene or vinyl chloride the guideline is 5 ug/l. While the nitrate standard is assumed to be a stable quantity for planning purposes, the synthetic organics guidelines are expected to change, and could be lowered. Table 1 shows the calculated water quality criteria which accompany various cancer risks from drinking water for two of the organics most often found in New York's groundwater. These criteria are all less than the 50 ug/l guideline.

The New York State Department of Environmental Conservation which is separate from the Department of Health has established ambient groundwater standards for certain of the synthetic organic chemicals, which specify the maximum concentration of the contaminants which can be released to

Table 1

Water Quality Criteria Suggested by EPA (1980 a,b)

Water Quality Criteria to Allow One Additional Cancer per:

| Chemical | 10,000,000 people | people | 1,000,000 people | 100,000 |
|---|---|---|---|---|
| Trichloroethylene | | 0.27 ug/l | 2.7 ug/l | 27 ug/l |
| Tetrachloroethylene | | 0.08 ug/l | 0.8 ug/l | 8 ug/l |

groundwater. For trichloroethylene, for example, the standard is 10 ug/l. We used this 10 ug/l standard as a starting point for development planning information. The 10 ug/l standard can be translated into a permissible loading rate per unit area for a particular area. For trichloroethylene the maximum permissible loading rate turns out to be 0.07 pound (3/4 of an ounce of liquid) per acre per year for Long Island's climate (Hughes et al., 1985). For all practical purposes this means that a facility using trichloroethylene must not discharge any of it to the groundwater since even a very small discharge will cause the standard to be violated

There is much less flexibility for a town in preventing synthetic organic chemical contamination. Most contamination from synthetic organic chemicals comes from industrial and commercial areas. The towns were able to reduce the risk of organic chemical contamination by keeping industrial and commercial development out of the important recharge areas as much as possible. In areas where industrial and commercial activities are already overly important recharge areas, the emphasis needs to be on encouraging and requiring waste disposal practices which do not endanger groundwater. Unlike the situation with nitrate, there was not an opportunity to design land use plans which could be expected to produce water with a certain acceptable concentration of the organic compounds. There are still differences in the ways communities approach prevention, but they are more subtle. A community's strategy for preventing synthetic organic contamination may be governed more by what is possible economically and politically in their situation than by how community leaders feel about the risks.

Presenting Information

The manner in which information is shared with a community has much to do with how well it is accepted. We found that presenting the technical information at the end of a project in terms of specific options has several advantages. It allows the intervenor to map out one or more specific actions that the community can take, but it clearly leaves the ultimate decision up to the community leaders. In most towns, we worked closely with one or more planners who worked for the town and lived in town. We developed a set of options in conjunction with these people, to make them realistic for the community.

In each town, the options were presented and discussed in report form and at one or more meetings bringing together the leaders who would have the responsibility of implementing the options. These meetings typically included representatives from the town, the county health and planning departments, the water supply companies and the cooperative extension service. The process of involving everyone from the beginning gave them a stake in the success of the effort. By the end of a project there was usually a consensus developing around one or more options as being appropriate for the community

CONCLUSION

To be effective, an intervenor must not enter into a local risk management situation assuming that he or she has all the answers ahead of time. Community leaders are often experts on what their community wants and what type of options are feasible politically and economically. Understanding the community context can allow an intervenor to develop technical information that is relevant to the immediate needs of the community. An effective partnership must exist between the intervenor and key individuals in the community. We feel that our projects have been successful when a community adopts steps for groundwater protection and the intervenors learn from the project how to better assist other communities.

NOTES

* This paper is part of a series of five related papers entitled "Enhancing Risk Management by Focusing on the Local Level."

** Water Resource Specialist, Center for Environmental Research.

REFERENCES

Hughes, H.B.F., J. Pike and K.S. Porter. 1985. Assessment of Groundwater Contamination by Nitrogen and Synthetic Organics in Two Water Districts in Nassau County, New York. Center for Environmental Research, Cornell University, Ithaca, N.Y.

Hughes, H.B.F. and K.S. Porter. 1983. Land Use and Groundwater Quality in the Pine Barrens of Southampton. Center for Environmental Research, Cornell University, Ithaca, N.Y.

Porter, K.S. 1982. Groundwater Information: Allocation and Data Needs. Center for Environmental Research, Cornell University, Ithaca, N.Y.

United States Environmental Protection Agency. 1980. Ambient Water Quality Criteria for Tetrachloroethylene. National Technical Information Service. Washington, D.C.

United States Environmental Protection Agency. 1980. Ambient Water Quality Criteria for Trichloroethylene. National Technical Information Service, Washington, D.C.

# POLICY CONSIDERATION IN THE SELECTION OF NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS FOR THE TACOMA SMELTER

Robert Ajax* and Janet Meyer**

Environmental Protection Agency*,
Pacific Environmental Services, Inc.**

## INTRODUCTION

This paper presents background information and the policy basis for the National Emission Standards for Hazardous Air Pollutants (NESHAP) that were proposed to limit inorganic arsenic emissions from the ASARCO smelter at Tacoma, Washington. The standard-setting approach used and the role public participation played in the development of the final standard are also discussed. Factors considered include the estimated community health risks and the uncertainties in these estimates; the need to reduce public exposure to arsenic and to protect health; the potentially available control measures; the economic impacts of plant closure on smelter employees and the local community; and the opinions of the local community as expressed in 3 days of public hearings and in over 650 comment letters.

