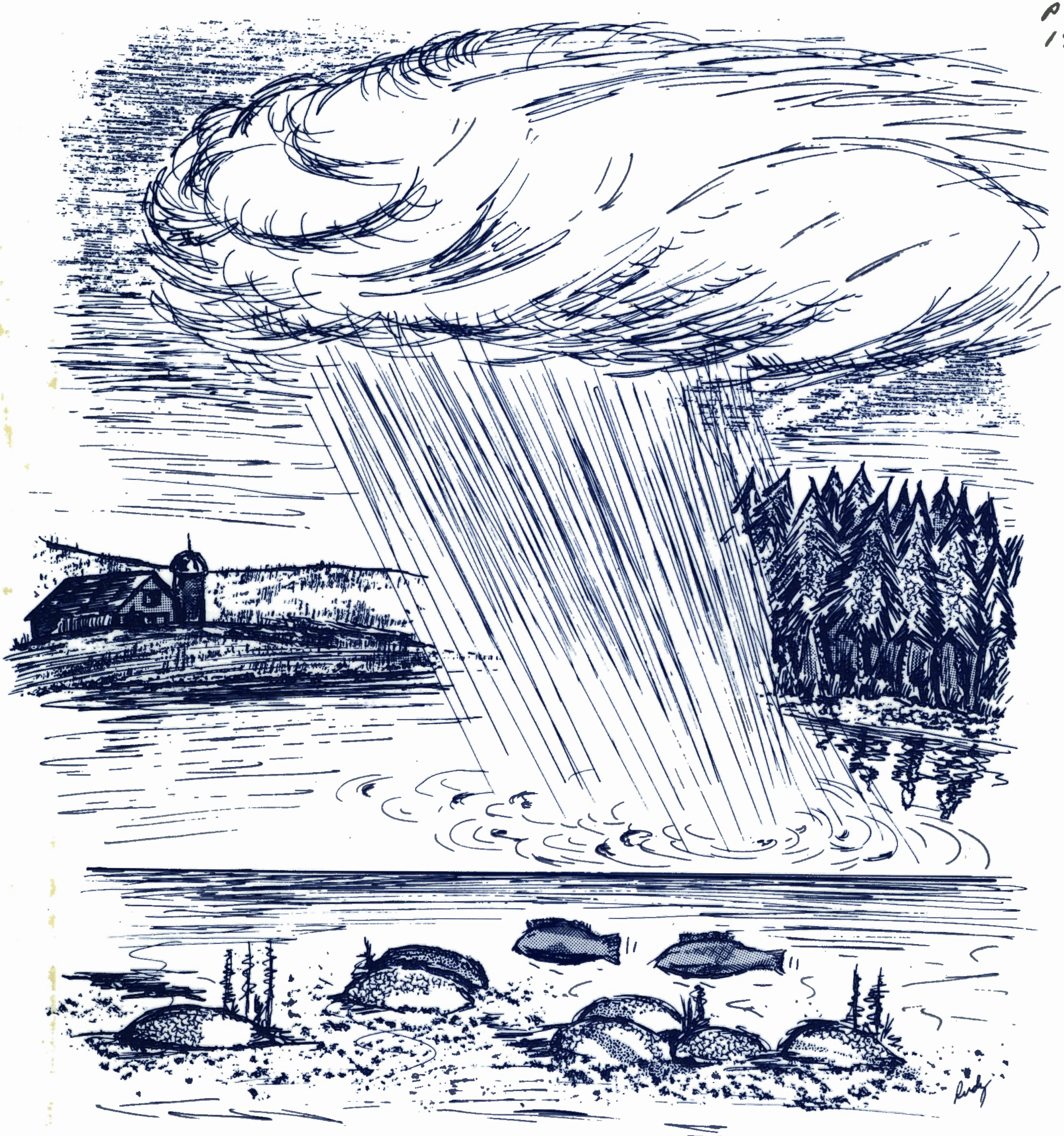
The Effects of Acid Rain in New Jersey



State of New Jersey

The Effects of Acid Rain in New Jersey

State of New Jersey

Report of Public Hearing

T H E   E F F E C T S   O F   A C I D   R A I N
I N   N E W   J E R S E Y

Sponsored by the

New Jersey Clean Air Council

and the

Governor's Science Advisory Committee

October 17, 1983

in the

State Museum Auditorium - Trenton, New Jersey

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APPENDICES (NOT ATTACHED)

1. Official Transcript (available from court reporter)
2. Prepared Testimony (available from DEP)

I. INTRODUCTION

Acid rain, more accurately described as acid deposition, has been implicated in the destruction of fish and plant life; the contamination of drinking water supplies through the leaching of heavy metals from soil, sediment and plumbing; the accelerated weathering of buildings, bridges and monuments; the aggravation of respiratory disease; and the reduction of visibility. Although they have become an issue of national concern, the ecological effects of acid deposition are primarily a problem in the Northeast because the region's soils and bedrock lack the capacity to neutralize increased acidity and because the region is downwind from a major source area of precursor pollutants.

Acid deposition results mainly from the transformation and transport of sulfur dioxide and various nitrogen oxide gases released into the atmosphere during fuel combustion. The resulting compounds can be transformed and deposited as dry particulate matter or in wet precipitation in the form of rain, fog, snow, sleet and hail. The most prevalent compounds of acid deposition are sulfuric acid, ammonium bisulfate and ammonium sulfate. In the Northeast, the sulfur component of acid deposition is dominant; however, the nitrogen component is particularly important during snow melt.

DEP reports, based upon emissions inventory data, that the major sources of acid rain in the eastern United States appear to be electrical generating facilities in the Midwest, an area which contributed 73% of the 15 million tons of sulfur dioxide emitted in states east of the Mississippi in 1978. Ohio alone contributed 17% of the total. By contrast, New Jersey emitted 0.6%; however, New Jersey does import approximately one third of its power from other states in the region.

When acidity is measured by the system called the pH scale, neutral is pH 7 and increasing acidity corresponds to decreasing pH values. Normal rainfall has a pH of approximately 5.6, due to the natural presence of carbonic acid in the atmosphere. Generally, rainfall that averages less than 4.6 is considered critical for surface waters in regions sensitive to acid deposition. New Jersey has several susceptible regions including the Pinelands in southern New Jersey and the Kittatinny Mountain Ridge, the Watchung Mountains and other highland areas in the northwest part of the state. Rainfall with an average pH level lower than 4.6 has been observed in New Jersey, making it a candidate for acid rain effects.

In order to study the effects of acid deposition in New Jersey, the New Jersey Clean Air Council (CAC) and the Governor's Science Advisory Committee (GSAC) co-sponsored a public hearing entitled, "The Effects of Acid Rain in New Jersey" in the State Museum Auditorium in Trenton on October 17, 1983. These groups held a joint hearing because they have a common interest. The CAC, an advisory body to the Commissioner of the Department of Environmental Protection, is required by law to hold a public hearing on a topic related to air pollution control at least once a year and report its findings and recommendations. Over the years one of the areas of intense interest to CAC has been acid rain. In response to a request to GSAC embodied in a legislative resolution, GSAC has underway a review of the data on the effects of acid deposition in New Jersey. While GSAC was authorized to use various resources of the state government in this review, no specific funding was authorized for it. Thus, the joint hearing with CAC was useful to GSAC in fulfilling its mandate.

Although the public was invited to participate in the forum, the two groups focused on securing expert testimony based upon scientific studies conducted in New Jersey. When such studies were not available, data from studies that were conducted elsewhere with results applicable to New Jersey were reported. The hearing committee also asked for recommendations on areas of future study and on abatement strategies.

The report presented here includes a summary of the testimony, a list of conclusions and a list of recommendations. Both the hearing transcript and the written papers submitted at the hearing can be inspected by contacting Mr. John Elston, Acid Rain Coordinator, Division of Environmental Quality, DEP, CN 027, Trenton, New Jersey 08625. The phone number is (609) 292-6710.

