

ACID DEPOSITION IN UTAH: AN ANALYSIS BY THE  
ACID DEPOSITION TECHNICAL ADVISORY COMMITTEE

Presented to:

Prepared by:

Utah Air Conservation Committee  
Utah Water Pollution Control Committee

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## II. INTRODUCTION

Concern over "acid rain" has extended past Scandinavia and eastern North America to areas of the world which were previously believed to be either unaffected or immune from the impact of acid deposition. The potential for acidification in western North America is now under review. State and federal agencies working with environmental issues have expressed the concern that acidification could be more devastating to the Western U.S. than it is in eastern North America. Groups such as the Environmental Defense Fund (EDF, 1984) and the World Resources Institute (1985) have voiced the concern that acidification may be taking place or that the possibility of acidification is so great that western industrial sources of acidic emissions must be better controlled.

The state of Utah realized that the study of acid deposition in this state had not been sufficient to know if Utah had an acidification problem. There was also concern that pending federal legislation might be inappropriate for the unique conditions of the West. To determine the status of acid deposition in Utah, Governor Bangerter issued a letter to the Department of Health on November 27, 1985 (Appendix A) requesting that an acid deposition task force be organized to study the issue and to report to the policy-making bodies in the state.

The Acid Deposition Technical Advisory Committee (ADTAC) was organized

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to include experts from state and federal agencies, universities and from the Air Conservation Committee and the Water Pollution Control Committee. The major objectives of ADTAC were to:

1. Review existing scientific data on acid deposition in Utah and the West
2. Determine additional data needs in order to understand the status of acid deposition in Utah
3. Recommend measures to be taken by the state in order to deal with the technical issues of acid deposition.

Five public meetings held from February to August, 1986 gave ADTAC the chance to hear scientific and technical experts present their findings and experience with acid deposition in Utah and the western United States. One meeting was held for industrial and environmental groups whom are concerned about acid deposition.

The format of this report reflects the information provided to ADTAC by the experts who made presentations and by the experts serving on ADTAC. The presentation material is summarized under Section VI, Technical Presentations. A summary of the discussions and conclusions of each work group is found in Section V, Discussion and Recommendations. The recommendations are not prioritized except for the major recommendations which are given in the Executive Summary. The Executive Summary, Section IV, contains the major

recommendations and determination of status. Attachments and short statements on acid deposition are found in Appendix A. A glossary of terms used in the

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report is included as Appendix B. This report is not a scientific document itself, since no science was performed in producing the report. It is a review of information presented to and considered by ADTAC scientists and technical experts.

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### III. CONTRIBUTORS

ADTAC was given three objectives by the governor. The first was to determine the status of acid deposition in Utah. The second objective was to determine what information would be needed to complete the scientific understanding of acid deposition in Utah. The third objective was to give technical recommendations to the state's statutory committees, the Air Conservation Committee (ACC) and the Water Pollution Control Committee (WPCC), for policy consideration.

ADTAC assembled experts from state and federal agencies, universities and the ACC and WPCC who deal with, or have working knowledge about acid deposition. The initial response to participate on the committee was so great that the committee design had to be modified. Initially, members were chosen for the committee itself. These members **were** given the responsibility of collecting data and arranging for experts on the subject of acidification to

make presentations before ADTAC. Advisors to ADTAC were later called upon to assist ADTAC in gathering and presenting data on acid deposition.

ADTAC members found the subject of acid deposition too great to address without subdividing into subjects which would allow each expert to contribute most effectively. The committee divided into work groups in order to concentrate on a smaller scope of subjects. The work groups which were organized include the aquatics, deposition, terrestrial and special interests work groups. The committee members,

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with their **work** group assignment and the organization they represent are listed below:

Mark T. Ellis, coordinator, Bureau of Air Quality

Dr. Wayne Wurtsbaugh, aquatics group leader, Water Pollution

Control Committee

Maureen Wilson, aquatics, Division of Wildlife Resources

Jay Pitkin, aquatics, Bureau of Water Pollution Control

Ray Hall, aquatics, U.S. Forest Service

Larry Svoboda, aquatics, Environmental Protection Agency

Dr. William Wagner, deposition group leader, Bureau of Land

Management

Dr. Dee Barker, deposition, Air Conservation Committee

Dr. Clyde Hill, deposition, University of Utah Research Institute

Dr. Fredrick Wagner, terrestrial group leader, Utah State

University

David Schen, terrestrial, State Lands and Forestry

Emily Hall, special interests group leader, Air Conservation

Committee

Advisors to ADTAC include:

Dr. Eugene Bozni'.ak, Weber State College

Paul Crosby, Dixie College

Dr. Richard Heckmann, Brigham Young University

Dr. Ronald Neilson, University of Utah Research Institute

Dr. Barry Quinn, Westminster College

Dr. Al Trujillo, College of Eastern Utah

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Each of the ADTAC members and advisors contributed to the achievement and formulation of the required objectives. Of great importance to the committee were the guest speakers who came at their own expense to share their findings and recommendations with ADTAC. Most of these presenters represented segments of the scientific community, although several private and industrial concerns were also represented. The following made considerable effort to make their expertise available to ADTAC:

Joan Auger, League of Women Voters, Salt Lake City

Gary Austin, Rocky Mountain Oil and Gas Association, Denver,

Colorado

Dr. David Brakke, Western Washington University, Bellingham, Washington  
James Bresch, Colorado State University, Fort Collins, Colorado Nina Dougherty,  
Sierra Club, Salt Lake City

Dr. Delbert Eatough, Brigham Young University, Provo Dr. Richard F. Fisher, Utah State  
University, Logan t/Dr. Alan F. Galbraith, Bridger-Teton National Forest, USFS,

Jackson, Wyoming

Dr. James H. Gibson, Colorado State University, Fort Collins,  
Colorado

Dr. Peter Hovingh, Intermountain Water Alliance, Salt Lake City

Michael Reichert, Utah Department of Fiealth, Salt Lake City

Dr. Dee Rees, Utah Power and Light, Salt Lake City

Dr. Larry L. St. Clair, Brigham Young University, Provo

Dr. Lorin Squires, Brigham Young University, Provo

Dr. Doyle Stephens, U.S. Geological Survey, Salt Lake City

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Al Trbovich, Kennecott, Utah Copper Division, Salt Lake City

Robert E. Yuhnke, Environmental Defense Fund, Boulder, Colorado

ADTAC could not have performed its assigned objectives without the great support of all of the people who sacrificed their time and expertise for this effort. The contributors were the key to the success of this phase of Utah's acid deposition investigation. The fact that so many people contributed to this cause without remuneration is a credit to the scientific community.

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#### IV. EXECUTIVE SUMMARY

The Acid Deposition Technical Advisory Committee (ADTAC) held meetings in 1986 on February 19, April 9, June 11, July 18 and August 6. The objectives for the formation of ADTAC (page 3) were outlined in the February meeting. The committee members were requested in that initial meeting to seek out all known research which had been done or was currently underway which would relate to acid deposition in Utah. Pertinent data were discovered from federal and state agencies and from industry. The major studies and findings from Utah monitoring and research work follow:

1. A sensitivity survey conducted by the Environmental Protection Agency (EPA) in 1984 sampled 20 lakes in the Uinta Mountains (see Dr. Stephens' presentation, page 79). The results from this survey were examined by the U.S. Forest

Service (1985). in the 1985 memo, these 20 lakes were described as ranging from "sensitive" to "ultra-sensitive".

2. The National Surface Water Survey (NSWS) began in 1984 to determine the sensitivity of lakes nationwide. The Western Lake Survey, Phase I (WLS-I) was the western portion of this EPA project, carried out in 1985 (see Dr. Brakke's presentation, page 88). Preliminary results which are not yet finalized for publication indicate that lakes in the Uinta Mountains are among the most sensitive in the world to acidification.

3. The National Atmospheric Deposition Program (NADP) is a federal project currently monitoring precipitation nationwide



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(see presentations by Drs. Wagner and Gibson, pages 58 and 62). Four sites useful to determining acid deposition trends in Utah are located at Logan, Green River, Bryce Canyon and Lehman **Caves**, Nevada (figure 1, page 12). These sites show annual precipitation to be within the normal pH range.

4. Utah Power and Light Company has sponsored intensive watershed studies at Mirror Lake since 1984 and surface water sampling in the Wasatch and Uinta Mountains since 1983 (see presentations by Drs. Hill, Neilson, and Rees, pages 70, 74 and 86). Acids and crustal materials are being collected at the Mirror Lake site. The ILWAS watershed model is also being calibrated for western watersheds (see Dr. Neilson's presentation, page 74).

5. The National Park Service (NPS) has been doing research in long range transport of sulfate for six years in Utah (see Jim Bresch's presentation, page 75). This research shows an influence on Utah's ambient sulfate concentration from out of state sources of sulfate.

Evidence was not presented to ADTAC which demonstrated that acidification is occurring in Utah. Of major concern to ADTAC was the sensitivity to acidification found in parts of Utah. Sensitivity is defined as surface waters with less than 200 ueq/l alkalinity (see page 21). with such low amounts of alkalinity, the possibility of acidification could become a reality if atmospheric acid loadings were to increase (see Dr. Squire's presentation, page 80). Data were sufficient for ADTAC experts to identify three areas in the state as

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sensitive. These include the Uinta Mountains, Wasatch Mountains and

Boulder mountain (figure 1, page 12). Seven other areas are suspected as being sensitive, but sufficient data for making such a determination are lacking. These areas include the Raft River Mountains, Deep Creek Mountains, Tushar Mountains, Thousand Lake Mountains, Henry Mountains, LaSal Mountains and Pine Valley Mountains.

Sources of acidic pollutants from human activities in Utah include

automobiles, urban combustion processes, coal fired power generators, copper smelting, mineral recovery and the oil and gas industry. Back trajectory analyses (Bresch, 1986) have provided evidence **of** long range transport of sulfates into Utah from southern California, the southwest copper smelting-region and the northwest. Proposed Congressional legislation would require many of these industries to reduce their emissions of acias and acid precursors. Retrofit of existing equipment could be very costly to Utah industry.

Of particular note was **that**, without exception, industrial, environmental and scientific interests expressed their concern that acid deposition has not been studied sufficiently in Utah. For acid deposition or for any other environmental issue, scientific data available on Utah's high elevation areas are apparently limited.

Recommendations

1- The state of Utah should become involved in the scientific study of acid deposition. Without legitimate scientific effort to justify

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proposed control measures, Utah sources could be placed in the position of complying with congressional directives without independent, first-hand knowledge of real needs. options for state involvement include:

a. Conducting original research and monitoring with state funding.

b. Include acid deposition investigations with existing state programs

which are engaged in monitoring and research.

c. The state would serve as a manager of programs and use contractors from universities and other research entities to perform the research. d. Cooperation with industry and the federal government for a coordinated research and monitoring program.

2- Monitoring must be done in the sensitive and potentially sensitive areas in Utah. Such programs may include deposition sampling, surface water and groundwater sampling, biological surveys and soil analyses. State and federal agencies may presently have the capability of providing many of these monitoring needs. Federal agencies and several large industries in the state are eager for the state to initiate a cooperative study of Utah's acid deposition status. Such a cooperative effort would include technical support and financial contributions from the interested parties.

3- Air pollution sources within the state should be monitored for their impact on Utah's acid contribution. At this point in time, the present criteria pollutant program followed by the state and by EPA

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allows some types of pollutants, e.g. hydrochloric acid, to go unrecognized for their contribution to acidification.

4- ADTAC or a similar technical committee should be continued in order to provide technical updates to the state policy makers. ADTAC members were unanimous in the feeling of success which this effort achieved. No private, state or federal funds were requested for this volunteer task force. Response by the scientific community was enthusiastic for the effort made by Utah in examining this complex issue. Scientists from Washington, Wyoming, Colorado and all over Utah came at their own expense in order to participate in this initiative.

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## V. DISCUSSION AND RECOMMENDATIONS

Each work group reviewed information presented during the meetings or information provided by members of the committee. Findings from the four work groups were found to have frequent overlap. This is expected from such a complex ecological issue. ADTAC worked under the charge to avoid economic and political considerations as much as possible and to concentrate on scientific issues. The main points considered by the work groups follow.

## Aquatics Work Group

Acid deposition studies have traditionally relied on surface water chemistries from lakes as a check on acidification. The assumption has been that a lake is a mirror of its watershed. Consequently, if watershed acidification is taking place, it should be easily observed in the chemistry of the lake. While this assumption does not always hold true, the ease of collecting data from surface waters makes water sampling attractive for acid deposition monitoring. Deposition and water sampling should be done concurrently if water quality effects and the contribution of atmospheric deposition to water quality are to be properly understood. Available water sampling data from Utah are limited. Peer reviewed and published data on water quality from the perspective of acid deposition in Utah are non-existent. The information which is available is from surveys and government sampling, much of which is related to watershed monitoring and is

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unrelated to acid deposition. Interpolation of agency data is required. Agency data on alkalinity are normally reported in milligrams per liter (mg/l). Transposition from mg/l is necessary into the more meaningful and sensitive microequivalents per liter (ueq/l) units ( $\text{mg/l} \times 20 = \text{ueq/l}$ ). Sampling data available to ADTAC are the following: Bureau of Water Pollution Control survey data of water chemistry and benthos, EPA lake chemistry data of 20 Uinta lakes in 1984, EPA Western Lake Survey of 33 lakes in Utah in 1985, Division of Wildlife Resources biological surveys, diatom surveys from lakes in the Uinta Mountains by

Dr. Samuel Rushforth, and Utah Power and Light study of 18 Wasatch and Uinta Mountain lakes.