The Environmental Protection Agency's (EPA's) initial activities relating to development of standards for inorganic arsenic began when "Standards of Performance for New Stationary Sources - Primary Copper, Zinc, and Lead Smelters," were promulgated in 1976. The Natural Resource Defense Council, Inc. (NRDC), subsequently filed a petition to review the standards because inorganic arsenic emissions from nonferrous smelters were not included among the regulated pollutants. In response to the petition, EPA made a commitment to gather data necessary for setting standards on arsenic emissions from copper smelters. In the fall of 1976 EPA initiated work to assess arsenic emissions from existing primary copper smelters and to evaluate appropriate control technology. Information obtained from this work indicated that fugitive arsenic emissions from copper smelters could also be a major source of arsenic air pollution and the greatest contributor to public exposure. This work eventually led to the proposal of standards in 1983 for glass manufacturing plants and primary copper smelters, with the most prominent part of the rulemaking pertaining to the ASARCO smelter at Tacoma, Washington (48 FR 33112). A final standard had been developed and was being reviewed within the Agency when ASARCO announced its plans to close the smelter. Because of the planned closure (which has now occurred), EPA did not issue a final rule. The period between 1976 and 1983-84 included several changes in EPA's administration and significant shifts in the approach to rulemaking. This paper provides a brief history of this rulemaking and discusses the risk management approach used in development of the standard, including the role local participation played in the development of the final standard.

## BACKGROUND

The primary copper smelting industry in the U.S. uses pyrometallurgical processes to extract copper from sulfide copper ores. At all primary copper smelters, two primary operations are conducted: (1) smelting the copper ore concentrates by melting the concentrates together with fluxes to produce an iron-copper sulfide mixture (matte) and an iron oxide slag; and (2) converting the matte to blister copper by oxidizing the sulfur and other impurities for removal in the offgases and oxidizing the iron for removal in slag.

In the pyrometallurgical process, arsenic is separated from the copper and its oxidized and volatilized into the process offgases or removed with the slag. The amount of arsenic emitted to the atmosphere during roasting, smelting, and converting is a direct function of the arsenic content of smelter feed materials and smelter configuration as well as the emission capture and control techniques used.

Arsenic is an impurity frequently found in copper ore deposits. At the 15 primary copper smelters operating in the U.S. in 1983, the average arsenic content of feed material charged to roasters or furnaces ranged from 0.0004 to 4.0 weight percent. As shown in Figure 1, the average arsenic content of the feed materials was well below 0.5 weight percent at the majority of smelters and only one smelter processed feed material with more than 1 percent arsenic. This was the Tacoma smelter which, in addition to processing high-arsenic copper ore concentrates, also recovered arsenic trioxide from waste materials. This significant difference between the Tacoma smelter and the remaining smelters and the urban location of the smelter led to the development of a separate standard for the Tacoma smelter.

Because of the high estimated risks for the ASARCO-Tacoma smelter and the community concerns, the Tacoma smelter became a principal focus of EPA's inorganic arsenic NESHAP development activities. As Dave Patrick and others in this session will describe, the potential for elevated community exposure was confirmed in several studies and risk estimates indicated both high individual and population risks. Consequently, following the listing of inorganic arsenic as a hazardous pollutant, development of a standard to limit emissions from the Tacoma smelter became a high priority.

## DEVELOPMENT OF STANDARD

### Proposal Risk Management Approach

The basis for the risk management approach to standard-setting is EPA's interpretation that it is not the intent of Section 112 to eliminate totally all risks from airborne carcinogens and that Section 112 standards which permit some level of residual risk can be considered to provide an ample margin of safety to protect public health. The standard-setting approach used to select the control requirements in the arsenic NESHAP was essentially the three-step approach first described in 1979 in the proposed air carcinogen policy (44 FR 58642). The first step consisted of determining whether current controls at the ASARCO-Tacoma shelter reflect application of best available technology (BAT). The BAT is the technology which, in the judgment of EPA, is the most advanced level of control which is adequately demonstrated considering environmental, energy, and economic impacts. For those emission points where BAT is in place, EPA determined whether a NESHAP standard is needed to assure that BAT will remain in place and will be properly operated and maintained. A primary consideration is the existence of other Federally enforceable standards. Also, EPA considered whether standards established under separate authorities (e.g., other EPA standards, other Federal, State, or local requirements) are effective in reducing emissions and whether Section 112 standards will be redundant and unnecessary. If BAT is not in place on specific emission points or if there is reason to expect that BAT may not remain in operation, these emission points are identified for development of standards.

The second step involved the selection of BAT for the emission points identified for development of standards. To select BAT for an emission point, regulatory alternatives were defined based on demonstrated control technology. The environmental, economic, and energy impacts of the alternatives were determined. Based on such an assessment, one of the alternatives was selected at BAT.

The third step involved consideration of regulatory alternatives beyond BAT for all of the inorganic arsenic emission points at the ASARCO-Tacoma smelter. This consisted of consideration of the estimated risk which remains after application of BAT along with considering costs, economic impacts, risk reduction, and other impacts that would result if a more stringent alternative were selected. If the residual risk is judged not to be unreasonable considering the other impacts or beyond BAT controls, more stringent controls than BAT are not required. However, if the residual risk is judged to be unreasonable, then an alternative more stringent than BAT would be required.

Development of Proposed Standard

Consistent with the above policy, EPA examined each inorganic arsenic emission source at the Tacoma smelter to determine whether the level of control reflects BAT. In this review, the Agency found that, except for converter fugitive emission controls, BAT was in place The converter fugitive emission controls identified as BAT were the air-curtain secondary hoods which ASARCO was installing in a phased program. It was EPA's assessment based on observations of the technology in Japan and review of ASARCO's plans that this technology would be about 95 percent effective in capturing fugitive converter emissions. The capital cost of the three hoods was estimated at $3.5 million and the annual operating cost was estimated at $1.5 million. The EPA performed an economic analysis based upon available data and concluded these controls should not have a significant economic impact on the smelter. Energy, solid waste and other nonair environmental impacts were estimated and judged to be reasonable.