The hearing officers from CAC were Dr. Paul J. Lioy (Co-Chairman), Dr. Wesley Van Pelt, and Mr. Irwin S. Zonis. From GSAC, the hearing officers were Dr. Donald F. Nelson (Co-Chairman) and Professor Frank Haughey. The conclusions and the recommendations of this report reflect those received at the hearing and evaluated by the hearing officers.

II. CONCLUSIONS

1. The annual average acidity of precipitation expressed in pH units was about 4.3 in New Jersey in 1980. All of the cases in the Northeastern United States where acidification of surface waters has occurred are in areas where precipitation pH averages 4.6 or less and where the soil and geologic materials have little capacity to neutralize precipitation acidity. Thus surface waters in some areas of New Jersey such as the Pine Barrens, the North Central Highlands and the Kittatinny Mountain ridges are in danger of acidification from acid precipitation.

2. Data on New Jersey streams and lakes are mostly of recent origin and are insufficient to establish long-term trends in acidification or to establish causes of acidification. In the Pine Barrens, a 20 year study of two streams has shown signs, but not indisputable signs, of acidification from acid deposition. Recent sampling studies have shown two lakes in the Pine Barrens and two in the Kittatinny Mountains to be very acidic; they also showed two lakes and three reservoirs in Northwest New Jersey to be endangered, that is, to have a low buffering capacity although not significantly acidic. Of 31 streams sampled, most were well buffered and should be resistant to the effects of acid deposition; at most four could be said to be endangered. Collation of a large set of water quality data for New Jersey from many different sources has indicated a trend toward acidification in about 1% of the sampling stations, but has also revealed an opposite trend toward increasing alkalinity at a somewhat larger number of stations. Trends

toward alkalinization are often associated with nearby urban development.

3. The recent National Academy of Sciences Report on Acid Deposition concludes that the amount of acid deposition is linearly related to the amount of sulfur emitted into the atmosphere when averaged over a large region and over a year. Thus an emission abatement program that reduces emissions by 50% would be expected to reduce deposition by 50%. Such a reduction could be expected to raise the pH level of rain in New Jersey by 0.3, for example, from 4.3 to 4.6. As stated above, the latter pH level of precipitation would pose little likelihood of acidification of surface water in New Jersey.

4. It is important to avoid acidification of potable water supplies, since acidic water can dissolve various toxic metals. Lead and cadmium, widely deposited from air pollution, can be mobilized in acidic water. Aluminum has been leached by acidic water from the soil in some locations to levels that endanger some fish species and which, in potable water, would exceed the safe level set for use in kidney dialysis. Acidic water can dissolve lead and copper from pipes in the distribution system. The City of Boston spends $1 million per year to neutralize its water supply in order to reduce the amount of lead dissolved from distribution pipes to an acceptable level.

5. Tree ring studies at 20 sites in the Pine Barrens, along with others in Pennsylvania, New York and Connecticut, show a dramatic reduction in growth beginning in the late 1950's and continuing to the present. It is believed that drought may have been the triggering stress, but, since previous droughts did not cause a sustained reduction in growth, an additional continuing stress on the trees is hypothesized. The nature of this additional stress is presently undetermined. Acid deposition, however, is one candidate.

6. Little is known about the effect of acid deposition on the many agricultural crops of New Jersey. For one variety of soybean (cultivar Amsoy), however, experiments have shown that an 11.7 percent reduction in crop yield resulted from controlled dosing of the plants with rain of pH 4.1, compared to pH 5.6, the nominal value for unpolluted rain. To the extent that this variety has been planted in New Jersey, there has been some economic loss. Such loss, however, can be avoided if another variety (cultivar Williams) is planted, since it has been found to be unaffected by acid rain.

7. Acid sulfate aerosols have been implicated by epidemiological and laboratory studies on both human volunteers and experimental animals with various respiratory health effects particularly in sensitive individuals, i.e., children, asthmatics and the elderly. Studies on respiratory mechanics have shown effects at concentrations of 1000 ug/m^3 or higher. However, the rate of particle clearance from the lung has been affected with exposures as low as one tenth of this amount. Since peak atmospheric concentrations have been observed to be as high

as one half of the latter exposures, further experimental studies of chronic exposures to these levels are needed.

8. Acid deposition causes accelerated weathering of buildings, bridges, and monuments. There is not, however, sufficient information available at present to estimate the economic loss now occurring in New Jersey from this effect.

9. Testimony was solicited on the costs to New Jersey's citizens for measures designed to reduce acid deposition on a multistate basis. Limited data were presented concerning the proposed 50% reduction of emissions from east of the Mississippi River. It indicated that the cost of electric power in New Jersey would increase by an amount of $130 million to $275 million per year. The focus of the hearing was not primarily centered on this "effect" of acid rain, and CAC and GSAC have concluded that it would be premature to arrive at a formal conclusion concerning control strategies.

III. RECOMMENDATIONS

All of the discussions at the hearing underlined the need for continued improvement in our understanding of long-range transport, source-receptor relationships and apportionment of sulfur oxides and nitrogen oxides to sources, all of which are subjects not specifically addressed at the hearing.

The specific testimony provided on the issue of acid deposition focused attention on the major needs of a coordinated research and monitoring program. Such a program would take the form of studies that are specific to potential or suspected problems in New Jersey, and studies that are focused on problems which could impact generally on locations throughout the Northeast. The following are separated along those two lines.

1. New Jersey's potential acid deposition problems require the following:

    a. Gather and analyze available historical records for soils, streams, lakes, and reservoirs to determine if there has been a significant change in acidity and related parameters over time. These analyses would provide a basis for comparison with new data and indicate needs for further studies to identify any influence caused by acid rain.

    b. Design a controlled experiment to determine how various adverse stresses affect the growth of trees such as the pitch or short leaf pine in New Jersey. Examine both mature trees and a group of seedlings given different degrees of initial chronic or acute stresses such as acid rain, ozone, drought, etc. for an extended duration, greater than 5 years.

c. Gather information on the quantities, types and varieties of commercial crops grown in New Jersey. Subsequently, assess their likely sensitivity to acidic deposition and develop a priority list for research. Choose those crops which are particularly important to New Jersey and which could potentially be the most affected and conduct control studies for the identification of the extent of any effects.

d. Develop a long-term monitoring strategy for a limited number of endangered reservoirs. This would include measuring water pH, toxic elements, and major ions (sulfate and nitrate). The study must be conducted for at least ten years to examine any possible changes in water quality due to further insults by acid rain, or improvements resulting from the introduction of further controls on sources.

e. Design an epidemiological study that would look for the health effects coincident with the occurrence of acidic sulfate and other irritant species. The study should be conducted using sensitive individuals (asthmatics, elderly, or children), and be done at urban, rural and suburban locations. Comparisons with continuing clinical and/or toxicological studies should also be made.

f. Conduct a study to determine if potable well water supplies are experiencing increases in toxic elements due to acidic deposition (leaching). Long-term investigations should focus on two areas: 1) areas potentially affected by hazardous waste dump sites, and 2) areas where there is a tendency to have low buffering capacity in the soil.

g. Develop quantitative data through field studies on the effects of acidity on fisheries in natural aquatic systems. Such studies should focus on a number of game species and should include species distribution, population status and trends, and the sensitivity of their reproduction and rate of growth to acidity of the water. Naturally reproductive and artificially stocked bodies of water should be assayed. Chemical analysis on both the water and the fish species should be conducted. This study should become part of the routine monitoring program of the DEP Division of Fish, Game and Wildlife.

2. The regional problems of acidic deposition would appear to be associated with soil chemistry, materials degradation, the mixture between dry and wet deposition, and alteration of ecosystems (fish, etc.). Financial resources for the broader questions identified in the preceeding should be sought from various agencies in the federal government. In addition, the State must continue efforts to have areas in the state designated for use as sites in major monitoring and research studies on acid

rain, such as those conducted by EPA or National Oceanographic and Atmospheric Administration. Historical records on materials degradation should be utilized for an appreciation of effects in areas with long-term pollution records.