The Bureau of Water Pollution Control (BWPC) routinely collects water samples from numerous lakes and streams in Utah. Some of the waters sampled by BWPC are located in the sensitive areas of the state. Besides routine measurements, BWPC conducted the Clean Lakes Inventory and Classification (1982) project to satisfy requirements of Section 314, Clean Water Act. Those data will be elaborated later. Benthic samples are also taken on an annual schedule. Although the samples are taken outside the sensitive areas, baseline data for major river systems are available through BWPC.

Prior to the initiation of the Western Lake Survey, Phase I (WLS-1), which is the western portion of the National Surface Water Survey (NSWS), EPA conducted a pilot survey of 20 lakes into the Uinta mountains to measure surface water alkalinity. Inferences of lake sensitivity have been made by EPA based upon those results. In a memo

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from the U.S. Forest Service (1985), designations which describe the degree of sensitivity of the surveyed lakes were given. All of the lakes were described as "sensitive", due to alkalinity measurements of less than 200 ueq/l. 25% of the sensitive lakes were designated as "very sensitive" with alkalinities between 76-100 ueq/l. 65% of the lakes were designated "ultra-sensitive", having alkalinities less than 75 ueq/l. The memo states that Uinta lakes, based upon these data, appear to be more sensitive than lakes in the Bridger Wilderness. The memo further

recommends monitoring in this area because of the low alkalinities and because the Uinta Mountains are downwind of a large nonattainment area, the Wasatch Front.

The WLS-I was conducted in 1985 throughout the western U.S. Results are not yet available for publication, but draft documents confirm the sensitive nature of lakes in the Uinta Mountains. Published data are expected at the end of 1986. Three lakes in the Boulder Mountains were also surveyed, but those results will not be published with the WLS-I results. Of the 33 lakes surveyed in Utah by WLS-I, 65% of the lakes are known to hold populations of fish. The Division of Wildlife Resources (DWR) has conducted habitat and population surveys of the high mountain lakes since 1955. DWR has determined that only three of the WLS-I lakes have reproducing trout populations. These lakes should be used for later phases of NSWS which will include long term watershed studies.

Diatom surveys (see Dr. Lorin Squires presentation, page 80) undertaken in the Uinta Mountains show the encroachment of

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acidobiontic species in some lakes (figure 2, page 19). These species have a pH preference for lakes with a pH of less than 5.5. Since the historical pH data from these lakes are usually higher than 5.5, it has been proposed that the extreme sensitivity of these lake systems and the presence of acid loving species of diatoms indicate that a slight increase in acid loading would acidify the lake.

Utah Power and Light (UP&L) has funded an intensive watershed study project in the Mirror Lake area since 1984 (see presentations by Dr. -z; Clyde Hill, Dr. Ron Neilson and Dr. Dee Rees on pages 70, 74 and 86,

respectively). Water quality data collected as a part of that study in the Wasatch and Uinta Mountains have not yet been released, but two presentations on the results by contracted researchers have indicated that pH levels tend to be above 6.0. Mirror Lake pH minima range around 6.1. Lake water alkalinities have been measured by the researchers at around 110-120 ueq/l. Transparencies of the water column are low, indicating advanced trophic status.

The Mirror Lake study is being used to calibrate the Integrated Lake-Watershed Acidification Study (ILWAS) model for use in the western U.S. Data used to drive the model include hydrologic, deposition, biological, geological and morphometry measurements of the watershed. Study results indicate that a large amount of alkaline material is found below the surface layers of soil. This material is apparently not native to the watershed and is presumed to be the accumulation of loess from the Great Salt Lake Desert. Groundwater moving through the loess picks up alkalinity up to 1,600 ueq/l

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(preliminary data). (Coordinator's note: in a letter submitted October 15, 1986 (Appendix A) Or. Neilson explains that the alkalinity measurements originally reported by UURI have been found to be in error by the researchers. The original data were presented as preliminary data. The numbers have been accordingly adjusted downward by approximately 400%. This adjustment does not alter the original thesis that mirror Lake soils contain sufficient alkalinity to provide buffering for atmospheric acids deposited at present rates.) Wet and dry deposition



measurements appear to show a 1:1 relationship. The researchers report that equivalent amounts of buffering crustal materials are imported with the atmospheric acids. The researchers feel that this indicates a buffering mechanism for sensitive lakes downwind from the desert. This buffer is projected to endure for at least 600 years under the condition that both crustal and acid deposition rates remain the same.

Nitrate builds up in the Mirror Lake system during the winter when biological activity is low. During the summer, biota consume the available nitrogen in the lakes to the point that no detectable nitrate is discharged from the lake outflow. Trophic analysis of Mirror Lake by BWPC show Mirror Lake to be mesotrophic. Current measurements of secchi disk transparency in the lake indicate that the lake remains at an advanced trophic status.

The major conclusion given by UP&L about the two years of research at Mirror Lake are that loess accounts for an adequate buffering mechanism for sensitive lakes such as Mirror Lake. The pH of the lake has never fallen below 6.08 even during spring run off. This indicates a stable pH regime. No damage to the watershed due to acid deposition has been observed.

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The mirror Lake study is the most intensive study conducted in Utah. The transport of crustal material and anthropogenic acid precursors appears to be quite different. Areas located further away from the desert may be more vulnerable to acidification since coarse crustal materials are removed from the atmosphere relatively short distances from the source. The further away from the source, the finer the crustal particles are. Two years worth of data are adequate to

determine that crustal transport is occurring, but may not be sufficient to determine the full magnitude of crustal deposition.

The designation of sensitivity of Utah's watersheds was initiated by the aquatics group. Sensitivity was proposed for watersheds where surface water alkalinity has been measured at less than 200 ueq/l. This definition is consistent with EPA's definition of water vulnerable to acidification. Stream data have not been as available as lake data, but these waters should be included in the sensitive areas also. Based upon existing data, ADTAC considers the Wasatch, Uinta and Boulder Mountains sensitive watersheds. Discussion was held of two other categories relative to acid sensitivity. The first is a description of areas suspected of being sensitive, based upon bedrock geology or upon water quality data downstream from where the sensitive area may be. Surveillance monitoring in the suspected sensitive areas is recommended. Some of these areas, as determined by ADTAC include the Raft River, Deep Creek, Pine Valley, Tushar, Thousand Lake, Flenry and LaSal Mountains (figure 1, page 12).

The effects of acidification are not restricted to sensitive watersheds.

Secondary effects from acidification have been observed which have lead, not

**to acidification, but in the alkalization of watersheds originally presumed**

to be insensitive to acid deposition. Kilham (1982) proposed that the acidification of a calcareous watershed leads to the accelerated leaching of alkalinity, increasing the trophic level of lakes. His proposal came from studies of a calcareous watershed in Michigan. This raises an interesting question regarding Utah which has vast areas assumed to be insensitive to acidification. If these areas are not completely immune from the effects of acid deposition because of secondary effects, the definition of sensitivity must be restated. Secondary acidification effects in calcareous watersheds may depend upon acid loading rates. The mechanism involved is the mobilization of calcium and magnesium carbonates in sufficient quantity to leach these carbonates out of the soil and into the lakes. The excessive amount of alkalinity increases the trophic level of the lakes.

Fertilization of sensitive watersheds with the deposition of nitrogen oxides (NO<sub>x</sub>) could be occurring in Utah. This secondary effect of acid deposition could be compounding the acidification problem. In 1980, BWPC undertook the identification and classification of all lakes in Utah. Location, size, ownership, use and trophic status were evaluated. This project (1982) was completed under the authority of Section 314, Clean Water Act, 1977. Of the inventoried lakes, 127 were evaluated for restoration priority where the state's analysis showed the water quality of the lake to be degraded. Trophic analysis of the lakes was accomplished for those lakes having available water chemistry data. 22 lakes above 9,000 feet elevation were found to have water chemistry data (figure 3, page 24). Of these 22 lakes, only four were evaluated as being oligotrophic. One lake was found to be dystrophic, three were eutrophic and the remaining 14 lakes were mesotrophic. Lakes above 9,000 feet are generally assumed to be pristine, oligotrophic lakes. The evidence

of advanced trophic status among high elevation lakes is a concern to ADTAC. This concern centers around the source of nitrogen in the lakes which has elevated the lake trophic status beyond the expected range. These lakes are typically frozen from mid autumn to early summer and receive little or no nitrogen input from within the watershed during this time. While increased visitor traffic may account for some nitrogen input to the lakes during the ice-free season, the possibility exists that atmospheric deposition may be contributing year-round to the nitrogen loading of the lakes. Utah lakes are reported to be nitrogen limited (Wurtsbaugh, 1986). If this is true for high elevation **lakes**, this implies that nitrogen introduced to these ecosystems is taken up as a nutrient instead of forming nitric acid. Biological uptake of the nutrient and the subsequent death of microbiota at the end of the growing season can lead to deoxygenation of the water. Deoxygenation takes place when ice covers the lake, cutting off any significant source of replacement oxygen. The process of decaying the vegetation removes the oxygen from the water. This situation, known as winterkill, can wipe out aquatic populations. Under this scenario fishkills would be occurring due to the deposition of an acid precursor, NO<sub>2</sub> but the effect would be manifest as over-fertilization, not as acidification. This scenario does not imply that acidification effects are not possible, only that fertilization is an additional effect of acid deposition. Projections of NO<sub>x</sub> increases of up to 150% within the state by 1995 (figure 6, page 50) make understanding of the impact of nitrate on Utah's watersheds imperative.

Also considered by ADTAC were the presentations made by researchers from other western states of studies in other western sensitive areas. Colorado and Wyoming have study programs which indicate the precarious sensitivity of

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watershed- in those states. Wyoming's Wind River Range is being studied by the U.S. Forest Service (Galbraith, 1985). An analysis of the data collected thus far indicates the high degree of sensitivity of soils, water systems and biota. While the deposition of atmospheric acids does not appear to be increasing, the ultimate question is how much loading can the present system take and what would be the impact of increases in the acid loading? No evidence of direct acidification effects has been found in Wyoming, but Colorado researchers have found what they believe to be detrimental effects of lake acidification. Dr. John Harte (1985) began acid deposition research in 1980 in the Mexican Cut Research Reserve. Sensitivity of cutthroat trout (Salmo clarki) and salamander (Ambystom bigrinum) to acidic water conditions was noted. A decline in the salamander population was found to be related to unsuccessful recruitment of new salamanders. It was proposed that the pH depression associated with an acid "pulse" at spring run off coincided with the spawning activities of the salamanders. The low pH water was killing the eggs at their critical stage of development.

### Recommendations

The aquatics work group found difficulty in separating aquatics from the other issues of acid deposition. The other work groups found the same problem. Several of the recommendations made by the aquatics group have been proposed for specific state or federal agencies since existing government programs appear capable of carrying out the work.

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The appropriateness of engaging existing government programs in the study of acid deposition monitoring and research will be an issue for discussion at the administrative level. Aquatics work group recommendations follow.

1. A reconnaissance survey should be conducted in the suspected sensitive areas to determine whether and to what degree those areas require designation as sensitive to acidification or to secondary or eutrophying effects.
2. Long term monitoring should be undertaken in at least two watersheds known to be sensitive. Two areas for consideration include the Uinta and Boulder Mountains. Monitoring parameters should include pH, alkalinity, base cations, anions, heavy metals and aquatic biota.
3. Monitoring of fish populations at selected lakes in known sensitive areas should be encouraged. Long term monitoring proposed by EPA for NSWS Phase III should be encouraged. Phase III should include key Utah lakes. EPA should be encouraged to coordinate with ADTAC in designating Phase III study areas in Utah.
4. Post construction ambient air monitoring by PSO sources, especially new power plants, should include monitoring for acid deposition of at least one downwind sensitive area.

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5. The Mirror Lake study should be continued. Expansion of the database and the incorporation of additional study objectives recommended by UP&L (see Dr. Rees' recommendations on page 87) are supported by ADTAC. Of special interest to western researchers is the development of the ILWAS model. This model could have broad application in the western U.S., where such a watershed model is needed for all-weather research.

6. Monitoring of snow chemistry and acid/crustal loads

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borne by the snow could be accomplished, through cooperation with the Snotel network operated by the Soil Conservation Service (SCS).

7. Critical loads of sulfate and nitrate in sensitive watersheds need to be determined. Nitrate loading and the fate of atmospheric nitrate in sensitive watersheds require study. This is especially important in view of recent and proposed construction of large sources of **NO<sub>x</sub>** emissions.

8. The state should continue the concept initiated by ADTAC. Technical experts should meet at least annually to give input to acid deposition monitoring and research in Utah. These experts should include state and federal government agencies, the academic community and researchers from the private sector.

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9. Cooperation between the various agencies, industry and universities should be sought through participation with ADTAC in monitoring **sensitive areas**.

10. Biological monitoring of aquatic ecosystems in the sensitive areas should include fisheries, benthos, diatoms, hydrophytes and bacteria.

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#### Depositor Work Group

The deposition work group considered the formation of acidic materials in the atmosphere, atmospheric transport, deposition, and long range transport of acidic materials and deposition. Recommendations were then formulated from the findings, and sources were not generally considered. The Bureau of Air Quality is an emission inventory for sources of criteria pollutants and is presently assembling an acid emission inventory. This information is available through



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rate of So is the transformation of SO- i-n a fog or cloud bank.