The EPA next assessed the residual health risks remaining after application of BAT and the availability of additional controls beyond BAT. As described in Dave Patrick's paper, the residual estimated health risks were relatively high compared to other sources previously considered for NESHAP. However, EPA's examination identified no additional technological controls that would significantly reduce emissions and associated exposures. Remaining alternatives were, therefore, limited to production curtailments and reduction in arsenic content of copper ore concentrates processed by the smelter. It was EPA's judgment that either would cause closure of the smelter. Thus, the decision involved a balancing of a BAT-based standard with relatively high estimated risks on the one hand against closure of the smelter with potentially serious personal and community impacts on the other. In reaching a decision, two factors became particularly important. One was the significant uncertainty in the many assumptions and data that went into the health risk estimates and the recognition by the Agency that these estimates should not be regarded as accurate estimates of the actual cancer risk. (These uncertainties included the significant uncertainties in the emission estimates, the dispersion modeling of the smelter, and the simplifying assumptions made in the risk analysis.) The second was the heretofore absence of any comments or opportunity for comments by the affected public. Based on this, the decision was made that the proposed standard should not go beyond BAT.

Other Considerations

It is important to note that the information that was available at the time of proposal and the policy approach which was followed were developed during the Costle Administration and the Gorsuch Administration. However, it was Mr. Ruckelshaus, who was appointed Administrator in early 1983, who was left with the responsibility for the actual proposal and final decisions. Due to the short court-ordered time schedule and the managerial changes which were being undertaken during the initial months of the Ruckelshaus Administration, there was little time available for the new Administrator to consider the far reaching implications of the policies embodied in the proposed regulation. These changes included the appointment of a new Administrator for EPA Region X where the smelter is located, and the replacement of the Assistant Administrator for Air, Noise, and Radiation by an Acting Assistant Administration. Consequently, at the time the standard was proposed, the Administrator made very clear that in this case, in particular, the final standard was still open to debate, and that full participation by the public in the process leading up to the publication of the final regulation for arsenic was especially important in order to guide the final decisions.

PUBLIC INVOLVEMENT

Public Participation. Consistent with the Administrator's belief that the opinions of the people directly affected by the rulemaking are important, extraordinary steps were taken to ensure that they were informed and afforded an opportunity for meaningful participation. Specifically, supporting information for the proposed standard was made available for public inspection in the area affected by the ASARCO-Tacoma smelter (Tacoma and Vashon Island). In addition, EPA conducted a series of three public workshops in the area during August 1983, to provide and explain information on the proposed standard. These workshops were well attended and included both formal presentations by EPA personnel and question and answer sessions. Because of these efforts to solicit public comment on the standard, some people perceived that the public was being asked to vote on the standard. The EPA subsequently clarified that the decision on the standard was the Administrator's alone, but that the administrator considered the opinions of the affected people to be an important element in the decisionmaking process.

A public hearing was held on November 2, 3, and 4, 1983, in Tacoma, Washington, and a second public hearing was held in Washington, D.C., on November 8, 1983. In addition, EPA met with the major interested groups (ASARCO, Sierra Club, Puget Sound Air Pollution Control Agency [PSAPCA], NRDC, and United Steelworkers of America [USWA]) on December 20, 1983, to discuss the dispersion modeling study for the ASARCO-Tacoma smelter and additional opportunities for emission control that were listed in the December 16, 1983, Federal Register notice (48 FR 55880).

During the public comment period, more than 650 comment letters were received on the proposed standard, the revised ambient modeling of emissions from the ASARCO-Tacoma smelter, and the additional analyses and proposed requirements described in the December 16, 1983, Federal Register notice. Most of the commenters made multiple comments, and many repeated comments made in other letters or by other commenters.

Overview of Comments. The majority of the comments received on the proposed standard were from members of the public and appear to be motivated by personal concerns and interest in the rulemaking. The public comments reflected the range of concerns of people living in the affected communities over the health and economic impacts of the ASARCO-Tacoma smelter's operations. To present the spectrum of comments, the comments have been categorized into five general positions. These five positions can be described as ranging from "not regulation is needed" to "the smelter should be closed." These general positions are briefly described below.

A small number of commenters expressed the opinion that regulation was unnecessary because existing air pollution controls were adequate. Frequently, these commenters argued that the ASARCO-Tacoma smelter's arsenic emissions did not present any threat to the health of local residents.

A slight majority of all the commenters recommended that EPA adopt only the proposed controls for converter air-curtain secondary emissions. As a group, these commenters tended to believe that there was not evidence of a public health risk from the ASARCO-Tacoma smelter's arsenic emissions and that EPA should evaluate the air quality improvement achieved by the use of the converter secondary hoods before imposing any additional control requirements.

Commenters expressing this opinion included ASARCO, current and retired ASARCO employees, and many residents of Tacoma, Ruston, and surrounding communities. Some of these commenters argued that the jobs and economic benefits to the area were of greater importance than any health risk from the arsenic emissions.

The third category of opinion held by commenters is that to reduce risks to a maximum extent feasible, the EPA should require converter controls and all other controls that may be technically feasible. A number of these commenters further commented that the proposed standard does not require any emission controls beyond those already required by PSAPCA, and the proposed standard was only delaying control of converter fugitive emissions. These opinions were expressed by local regulatory agencies and the USWA, and a number of environmental groups, civic organizations, and private individuals. Many of these groups and individuals (including, in particular, Washington Fair Share, Tacoma City Council, Tacoma-Pierce County Chamber of Council, and Tahomans for a Healthy Environment) emphasized that the Tacoma area can have both jobs and health through application of best controls and new smelting technology. These commenters favored continued operation of the ASARCO-Tacoma smelter as long as emissions are well controlled. To achieve this goal, the groups and individuals made specific recommendations for additional controls.