Funding Recommendations

Unfortunately, the constraints placed upon the Federal programs and the additional constraints usually associated with state programs (year to year funding of research) make all of the above difficult to accomplish, even using a stepwise approach for implementation. Therefore, to accomplish the important task of determining the effects of acid rain both in the near future and after any control strategy is implemented, a more stable funding mechanism is required. The recommended approach is the creation of an Institute for Environmental Research, which would have as one of its major tasks research on the problems of acidic deposition in the northeast. This institute should be funded by a consortium of northeastern States, industries and other private organizations. Its purpose would be to address the scientific issues of environmental problems, such as acid rain, in a timely and consistent manner. This institute could be used to address both local and regional issues. However, it must also be given a charter broad enough to obtain an overall understanding of any environmentally related problem. This is especially true of acid rain.

CAC Recommendation on Controls

Though no attempt was made in the hearing to evaluate the issue of further emission controls, CAC through its long experience with, and knowledge of, air pollution in New Jersey makes this further recommendation:

The State of New Jersey has very stringent regulations on the levels of sulfur in fuels burned for energy and heating within the State. However, since our state receives acid rain and has areas that are sensitive to the effects of acid rain, further reductions in emissions are desirable. Any control strategies implemented to reduce sulfur emissions must be directed to those states that are emitting the largest quantities of sulfur. Further restrictions on the sulfur levels in fuels burned within New Jersey would be inequitable.

IV. SUMMARY OF TESTIMONY

Twenty six people submitted testimony at the hearing - five in writing only (see Table 1). Opening remarks were provided by State Senator Walter E. Foran, sponsor of legislation committing $100,000 for the study of acid rain; Assemblywoman Maureen B. Ogden, sponsor of several pieces of acid rain legislation; and Paul H. Arbesman, Deputy Commissioner of DEP. Ten speakers participated in the seven invited presentations, and eight spoke for the public. Their comments covered the areas of environmental effects, health effects, control technology, public policy, economic impact and public participation. Organization of the testimony by subject and project location is found in Table 2.

A. <u>WATER</u>

Six people testified on the effects of acid deposition on aquatic systems. Most of them indicated that acid deposition may be causing increased acidity of lakes and streams in New Jersey.

According to Dr. George Hendrey of Brookhaven National Laboratory, who is conducting a national acid rain study for the Environmental Protection Agency, the waters in large areas of the eastern section of the United States are experiencing increased acidification and a loss of buffering capacity. All affected areas received rainfall averaging pH 4.6 or less (see Figure 1). Precipitation data taken in 1980 show New Jersey with an average pH of 4.3. Dr. Hendrey also pointed out that over the last ten years, sulfur concentrations have been declining, but this fact does not mean that sensitive lakes have stopped being acidified or that the potential problem of soil acidification has been ameliorated.

Although the receiving waters in some areas show signs of <u>reduced</u> acidity, Dr. Hendrey stated that they may be subject to local causes such as urban development and agricultural liming. The regional picture, however, shows unmistakable signs of increasing acidification. He believes the evidence documenting the increased acidification is "overwhelming" and stated in his accompanying written testimony that "no counterargument has been put forward which explains acidification in these areas as well as does acid deposition."

Dr. Hendrey also spoke about the effect of acidification on animal and plant life in lakes. Although stressing that no lake is ever dead, he said that each experiences changes in the relative numbers and types of organisms. There is a progressive decline in fish life related to each species' sensitivity to a particular pH level, matched by a decline in the animals and plants which form their food supply, and the bacteria which play an important part in the function of an aquatic system.

Although liming can be used to mitigate the effects of acid rain in lakes, Dr. Hendrey referred to it as "a Disneyland approach" because it creates an artificial environment which must be constantly maintained.

Professor Arthur Johnson of the University of Pennsylvania supported Dr. Hendrey's contention that acid deposition has acidified lakes and streams with low buffering capacity in the eastern United States. His studies of McDonald's Branch and Oyster Creek, two streams in a pristine area of the Pinelands, suggest this effect, which he said probably occurs in other small, wet areas in the Pinelands but cannot be extrapolated to other areas of the State.

Professor Johnson documented two trends in the Pinelands. The first, between 1963 and 1978, indicates that stream pH values of less than 4 increased in frequency after 1971 and that pH values of less than 3.5 appeared after that date. The trend was reversed between 1978 and 1981. Factors involved with the reversal could be high stream flow or precipitation with higher pH values, resulting from a recession-induced reduction in industrial activity and coal-fired power generation.

In commenting on sources of acid precipitation in the Pinelands, Dr. Johnson referred to a study that he and a colleague at Drexel University carried out over a 3½ year period. Their analysis of the air parcel trajectories involved in 20 storms suggest to him that local sources in the Washington-Philadelphia corridor, as well as distant sources in the Ohio Valley, are implicated in acid precipitation in the Pinelands.

Dr. Johnson agreed with Dr. Hendrey that acidification studies in the Northeast showed that "all of the cases where acidification has occurred are in areas where the soils and geologic materials have little capacity to neutralize precipitation acidity, and where precipitation pH averages 4.6 or less." He concluded, based on average precipitation pH in New Jersey and on the recent National Academy of Science report, which showed a direct (linear) relation between source emissions and acid deposition, that a 50% reduction in emissions would raise pH levels in New Jersey to 4.6 or higher, that is, outside the critical range.

Recommending areas for future study, he suggested identification of the pathways by which water flows to stream channels in the Pinelands and the quantification of processes which generate and consume acidity along the way. He also suggested setting up research stations in small headwater areas in both the northern and southern parts of the state which would include studies of dry deposition.

George Kish, a hydrologist with the United States Geological Survey, (USGS) supported Professor Johnson's contention that surface waters in the Pinelands may be susceptible to acidification. In 1982, he undertook a cursory review of 100 stream sites in a joint USGS-DEP cooperative sampling program and found that 13 exhibited increased acidity over a seven year period. He stated that the trends need additional verification. Although a similar trend is not apparent in groundwater, he believes more emphasis should be placed on understanding how groundwater is affected by acid deposition.

Mr. Kish was particularly concerned about the leaching of toxic metals from soils in the Pinelands. He stated that there is a correlation between high levels of aluminum, low pH, and dissolved humus in streams. In addition, he noted that trace metals (such as lead and cadium) deposited in dry form might be dissolved in acidic water. This is of significant concern in urbanized areas such as New Jersey.

Professor Mark Morgan of Rutgers explained that the acidity of water in the Pinelands is caused by natural processes and changes as the water passes through various levels of soil. At first, the water is acidified by natural processes such as the dissolution of humic acids; then, as it passes through bog sediments, it becomes more alkaline. When the water returns to the surface and enters a stream, it is reacidified by natural processes.

Dr. Morgan then questioned whether these naturally acidic waters were becoming more acidic as a result of atmospheric deposition. In contrast to Prof. Johnson, he concluded that over the long run, they were not. Although he agreed with Professor Johnson's findings that water in the Pine Barrens became more acidic between 1963 and 1978, he contended that inclusion of the 1978 to 1982 data showing increased alkalinity indicates that there have been no long term changes in the pH of Pinelands surface waters. He further stated that "some sort of disturbance in the early 1960's" - perhaps a drought or the severe 1963 Pinelands fire - elevated pH, which then gradually returned to more normal levels.

Dr. Morgan recommended a research project that would re-examine the sites used in a 1970-72 study and compare the two sets of data on surface water and precipitation chemistry. He also recommended studying the acid tolerance limits of key Pine Barren species and the interaction of heavy metals and humic acids.

Dr. Alan McIntosh and Dr. Samuel Faust of Rutgers University gave a two-part presentation which reviewed the effects of acid deposition on surface water, fish, and mobilization of toxic metals.

Discussing areas in the state which may suffer long-term changes because of watershed characteristics, Dr. McIntosh referred to the Kittatinny Mountains in northern New Jersey, the Highlands in the central part of the state, and the Pinelands in the South. He and Dr. Faust have undertaken several studies of bodies of water in sensitive areas. They looked at 31 trout streams in the State, and found that most were adequately buffered. They identified five lakes, three of which are reservoirs, as being "endangered" because of their low neutralizing capacity, and recently started a study of three acidic ponds in the Kittatinny Mountains.