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Hydrogen peroxide (H O 2 2) acts as a catalyst in fog and clouds,

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increasing the conversion rate of So 2 to SO4 **by a factor of 10.**

Nitrogen oxides. (NOX) exist as NO, NO2 or NO 3' NOX can be

transformed to **NO-**, a nutrient or **HNO** nitric acid. Both

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forms are referred to, as nitrate and are shown as  $\text{NO}_3$  throughout the report. The study of  $\text{NO}_x$  conversion is not as advanced as for  $\text{SO}_2$  conversion. While the daytime conversion of  $\text{NO}_x$  to  $\text{NO}_3$  is up to

three times higher than the  $\text{SO}_2$  conversion, nighttime conversion of  $\text{NO}_x$  is even higher. The chemical pathway is apparently different from the  $\text{SO}_2$  conversion pathway. It is presumed that a different catalyst is used, but the catalyst and the nighttime process are unknown.

The role of hydrochloric acid ( $\text{HCl}$ ) is not well defined.

Anthropogenic sources of  $\text{HCl}$  are rare world wide, but sources of anthropogenic  $\text{HCl}$  are found in Utah. While natural sources of chloride (designated simply as  $\text{Cl}$ ) include crustal dust from the Great Salt Lake and the West Desert, the potential exists of anthropogenic  $\text{HCl}$  being deposited and having an effect on the environment. Virtually no information is available from the research community about  $\text{Cl}_2$  and  $\text{HCl}$  emissions. It is interesting to note that the average pH measured in Utah sampling projects was lowest in north Salt Lake Valley. Chloride constituted a large percentage of acid constituents in the Salt Lake Valley samples.

Oxidants are important in the chemical transformation of acid precursors to acids and as direct sources of environmental damage.

The National Acid Precipitation Assessment Program (NAPAP) has initiated research emphasis on oxidants through the acid deposition program (Kulp, 1986). Catalytic oxidants of concern to ADTAC are ozone ( $O_3$ ) and hydrogen peroxide ( $H_2O_2$ ). ADTAC is concerned with the direct effect of ozone as well as with its catalytic ability. Ozone is being investigated as the causal agent for damage to trees which was originally ascribed to "acid rain" (Miller, 1984). Ecological damage by ozone could occur in Utah and may be of particular concern to the Lone Peak Wilderness and to National Forests located on the Wasatch Front which are adjacent to the ozone nonattainment area.

The transport of acids and acid precursors is dependent upon meteorological patterns. More information from the meteorological community is needed in order to improve understanding of climatological patterns, seasonal variations and short/long range transport patterns. This information will allow scientists to establish the relative contribution of in-state vs. out of state contributions to acid deposition in Utah.

Short range transport and residence time **will** have a direct bearing on

the relative effects of in-state  $NO_x$  and  $SO_2$  emissions on Utah's sensitive areas. Since the transformation of  $SO_2$  to  $SO_4$  is a relatively slow process, it is almost certain that local sources of  $SO_2$  are not the exclusive source of  $SO_4$  deposited in Utah. On the

other hand,  $NO_x$  emissions generated locally may well be impacting the sensitive areas of Utah due to a faster conversion rate (see Dr.

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Delbert Eatough's discussion on chemical transformation, page 65). Source tracking would be needed to evaluate the actual **impact of local** sources of air pollutants upon local sensitive areas.

Long range transport brings  $\text{SO}_4$  to Utah from other areas. Back trajectory analysis methods (see Jim Bresch's presentation, page 75) have identified Southern California, the southwest "copper belt" of Arizona and New Mexico and the Northwest as sources of  $\text{SO}_4$  in Utah. The contribution of  $\text{NO}_3$  through the long range transport mechanism has not been defined to ADTAC. Chloride emissions from Utah are not appearing at long range sampling sites. This might indicate that  $\text{HCl}$  deposition is strictly a local phenomenon.

The deposition of atmospheric acids considers two major forms of acid. Wet deposition is acid which is entrained in any form of precipitation, i.e., rain, snow or fog. Dry deposition occurs in particulate form irrespective of precipitation events. A third form, which is only now being studied involves the formation of acidic ice, referred to as rime ice. *Rime* ice forms out of fog or clouds which contact the earth's surface or objects on the ground.

Deciding the pH of pure precipitation has stirred considerable controversy. Earlier definitions of acidic precipitation (Likens, 1976) assumed the pH of de-ionized water, with a pH of about 5.6, to be the pH for natural precipitation. Later research has concluded that naturally occurring organic acids are also found in rainwater. These acids tend to lower the pH to a level of about 5.2 (see Dr.

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Gibson's presentation, page 62). Consideration of naturally occurring crustal materials as found in the West has not generally been included in the "natural rain" definition. Since crustal materials tend to raise the pH, 5.2 might be regarded as the worst case natural pH level.

A study of throughfall chemistry in northern Utah included deposition sampling from the early 1970's. At the Blacksmith Fork River drainage, wet precipitation episode sampling recorded pH levels as low as 2.9 (Hart, 1974). The range of pH also extended into alkaline levels. The fact that such low pH measurements have been recorded in Utah is a concern. However, the source of acids which created such low pH levels is not known.

Data collected by the National Acid Deposition Project (NADP) in Utah show annual weighted averages for wet deposition. Of the four monitoring sites applicable to Utah, only the Lehman Caves, Nevada site has a full year of data available. The Lehman Caves site has an annual mean pH of 5.68. The other sites have not been in place sufficiently long to have a full year of data. The Bryce Canyon site has nearly a full year of data and shows a mean pH of 5.79. The Logan and Green River sites do not yet have a complete year's worth of data available.

Monthly measurements from Bryce Canyon and Lehman Caves indicate normal ranges of precipitation pH at lower elevations. Sampling at Mirror lake (non NADP) shows the annual weighted mean pH to be between 5.1 and 5.2. Figure 4 (page 34) shows relative pH isopleths across the nation. Utah's lowest annual precipitation is a full pH unit higher than the lowest averages recorded in the East.

Precipitation pH must not be examined alone. pH is the measure of hydrogen ion activity and is not meaningful in measuring acidity. Additional parameters must also be considered i.e., sulfuric, nitric and hydrochloric acids. Crustal and gaseous buffers are not considered in NADP measurements. In order to understand the full implication of atmospheric deposition, the loading rates of acids and buffers must be correlated with pH for a complete assessment of deposition composition. It has been observed that precipitation pH increases with increased precipitation volume (see Dr. Brakke's presentation, page 88). This is due to a dilution of the acids being precipitated. Measuring the acidity of wet deposition must necessarily consider the precipitation volume and the form of precipitation.

Dry deposition of acidic particulate is a source of acid which is difficult to measure. NADP does not presently include the dry deposition portion in its monitoring program because of uncertainties in interpretation of the data. The difficulty lies with the ability to capture and hold dry particulate in the sampling container. Wind may prevent particle settling or remove deposited materials out of bucket collectors. Ambient measurements have been proposed using low-volume samplers, but this method assumes a constant deposition velocity. Dry deposition remains an important part of the total deposition picture. Even with the recognized problems, attempts should be made to quantify dry acids. Throughfall measurements, which assume that trees act as particulate collectors, have been used at Mirror Lake. Those measurements indicate a 1:1 ratio between wet and

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dry deposition amounts. Some researchers in the Southwest have proposed wet/dry ratios as high as 1:15. Given the limitations of the different ways to sample dry acids, ADTAC believes

it best to have a consistent method of collection rather than worry about whether throughfall was indeed the best available dry sampling method. Research should be undertaken to find the best dry sampling method. It was the opinion of ADTAC that a way to correlate throughfall data to the improved methodology may also be developed.

Other uncertainties exist with deposition and the interpretation of monitoring measurements. Crustal materials such as calcium and magnesium carbonates can act as buffers to atmospheric acids. Dr. Eatough (see June 11 presentation, page 65) reported that the majority of SO<sub>2</sub> converted to SO<sub>4</sub> within a plume was buffered by crustal

material. Ammonium (NH<sub>4</sub><sup>+</sup>) provides another source of buffer,

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though this buffer is not as prevalent in Utah as it is in other parts of the country. NADP makes no distinction between species of sulfate in its report of deposited sulfate. A concern has been voiced by some researchers in the West (Hidy, 1986) that a large portion of collected sulfate is in the form of insoluble CaSO<sub>4</sub>. This material has been attributed solely to crustal origin. This assumption does not take into consideration the substantial conversion of SO<sub>2</sub> to CaSO<sub>4</sub> within a plume. Distinguishing between crustal CaSO<sub>4</sub> and CaSO<sub>4</sub> which has been transformed in a SO<sub>2</sub> plume may be very difficult. ADTAC believes that it would not be advisable to make a distinction between soluble and insoluble SO<sub>4</sub> in measuring sulfate deposition, since the insoluble CaSO<sub>4</sub> may be partially anthropogenic.

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Transport of crustal dust must be considered in the acid deposition scenario. This is critical to the understanding of local source input and local buffering effectiveness. Dr.



**Ran Neilson, who is participating in the Mirror Lake study, maintains that crustal material begins to precipitate immediately after entrainment into the atmosphere. The range of crustal transport is not known, but Dr. Neilson has demonstrated that about half of all such dusts fall out between the Alta sampling site located on the west face of the Wasatch Range and the Mirror Lake sampling site. Acids, on the other hand, generally do not begin precipitating until they are converted into particles. Given the time lag between emission and conversion, it is conceivable that local acid emissions are not precipitated within the range of crustal dust. This implies that acid deposition begins beyond the effective range of atmospheric buffers. Assuming that sources along the Wasatch Front of acids and crustal materials are approximately co-located, atmospheric buffering material will not impact all sources of acids. This issue must be studied.**

Some states have enacted laws relative to the deposition of wet sulfate. States known to have acid rain control laws are California, Washington, Massachusetts, Minnesota, New Hampshire, New York and Wisconsin. Threshold levels of wet sulfate deposition are usually included in the legislation. These levels are assumed to reflect safe quantities of sulfate loading. Incorporated into the acid rain control legislation is the requirement for in-state reductions of emitted sulfur and/or nitrogen. States acid rain laws include provisions for research and monitoring of sensitive areas. This

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information provides verification of emission reduction programs. New York's law required the cooperation of state agencies and industry in studying their baseline status of deposition and biota in the sensitive areas. The cooperative agreement included the financing of study efforts.

Acid deposition and atmospheric visibility are closely related. The visibility problem is one of the most difficult environmental issues facing Utah. Visibility impairment is caused by small particles in the air which reduce visual range, color, contrast and tincture of a scene. The particles which reduce visibility are predominantly nitrate and sulfate. Back trajectory analysis, one of the tools being used for visibility studies (see Jim Bresch's presentation, page 75) has been used to determine out of state source contributions of  $SO_4$  to Utah.

Major conclusions from the deposition work group include the following: 1. Acid deposition is occurring in Utah. The full extent of that deposition is not presently known. Sources of the acids are outside Utah as well as within the state.

2. Utah has ecosystems sensitive to acid deposition. These ecosystems need to be fully defined and monitored for change which could be induced by atmospheric acids.

3. Crustal material generated off the desert floor is entrained by wind action and carried for unknown distances. This material can act as an acid buffer. The range of crustal material

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transport and its role in buffering atmospheric acids needs more study.

4. The present deposition monitoring network (NADP) is located primarily in low elevation sites. Monitoring should be expanded to include sensitive areas.
  
5. Some states have acid deposition regulations. It appears premature for Utah to attempt legislation or to define threshold limits. Sensitive areas could use deposition threshold levels as an early warning device for potentially damaging loadings.

### Recommendations

**The deposition work** group recommendations include:

1. Deposition monitoring should begin in the sensitive areas . Present NADP sites are not adequate for assessing acid deposition in sensitive areas. Some of the considerations for siting should include high elevation, at or above timberline, and sensitive or low-alkalinity rock type.
  
2. Threshold limits should not be established until acid deposition impacts are documented. At that time, a threshold limit may be desirable.

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3. Utah should coordinate information from other projects working on acid deposition and visibility. Possible sources of information would include, but are not limited to the

Subregional Cooperative Electric Utility, Department of Defense, National Park Service, Environmental Protection Agency Study on Visibility (SCENES), National Acid Precipitation Assessment Program (NAPAP), Western Atmospheric Deposition Task Force (WADTF), US Forest Service (Rocky Mountain Range and Experimentation Station), Western Conifer Cooperative.

4. Source/receptor models may be used to assess potential impacts on watersheds from sources. Modeling of various kinds are available, each with a specific objective. Of interest to ADTAC was the back trajectory model used by the National Park Service, the RADM model being developed by EPA and the ILWAS model being modified by UP&L.
5. In state and out of state source contributions need to be defined. The respective role of both acids and crustal materials must be understood.
6. Windflow (synoptic event) patterns must be understood. Year to year variations, as they affect Utah, should be researched.
7. Tracer studies should be conducted to determine individual source impacts on Utah. These studies should include short and long range tracking.

8. **Dry** Deposition is poorly understood. The contribution to total acid loading in sensitive areas by the dry component must be quantified. Consideration of soluble vs. insoluble fractions should be made.
9. The pattern and range of buffering crustal materials should be established. Fallout rates and specific buffer species need to be studied.
10. **NO<sub>x</sub>** emissions and the resultant nitrate deposition component of acid deposition requires more study. A number of secondary effects such as lake eutrophication, fertilization of forests, etc., need to be assessed in relation to the acidification.
11. oxidants such as ozone and H<sub>2</sub>O<sub>2</sub> play an important role in the chemical transformation of atmospheric acids. oxidants may have a direct effect on the ecology of Utah. The role of oxidants should be studied.
12. ADTAC or a technical review group similar to it should be perpetuated. Through this mechanism, various state and federal agencies have been brought together to study this complex problem. Further progress on this issue depends on agency cooperation.