The fourth category of comments reflects that opinion that the proposed standard does not provide an ample margin of safety and that EPA should require emission reductions so there are no remaining risks or only negligible risks. This opinion was expressed by a significant number of the commenters, predominantly residents of Vashon Island but also including residents of Tacoma and Ruston. Commenters stating this opinion also considered reduction of risks and health protection more important than allowing the smelter to continue operation and the retention of jobs. Within the group, some commenters expressed concerns regarding the effects of the ASARCO-Tacoma smelter's emissions on their health and on the environment in general. Frequently cited concerns of this group are the accumulation of arsenic and heavy metals in the soil and water, the warnings by the local health department against growing and consumption of certain garden vegetables, levels of arsenic measured in the urine and hair of children living in the area, and fallout of emissions on automobiles and property.

The final category in the spectrum of public opinions proposed that the ASARCO-Tacoma shelter should be required to process low-arsenic content copper ore concentrates or be required to cease operation. These commenters believed that arsenic emissions (and other emissions) from the ASARCO-Tacoma smelter present significant health risks to the surrounding population. This opinion was expressed by a significant number (but a smaller number than the preceding category) of public commenters. Frequently, these commenters stressed that the Tacoma area would benefit financially and aesthetically from closure of the smelter. These commenters thought that the ASARCO-Tacoma smelter was a significant contributor to the negative image for the area and to loss of new business opportunities to other locales.

## RISK MANAGEMENT POLICY AND APPROACH AFTER PROPOSAL

The final standard that was under consideration within EPA at the time ASARCO announced its decision to close the smelter was based upon an assessment of a wide range of factors and on the risk management policy described previously. The draft standard reflected application of the best technology which was available and could be applied without causing plant closure or imposing costs that far exceed any public health benefit. The factors that were considered during the development of the final standard fall into five broad categories: (1) health risks and the uncertainties in the health risk estimates and the need to reduce exposure in order to protect public health; (2) the potential to reduce emissions; (3) the economic impacts of plant closure on the local community and on the smelter employees; (4) the opinions of the local community as expressed in the hearings and comment letters, and (5) other environmental considerations. These are each described in more detail below, except for the health risk estimates and uncertainties which are discussed in Mr. Patrick's paper.

<u>Potential Emission Reductions</u>. A range of potential emission control options were identified which were, or may have been, applicable to the ASARCO-Tacoma smelter. These included: (1) converter fugitive emission controls; (2) equipment and work practice controls for other low-level fugitive emission sources; (3) control of emissions during malfunctions; (4) more efficient main stack control devices; (5) new smelting technology; (6) new arsenic trioxide production technology; and (7) limits on he arsenic content of copper ore concentrates processed. Table 1 lists the availability of the control options. Figure 2 compares 1982 estimated arsenic emission rates from the ASARCO-Tacoma smelter with estimated arsenic emission rates for the different control options.

The conclusions in Table 1 regarding technical feasibility and affordability reflect the position of EPA technical staff at the time the final rule was being prepared. The conclusions regarding affordability pertain to whether the additional control measures are in themselves affordable, assuming that in the absence of further control the smelter would remain profitable. In addition to the previously cited costs of converter controls, equipment and work practice controls and curtailments during malfunctions were estimated to involve capital costs of $750,000 and annualized costs of $1,540,000. While substantial, EPA's analyses indicated these costs would not cause closure. In contrast, EPA's analysis of the effect of limits on the arsenic content of concentrates showed that even if low arsenic copper ore concentrates were available, it would be affordable to replace only a small proportion of the high-arsenic with low-arsenic concentrates. Even this would be costly. For example, based on EPA's analysis, a 15 percent reduction in the amount of high-arsenic concentrates would result in approximately $2.8 million reduction in net income.

Based on this, it is clear that, from the perspective of risk management there were, in fact, only two options: (1) application of all available, feasible controls which would reduce emissions by approximately 20 percent, and (2) closure of the smelter. There were differences in opinion both within EPA and among the commenters as to what technologies were available, the effectiveness of various technologies, and the appropriate monitoring and enforcement approaches. However, none of these, even in the most effective combinations, could come close to reducing emissions and risk to near zero, and in the broader perspective, did not substantially alter the basic choices which were available

Effects of Closure. Because the alternative of requiring the ASARCO-Tacoma smelter to process primarily low-arsenic concentrates would likely result in closure, EPA updated a study on the impacts of closure of the smelter on the local business, employment, and tax revenues in the Tacoma area. Other potential societal impacts were considered qualitatively through consideration of public comments on the effects of closure and the desirability of closure of the ASARCO-Tacoma smelter. The updated evaluation indicated that closure would: (1) increase the local unemployment rate by an additional 0.7 percentage points; (2) reduce local business revenues by about $21 million annually; and (3) reduce tax revenues to State and local governments by about $2.7 million annually. The study did not assess the other economic effects of the smelter's operation, such as unemployment insurance costs, retraining costs for employees, effects on property values, health care costs, and home and auto maintenance if the smelter closed.

The above information was considered along with the public comments on the societal impacts of closure of the ASARCO-Tacoma smelter. The majority of public comments on the societal impacts of closure focused on the anticipated employment and local economic impacts. Some commenters argued that closure would improve economic development opportunities for the area, hence an ultimate positive economic impact on the area. In contrast, most commenters believed that closure would have a negative economic impact on the Tacoma area. A majority of commenters did not favor closure because of the negative economic impacts on the area, the lack of demonstrated health effects, and a belief in the possibility for additional significant emission reductions at the smelter. The other societal impacts of concern were discussed in the smelter workers' Union comments on the proposed standards. These additional impacts included health risks due to unemployment and toxic waste disposal problems that would occur in other communities from the need to dispose of the arsenic that ASARCO had been recovering. The Union also argued that EPA should consider the impact of forced closure of the smelter on public health and reject deliberate creation of unemployment as a regulatory strategy. In support of this point, the Union cited the finding of a 1976 Joint Economic Committee of the U.S. Congress that unemployment has been associated with increased deaths and illness. Assuming the results of this study can be applied to counties, and using the risk estimates developed in this study, the USWA estimated that a 1 percent increase in unemployment, sustained over a 6-year period, would represent an increase in the mortality rate in Pierce County of 91 deaths.