Regarding the effects of acid deposition on fish in New Jersey, Dr. McIntosh stated that we do not have enough information to draw conclusions, but laboratory experiments indicate that low pH can affect the blood chemistry, respiratory functions and reproductive processes of fish. His observations in the Kittatinny Mountains substantiate findings in the literature which indicate that Yellow Perch can tolerate pH values as low as 4.2. (whereas populations of other species would not be able to tolerate such low pH values.)

Both men referred to the release of toxic and hazardous metals as a potential problem related to acid deposition, and Dr. McIntosh said they are investigating cadmium, zinc, and lead levels in the three Kittatinny lakes.

Dr. McIntosh recommended the development of a program to collect background chemical and biological data from surface waters where long term changes may occur and suggested a study of small sensitive and non-sensitive watersheds in the northern and southern parts of the state.

Dr. Faust said we need studies to determine the neutralizing capacity of lakes and soils in the State and indicated that clay in lake sediment (as well as limestone) has a neutralizing effect. He also described a graph he developed for describing the buffering capacity of lakes and called for the development of a mathematical model to predict future impacts and the amount of time we have before our lakes become permanently acidified.

Dr. Robert Goldstein of the Environmental Assessment Program of the Electric Power Research Institute (EPRI) appears to have the model which Dr. Faust feels is required to assess lakes. This sophisticated model, an integrated perspective of a watershed's vulnerability to acid deposition, was developed by EPRI as part of a study of Adirondack Lakes and considers factors such as rainfall, sediment, snowpack, soil, vegetation canopy, watershed hydrology and chemistry, and the weathering potential of soils and rocks. The EPRI study indicates that soil depth plays a major role in the differing manner in which two Adirondack lakes respond to acid precipitation. New Jersey could utilize the model once it developed its own data, but the study would cost roughly $300,000.00 for one lake.

B. LAND

Forests

There does not appear to be any conclusive evidence that acid deposition is affecting forest growth in New Jersey. Professor Johnson has carried out studies in the Pinelands which demonstrate a dramatic growth decrease in pitch and short leaf pine. This began in the 1950's and has continued to the present time. Studies in New England and Germany indicate a similar decline in spruce, and he suspects that a combination of environmental stresses, including drought, may be responsible. There may, however, be a contributing man-made stress such as acid rain, because studies of tree cores dating back to the 1600s do not indicate other patterns of sustained, reduced growth, triggered by droughts.

Professor Johnson also recommended further research on the cause of reduced growth. He suggested a controlled project to test the effects of ozone and acid deposition on pitch pine seedlings or field experiments with larger trees to see what factors can enhance drought stress.

Crops

Dr. George Hendrey testified on the results of a Brookhaven National Laboratory (BNL) study on soybeans dosed with simulated acid rain. When dosed with a solution of pH 4.1 (comparable to atmospheric levels at the growing site) one particular soybean variety (cultivar Amsoy) had a reduction in yield of 11.7%, compared to yields obtained at pH 5.6. Another variety (cultivar Williams) studied at BNL showed no effect. Although New Jersey has a large soybean crop (over 6 million bushels in 1978), the results of the studies may not be applicable here, since they only apply to two varieties of soybean. Other analyses indicate that at least 1% of the soybean crop in the country is lost because of acid rain, at a national cost of $50 million in 1979. It is believed that ozone in the lower atmosphere causes an even greater loss.

Dr. Hendrey recommended that New Jersey support field research to evaluate the effects of acid rain on crops and submitted figures indicating that suitable equipment to test one crop per year would cost $50,000 - $100,000, plus the salaries of two or three full-time researchers.

Soils

Although several researchers indicated that elements in the soil can neutralize the effects of acid deposition, they had little information on the effects the deposition can have on the soil itself.

Professor Johnson stated that both wet and dry acid deposition can accelerate the loss of nutrients from soils, but in most cases, probably not at consequential rates. In a paper he submitted with his testimony, he reported that in high elevation forests of Eastern North America some metals, particularly lead, accumulate in the soil at a rapid rate, probably as a result of atmospheric deposition.

Mr. Kish pointed out that forest litter reacts with such metals to produce organic-metal complexes which tend not to be transported in the hydrologic system. Acid deposition, however, tends to mobilize them. The removal of this covering, in combination with acid deposition, may cause increases in lead concentrations in shallow wells. The high lead concentrations observed in Berkeley Township and Beechwood Borough may be due to this effect.

Prof. Faust described a recent test of soil samples taken from various locations in New Jersey. The results of a comparison of a number of soil samples taken forty years ago with the new samples from the same sites do not indicate any consistent changes in soil acidity.

Dr. McIntosh indicated that New Jersey soils contain high levels of metals, but there is no evidence that acid deposition is a factor.

C. HEALTH

Four speakers discussed the possible adverse health effects of acid deposition - two from the standpoint of the inhalation of airborne particles such as sulfuric acid, ammonium sulfate and ammonium bisulfate and two from the standpoint of the ingestion of water drawn from acidified surface or ground sources.

Richard B. Schlesinger, Ph.D., of the Institute of Environmental Medicine at New York University Medical Center, reviewed the studies which scientists have carried out on population groups and in the laboratory in order to determine whether airborne sulfates have any effect on human health. Although he believes that the design of most of the studies are flawed, Dr. Schlesinger concluded that they suggest a deleterious effect on the respiratory system, particularly on lung function, with sensitive individuals, such as children, asthmatics, and the elderly being more susceptible than the rest of the population. Exercise also appears to enhance the response.

Most recent clinical studies involved exposing subjects to 1,000 ug/m^3 of sulfuric acid (as compared to 60 ug/m^3 - the highest level detected thus far in ambient air pollution studies on acid sulfates) and found no changes in respiratory mechanics. In contrast, studies conducted on humans and other species have shown effects of sulfuric acid (H_2SO_4) on the tracheobronchial mucocilliary clearance rates in the respiratory system at concentrations of 100 ug/m^3 for one hour exposure. Thus, they are near the highest ambient measurements that have been found for H_2SO_4.

Sulfuric acid appears to be the most potent of the three common sulfur oxide particles, followed by ammonium bisulfate and ammonium sulfate. Since sulfuric acid can cause changes in the lungs which are similar to those occurring in people who have chronic bronchitis, the pollutant may be a factor in causing that disease.

According to Linda Stansfield, Program Consultant for the American Lung Association of New Jersey, the effects of sulfur dioxide (a precursor to acid deposition) and sulfuric acid can "cause continuous and disabling symptoms among New Jersey's residents who are sensitive." Her testimony was based on a report entitled "Sulfuric Oxides and Public Health: Evidence of Public Risks" which was prepared for the American Lung Association by Kawecki Associates of Chevy Chase, Maryland. The report stated that one third of the mass of total fine particles in the air is composed of sulfates. Summer sulfuric acid levels in the northeast have on occasion exceeded 25 ug/m^3. (The relationship between SO_4^{-2} and acid sulfate species is dependent upon a number of factors.) According to the report, "duration of exposure, particle size, and chemical composition all appear to be important in determining changes in pulmonary function at low concentrations." The report also indicated that the elderly and persons with respiratory and cardiovascular disease are more susceptible to sulfate pollution than the general population.

The testimony of Floyd Taylor, Executive Director of the New England Water Works Association (NEWWA), indicates that continued acid deposition in the Pine Barrens could cause problems with the potable water supply of the region. The NEWWA sampled seven wells in the Pine Barrens as part of a study to determine the effects of acid deposition on public water supplies in New England and the Appalachian Mountain chain. Five of the seven wells showed indications of exhausted or nearly exhausted buffering capacity as well as corrosive water, although there are indications that they are "subject to acidic influences other than acid rain." Four of the wells also contain levels of aluminum, presumably caused by acidic leaching of soils. Thus the water from these wells would require treatment if used in kidney dialysis machines. This pattern of increased acidity, reduced buffering capacity, and greater aluminum content was repeated throughout the study area.