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Terrestrial Work Group

The terrestrial ecosystem is the key to either the defense or vulnerability of a watershed to acidification. The acid neutralizing capacity (ANC) of the watershed confers resistance to acidification, protection of lakes and streams against chronic pH depressions, demobilizes the movement of heavy metals in the watershed and alleviates a host of other problems which acidification brings. The lack of ANC is the issue which concerns ADTAC and which determines the sensitivity of watersheds. Bedrock geological type (Norton, 1982) and the accumulation of soils appear to be major factors in determining the sensitivity of a watershed. To this end, ADTAC sought out geological information for the sensitive, suspected sensitive and the secondarily impacted areas in the state. Norton (1982) produced a map of acid sensitivity based upon bedrock geology (figure 5 and table 1, pages 43 and 44). The map does not account for soil accumulation on top of the bedrock and makes the sensitive areas of the state appear to be much larger than they are.

Bedrock types which are typically sensitive include granites, quartz, sandstone and granitic gneisses (see Dr. Brakke's presentation, page 88). The weathering of these rock types yields low amounts of alkalinity. Dolomites and Limestone produce large amounts of alkalinity. Lacustrine sediments, common in Utah from lake bed deposits, are also rich in acid buffering potential.

Topography will also have an impact on watershed sensitivity. Steep

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Class I

Low to no acid-neutralizing-capacity. (widespread effects on aquatic ecosystems expected from acidic precipitation)

Characteristic bedrock types:

Granitic gneiss

Quartz sandstones or metamorphic equivalents

## Class 2

Medium to low acid-neutralizing-capacity. (effects from acidic precipitation restricted to first and second order streams and small lakes. Complete loss of alkalinity unlikely in large lakes.)

Characteristic bedrock types:

Sandstones, shales, conglomerates, or their metamorphic equivalents (no free carbonate phases present).

High grade metamorphic felsic to intermediate volcanic rocks

Calc-silicate gneisses with no free carbonate phases

## Class 3

High to medium acid-neutralizing-capacity. (effects from acidic precipitation improbable except for overland run-off effects in areas of frozen ground) Characteristic bedrock types:

Slightly calcareous rocks

Low grade intermediate to mafic volcanic rocks

Ultramafic rocks

Glassy volcanic rocks

## Class 4

"Infinite" acid-neutralizing-capacity. (no effect on aquatic ecosystem)

Characteristic bedrock types:

Highly fossiliferous sediments or metamorphic equivalents

Limestone or dolostones

## Class 5

Covered by glacial debris or Quaternary alluvial material which obscures the bedrock. Loess is common in the high plains.

**Table 1.** Classification descriptions for acid sensitivity by bedrock geology, Norton, 1982. See figure 5 for sensitivity map of Utah.

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gradients tend to pass runoff over the surface of the soil or **rock**, not allowing the precipitation to percolate through the soil column. This in turn negates any buffering which may have been available in the soil column. The precipitation runoff is left much less affected by the watershed before it enters lakes or streams. If the precipitation trends toward acidity, the degree of acidity remains in the runoff.

ANC is normally indicated by measurements of alkalinity. Alkalinity is the capacity of a solution to neutralize acids (Hem, 1970). Alkalinity is normally reported as  $\text{CaCO}_3$ , but refers to carbonates, bicarbonates, phosphates, hydroxides and other weak acids which can neutralize strong acids. The measure of pH indicates only the activity of hydrogen ions already within the soil column. This measurement is therefore of value to determine the amount of acidity which has already occurred, while the measure of ANC indicates the amount of buffer available for neutralizing acids. Since sensitivity is the parameter which should be measured in Utah, examination of available buffer is the key to the determination of sensitivity in the watershed (see Dr. Brakke's presentation, page 88).

Another key ingredient to sensitivity deals with the hydrology of the watershed. The frequency of precipitation events, volume for each event and the concentration of acids and crustal materials greatly influence the sensitivity of the watershed (see Dr. Brakke's presentation, page



88). The variation of any of these factors **will** change the input of acids being deposited into a watershed and thereby

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influence the watershed acidity. In Utah, it has been shown that low volumes of precipitation usually have higher concentrations of acids and bases than do heavy precipitation events.

The effects of acid deposition must be anticipated in a sensitive watershed. Interpretation of rainfall pH, sulfate loading or other deposition monitoring methods are valid only in the context of the effects upon a particular watershed. For example, in soils where sulfate adsorption is still occurring, sulfate can be deposited without creating an acidifying effect on soil (see Dr. Brakke's presentation, page 88). The same concept holds true for nitrate deposition. If a watershed is nitrogen limited, the nitrogen deposited from the atmosphere will be consumed as a nutrient and will probably never create an acidifying effect. This does not imply that there is no effect from the deposition of sulfates or nitrates under the above described conditions. It means that the effects of deposition may not be to create acidification.

The biological impact of greatest concern to terrestrial ecosystems in Europe and eastern North America deals with the effect of acids on tree leaves and needles. Different forms of acids such as wet deposition, dry deposition, cloud and fog acidity and rime ice (rime ice is ice formation on objects from cloud water) seem to have different impacts on plants. of great concern in the West is the cloud, fog and rime ice impact. The Western Conifer Cooperative has begun the

study of cloud , fog and rime ice effects on high elevation forests in the West. Since cloud, fog and rime ice can have acid

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concentrations 10 times greater than in wet deposition, the frequency of these events occurring on forest ecosystems is being studied to assess the impact of this phenomenon. Some researchers are looking past the direct impact of acids on the trees and plants and to the effect of soil acidification (see Dr. Fisher's presentation, page 60). New research indicates that leaf chlorosis and reduced needle life may be due to mineral deficiencies caused by soil acidification and not **by** the direct acidification of the leaves themselves. As acids leach calcium and magnesium from the soil, these available nutrients become more scarce, producing nutrient deficient appearance described as chlorosis.

Mycorrhizal fungi and other soil microorganisms are sensitive to shifts in acidity. Acidification of soils has been proposed by ADTAC to disturb these communities making an impact on plant nutrition. Since these communities often serve as symbionts with higher plant forms, the inhibition of these microorganisms will affect the higher plants' ability to absorb needed nutrients.

Acid impacts on plants are easy to determine with individual plants such as lichens (see Dr. St. Clair's presentation, page 61). The acids cause leaking of cell constituents through the cell wall. Chemicals such as sulfate and lead become permanently established in the plant thallus or body, to serve as a long term record of atmospheric gases and particulates which the plant has

absorbed. Similarly, long term records of atmospheric deposition are thought to be preserved in tree rings. Some researchers have proposed that tree

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cores may contain concentrations of sulfur **which** would indicate atmospheric concentrations of sulfate.

The sensitivity to acid deposition, for trees or for microorganisms can include partial impairment to reproduction, photosynthesis, nutrient uptake, etc. The weakening of a specific community by partial impairment is an opportunity for competing communities to enter the ecosystem. Concern was voiced by ADTAC about the potential of acid deposition providing the weakening element, thus allowing the encroachment of parasites, predators or noxious communities into an otherwise stable ecosystem,.. Symbiotic relationships would require careful study, but the general concern for such relationships centers on impairment of one symbiont such as mycorrhizal fungi, which would lead to impaired nutrient uptake by trees.

Effects from acidification may also be delayed through biological activity. Sulfur absorbed into leaves may become converted into  $\text{SO}_4$  and be entrained by the leaf when the leaf drops. Upon leaching or decomposition of the leaf, the sulfate is then released into the ecosystem. Additional data on this phenomenon are desired.

Abiotic effects on the terrestrial ecosystem from acidification involve the leaching of calcium and magnesium, corrosion of man made structure, and the weathering of soils and rock. The committee did not examine the potential for damage to man made structures, but this type of corrosion does occur in parts of the world. Susceptible stone

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may require examination for acid damage. T's would be especially

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true for **cl@L-Jer** structures. **e4eat'!-iefi-.,ig** of so@.is and rock relates to  
the soils. issue discussed previous.'Ly. A part of the weathering  
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natural process well known to soi-" scientists. The process which is not **well** understood is the  
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available, western researchers are following for an entire watershed study area. The watershed should be sufficiently secluded from human activity that experimental determination of the acidification of a watershed can be observed without human interference so that the balance of atmospheric acids and watershed ANC can be studied.

NO emissions have been increased by 150% in parts of Utah  
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environmental consultant, to increase as much as 150% in parts of Utah  
in the next decade (figure 6, panel 4) NO emissions are  
believed to have a much greater impact on sensitive areas than

are local SO emissions. of NO or  
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is at least 40% of the total  
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transformation within the atmosphere can act as either an

acid (HNO<sub>3</sub>) or a nutrient

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systems. The impact . c,, areas in Utah  
appears at present to be exclusively fertilization (see Dr. Hill's  
presentation, page 70j. Overi@ert,4L!ization may i-fi-t-lair the ability of

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some plant-@ and trees to survive cold weather. The amount of nitrate  
required to become excessive is not known. What seems apparent at the  
Mirror Lake Study area is that in the warm season, most of the nitrate  
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is consumed by the biota either it enters the lake system or

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before it leaves the lake. In cold weather, nitrate begins to show up

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It has been proposed that

in the watershed are using the nitrate filter, they become deactivated by the cold. Cold weather allows the buildup of nitrate to take place. If the nitrate converts to the acidic form, acidification of the ecosystem would be

#### Recommendations:

A number of recommendations came from the Terrestrial Work Group.

Three were deemed

Without assuming any order of priority, the following were deemed important by the group:

1. Data are needed in order to establish a baseline for terrestrial ecosystem in the highest priority should be the study of the sensitive areas.
2. Areas which are suspected as being sensitive to either acidification or to secondary effects of atmospheric acids should be studied.
3. Soils should be studied to determine their acid neutralizing

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capacity (ANC). This is especially critical in areas where there are shallow soils. The use of soil lysimeters would make low cost-monitoring of soil solution chemistry possible.

4. Vegetation surveys in the sensitive and suspected sensitive areas **will** also be needed.

5. Lichen analyses appear to have a good potential for assessing historical and present status of acidification. Lichen analyses would require the establishment of a baseline network.

6. Long range sensing is a tool that has been proposed by such groups as the Jet Propulsion Laboratory for sensing the acute impacts of acidification on watersheds. This is a possible monitoring method after the establishment of vegetative survey information.

7. Tree ring chemistry may perform the same function as lichen surveys in obtaining a biochemical record of historic atmospheric chemistry.

8. The condition and range of soil organism communities and their health may aid in the determination of the synergistic effects of acidification.



9. Plant nutrition including symbionts, soil condition and

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plar.' requirements in sensitive areas needs more study.

10- ;Source/receptor studies **will** eventually be required if .J.nipacts on the receptors are being found. Tracer studies and back trajectory modeling are recommended.

'Ll. A clearing house is needed for the research underway in the state as well as **in** the West.

12. The state needs t,3 become involved in science. This involvement may not be in the actual research itself, but that is also a possibility which the state neeos to explore.

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### Special Interest Work Group

ADTAC encountered a number of groups which directly represented either industry or environmental interests who desired input to the committee. While some of the input is more appropriately addressed by the statutory committees, some research had been done which was relevant to the acid Deposition issue. To accommodate these interests, the special interest work

group was formed. The special interest group sponsored a day of presentations which allowed industrial and environmental groups a chance to give their views on acid deposition.

While taking varied philosophical views on acid deposition, it should be noted that all participants urged the state to get involved in acid deposition research and monitoring. ADTAC was contacted initially by industry. Concern was voiced about pending legislation in Congress which might be unfair to industry in Utah. Popular bills now before Congress are requiring nationwide emission standards for both SO<sub>2</sub> and NO<sub>x</sub> emissions. The utilities in the state, especially those with older generating units, are concerned that the emission standards for NO<sub>x</sub> may be unnecessarily restrictive. Retrofit of existing boilers may be possible at a cost of \$3 million. If retrofit is not easily accomplished, units may be forced into retirement. Large scale replacement or major retrofit could cost \$500 million for UP&L alone.

Another concern about the Congressional bills is that the major thrust for control is directed at SO<sub>2</sub> emissions. Some bills would have all

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states pay for SO<sub>2</sub> controls for Midwest polluters. Utah's industry already meets an SO<sub>2</sub> emission limit of 1.0 pound per million BTU, established by state regulation. Proposed legislation would limit SO<sub>2</sub> emissions to 1.2 pounds per million BTU. Utah industries already use coal with a sulfur content of less than 1.0 pound per million BTU, so the proposed standard is being more strictly enforced by existing state regulations. Midwest and eastern states which use 2-6% sulfur coal will likely be required to either use low sulfur coal or install control

equipment which will be more efficient in removing sulfur from. plant emissions. Congress is proposing to tax the nation's electricity users in order to pay for the new control equipment. Western states and industries generally oppose a nationwide tax since western utilities already meet strict sulfur removal and fuel-sulfur standards. Western industries have voiced concern that they have made a significant investment into control equipment and that paying for eastern utilities, retrofit requirements constitutes double jeopardy for the western industries which have made the pollution control investment. This desire has been expressed by Utah industries to pay for the clean-up of Midwestern industry which has not made the environmental investment similar to Western industry.

The copper industry feels that its Utah emissions are already well controlled and does not favor further government mandated SO<sub>2</sub> removal from emissions.

All industrial representatives voiced their concern over the lack of acid deposition study being done in the West and especially in Utah.