Public Opinions. Both specific comments on smelter controls and general public opinions on the proposed standard played an important role in the final assessment of the appropriate level of control for the ASARCO-Tacoma smelter. The specific comments on smelter controls illustrated the need for extensive involvement with day-to-day operations of the smelter, and affected the specific control measures evaluated after proposal. In particular, owing to comments and recommendations by State and local agencies, members of the community, and EPA Region X, increased emphasis was placed on evaluating means of reducing emissions due to upsets and preventable malfunctions and of ensuring proper operation and maintenance of control equipment. In general, the majority of comments supported the position (1) that standards should be designed to reduce emissions and health risks to a minimum, and (2) that setting standards at overly restrictive levels which would result in closure was not appropriate.

Other Pollutants and Past Emissions. Although this rulemaking specifically addressed inorganic arsenic emissions, and was conducted under Section 112, other considerations were the other pollutants emitted by the smelter, other environmental impacts of the smelter, and other environmental standards affecting the smelter. These concerns were raised in the hearing and workshops by a number of commenters, many of whom expressed frustration over the narrow focus of the rulemaking. The EPA shared this concern and recognized that arsenic control at the smelter should not be considered in isolation. Even in the context of Section 112 alone, consideration of other environmental impacts were important because new control technologies and smelter processes that affect arsenic emissions also affect other pollutants. Beyond this, EPA considered other environmental impacts of the smelter, the impact of this standard on emissions of other pollutants, and the adequacy of actions being taken under other environmental statutes to address other environmental impacts of the smelter. Specific actions considered included actions being taken to reduce occupational exposures to arsenic, and actions being taken by EPA to clean up past emissions from the smelter.

On consideration was that the standard for inorganic arsenic emissions would also reduce particulate matter emissions. Consequently, emissions of other pollutants (e.g., lead or antimony) which are also present in particulate matter would also be reduced by BAT controls. Emissions of gaseous pollutants, such as $SO_2$, would not be reduced; however, there are other regulations that limit emissions of these pollutants from the ASARCO-Tacoma smelter. In particular, ASARCO was required by the 1981 PSAPCA Board Order to achieve 90 percent control of $SO_2$ emissions by 1987.

The other environmental impacts of the smelter were being studied by EPA, and efforts are underway to solve the problems identified. The Superfund program (Comprehensive Environmental Response Compensation and Liability Act) is designed for EPA to take actions needed to protect public health from exposure to hazardous substances in all environmental media. The EPA is using its Superfund program, therefore, to investigate other pollutants, such as cadmium and lead, and to remedy the problems resulting from exposures to these pollutants. Investigations funded in part or entirely by the Superfund program are underway or being developed to study the potential health problems resulting from the historical accumulation of arsenic, lead, and cadmium in the vicinity of the ASARCO smelter. Efforts are also underway to reduce discharges of pollutants into Commencement Bay. It was EPA's conclusion that this work will aid in the characterization and resolution of the environmental problems associated with the ASARCO-Tacoma smelter's operations that would not be affected by the stringency of standards limiting air emissions.

The Agency also recognized that even at the control levels required by the NESHAP standard, that some degree of accumulation of arsenic and heavy metals in the soil may occur. However, the present levels of these materials in other environmental media are largely the result of the much higher emissions from the smelter before effective control equipment was installed. Emissions had decreased significantly over the past 20 to 30 years. Although the standard would not have eliminated arsenic and heavy metal deposition, EPA believed that the controls would have reduced emissions significantly and would reduce accumulation in the environment.

## SUMMARY AND CONCLUSIONS

The policy basis for the rulemaking action affecting the Tacoma smelter was consistent through the development of the proposed and final standard. In particular, the risk management policy continued to be based on EPA's interpretation that it is not the intent of Section 112 to eliminate totally all risks; and that standards which permit some level of residual risk can be considered to protect the public health. The basic standard-setting approach of identifying controls and weighing the broad range of impacts and benefits of the alternatives also was used throughout the rulemaking.

This rulemaking action did, however, differ from other NESHAP rulemakings in the unusual level of public involvement in review and development of the final standard. Public involvement with the arsenic standard was greater than normal due to EPA efforts, under Mr. Ruckelshaus' leadership, to obtain and consider the opinions of the affected people. This was a significant departure from an earlier decision by EPA to discontinue NESHAP development based on the conclusion that BAT controls were already planned. This public involvement affected the regulatory process in several ways. First, the extensive local involvement in the process resulted in increased understanding by EPA of the variations in daily operations of the smelter which were not necessarily evident during brief on-site inspections. This experience showed EPA the value of local involvement and the need for EPA local partnership in the NESHAP process. Second, once the benefits, risks, and uncertainty associated with alternatives were described to the public the majority of those commenting on the standard tended to make decisions similar to those made by EPA.