Mr. Taylor also reported that corrosive water had leached lead out of pipes and into the Boston water supply. Although there is no evidence that a similar problem exists in New Jersey (all seven wells tested met federal requirements for lead and cadmium), it presumably could occur in areas with lead piping, and not necessarily at very low pH levels, since measured levels in the Boston water supply were 5.8, 6.2 and 6.3. By comparison, the five wells in the New Jersey Study were more acidic, with levels ranging from 4.1 to 4.5. It costs Boston $1 million a year to add sodium hydroxide to the water supply to reduce the acidity which causes lead corrosion. Mr. Taylor reported that Scituate Reservoir, which supplies the City of Providence, Rhode Island, has had a steady drop in pH from 1937 to 1981, apparently due to acid deposition.

George M. Haskew, Jr., Executive Vice President of the Hackensack Water Company, submitted written testimony stating that his company had not found any changes in raw water supply attributable to acid rain. An accompanying table, summarizing pH levels between 1960 and 1982 indicated no increase in acidity for that water purveyor. The levels of pH in that water supply showed no acidity; all samples were alkaline with pH values ranging from 7.1 to 9.1.

George Kish, a hydrologist with the United States Geological Survey (USGS), also expressed concern over the leaching of toxic metals into water supplies in the Pinelands. He referred to studies in Sweden which indicate that copper, corroded from water pipes by acid water, caused health problems in consumers. Mr. Kish also said that aluminum, which may be a problem in some groundwater supplies in the Pinelands, has been implicated in Alzheimer's disease. (It is not known, however, whether it is a cause or effect.)

The USGS has allocated $270,000 for a three year study of the effects of acid deposition on groundwater supplies in the Pinelands but needs a matching grant to get the project underway.

The New Jersey Chapter of the Sierra Club submitted written testimony expressing its concern that acidic deposition could leach toxic materials out of landfills and reservoir sediments into groundwater and potable water supplies.

D. MATERIALS

Dr. T.E. Graedel of Bell Labs submitted written testimony in which he stated that acid deposition can cause materials damage. In order for effects to take place, both moisture and reactive molecules, such as sulfuric and nitric acid and their precursors, must be present. The nitrogen compounds can affect copper alloys, and the sulfur compounds attack steel and stonework as well. Soot probably accelerates the reaction.

Dr. Graedel added that is is not possible to say how much materials damage is caused by acid rain as compared to damage caused by other pollutants and natural agents. He said that New Jersey could aquire information on the problem by participating in national research, particularly since one of the national sites is located in Chester in Morris County. Important data could be derived from industrial sites and tombstones near existing DEP monitors.

E. ECONOMICS

Mr. John D. Feehan, Chief Executive Officer of the Atlantic City Electric Company, applauded the hearing committee for its scientific approach and urged it to be a voice for reasonableness. His concerns centered upon costly SO_2 abatement strategies that might be imposed on the electric power generation industry prior to obtaining an adequate understanding of the acid rain problem. In particular, he did not want to see a mandated return to burning low sulphur foreign oil since its supply has been proven subject to disruption and its price to extraordinary inflation.

Mr. Robert A. Geiger, Environmental Affairs Manager for Public Service Electric and Gas, spoke on behalf of three major New Jersey electric utilities, his company, Jersey Central Power and Light, and Atlantic City Electric. He stated that their position is that more research on cause and effects should be done before a costly reduction program is implemented.

Mr. Geiger then summarized the present status of electrical power generation for New Jersey users. He stated that 50% comes from gas, oil, and nuclear, 13% from coal burned in New Jersey, and 37% from coal burned ouside the state. He testified that in 1980 SO_2 emissions from New Jersey utilities represented only 35% of the total SO_2 emissions in the State, that New Jersey's SO_2 emissions per megawatt-hour were third lowest of the 27 states east of the Mississippi River, that a 70 to 80% reduction in ambient SO_2 levels have been achieved and maintained in New Jersey for the past decade at a considerable cost to the ratepayer, and that New Jersey is well within the State Implementation Plan.

Mr. Geiger then discussed the costs to New Jersey ratepayers of various SO_2 abatement proposals. Installation of scrubbers on the coal-fired plants that supply 37% of New Jersey's power would have cost our ratepayers $275 million in 1982, he testified. The comparable cost for switching to low sulphur coal would be a minimum of $180 million. A further concern, he said, is that the suppliers of this 37% of New Jersey's power might choose to close down the plants in order to meet emission standards. This would necessitate an increase in power generation and hence emissions in New Jersey. Mr. Geiger concluded by urging that any further control strategy provide credit for past reductions in SO_2 and NO_x emissions.

F. PUBLIC PARTICIPATION

Several speakers commented on the public's participation in the gathering of acid rain data. Ann Morris, Director of the Resource Center of the Association of New Jersey Environmental Commissions, spoke about the organization's citizen acid precipitation network. Elaine Fisher, Program Consultant for the Chest and Health Association of Southern New Jersey, explained that the organization will collect samples for a Department of Environmental Protection acid rain monitor. It will also utilize an acid rain index in its weekly air pollution radio spots.

Susan Remis, Staff Attorney for the Division of Public Interest Advocacy, testified to the need for a state acid rain control program. So did several other speakers representing environmental and public interest groups.

V. SUMMARY OF OTHER RESEARCH IN NEW JERSEY

There have been several other studies of acid deposition conducted in New Jersey which were not described at the public hearing. A brief summary of this research into the effects of acid deposition in New Jersey and the atmospheric processes which are involved is presented here. Table 3 summarizes the topics which have been studied and indicates project location.

A. Water

Dr. Crerar of Princeton University has conducted studies of the hydrogeochemistry of the New Jersey Pine Barrens over a ten year period (1970-1980). His work focused primarily on the drainage basins of Cedar Creek and the Mullica River. Precipitation samples were collected from a network of eight rain gauges at approximately two week periods. Analysis of the samples concentrated on the ion composition of the precipitation. Sulfates proved to be an important constituent.

Two groups, the National Acid Deposition Program (NADP) and the U.S. Environmental Protection Agency (U.S. EPA), have included New Jersey in national studies of the sensitivity of surface waters to acid deposition. The NADP report, edited by Stephen Norton of the University of Maine, consists of a series of state maps showing the distribution of surface waters sensitive to acid precipitation based on geological considerations. The map of New Jersey, which appears in Figure 2, shows that most of the geology of the state offers medium to low acid-neutralizing capacity indicating that the effects of acid deposition should be restricted to streams and small lakes. Complete loss of alkalinity is unlikely in large lakes. Pockets of geology with low to no acid-neutralizing capacity appear in the northwestern part of the state indicating a potential for effects on aquatic ecosystems there.

The U.S. EPA report was edited by James Omerink of the Corvallis Environmental Research Laboratory. One result of the study is a synoptic map of surface water alkalinity in the United States based on data from approximately 2,500 streams and lakes. Many of the data points were located in New Jersey. The map shows a large area of extremely low alkalinity in the Pinelands area of southern New Jersey, (see Figure 3). Areas of moderate alkalinity cover most of northern New Jersey with some high alkalinity areas in the valleys of the Kittatinny Mountains.

B. Land

New Jersey soils have been studied as part of the U.S. Department of Agriculture Soil Conservation Survey. Wiklander and Bache have used the Soil Conservation data to characterize the soils of New Jersey. Based on lime potential, cation exchange capacity, pH and base saturation, they identified soils which may be sensitive to acid deposition in Burlington, Cape May, Gloucester and Monmouth counties.

Dr. Eileen Brennan, at the New Jersey Agricultural Experiment Station, Rutgers University, has undertaken an assessment of the impact of acid rain on vegetation in New Jersey by means of a joint field and laboratory study. Surveillance of agricultural crops and native vegetation was undertaken to detect any change in plant growth of unknown etiology that may be due to acid rain. Laboratory studies were designed to test especially sensitive plant systems that in turn might be used as "markers" in field situations. Results were inconclusive.

C. Health

A consortium of researchers from New York University Medical Center, New Jersey Institute of Technology, Institute of Medical Research in Camden, and the DEP Office of Science and Research carried out a two year program to monitor fifty toxic air pollutants (including sulfate) at three urban sites and one rural location in New Jersey during six-week intervals in the summer and winter seasons. Sulfates were found to reach 30-50% of inhalable particulate concentrations at all locations. The maximum 24 hour sulfate concentration was 31.7 ug/m^3 measured at Camden during the 1981 Summer campaign.