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Specific research recommendations included monitoring watersheds above timberline, study of meteorological patterns, ecological study of sensitive areas for acid impacts, source/receptor relationships and dry deposition contributions. Cost for additional controls in light of no evidence of acid damage in the West was also mentioned by industry. The contention is that if no adverse impacts have been observed, why should industry be required to expend additional

monies to further reduce emissions of acidic pollutants. Sound scientific study was regarded as essential to the formulation of appropriate policy.

The environmental groups voiced support for the Governor's decision to have the state examine the status of acid deposition in Utah. The issue of natural resources was often cited by these groups as critical in the acid deposition scenario. Protection and preservation of sport and recreational opportunities was a concern. The primary concern was for fisheries. Acute acidification as it occurs with acid pulses from spring runoff has been documented in the West. Due to limited study in Utah, only mild pulses in a "buffered" watershed (Mirror lake) have been observed. More research in areas located away from the buffering effects of Great Salt Lake Desert dust were called for.

Study of watersheds and forests for acid, oxidant and visibility impacts was requested. Since visibility reduction is caused largely by nitrate and sulfate particles, the visibility issue is closely linked to acid deposition. Coordination with state and regional visibility efforts was recommended.

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Tighter control on automobile and on NOX emissions from large sources was recommended by (L&M). Approval was voiced for inspection and maintenance programs in the state. Increases in the emission of NO was a threat to the environment. r e, -z r, . c u g h

environment that selected, the of NO was  
recommended for large x

Enforcement of the Clean Air Act in the West was of  
concern to several environmental groups. While no copper smelters in  
Utah have NSR permits, the industry has been a voice for additional control  
of sulfur emissions is recommended. The groups acknowledged the  
progress which the industry has made in controlling SO

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emissions in the region. The EPA has set a  
a specific level of sulfur dioxide was set at 1.0 parts per billion.

reductions, though

environmental groups have been successful in  
the EPA's study of Utah's  
air quality. The EPA's study  
has shown that sulfur dioxide levels in  
Utah are higher than in other states.

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## VI. TECHNICAL PRESENTATIONS

Dr. William Wagner, ADTAC, February 19-- The National Acid Deposition Program (NADP) and the National Trends Network (NTN) have located three sites in Utah for monitoring precipitation pH. These sites are at Logan, Green River and Bryce Canyon. Another NADP/NTN site is located near Lehman Caves on the Utah/Nevada border. This station is located close enough to Utah and is considered upwind such that the data collected can be considered Utah data. Some data are also available from monitoring done at Cedar Mountain, southeast of Price. The Cedar Mountain site is no longer in operation.

Mark Ellis, ADTAC, April 9-- The Western STAR will be coordinating with EPA on a model which will be used to predict the effect and impact of deposition from sources and upon receptors on a mesoscale (300 km<sup>2</sup>) size. This effort will hopefully lend strength to the regional permitting program which is to come out of STAR.

The states of Minnesota and New York have enacted their own acid deposition legislation. The legislation is designed to set a threshold limit for wet sulfate deposition of 11 kg/ha/yr for Minnesota and 20 kg/ha/yr for New York. Both states considered it of critical importance that, as acid "importing" states, surrounding acid exporting states be put on notice that their emissions could violate standards within the importing states. These states also felt it necessary that state legislation be passed prior to national

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legislative action in order to gain primacy over the Congressional action, and at the same time show encouragement to Congress for national acid deposition legislation .

Incomplete data from STORET, EPA's water quality databank, lead to the decision to sample lakes only from the Uinta and Wasatch Mountains. It is recommended that the aquatics work group consider addressing the STORET data which might indicate some of the other areas in the state which are assumed to be sensitive (less than 200 ueq/1 alkalinity).

Dr. Wayne Wurtsbaugh, ADTAC, April 9-- A study was conducted by Dr. Jay Messer, USU, of some chemical constituents of snow cores taken along the Wasatch Front. Seventeen core samples were pulled in locations ranging from Bear Lake Summit on the north to Strawberry Summit on the south. No abnormally low pH measurements were found. Leaching of acids through the snow pack was discussed, but that issue was not resolved since no follow-up study was made. Sulfate was found to be in greater abundance than nitrate. Chloride decreased in concentration as distance from the Salt Lake Basin increased. Messer contended that gypsum dust from the Great Salt Lake Desert had an impact on all of the Wasatch Front snow core samples.

Work by Kilham, University of Michigan (1982), has been done on the effects of acidification of calcareous watersheds. A small calcareous lake was thought to have become more eutrophic



due to accelerated leaching of alkaline minerals into the water by atmospheric acids. If this is the case, then the sensitive areas of Utah would include a

(59)

wider range of "sensitive" watersheds and ecosystems than the traditional sensitive areas. The net result of alkalinity leaching would be accelerated eutrophication of lakes statewide.

Dr. Richard Fisher, USU, April 9-- Soils, regardless of pH maintain electrical neutrality so that whatever ions enter the soil system will force the exit of other ions in order that the electron balance can be maintained. As soils age, they become more acidic. This is due to the initial loss of calcium, magnesium, iron and potassium. The soils in most of Utah's forests are rich in carbonates and poor in sulfates. Hydrogen is always present in soils, making them acidic regardless of age, unless they contain high salt concentrations as many low elevation Utah soils have. "Young" lakes tend to be more alkaline. Beginning at formation, the lakes gain in alkalinity for a time, then begin a gradual net decrease in alkalinity. Cation stripping results from the loss of nitrate, sulfate and ammonia from the soil, along with accompanying anions. This makes room for more hydrogen and thereby lowers the soil pH. Soils so stripped become hydrogen saturated clays. Lowered soil pH changes the valence of aluminum and other heavy metals, causing them to become toxic.

Forest decline in Germany is thought to be tied to oxidants such as ozone. The decline may not be from foliar damage at all, but from a chemical imbalance in the soil resulting in calcium and magnesium deficiencies. Soils have three distinct pH plateaus, between which a period of

stable buffering occurs. The plateaus lie at pH 6.5, 5.5 and 3.5. The drop from one plateau to another occurs without warning.

(60)

Dr. Larr,%, St. Clair, BYU, April 9-- Lichens can serve as biological monitors of air pollution. Lichens are found on a wide range of substrates and in diverse environments. As symbionts, lichens are sensitive to nutritional shifts. Due to the nature of the thallus (plant body), the plants serve as chemical sinks, preserving a living record of the ambient atmospheric chemistry. A variety of approaches can be used with lichen monitors. These include floristic surveys, ecological surveys, photographic records, thallus analyses, physiological factors and any combination of the above. It was recommended that documentation of the lichen data base be undertaken to enable scientists to assess air quality status at a very low cost, ranging from \$6-12 per saffole.

Maureen Wilson, ADTAC, April 9--- A three phase project to study the Uinta Range fishery was begun in 1955, The first phase examined 900 lakes for lake morphometry and fishery population status. Phase II began in 1971 and placed 587 of the phase I lakes on a management program. This phase was completed in 1984,

Based upon data collected by @;@WR, -O of the ii,@!-@+,-a lakes surveyed by the NSWS project held fish populations. only three lakes contained L-

reproducing populations. Since the inhibition and/or cessation of reproduction is the earliest sign of trout population stress, it would be logical to bias towards the selection of these lakes for later study phases of the NSWS project. The three lakes of highest priority surveyed by EPA include: Allred Lake (Duchesne County, Section 14, Township 4 N., Range 4 W.), Shadow Lake(Duchesne County, Sections 28,

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33, Township 4 N., Range 4 W.) and Rhoads Lake (Summit County, Sections 15, 16, Township 1 S., Range 8 E.).

Dr. James Gibson, NADP Director, June 11-- The agricultural community was initially concerned about the effects of acid rain on agricultural crops. This concern led to the formation of the National Acid Deposition Program (NADP) in 1978. Acid "rain" was mislabeled since acidic gases and particles must also be addressed. The whole picture of acidic deposition (gases, particles, aerosols and liquids) is now much better addressed. A major impact from atmospheric acids on man-made materials and structures is being observed. Agriculture has not proven to be adversely impacted by acid deposition. Attention has switched from acid deposition to ozone effects on crop loss.

NADP objectives originally centered on the spatial and temporal trends of wet and dry acid deposition. Gene Likens published an article in 1976 dealing with trends of precipitation pH over a 20-year period. His assumption was that increased levels of atmospheric acids were decreasing the precipitation pH. Later work is showing that decreased buffering, not increased emissions, are more likely responsible for declining precipitation pH.

NADP now samples only for wet deposition. Sampling design includes field criteria, frequency of taking samples and siting criteria. No event sampling is being done. Samples are taken

weekly on Tuesdays at 9:00 a.m. NADP is for the purpose of determining regional, non-source specific pH trends. Source sampling is avoided since this is the

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responsibility of EPA or the states. Major cations and anions are sampled and sent to the Illinois State Water Laboratory.

Precipitation data sites are subject to field quality assurance protocol, operator training and site visitation by EPA auditors. Data are handled through Colorado State University. Or Gibson pointed out that the Cedar Mountain data are not considered reliable and are therefore of dubious value. **Field** a variety of forms are available from CSU. EPA banks any precipitation data Submitted to the agency.

Dry deposition usually, since it does not measure

gases and aerosols. Field of dry deposition monitoring

is to measure ambient air concentrations and then to infer deposition. Methods of determining

wind velocities are under

study. Thirty new sites are being installed in the east which **will**

monitor for nitrogen, sulfur and ozone. The study is to verify the RADM model.

Present network monitoring limitations include the lack of high elevation sites, lack of dry deposition monitoring and lack of cloud, fog and rime ice monitoring.

Western pH tends to be lower than in other areas.

Precipitation **pH** is **now** have a natural pH of about **5.2 due**  
to the presence of natural organic acids. West-Lern precipitation **may**

**i-**  
have a higher natural pH. **ii-** West, natural alkaline dust as well

as the natural organic z@-re found in precipitation. Dr. Gibson  
estimated that natural precipitation in the West may be around pH 5.6.

(63NJ)

Dr. Doyle Stephens, U.S. Geological Survey, June II-- Salt Lake Valley monitoring study (1980-1981) was a part of the nationwide river runoff program conducted by USGS, EPA, Salt Lake County Flood Control and the Bureau of Water Pollution Control. The objective was to determine the quantity and quality of runoff water in the urban areas. Atmospheric collectors were used in conjunction with this study. Four Best Management Practice (BMP) basins are located in Salt Lake County. The county was interested in ascertaining the effectiveness of management practices. Collectors were located at: Sandy City Public Works, Bells Canyon (Alta High School), USGS Building (1745 South 1700 West), Dixie Valley (5000 South 3500 West), Firestation No. 9 (Fairgrounds) and the University of Utah meteorological site at the mouth of Red Butte Canyon. Collection equipment used was Aerochemetric samplers for wet/dry sampling. Wet sampling was done only when runoff was created. No sampling was done in the winter for snowfall since this did not result in an immediate runoff event. Acidic rainfall events appeared mostly in spring and fall. With a demarcation of pH 5.6 between acidic and nonacidic precipitation, about 40% of storms sampled were determined to be acidic. Samples were taken by episode. Conductivities and pH were run at the Salt Lake USGS office. The rest of the constituents were run by the USGS lab in Arvada. One composite sample of snowfall had a pH of 5.0. Alkalinities of samples ranged from 3-19 mg/l. Lowest pH recorded was 3.9 from the Fairgrounds, upper pH was about 7.0. pH means were not volume weighted.

Bells Canyon had the most acids recorded from its sampling. Each storm appeared to have independent characteristics, varying according to season. The longer the storm, the more dilute the sample. Chloride

(64)

comprised 25-50% of total dustfall constituents by weight. Chloride was most concentrated to the north, less to the south. No correlation was found between dustfall concentrations and land use in the vicinity of the collectors. Solids collected were as high as 25 lbs/acre/month.

A source of trace metals appears to originate in Utah County, i.e., U.S. Steel. The chloride allegedly came off the Great Salt Lake area.

Dr. Delbert Eatough, BYU, June 11-- Dr. Eatough's major study has been with the atmospheric chemistry of sulfur and nitrogen oxides. Coal combustion contributes to large portions of total sulfur and nitrogen oxide emissions. With the Kennecott smelter shut down, combustion is the main source of these acid precursors. Dr. Eatough indicated coal burning industries such as the utilities and U.S. Steel as major contributors to acid precursors. These also contribute most to the visibility problems. Soil particles are generally larger and do not scatter the light as much as the anthropogenic sources of sulfur and nitrogen oxides, phosphorus and lead.

Chemical pathways available to atmospheric pollutants include: (1) the pollutant will be deposited without chemical change. The pollutant may become changed to an acid on the

ground or in the watershed; (2) a dry reaction of precursors to nitric acid ( $\text{HNO}_3$ ) or sulfuric acid ( $\text{H}_2\text{SO}_4$ ); and (3) in clouds, a wet reaction may transform the precursors into acid.

Sulfate has had the most study of all the atmospheric acids. About

(65)

0.5-2%/hr of emitted sulfur from a plume is converted to equal parts

of sulfuric acid and sulfate metal salts. The objective of  $\text{SO}_2$

chemistry study is to determine how rapidly and to what products  $\text{SO}_2$

is converted. The use of a tracer allows the change of  $\text{SO}_2$  over

time to be examined as the plume moves along. Sulfur reactions tend to be a first order, gas reaction which occurs in a linear transformation from  $\text{SO}_2$  to other compounds. The reaction occurs in daylight. The reaction rate increases with temperature increases. For the conversion of  $\text{SO}_2$  to  $\text{SO}_4$  the hydroxyl radical is the

driving force. The conversion rate is approximately 5%/hr in the

summer and less than 1%/hr in the winter.