FRAMEWORK FOR ACID DEPOSITION DECISION MAKING

William E. Balson*, D. Warner North* and
Richard Richels**

Decision Focus Incorporated*
Los Altos, California
Electric Power Research Institute**

ABSTRACT

Acid precipitation and dry deposition of acid materials have emerged as an important environmental issue. This paper presents a framework for the analysis of decisions on acid deposition. The decision framework is intended as a means of summarizing scientific information and uncertainties on the relation between emissions from electric utilities and other sources, acid deposition, and impacts on ecological systems. The methodology for implementing the framework is that of decision analysis, which proves a quantitative means of analyzing decisions under uncertainty. The decisions of interest include reductions in sulfur oxide and other emissions thought to be precursors of acid deposition, mitigation of acid deposition impacts through means such as liming of waterways and soils, and choice of strategies for research.

The paper review two versions of a decision tree model that implements the decision framework. The basic decision tree addressed decisions on emissions control and mitigation in the immediate future and a decade hence, and it includes uncertainties in the long-range transport and ecological impacts. The research emphasis decision tree addresses the effect of research funding on obtaining new information as the basis for future decisions.

KEY WORDS: Decision Analysis, Methodology, Acid Rain, Acid Deposition, Decision Tree, Research, Air Pollution

INTRODUCTION

The terms "acid rain" and "acid precipitation" are used to describe the complex chemical changes that result from the presence of oxides of sulfur, oxides of nitrogen, and other compounds in the air that may lead to increased acidity in precipitation, in ground and surface waters, and in soil. A more comprehensive and accurate term is "acid deposition," since the transfer of acid material from the atmosphere to the biosphere may occur not only in the aqueous phase, (e.g., rain snow, fog) but also as dry deposition, in which gaseous or particulate material is absorbed by the ground, vegatation, or surface water.

As the debate on acid deposition has intensified, the need for an integrating framework for balancing the potential environmental effects with the costs of emissions control has grown. Industry and government are faced with the immediate decision of whether to (1) impose additional controls on power plants and other potential sources, (2) take steps to mitigate the possible effects of acid deposition, or (3) wait until additional understanding can be achieved on the relationship between emissions and ecological effects. The choice involves the careful balancing of very different types of risks. Acting now to reduce emissions carries the risk that large expenditures will be made with little or no beneficial effect, while waiting carries the risk that significant ecological damage will be incurred that could have been prevented by prompt action.

If the results of the extensive research programs underway in the United States, Canada, and Europe were available today, the choice might be less difficult. But unfortunately, resolution of crucial uncertainties may not occur for five to ten years or longer. Until that time, it will not be possible to predict accurately how changes in emissions will affect the extent of ecological damage from acid deposition. In the absence of perfect foresight, what is needed is a means of reasoning about the best decision based on the information available today.

The object of the research reported in this paper has been to develop a framework to summarize current information and uncertainties on acid deposition. The framework is intended to aid decisionmakers in assessing strategies for control of anthropogenic emissions and for mitigating the effects of acid deposition. The framework is also intended to aid in the evaluation of research programs for organizations such as the Electric Power Research Institute or the United States Government, which are spending substantial funds to develop better information as a basis for future decisions.

OVERVIEW OF THE DECISION FRAMEWORK

To understand the effects of alternative control strategies, it is necessary to understand the relation that various levels of emissions reduction may have on the impacts of acid deposition. The potential changes in impact must then be balanced with the cost of achieving emission reductions. The comparison of various control strategies is made difficult by several factors:

- There is a large degree of uncertainty about the relationship between emissions and impacts.
- It is difficult to compare the value of changes in impacts with the costs of emission reductions.
- People involved in assessing control and mitigation strategies have different degrees of uncertainty and different opinions about the evaluation of costs and impacts.
- The uncertainty in the relationship between emissions and impacts will only resolve over time.

The decision framework is designed to allow explicit treatment of each of these factors, separating the evaluation of costs and impacts from consideration of the resolution of uncertainty over time. In doing this, the framework provides a vehicle for discussion and investigation of sensitive assumptions, which can lead to the building of a concensus.

Three stages can be distinguished in the relationship between control alternatives and impacts, as shown in figure 1. First, there is the effect that control strategies will have on emissions. Then, changes in emissions must be related to changes in acid deposition. Finally, changes in acid deposition must be related to changes in the various impacts that can be identified, such as decreased forest productivity and the loss of sport fisheries. There is scientific uncertainty about each of these stages. Relatively little is known about how specific changes in acid deposition will affect changes in impacts. The range of estimates given by respected scientist varies by several orders of magnitude. There is somewhat less uncertainty regarding how changes in emissions will affect changes in deposition; however, the range of uncertainty is still quite large, primarily due to the complex nature of the chemical transformations that occur in the atmosphere. There is comparatively little uncertainty about how reduction strategies would affect changes in emissions. Accordingly, in implementing the framework the importance of uncertainty in the other two stages has been stressed.

At present, the scientific evidence regarding the effects of emissions is contradictory and subject to different interpretations by various experts. The decision framework allows an investigation of the implications of the differing assessments and evaluates the importance of the disagreements in terms of their effects on the choice of a control or mitigation strategy. Many experts who disagree about the interpretation of the current state of knowledge, agree that in five to ten years many of those disagreements will be settled. Thus, in the decision framework, the choice is characterized as one in which we may act now, at a large cost, and accept the possibility that emission reduction will have little beneficial impact. Alternatively, we can wait five to ten years to act on better information that may become available, and accept the possibility that damage may occur during that period. In each case, there is a possibility that the decision will turn out to have been incorrect. From our current state of knowledge, we cannot be sure.