Research on acidic aerosol was conducted in one 6 week field study at High Point in 1977. The results showed hydrogen ion (expressed as equivalent H_2SO_4) had a six hour average concentration of 17.8 ug/m^3. As described elsewhere in this report, these concentrations are believed to be well below the levels at which tracheobronchial mucocilliary clearance rates would be affected.

D. Materials

The U.S. Bureau of Mines operates a material damage study site in Chester, co-located with the U.S. DOE acid precipitation monitor. A rack of seven metals is exposed and weight loss is observed. There is also analysis using x-ray diffraction of crustal material on the sample metals. To date, there have been no reports relating observed deterioration to acid deposition.

A study to evaluate materials damage caused by acid deposition is planned at a site in Elizabeth.

E. Economics

DEP conducted an analysis of the cost of acid rain controls in the spring of 1982. This study was conducted because New Jersey imports a substantial quantity of electric power, much of it from high sulfur emitting power plants. As a result, New Jersey residents would have to support the cost of midwest emission controls. Using information supplied by the three New Jersey electric utilities and cost models developed by EPA, DEP estimated that compliance with legislation requiring a 10 million ton/year reduction in SO_2 emissions for a 31 state region would cost New Jersey $130 million per year, based on 1980 costs. The New Jersey electric utilities at the time estimated that the cost would be about $340 million per year. Mr. Geiger, in his prepared testimony, provided an estimate of $180 to $275 million per year. These estimates differ because of basic assumptions concerning the type of control strategy (fuel switching vs. scrubbing) and the anticipated distribution of SO_2 reduction required of utilities in the exporting states. DEP assumed that all emission reductions would be achieved by scrubbing. Thus DEP's estimate of $130 million can be compared to Geiger's $275 million estimate. The utilities also assumed that all of the out-of-state facilities actually supplying them with power would be affected and that some of these facilities would possibly close down rather than use scrubbing or other control techniques.

F. Transport

Several studies have demonstrated the potential for long-range transport of sulfates and nitrates from the midwest to the northeast. Two that specifically relate to New Jersey are described below.

Researchers at the Interstate Sanitation Commission in New York City, including George Wolff (now with General Motors) and Paul Lioy (now with New York University) reported on acid precipitation in the New York Metropolitan Area and its relationship to meteorological factors in the late 1970's. This study examined the spatial, meteorological and seasonal factors associated with precipitation pH in the New York area (including four sites in New Jersey) from 1975 through 1977. The mean pH was about 4.3 and the lowest values occurred during the summertime. This study and another by Wolff, et al., have produced evidence indicating that long-range transport of sulfates is often a more important factor than locally generated pollutants in the northeastern U.S.

Dr. Reiss and Mr. Salkovitz, Department of Meteorology and Physical Oceanography, Rutgers University, constructed three dimensional backward trajectories from numerous precipitation events in New Jersey for which ion concentration and/or pH measurements were available. An attempt was made to find associations between the measured properties of the precipitation and the regions through which the air had earlier passed. As expected, lowest pH values and highest sulfate ion concentrations were associated with air whose trajectory earlier had carried it over the Ohio Valley. Contrary to expectation, highest nitrate concentrations were associated with similar trajectories.

G. Precipitation Monitoring

One of the earliest investigations of rainfall acidity in New Jersey was conducted by Professor Lecher of Trenton State College. Measurements of pH of rainfall samples at Trenton, New Jersey, were made during June, 1974. Rainwater samples obtained from a variety of storm types exhibited pH values ranging from 3.69 to 4.10. A mean monthly pH of 3.97 was calculated for

June, 1974. This mean was weighted according to the sample volume and pH of each individual storm.

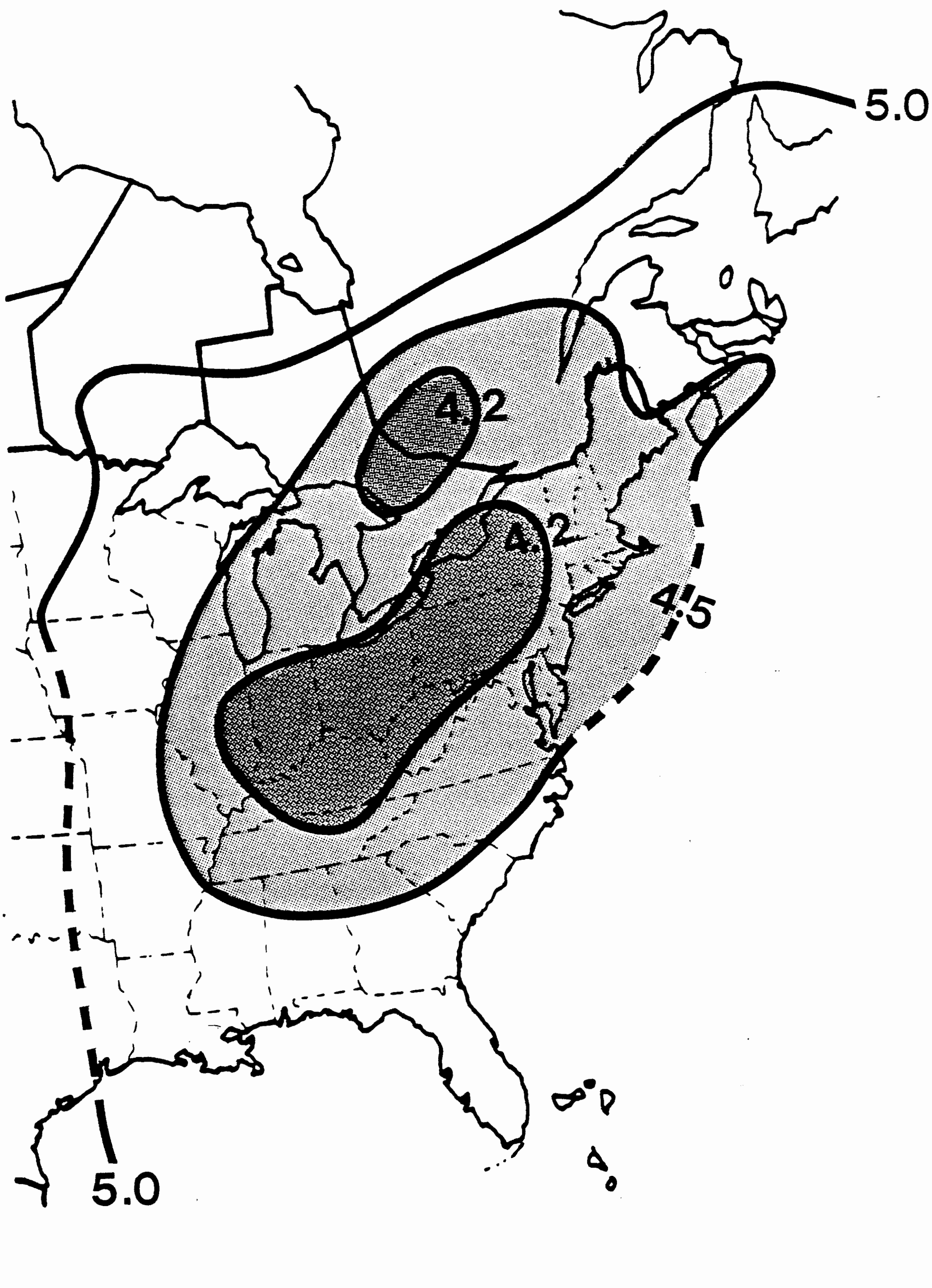
The U.S. Department of Energy Environmental Measurements Laboratory (EML) is studying the effects of changing patterns of energy use upon the major element and trace element chemical composition of precipitation, dry deposition and total deposition. Samples of wet, dry and total deposition have been collected on a monthly basis at seven sites within the United States including a site in Chester, New Jersey. The main objective is to gather data on the geographical differences and time trends in precipitation chemistry and in concentrations of pollutants in deposition. These will be related to changing rates of use of various fuels and especially to increasing rates of coal combustion. The Chester data are available back to October 1976. USDOE recently expanded their network to include a quasi-event precipitation monitoring site at Rutgers University in New Brunswick.