Neutralization of atmospheric  $\text{H}_2\text{SO}_4$  in a plume is typically accomplished by atmospheric ammonia. Since ammonia is substantially

lacking in Utah's arid climate, it is apparent that  $H_2SO_4$  neutralization is being done by mineral bases, principally calcium.

Dr. Eatough mentioned that the chemical conversion of  $SO_2$  to  $H_2SO_4$  is accelerated by a factor of 10 if the reaction takes place in a fog bank. Hydrogen peroxide ( $H_2O_2$ ) appears to be the catalyst which accelerates this higher rate of reaction in the saturated conditions found in fog banks and clouds. He called for more research into the gas and liquid phases of these acids. Not as much is known about the reaction of  $NO_x$  to nitric acid ( $HNO_3$ ). *The sampling methodology for  $NO_x$  is much more difficult. Due to the volatile nature of gas phase  $HNO_3$  and the fact that it adsorbs rapidly, a diffusion denuder is used for  $NO_x$  sampling. The*

(66)

**gas is removed first onto the sides of the denuder tube. Particles of  $NO_3$  are trapped in a sorbent filter so as to keep the two phases separate. Without the separation, the various species convert rapidly back and forth. A second filter lies behind the sorbent filter in order to separate the evolved gas from the particulate.**

**The daytime reaction of  $NO_x$  to  $HNO_3$  appears to have a threefold**

***greater rate than the  $SO_2/H_2SO_4$  reaction. Apparently, the nighttime reaction for  $NO_x$  conversion is even higher than the daylight reaction. This indicates that a different chemical pathway is followed.***



*Dr. Eatough also discussed some of the **visibility work** in **which** he has been involved in the L.A. Basin and the Grand Canyon area.*

*Dr. Alan Galbraith, U.S. Forest Service, June 11-- As a follow-up to Dr. Eatough's presentation, Dr. Galbraith supported the claim of higher SO<sub>4</sub> formation in the summer since the rate of SO<sub>4</sub> deposition in the Wind River Mountains is much higher in the warm seasons than in winter.*

*Dr. Galbraith coordinates the acid deposition study in the Wind River Range, Wyoming. The importance of this work to Utah is many fold. First of all, there are many similarities between the Wind River Mountains and the Uintah Mountains in Utah. The rock types, shallow to nonexistent soils, heavy precipitation and other factors appear to be similar. The same concern for receptor sensitivity would be*

*(67)*

*assumed as **well**. Utah is also upwind from the Wind River study area. Emissions from the Wasatch Front may be influencing the Wyoming wilderness area. Impacts from emissions are also suspected from the **L.A.** Basin and from the southwest copper smelters.*

*In the sampling program, a large change in pH takes place between the field conditions and when the pH is measured in the laboratory. Field pH is used in preference to the laboratory readings. Field pH has averaged between 4.26 and 4.63 before 1985. The 1985 weighted average rose to 4.9. The increase may have been due to trona field emissions which are composed mostly of phosphate dust.*

*Four NADP sites are found on the west, south and north sides of the study area. Watershed monitoring is also done. No statistical difference is apparent between the four sampling sites. SO<sub>4</sub> concentrations do not vary much in the same seasons, but the amount of SO<sub>4</sub> so increases with increases of precipitation. In the watershed, 4*

*lakes and streams are sampled for physical parameters such as dissolved oxygen, pH, temperature and conductivity. Samples are taken from lakes out of the epilimnion and the hypolimnion. Benthic samples are taken to examine the health and diversity of the aquatic macroinvertebrate community. Planktonic samples are also taken. An apparent impact from acidity is that the diversity of the benthic community decreases with increases in acidity. Certain species such as the stone fly are very sensitive to acidification. Acidification also has an effect on the gill lamellae of fish, allowing aluminum to accumulate on the lamellae and to block the transfer of gases, leading*

(68)

*to suffocation. Soils in the watershed are shallow. The soil columns found there have a low ion exchange capacity. This decreases the likelihood that soil sulfate adsorption is able to take place. Lichen sampling has been done by Mason Hale of the Smithsonian Institute. He finds that lead levels in lichens are two to three times higher in the Wind River Mountains than in a base line site in Colorado. The elevated lead levels are an indication of acidification in the*

*study area. Sediment cores are taken in the lakes to study the history of the watershed. Heavy metals and diatom remains are examined from the strata in the sediments, giving an indication of pH levels in the past and to determine possible trends towards acidification.*

*Conclusions of Dr. Galbraith's presentation listed seven points:*

- 1. Annual average precipitation pH in the study area has ranged from 4.6 to 4.9.*
- 2. The watershed has an extremely low buffering capacity.*
- 3. Soils are sparse and tend to be acidic.*
- 4. Lake and stream alkalinities are low.*
- 5. Lichen analyses indicate elevated levels of lead in the thallus, an indication of acidification.*
- 6. Lakes, while having low alkalinities, are maintaining alkalinity levels.*
- 7. Wind River lakes are probably more sensitive to acidification than are lakes in Scandinavia and the Eastern United States.*

*The next portion of this project would be to see the effects of increasing, possibly doubling, the influx of sulfate to the*

*(69)*

*watershed. Also of concern to the study is the effect of acid pulses into the study lakes. Acid pulses have been reported in Wyoming and Colorado.*

*Dr. Fredrick Wagner, ADTAC, June 11-- Dr. Wagner reported on deposition and sampling work which was done by George Hart and Dennis Parent in the Blacksmith Fork drainage (1970-1971) and by David White on Chicken Creek. -The Blacksmith Fork study examined the effects of trees on the precipitation in the watershed. Samples were taken beneath the canopies of Douglas Fir, Rocky Mountain Juniper and in the open. Major cations and anions were*

*examined. It was felt that the canopy was collecting ions which were washed off the needles in the process of throughfall. The net effect of canopy throughfall was to decrease the pH of the precipitation. An inverse relationship was observed between No 3 and pH. The event sampling pH ranged as low as 3.2.*

*Regarding the Chicken Creek study, the annual average pH was 6.2. Precipitation pH was lower during rain events than with snow, possibly relating back to the lower rate of SO<sub>2</sub> conversion in the winter discussed earlier.*

*Dr. Clyde Hill, ADTAC, June 11-- The Mirror Lake watershed study was begun in 1983 with the following objectives:*

- 1. Determine the composition and acidity of precipitation in the Mirror Lake area.*
- 2. Determine the composition and acidity of surface waters in*

*(70)*

*the sensitive areas.*

- 3. Evaluate the present watershed acidity and the potential effects of acidification.*
- 4. Establish a baseline from which changes in time can be measured.*
- 5. Enumerate the factors involved with surface water acidity.*
- 6. Modify the ILWAS model to predict acidification effects in Western sensitive areas.*
- 7. Perform a mass balance for predicting alkalinity depletion.*

*The study involved the examination of 14 Uinta lakes, 6 Wasatch lakes and comparative measurements from a few lakes in the Wind River Mountains. The major focus of the study is in the basin of Mirror Lake itself. Initially, acid inputs and neutralization potential were examined. Acids which were examined for input included H<sub>2</sub>SO<sub>4</sub>, HNO<sub>3</sub> and HCl in particle and gas phases. Organic acids and acids from organic material decay were also calculated into the acid input. These natural acids were calculated to represent 66% of the total acid input to the watershed.*

*Neutralization of all acids within the basin takes place mostly in the subsurface soil and rock layers. Due to the nature of the parent rock material, little natural buffering can be expected. Unexpectedly high water alkalinities, up to 1600 ueq/l (preliminary data), were encountered in the subsurface water courses. (Coordinator's note: In a letter submitted October 13, 1986 (Appendix A) Dr. Neilson explains that the alkalinity measurements originally reported have been found*

*(71)*

*to be in error by the researchers. The original data were presented as preliminary data. The numbers have been accordingly adjusted downward by approximately 400%. This adjustment does not alter the original thesis that Mirror Lake soils contain sufficient alkalinity to provide buffering for atmospheric acids deposited at present rates.) Such high alkalinities are presumed to originate from wind blown particulate off the Great Salt Lake Desert. Thousands of years of accumulation would account for the generous alkalinities now being measured.*

*The project also examines the following: dry deposition through the mechanism of tree throughfall, snowfall sampled in pits, a complete hydrology of the basin, soil analysis, vegetative cover and some biotic sampling.*

*Observations and preliminary results indicate that:*

1. *The average, annual weighted precipitation pH lies at 5.12.*
2. *Surface water pH from Mirror Lake has been recorded at no lower than 6.1. It is felt that this pH represents stability within the system at a level which will not adversely impact lake biota.*
3. *Due to the presence of wind blown dust or loess, sufficient buffering of the imported acids appears to be present in order to neutralize the waters moving through the basin of Mirror Lake. Unknowns include how much of the loess is soluble calcium and magnesium, what is the predicted availability of alkalinity*

(72)

*and the timetable of extinction for the known alkalinity at present acid loading. The effect of increasing the acid load is also unknown.*

A. *Nitrate (NO<sub>3</sub>) does not appear in the basin outflow and is found in only small amounts in inflow streams to Mirror Lake. This indicates active biological use of NO<sub>3</sub> as a nutrient. The role of NO<sub>3</sub> as an acidifier is negligible. The lake was*

*not found to be in an advanced trophic state. This would indicate that nitrogen is a limiting nutrient in the watershed*

*and that the nitrogen is consumed within the watershed and not*

*leached into the Quaker course. It is proposed that the reduction of nitrate may be removing hydrogen ions from the system.*

5. *Snowmelt, in fact, produces the lowest pH levels.*

Stratification occurs within the lake with a chemocline being established in the water column. With the strong chemical gradient plus the thermal gradient, runoff simply flows through the epilimnion to the outflow and does not impact the entire water column. Evidence exists that the chemocline is also established at various depths by springs entering the lake.

6. The T<sub>1000</sub> isroghfall deposition is felt to be an effective method and

correcting dry deposition. There are some

1. Limitations on this dry deposition sampling method.

7. The net effect of acid/dust influx to the watershed leans toward acidification. Although the major contributor to watershed acidification is natural organic acids within the system, the atmospheric acids are a substantial contribution.

(73)

The rate at which the acids are leaching the alkalinity out of the system has not yet been determined.

Dr. Ron Neilson, UURI, June 1982 - The ILWAS model is to be adapted for use in the complex terrain of the western United States such as that found in the Mirror Lake basin. Working with the data produced by Dr. Hill's research, an enormous amount of data are available for input to the model. Calibration of the model is not yet complete. The variation of application of

ILWAS from the eastern U.S. where the model was developed, and the Mirror Lake basin is the reason for the recalibration. Acids modeled by ILWAS include  $H_2SO_4$ ,  $HNO_3$ ,  $HCl$

plus HF,  $PO_4^{3-}$  Base cations, metals, ammonium,  $CO_2$  buffer,

organic acids, etc., are included. Complete model parameters are enumerated in "Integrated Lake - Watershed Acidification", Water, Air and Soil Pollution, Vol. 26, No. 4, 1985.

A major advantage to the model is that the nonlinear processes such as cation exchange rates are more easily modeled than calculated. The model also allows prediction of effect by varying any or all of the modeled parameters. The model is driven by daily time steps for meteorological and other conditions.

Comments on the ILWAS model conveyed a great deal of support for this model by other participants in the meeting. Enthusiasm for such a program was apparent, especially from other researchers. Broad application for ILWAS is anticipated for other watersheds in the West.

(74)

Jim Bresciani, Colorado State University, July 18-- CSU has been doing research in long range transport for the National Park Service (NPS). Lowell Ashbaugh from U.C., Davis performs many of the measurements taken on fine (less than 2.5  $\mu m$ ) and coarse (greater than 2.5  $\mu m$ ) particulate. Sample sites are located in remote areas, usually National Parks. Sites are



supposed to be regionally representative. The Bryce Canyon site is located at 8,000 ft. elevation. The Canyonlands site is 5900 ft. elevation. Measurements are made of gross sulfur. The Canyonlands site is consistently higher in sulfur than the Bryce canyon site. Regional trends show increasing concentrations of sulfur at the southern locations. The western U.S. maintains only one tenth the concentration of sulfur which the eastern U.S. maintains. Several sources in Mexico, southern California, the Mojave power plant (Nevada), the Navajo power plant in Arizona, and other large sources in the region may be impacting Utah. Concentrations of sulfur detected in the summer are higher than in winter, probably due to more rapid chemical conversion in the summer than in the winter; or else the transport mechanism is better in the summer since emissions from most of the sources would be coming from the south on the Bermuda High and its south winds. Great Basin inversions in the winter may concentrate sulfur.

The model used was a version of the ARL-ATAD model (Heffter, 1980) used by NOAA. This is a single layer, variable depth transport layer model which assesses an area of 300-3,000 meters above the terrain. Distance weighted interpolation is made on measurements from radiosondes. The only radiosonde in Utah is at Salt Lake City. other

(75)

radiosonde stations are Desert Rock near Las Vegas, Winslow, Arizona, and Grand Junction, Colorado. SCENES data will help to fine-tune the trajectory analyses made now with the sondes. Back trajectories track an air parcel from its receptor in three (3) hour time steps back five

(5) days or until no more data are available.

The statistical method of analysis for the back trajectory endpoints is accomplished by establishing 1 x 1 degree grids. With the grid system, residence time plots are established and contours lines are drawn. The statistical methods are used to evaluate a variety of receptor scenarios. Since the back trajectory models work from the receptor site backwards in time, a statistical base can be established from collected data. The Bryce Canyon and Canyonlands sites have six years of data available. These data provide a good base upon which to make statistical inferences on the scenarios modeled by back trajectory.