The strategies that are available and the resolution of uncertainty at different points in time are represented as a decision tree in figure 2. A decision tree is simply an effective way of describing a set of scenarios. Each particular set of decisions and outcomes representing how uncertainty could resolve comprises a scenario. Each scenario answers a "what if?" question corresponding to what if a particular strategy was chosen followed by a particular change in deposition and finally by a particular change in impacts. The decision tree of figure 2 provides a generic representation of the time sequence of choices among decision alternatives and the resolution of uncertainty in the areas enumerated in

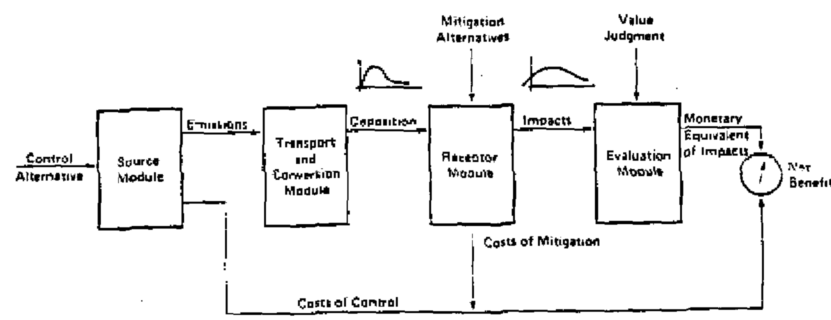


Figure 1

Overview of Decision Framework

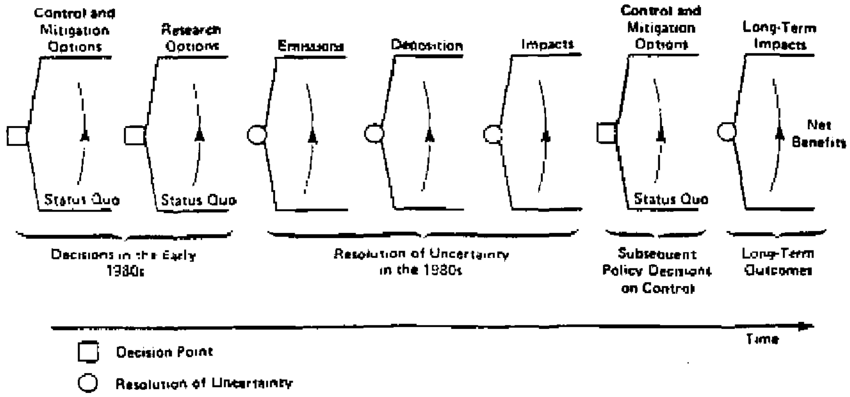


Figure 2

Decision Tree for Acid Deposition Policy

the framework of figure 1. The first two stages, shown at the far left of the figure, are the decisions within the next few years on control and mitigation options and on a national research program on acid deposition. The next two stages represent resolution of uncertainty on the relation of deposition to emissions and the relation of impacts to deposition as the research program is carried out and new scientific knowledge is obtained. Next comes a decision point in the early 1990's, when national policy on control and mitigation would be reassessed and an alternative chosen on the basis of the new information that has recently been made available. Further resolution of uncertainty on deposition, and impacts of acid deposition then follows. Additional uncertainties can easily be introduced.

The decision tree of figure 2 provides a rich sequence of scenarios describing the decisions and outcomes characterizing national policy on acid rain. It includes two stages of decisionmaking, one with present information and one with the information that might become available five to ten years hence following an extensive research program. The decision tree explicitly includes the option of taking action now to control emissions or mitigate the effects of acid deposition and the option to wait until better information becomes available in five to ten years. The effect of today's research funding decisions and the choice of emphasis in the research program may strongly affect what information becomes available in the next five to ten years, and this interaction is explicitly considered in the decision tree framework. The decision framework provides a useful separation between value judgments on costs and benefits and scientific judgments about uncertainties in the impacts of acid deposition. Each scenario in the decision tree may be considered as having impacts on a number of concerned parties: consumers who may have pay more for electricity because of decisions to impose controls on power plants, fishermen and recreational property owners who stand to lose if sport fishing in a given lake is degraded by acid deposition, forest products firms and property owners who suffer economic losses if forest productivity is reduced, and members of the general public who are concerned about possible ecological changes from acid deposition. The evaluation of impacts on these diverse parties is difficult because people see that some parties bear more of the costs while other parties receive more of the benefits resulting from a particular decision alternative. People in Ohio benefit from cheaper electricity because their power plants burn coal with a higher level of sulfur emissions than would be allowed in many other Eastern states. People in New York may benefit from reduction in Ohio River Valley sulfur emissions if the reduction improves the fishing in Adirondack lakes. The political reality is that government officials must evaluate how tradeoffs will be made between the costs that one group bears and the benefits that another group receives. Issues of equity and property rights make such value judgments extremely difficult. It is useful to separate these value judgments from the uncertainty in the effects that long-range transport of sulfur and other pollutants may cause. The decision framework accomplishes this desired separation between the answer to the question of what will happen under a given choice of control and mitigation strategies and the societal evaluation of what each outcome is worth.

IMPLEMENTATION OF THE DECISION FRAMEWORK

The decision framework has been implemented as a computer model that represents a set of decision trees that are fast, flexible, and easily used. The model is designed to run on both mainframe computers and the IBM-PC. Two decision trees are available. Both are based on the structure shown in figure 2. The basic tree, illustrated in figure 3, assumes that uncertainty on the relation of emissions to deposition and on the extent of ecological impacts will be resolved by the second decision point five to ten years from now. This basic tree can be used to quickly evaluate strategies and calculate the value of achieving full resolution of uncertainty. The research emphasis decision tree, illustrated in figure 4, allows an explicit characterization of the results of research programs. While this tree is more complex, it allows the investigation of