DEP operates two precipitation monitors at Washington Crossing State Park. One is a weekly sample and the other is collected after every rainfall event. The weekly sampler has been in operation since August 1981 and is a part of the National Acid Deposition Program (NADP). The weighted mean pH of rainfall sampled at Washington Crossing was about 4.1 in 1982.

Since October 1982, Atlantic Electric has been operating a precipitation monitor in Millville. Samples from that site are sent to the DEP Air Quality Surveillance Laboratory for analysis. A similar arrangement will be initiated with the Chest and Health Association of Southern New Jersey at a site in Ancora. This monitor should begin operation in the fall of 1983.

Brookhaven National Laboratory is planning a Mesoscale Acid Deposition study, scheduled to begin in November 1983. This study is composed of a field experiment and a modeling activity. The field experiment is aimed at sampling precipitation for nonconvective storms in the vicinity of a large urban center (Philadelphia). During the exploratory field study, approximately 25 automatic wetfall collectors will be deployed around the city and between 20 km and 60 km from the city's center. A subset of these monitors will be chosen for the main field study. The modeling activity will provide an assessment tool for damage to materials from urban plumes. The modeling task is still somewhat undefined.

DEP will soon undertake a program to model the impact of the B.L. England power plant in Beesley Point on acid deposition within the State. The Enviroplan Climatological Dispersion and Deposition Model (ECDM) will be applied for two emission scenarios: 1) a base case representing present SO_2 emission levels, and 2) some percentage reduction (e.g. 20%) in SO_2 emissions from the base case. ECDM will predict the impact of each scenario on annual average precipitation pH and both wet and dry deposition of sulfate.



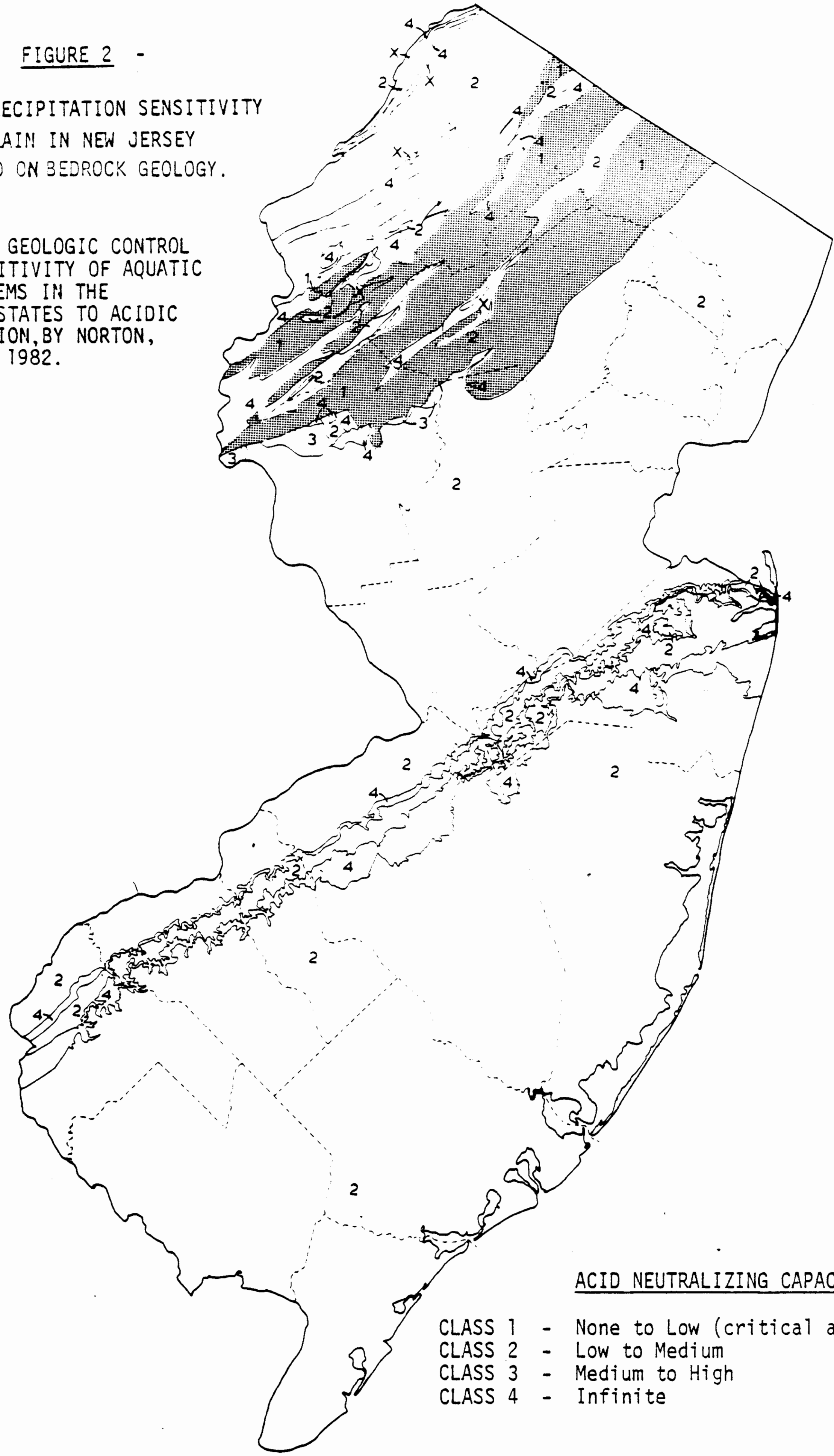
<u>FIGURE 1</u> - PRECIPITATION PH IN THE EASTERN UNITED STATES IN 1980.

FROM HENDRY'S TESTIMONY AT CAC/GSAC PUBLIC HEARING, OCTOBER 17, 1983.

FIGURE 2 -

ACID PRECIPITATION SENSITIVITY
OF TERRAIN IN NEW JERSEY
- BASED ON BEDROCK GEOLOGY.

FROM BEDROCK GEOLOGIC CONTROL OF SENSITIVITY OF AQUATIC ECOSYSTEMS IN THE UNITED STATES TO ACIDIC DEPOSITION, BY NORTON, ET AL., 1982.



ACID NEUTRALIZING CAPACITY

CLASS 1 - None to Low (critical area shaded
CLASS 2 - Low to Medium
CLASS 3 - Medium to High
CLASS 4 - Infinite

FIGURE 3

ALKALINITY OF SURFACE WATERS IN THE NORTHEAST. FROM NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM ANNUAL REPORT, 1983.