**The trajectory analyses provide the following information for each receptor:**

1. The geometric mean of fine sulfur concentration for the period September 21, 1979 to June 30, 1985 is 220 ng/m<sup>3</sup> at Bryce Canyon and 240 ng/m<sup>3</sup> at Canyonlands. Summer values are substantially higher than winter values with variations from 150 ng/m<sup>3</sup> in the winter to 330 ng/m<sup>3</sup> in the summer at Bryce Canyon and from 250 ng/m<sup>3</sup> in the spring to 350 ng/m<sup>3</sup> in the summer at Canyonlands. The Canyonlands winter mean

(76)

-@ntration is 290 ng/3

conc- m

2. overall residence time plots show the main pathways to a receptor. The main pathways for Bryce Canyon show a dominant pathway of sulfur from the southwest or the Southern California area. Another major pathway, common in the winter, originates in

the northwest. The Canyonlands site has a similar bimodal pathway from California and from the northwest, except that the northwest pathway is stronger at this site than at Bryce Canyon.

3. High fine sulfur concentrations are defined as episodes of three (3) events which exceed the mean sulfur concentration by one standard deviation. Under this scenario, the northwest pathway is reduced for the Bryce Canyon site but is strengthened for the Canyonlands site. Contours are strongest for both sites from California, but now the pathway from the south is more pronounced. Packing of the contours around the sites are evidence of the stagnation which occurs during inversions.
4. The high concentration conditional probability is the percentage rating by which those areas surrounding the receptor have the probability for causing a high sulfur concentration event.

Those areas are predominately to the east and south of both sites. Some influence from Colorado is plotted for the Canyonlands site. The eastern site is biased from a single event in April 1983 when midwest air blew into the receptors, causing a high sulfur event. Such an occurrence is rare indeed, so the midwest region, though it has had a historic impact on the two (2) sites, is very low in its probability of recurrence and therefore statistically insignificant. The major sources

(77)

for high concentration probability are the southern copper smelters. Bryce Canyon has 20% probability of high sulfur concentration from Salt Lake County and from southern California; Canyonlands receives high probabilities from southern Colorado and southern Idaho as well as from the south (Arizona, New Mexico and Texas).

5. The category named the high concentration source contribution shows where the greatest source of sulfur originates. It differs from the conditional probability (4) in that the frequency of high sulfur air and not the highest concentrations of high sulfur air is considered. In this case, southern California is the major pathway for this category by virtue of the quantity of air parcels traveling this route. Minor pathways for Bryce Canyon include southern Arizona, central Oregon and northeast Nevada. Minor pathways for Canyonlands include southern Arizona and the Northwest. Some impact is suspected from the Great Basin and the Salt Lake City area.

6. The low concentration conditional probability represents the concentrations below 109 ng/m<sup>3</sup> and the probability of occurrence by pathway. Bryce Canyon pathways lie mainly in Colorado, Idaho and over the Sierras. Canyonlands is similar to the Bryce Canyon pathways except for higher values out of the Midwest, Texas, Arizona and New Mexico.

The conclusions of Mr. Bresch are that long range transport of fire particulate into Utah does occur. Major pathways are from southern California and from the southern "copper belt" area.

Quantification

(78)

of the transported sulfur has not been made, nor has the distinction between trajectories traveling through precipitation and without precipitation been attempted. Recommendations made are for further modeling efforts and for more study of the source impacts on long range transport.

Dr. Doyle Stephens, U.S. Geological Survey, July 18-- An EPA pilot program was initiated in 1984 for the National Surface Water Survey (NSWS). The overall objectives included phase I sensitivity surveys of surface waters, phase II biological sampling and phase III long term monitoring. In Utah, the pilot survey for phase I was conducted in the Uinta Mountains. Twenty lakes were surveyed from the Uintas at elevations from 10,300 to 12,000 feet. Field pH readings of the surveyed lakes ranged from 6.7 to 7.25. All lakes were classified as sensitive with alkalinities less than 200 ug/l. Historical data indicated that 16 of 22 lakes were in the sensitive range. Fisheries surveys conducted by the Division of Wildlife Resources showed 65% of the 900 lakes surveyed to be suitable for fisheries.

Three groups of lakes were sampled - Northeast, Southeast and Southwest lakes. Geological mapping of sensitive areas by bedrock type (Norton, 1982) shows four (4) classes of sensitivity to acidification. Small plots of Class I areas (most sensitive) are found in the Red Mountains, Bull Valley Mountains, San Francisco Mountains, Deep Creek Range, Ochre Mountains and Granite Peak. These are located in the southwest to west central parts of Utah. A large Class II area is identified in the Uinta Mountains. A belt of

(79)

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(79)

**limestone bisects the Uinta Class II area. Dr. SteDhens showed the limestone belt, which includes four of the southeast lakes: Upper Reeder, Mid Reeder, Wigwam and Papoose lakes.**

Field data collected included pH, conductivity, temperature, transparency and chlorophyll. Southwest lakes were lowest in sulfate. Northeast and Southeast lakes were highest in sulfate; Northeast being the highest group of all. Metals, including aluminum, iron and manganese had no clear distribution by area. The highest alkalinities were found in the lakes located in the limestone belt. These lakes also tended towards the highest acidity of the lakes sampled. Nitrate was below measurable detection limits for all of the southwest lakes. Measurable nitrate was found in the Northeast and Southeast lakes. The reason for variation from west to east in nitrate concentration is unknown. Conductivity tended to be lowest among the highest elevation lakes.

Dr. Loren Squires, BYU, July 18-- Diatoms may be used for monitoring of lake and stream acidity through species pH preference. With 10,000 living species and 10-20,000 extinct species, many diatoms have been shown to occupy a narrow niche for pH tolerance. Living

diatom samples or core samples for dead diatoms may be taken to evaluate species number and diversity. By evaluating the species diversity, pH habitat may be inferred from historical and present populations. Species are determined strictly through morphology. Diatoms have a silicate frustule which preserves a long term record of the organism's existence.

(80)

Various water quality parameters have been cataloged for the numerous diatom species. Some of these parameters include salinity, oxygen, nutrients, water current, temperature, pH, organic loading and the kind of water body, i.e. lake or stream. Most valuable for habitat analysis are the diatoms with a narrow ecological niche.

For diatoms which are characterized by pH influence, the following classifications apply:

Acidobiontic: occur at a pH below 7 and develop best below pH 5.5

Acidophilous: occur at a pH around 7 and develop best below pH 7

Circumneutral or Indifferent: Develop best around pH 7  
Alkaliphilous: occur at a pH around 7 and develop best above pH 7

Alkalibiontic: Occur at pH above 7

Besides evaluating historic and present pH ranges, diatoms can be used to assess long term changes in lakes resulting from shifts in climate, the watershed soils and vegetation. Diatoms can detect anthropogenic changes in a watershed and acid deposition.

The mechanism for using the diatoms for monitoring acidification includes taking a water sample, core sample or a benthic sample, filtering the sample through a 2.5  $\mu$ m filter, boiling the sample in acid, then examining the frustules through a microscope. Relative densities are determined for each population. The relative densities are used to make an index which can then be used to biologically

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calibrate a lake.

Dr. Squires suggests that the alpine areas in the state, particularly the Uinta Mountains and the Wasatch Range be monitored for acidification. A limited amount of work has taken place which places

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the Uinta Mountain lakes in a marginal acidification status. Dr. Squires examined some of the known population indices with recorded pH values. He predicted a lower pH than what has been reported. This suggests a tenuous equilibrium which could shift with slight increases in acidification. This shift would make the environment even more favorable for the acidobiontic populations. Dr. Squires qualified this prediction **by** adding that his diatom indicator model must be calibrated to the Uinta Mountains.



Dr. Squires recommended that more effort in studying the sensitive areas' diatoms be expended. most of the current comprehensive acid deposition research incorporates diatoms in the study. Diatom indices should be generated for this area.

Michael Reichert , Bureau of Water Pollution Control

Michael Reichert , Bureau of Water Pollution Control, July 18-- A review of the alkalinity/acid sensitivity paper by On-ernik and Griffith was presented. Omernik and Powers had produced a paper which served as a foundation for EPA's acid sensitivity determination for the National Surface Water Survey. The reason for the Omernik work was to present a national perspective of acidification potential. Various factors in presenting the accompanying sensitivity map included: land use, elevation, watershed size, topography and geological information on parent rock type.

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3400 water sampling locations were used from STORET, USGS, state agencies, other Federal agencies and universities. A problem in evaluating the alkalinity data was that several methodologies for determining alkalinity were used. Methods included: potentiometric titration to a single endpoint, potentiometric titration to a double endpoint, calorimetric titration to a single endpoint, Gran titration and unknown or undeclared analyses. Another problem was that many of the sampling locations had few, or perhaps only one, sample.

Water quality data accumulated by the Bureau of Water Pollution Control (BWPC) shows alkalinity in mg/l. The conversion of mg/l to ueq/l is made by multiplying mg/l by 20. Thus, 10 mg/l = 200 ueq/l and is the accepted threshold for acid sensitivity. The State Health Lab uses potentiometric titration to a double endpoint. BWPC data submitted July 23 from Mr. Reichert shows values around the state which have been recorded at less than 31 mg/l or 620 ueq/l or less.

BWPC data show sensitive waters in the Uinta Mountains and the Wasatch Range. Stream sample data from the Deep Creek Mountains are collected at the foot of the mountains. Many data points fall below the 30 mg/l level. It is felt that, given the distance the streams travel and the buffering which occurs at the sampled elevations, the Deep Creek Mountains may, further upstream, be very sensitive, having very low alkalinities. Several areas must receive more monitoring before a designation of sensitivity would be assigned. These include: Thousand Lake Mountains, Tushar Mountains, Deep Creek Mountains and the La Sal Mountains. Areas which have shown low alkaline waters include the Uinta Mountains, Wasatch Range and the Boulder Mountains.

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Al Trbovich, Kennecott, August 6-- Studies have been contracted by Kennecott, Utah Copper Division (UCD) in order to assess the company's contribution to regional sulfur loading and any detectable environmental impact on sensitive areas. Reference studies cited by Mr. Trbovich include:

"Evaluation of the Potential for Acid Deposition Effects Due to Emissions From Kennecott's Utah Smelter", J.R. Young, et. ai, Environmental Research and Technology, Inc., 2625 Townsgate Road,

Westlake Village, California 91361, ERT No. P-B550-000, September 1983.

"Western Smelters and Acid Rain: Setting the Record Straight", Copper Smelter Information Committee, 2702 North Third Street, Suite 2015, Phoenix, Arizona 85004, July 1985.

"Acid Deposition and the West, a Scientific Assessment", George M. Hidy and James R. Young and others, ERT, Inc - , 975 Business Center Circle, Newbury Park, California 91320, ERT No. P-D572-503, March 1986.

The study which is summarized in the September 1983 document (the clearing house has a copy of all the cited documents) was discussed. A block of the Western U.S. encompassing eastern Utah, western Colorado and southwestern Wyoming was examined for emissions impact from the Utah smelter. NADP data from sites located in this region were used to provide sulfur data as wet deposition. Precipitation events were analyzed with the distinction made between significant events and insignificant events. Significance was based upon meteorological data; high significance for storms moving from UCD to the sampling area. Low significance indicated storms moving in other directions.

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Sampling results of wet sulfate were reported to show **low** to no impact on monitoring sites on account of LJCD emissions.

Modeling was also done which would depict the ambient concentration of sulfate at six sites from Silver Lake on the Wasatch Range to Colorado. The modeling assumes no deposition along the way. Undetectable concentrations of sulfate were predicted. Unfortunately, these results are in ambient concentrations and not in deposition loadings. Unfortunately, a deposition velocity is not available.

Conclusions from the presentation include:

1. No credible scientific evidence exists of adverse, regional scale ecological effects associated with acid deposition in the West.
2. Western wet sulfate deposition is **well** below levels associated with adverse ecological effects.
3. Dry deposition of sulfate is not necessarily large in sensitive areas where precipitation is high.
4. Anthropogenic acids should not increase significantly in the West.
5. Systematic study of the West is needed to enhance the understanding of acid deposition on ecological processes in potentially susceptible regions.

Gary Austin, Rocky Mountain Oil and Gas Association, August 6-- The petroleum industry has a 30-member committee, chaired by Mr. Austin, which has produced a position on acid deposition. Basically, the position is:

1. Acid deposition is a complex issue for which quick resolutions are

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not needed. There is no evidence that legislative or regulatory remedies are needed.

2. Conditions in the West are so different from Europe and eastern North America that comparisons are not applicable. 3. The Clean Air Act is sufficient to control existing and new sources of acid pollution in the West.

4. Some areas in the West may be susceptible to acid deposition.

5. Natural precipitation in the West is acidic. Analysis of precipitation data does not reveal significant variances from natural conditions.

6. Extensive research programs (at the local, state and national levels) are planned or in progress to study acid deposition. Congress has mandated that sufficient data be accumulated to develop a national policy on deposition by 1989, if needed.

Dr. Dee Rees, Utah Power and Light, August 6-- The company's position on acid deposition is that, since the people of the company live in the environment, the company is therefore concerned about the preservation of the environment. The company has invested in pollution control equipment for the control of particulate and So<sub>2</sub>. A recent experiment was conducted by Combustion Engineering to determine the ways of reducing **NO<sub>x</sub>** emissions from the existing boilers. Emissions were lowered to 0.41 lbs/mm BTU. The company feels that present bills before Congress will tax citizens of Utah for controls which are already in place on Utah utilities. UP&L feels that research data show that Utah is well protected from acid deposition by virtue of the buffering alkaline dusts in the atmosphere. The company has an obligation to protect its rate payers from costs related to environmental

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problems which may not exist.