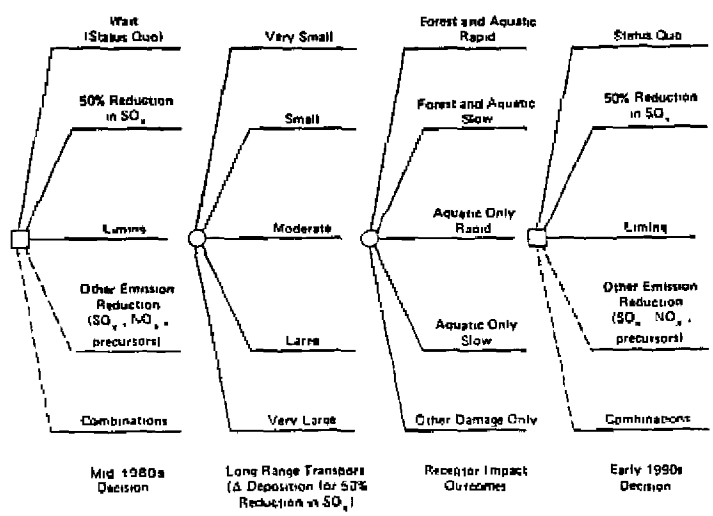


Figure 3

Decision Tree with Full Resolution of Uncertainty by the Early 1990s

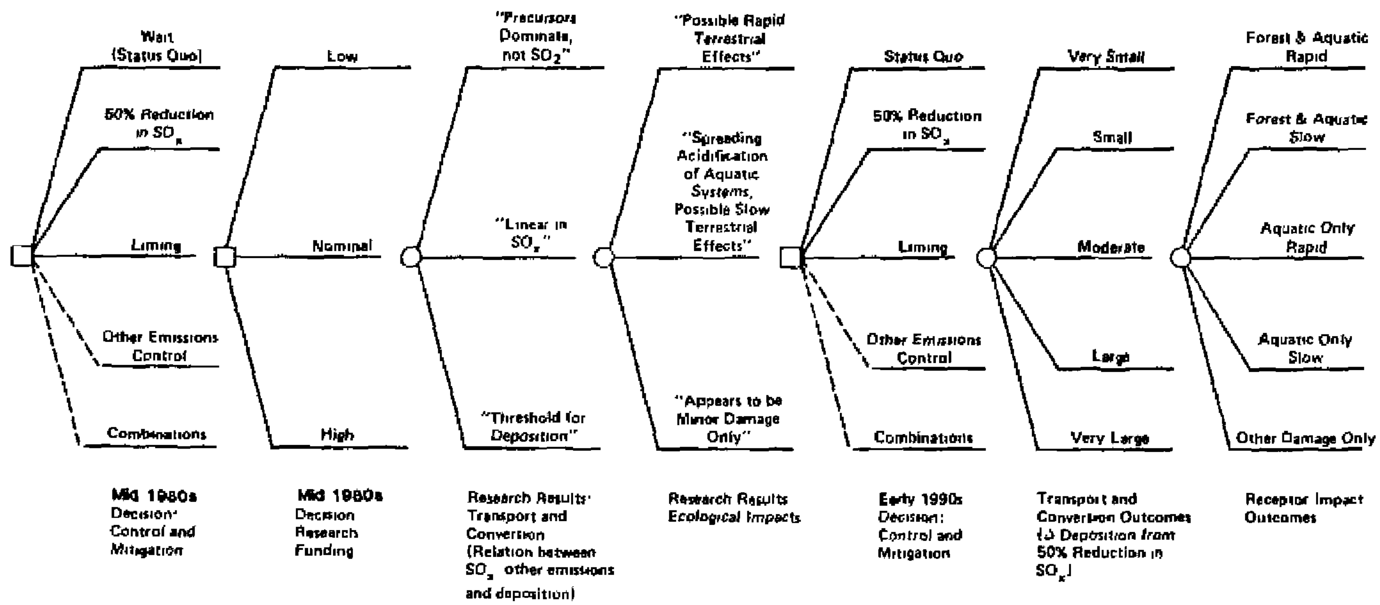


Figure 4

Decision Tree with Resolution of Uncertainty Dependent on Research Funding Decision research alternatives that result in partial resolution of uncertainty. Both decision trees utilize the same basic assumptions and evaluations, the only difference being the extent of scientific judgment required to understand how uncertainty will resolve over time.

The relations are built up from simple modules that are easily understood graphically. The reduction in emissions resulting from a specific strategy is phased in over time. Various assumptions about the change in deposition that results from a change in emissions can be utilized. The pattern of lake and forest acidification that occurs can be varied. Each of these relationships can be changed within a wide range of possibilities and each is modular so that it can be replaced by an entirely different set of assumptions if desired. For example, the module that calculates the reduction in emissions could be replaced by a specific time pattern of emissions that is input by the user.

The decision framework can aid in generating concensus by testing a wide range of assumptions for their importance to control decisions. The implementation of the framework as a computer model aids this testing process by making changes in assumptions straightforward. The model has been tested on several illustrative cases examining both national and state acid deposition control alternatives.

ACKNOWLEDGEMENTS

This work was sponsored by the Electric Power Research Institute. Portions of this paper have appeared elsewhere. Any opinions expressed are those of the authors alone.

REFERENCES

Balson, W. E., Boyd, D. W. and North, D. W., 1982. "Acid Deposition: Decision Framework--Volume 1: Description of Conceptual Framework and Decision Tree Models--Final Report (RP 2156)," EPRI EA-2540, Palo Alto, CA, Electric Power Research Institute, August.

Balson, W. E. and North, D. W., 1983. "Acid Deposition: Decision Framework--Volume 3: State-level Application--Final Report (RP 2156)," EPRI EA-2540, Palo Alto, CA, Electric Power Research Institute, December.

Balson, W. E., North, D. W. and Colville, G., 1985. "Analysis of Sulfur Dioxide Control Strategies Related to Acid Deposition in Wisconsin--Volume I," Wisconsin Utilities Acid Deposition Task Force, Milwaukee, WI, May.