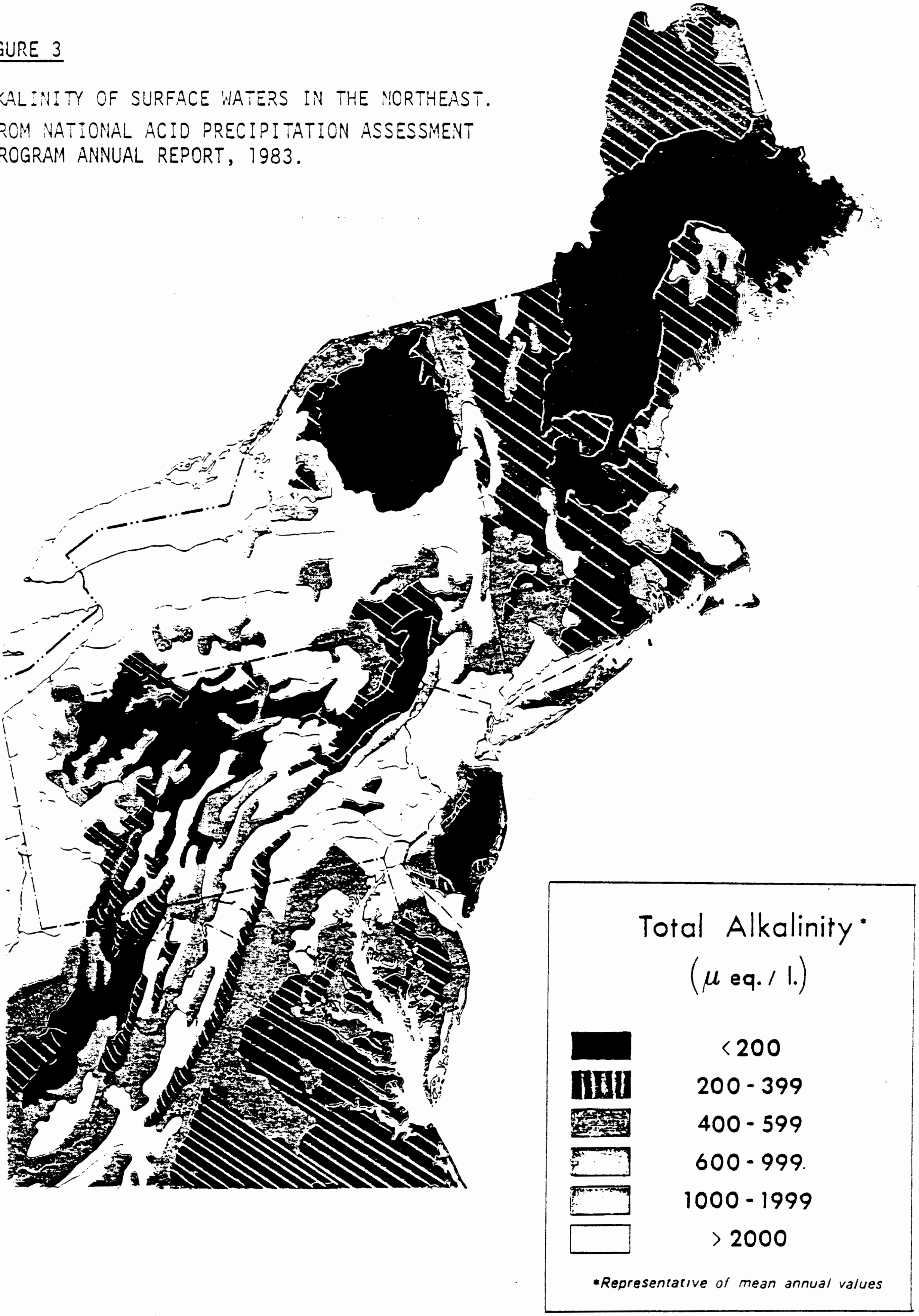


TABLE 1. LIST OF SPEAKERS

NAME:

1 SENATOR WALTER FORAN, Twenty Third District, NJ

2 ASSEMBLYWOMAN MAUREEN B. OGDEN, Twenty Second District

3 PAUL H. ARBESMAN, Deputy Commissioner, Department of Environmental Protection

4 DR. GEORGE R. HENDREY, Head, Terrestrial and Aquatic Ecology Division Brookhaven National Laboratory

5 PROF. ARTHUR H. JOHNSON, Department of Geology, University of Pennsylvania

6 DR. RICHARD B. SCHLESINGER, Institute of Environmental Medicine, New York University Medical Center

7 SUSAN REMIS, Esq., Staff Attorney, Division of Public Interest Advocacy

8 GEORGE KISH, U.S. Geological Survey, Water Resources Division, Trenton, NJ

9 BRADLEY WIENS, Director of Environmental Affairs for Anchor Glass Container Corporation

10 DR. ALAN W. McINTOSH, Division Director, Division of Water Resources Center for Coastal and Environmental Studies, Rutgers

11 PROF. SAMUEL D. FAUST, Environmental Sciences Department, Rutgers

12 PROF. MARK D. MORGAN, Department of Biology, Rutgers

13 MR. FLOYD TAYLOR, Executive Director, New England Water Works Association

14 MR. JOHN FEEHAN, Chairman of the Board and President of Atlantic City Electric Company

15 MR. ROBERT GEIGER, Public Service Electric and Gas Company

LIST OF SPEAKERS CONTINUED:

NAME:

16 ROBERT GOLDSTEIN, Electric Power Research Institute

17 MS. ELAINE FISHER, Program Consultant for the Chest and Health Association of Southern New Jersey

18 MR. ROBERT KAPLAN, Public Education Assistant, INFORM

19 MS. LINDA STANSFIELD, Program Consultant with the American Lung Association of New Jersey

20 MS. ANN MORRIS, Director of the Resource Center of the Association of New Jersey Environmental Commission

21 MR. JOHN ELSTON, Department of Environmental Protection, State of New Jersey

TESTIMONY INCORPORATED INTO THE RECORD

NAME:

22 ELEANOR GRUBER, Co-director of the Natural Resources Committee of the League of Women Voters of New Jersey

23 JANET FILANTE, Program Director, Delaware Valley Citizens Council for Clean Air

24 MEG KELBAUGH, New Jersey Chapter of the Sierra Club

25 GEORGE M. HASKEN, JR., Executive Vice President, Hackensack Water Company

26 T. E. GRAEDEL, Ph.D., Member of Technical Staff, Bell Labs

TABLE 2. RESEARCH REPORTED BY INVITED SPEAKERS ON EFFECTS OF ACID RAIN IN NEW JERSEY

X - Research specific to New Jersey

(X) - Research extrapolated from areas outside New Jersey

REGIONS

EFFECTS	Highlands (Sussex, Warren)	Water Storage (Passaic, Morris, Hunterdon)	Metropolitan (Bergen, Essex, Hudson, Union, Somerset, Middlesex, Camden, Gloucester)	Agricultural (Monmouth, Mercer, Burlington, Hunterdon)	Pinelands (Atlantic, Ocean, Burlington)	Common to all areas
Water						
Recreation & Wildlife	2,3 X	2,3 X			2,3,5 X	1,4 (X)
Water Supply		2,3 X			2,3,5,7 X	
Land						
Soils & Vegetation					8 X	
Agriculture						
Material & Property						
Health						
Direct (airborne particles)						10 (X)
Indirect (drinking water)			6 (X)			

1. Hendrey, Brookhaven
2. McIntosh, Rutgers Cook
3. Faust, Rutgers Cook
4. Goldstein, EPRI
5. Morgan, Rutgers Camden
6. Taylor, New England Water Works Association
7. Kish, USGS
8. Johnson, Pennsylvania
10. Schlesinger, N Y University Medical Center

TABLE 3. OTHER RESEARCH ON CHARACTERIZATION AND EFFECTS OF ACID RAIN IN NEW JERSEY

Y - Research specific to New Jersey

(Y) - Continuing or planned research specific to New Jersey

REGIONS

	Highlands (Sussex, Warren)	Water Storage (Passaic, Morris, Hunterdon)	Metropolitan (Bergen, Essex, Hudson, Union, Somerset, Middlesex, Camden, Gloucester)	Agricultural (Monmouth, Mercer, Burlington, Hunterdon)	Pinelands (Atlantic, Ocean, Burlington)	Common to all areas
EFFECTS						
Water - Recreation & Wildlife						
Water Supply					13 Y	2,4 Y
Land - Soils & Vegetation						9 Y
Agriculture				6 Y		
Material & Property			1,10 (Y)			
Health - Direct (airborne particles)						10 Y
Indirect (drinking water)						
ATMOSPHERIC PROCESSES						
- Transport			10,11 Y			7 Y
- Precipitation Monitoring			5,12 (Y)	5,8,14 Y	3,5,13,14 Y	

1. U. S. Bureau of Mines
2. Norton, U. of Maine
3. Dittenhoefer, Enviroplan
4. Omerink, USEPA
5. Petrinos, Brookhaven
6. Brennan, Rutgers - Cook College
7. Reiss, Rutgers - Cook College
8. Lecher, Trenton State
9. Soil Conservation Survey, USDA
10. Lioy, et al, New York University
11. Wolff, et al, General Motors
12. Feely, USDOE
13. Crerar, Princeton U.
14. Held, NJDEP