Regarding the Mirror Lake study area which UP&L is funding, several points were brought out. The mean alkalinity of deposition into the watershed is -5 ueq/l. This includes the balance of anthropogenic acids and the basic crustal cations. Snow melt produces a depression in the pH level of Mirror Lake, but not less than 6.08 pH. Nitrate (**No 3**) is not detectable except in the winter. It is thought that warm weather permits the biological activity which **will** consume the nitrate. Cold weather **will** inhibit biological activity and thereby allow the accumulation of nitrate.

The conclusions reached by Mr. Rees include:

1. There is no evidence in the Mirror Lake watershed of damage due to acidification.
2. There exists within the ecosystem sufficient alkaline material to neutralize acids imported to the watershed.
3. Imported alkaline dust has a significant impact on neutralizing acids.
4. The net input of acidity into the area is near zero.
5. It is estimated that, at present deposition rates, hundreds to thousands of years worth of alkalinity are available.

Dr. Rees recommended further study into the alpine lakes found above timberline. Climatology must now be related to watershed input. The source/receptor relationship must be studied. An improved ability to predict receptor impact should also be developed. The contribution of dry deposition

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to total watershed loading must account for both cations and anions.

Statement submitted by Intermountain Power Plant, James Anthony, August 5-see Appendix A.  
Maureen Wilson, Colorado River Wildlife Council, August 6-- This group is comprised of state and federal wildlife agencies found along the Colorado River drainage. A perspective paper was handed out which outlines the rationale behind the CRWC resolution (Appendix A). The perspective paper cites numerous reports of acidification and enumerates concerns about atmospheric acids. The interest of CRWC is: . . . because it (CRWC) is a resource directed entity composed of the state conservation agencies of the seven Colorado River drainage states which are charged with management of the fish and wildlife resource. Acid precipitation is potentially damaging to fragile environments supporting important fisheries, wildlife and forests." The perspective paper recommended that coordination from a single entity be implemented for acid deposition monitoring and research.

Dr. David Brakke, Western Washington University, August 6-- Lakes are complex systems and are part of larger watersheds. Surface conditions within the watershed are particularly important. Speaking from the perspective of the lake, the surface conditions such as bedrock type, mineral weathering, etc., influence the lake water.

The chemical balance within the system passes through some chemicals such as sulfate. Other chemicals such as calcium and magnesium are leached from the system. Nitrate is usually retained by the system. Since nitrate usually

does not pass from the system, acidification is not usually a problem with nitrate de - position. Hydrogen ions can be brought into the system or can be produced within the system. Hydrogen can be generated through biological ' activities. Heavy metals may be a component of the soil. The chemistry of precipitation or of the watershed can make heavy metals mobile within the system.

In order for lake or water acidification to occur certain conditions must be present. These include:

1. Geologic and soil conditions must be conducive to influence by hydrogen ions. This implies watershed or base material sensitivity.
2. Hydrologic conditions will influence sensitivity. This includes water input, retention, etc.

Some types of rock such as limestone and dolomite will have more alkalinity available through the weathering process. Granites, quartz sandstone and granitic gneiss are rock types which yield low amounts of alkalinity even after long-term weathering.

pH is not a good indicator of acidity or of acid neutralizing capacity. This is because of the nature of acid buffers which do not show the one to one effects of hydrogen ion adsorption until the buffering capacity is consumed. After that point, the damage to the buffer system has been done and the ability to neutralize any more acid is no longer available without the addition of more buffer. Measuring pH to determine the impact of acidity on surface waters is therefore akin to shutting the barn door after the horses have escaped.



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The effects of low pH on lakes and fish include the liberation of aluminum. Aluminum adheres to the gill lamellae of the fish and actually suffocates the fish.

Extensive regions throughout the West have very low ionic strength waters. These waters are much more dilute than the lakes in the East where acid deposition is having detrimental impacts. The national lake survey which was originally designed to sample just the east, southeast and midwest parts of the nation, was redesigned to include the West. The inclusion of Western lakes allowed a national perspective on sensitivity and thereby included the most sensitive areas in the nation.

The areas and lakes chosen for sampling in the national survey were statistically chosen from alkalinity maps assembled from surface water chemistry data. The sampling program itself was carried out by EPA and the Forest Service. Forest Service sampling took place by foot, horseback and llama. Quality assurance work shows that the Forest Service sampling method had equivalent confidence levels with the EPA helicopter sampling method. Much of the data collected will be relevant to other projects besides acid sensitivity. External review of the NSWs project will be going out shortly.

About 35% of Western lakes are above 10,000 feet elevation. These lakes have limited or no soils and trees to buffer acids. Rock type becomes the dominant factor of buffering capacity. The rock type is not necessarily correlated to elevation. Therefore, the sensitive lakes are understandably found in "sensitive,, rock types. The sensitivity/elevation correlation is not well established. Sensitivity is also influenced by hydrological factors.

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The results from the Eastern lake survey show that there is a difference between sulfate concentration and acidity in waters. Sulfate may be generated within the watershed. Sulfate may be generated by mineral weathering, making bedrock analysis imperative. In the West, sulfate may also be blown in as calcium sulfate, a crustal dust not related to anthropogenic sulfate. Sulfate retention processes in the watershed show that sulfate deposited into the region may be higher than the sulfate in the water. The sulfate adsorption process will continue until all of the adsorption capacity is consumed. Sulfate will then begin moving out of the watershed. Sulfate removes bicarbonate alkalinity from the watershed, leaching the acid neutralizing capacity from the system.

Snow melt in the low alkalinity regions has a high impact on the lake itself. Western regions have high snowfalls which, upon melting, can inundate a lake system with very dilute waters. If acids are also contained in the snow, the already low alkalinity of the watershed can be impacted heavily during the runoff. The concentration of acids in either snow or rain appears to decrease with increased volume of a particular precipitation event.

Lake chemistries and sensitivities in Scandinavia are comparable to waters found in the western U.S. Sulfate deposition is not an accurate measurement of acidification. Sensitivity of a watershed is much more accurate. At pH 5.3, alkalinity becomes negative. Lakes with pH above 5.3 have some buffer as available bicarbonate .

Dr. Brakke does not agree with threshold, target, critical or other types of acid loading criteria in sensitive or other areas. Loadings are political decisions which can be adjusted to meet expediency. Sensitivity can be

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defined as calcium and magnesium concentrations in a watershed in conjunction with hydrological patterns. Critical loads must be applied locally if they are to be addressed at all. Critical loads and threshold limits have a danger. For example, if the West were to adopt the same threshold for sulfur as the East, without ever attaining the threshold, greater impact would be anticipated in the more sensitive Western lakes.

Phase III of the NSWS will probably be implemented because of the findings that so many of the lakes sampled in the West have such low ionic strength. Phase II will probably not be attempted in the West. Due to existing biological and temporal data available, Phase II would probably not be necessary. Phase III will include 400 lakes nationally and could include about five lakes from the Uintas. Phase III is designed for long-term monitoring and study of the entire lake system.

Joan Auger, League of Women Voters, August 6-- See Appendix A.

Nina Dougherty, Sierra Club, August 6-- The Sierra Club supports the Governor's efforts to investigate the status of acid deposition in Utah. The Sierra Club has been involved with air quality issues in Utah. This includes not only acid deposition, but also the issues of visibility, prevention of significant deterioration (PSD) and control programs. This involvement is important for the purpose of protecting the quality of Utah's air. Regional haze is a problem

which is becoming more evident along the Wasatch Front in particular and throughout Utah in general. The Sierra Club believes that Utah should be concerned with the issue of acid deposition. Long range transport could cause lake acidification in this area if controls are not maintained.

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Ms. Dougherty recommended a target load of acids in order to prevent acidification of lakes. She also recommended the continued reduction of sulfur dioxide from copper smelters. Utah should be aware of and make preparations for impact from SO<sub>2</sub> emissions from other copper smelters, particularly those in southern Arizona, New Mexico and Mexico. Utah should also limit NO<sub>x</sub> emissions from industry, particularly from the power plants and from any potential oil shale developments. Other areas such as California and Japan limit NO<sub>x</sub> emissions. Mobile sources must be addressed, in particular for regions that are going to experience large population increases. Diesel engines, large trucks and other vehicles must be controlled. Maintenance and clean operation are imperative for insuring that adverse impact from the mobile sources is not experienced. Action on preventing the occurrence of acid deposition must begin now. Since cleanup costs are so involved and so expensive, it is better planning to address the issue before acid deposition becomes a real problem in the West. Additional benefits of controlling acid deposition would include improving the visible haze problem in this area, improving the health of people in the area of sources and improving the climate by reducing emissions of CO<sub>2</sub>.

Robert E. Yuhnke, Environmental Defense Fund, August 6-- The Environmental Defense Fund (EDF) began its concern with acid deposition in 1981. Congress turned its attention to the protection of the East from acid deposition and the effects from that phenomenon. EDF was concerned that the western U.S. was being neglected in the acid deposition issue. The available

data base for acid deposition work was very poor in 1981. Since that time, considerable effort has been undertaken to increase the data base, mostly in areas outside of Utah. Studies in the East show that damage is occurring and that lakes are being acidified from atmospheric deposition. The problem in the East is one

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of assessing accountability for cleanup measures. In the western U.S. damage is not as apparent. The strategy for control in the West is for the purpose of preventing the eastern experience. In the early stages of atmospheric deposition sampling, sites were evenly scattered throughout the West. Although the sites are representative, they do not account for high elevation, sensitive areas of the state which are the main concern for acid deposition. It was felt that high elevation areas where more precipitation was found, would be more highly impacted. This was thought to be a combination of greater precipitation and to a presumed washout at lower elevations of crustal materials which would have provided a neutralizing or buffering effect on the airborne acids. Research did find that calcium levels are lower in high elevation sites than in the lower elevation sites. Sulfate appears to be evenly distributed from high elevation to low elevation sites.

John Harte, University of California began sampling in the Mexican Cut area of Colorado and found snowpack pH of 4.1 and precipitation pH of 4.5 during his initial year of sampling in 1980. Observations of impacted salamander populations by Dr. Harte's group raises suspicions of spring acid pulses from melting snow that would act to inhibit the spawning activity of those populations. A two week period of pH 4.9 coincided with the time that breeding populations of salamanders were impacted by the acids in the watershed. The zone of impact was the littoral zone of the lake, not the entire water column of the lake. Although this represents a small portion of the entire volume of the lake, it represents the most important area in terms of biological activity within the lake system.

Sulfate deposition rates in areas around Mesa Verde are comparable to sulfate

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deposition rates in acidified areas in Scandinavia. Since the Mesa Verde area is adjacent to the San Juan Wilderness, a paired monitoring site has been installed to determine if similar rates of sulfate deposition will be found in the wilderness area itself.

EDF began looking at sources of sulfur and found that 70% of the sulfur in the West originated with the copper smelters. Power plants and possibly steel plants accounted for some of the rest of the sulfur in the region. The biggest reason for the high SO<sub>2</sub> emissions from copper smelters was that several of the smelters had not maintained their schedule for control of SO<sub>2</sub> emissions. Concerns over the uncontrolled smelter emissions from the proposed Nacazari smelter in northern Mexico lead to negotiations between the U.S. Government and the Government of Mexico. Nacazari now has 91% SO<sub>2</sub> removal from its emissions. *Long range transport is thought to be the origin for sulfate levels in the San Juan region and in the Mexican Hat area where higher than expected levels of sulfate have been found. Deposition rates in the receptor areas of the San Juan's showed similar rates of decrease as the production decreases suffered by the copper industry in 1981. This lead EDF to the conclusion that sulfate deposition was very strongly influenced by the copper industry.*

*Projections for regional SO<sub>2</sub> emissions for 1995 show SO<sub>2</sub> to be only slightly increased between the period of 1980 to 1995. The increase of NO<sub>x</sub> from the period 1980 to 1995 is*

*expected to be on the order of 150% in central Utah. This does not account for a discontinuation of the proposed UP&L Hunter Four Project. The addition of the Bonanza Power Plant is also not accounted for. It is not known whether the installation at Bonanza would be equivalent*

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*to the Hunter Four Project. Nevertheless, increases in NO x emissions through 1995 are expected to be quite large.*

*Mr. Yuhnke recommends that with the doubling of NO x emissions, evaluation of NO x on sensitive lake systems should not be undertaken. He further advocates the use of selective catalytic reduction for removal of NOx emissions. This kind of NO x removal is currently being done in Japan and in California.*

*Dr. Peter Hovingh, Intermountain Water Alliance, August 6-- Dr. Hovingh's presentation dealt with the population of salamanders in the Wasatch Range and more particularly in Desolation Lake. He emphasized the decimation of the population, which was apparently the result of a bacterial infection. It was his observation that if acid deposition damage were to occur in our high mountain lakes, no one would notice since very little scientific study is*

*being undertaken in those regions. The synergism of acid deposition and the lake bacterial population may have combined to kill off the salamanders.*

*Several ADTAC members concurred with the possibility of synergistic effects of bacteria and atmospheric acids.*

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APPENDIX A

NORMAN H. BANGERTER

GOVERNOR

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STATE OF UT@@@ll

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OFFICE OF THE GOVERNOR  
SALT LAKE CITY

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November 27, 1985

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Suzanne Dandoy, M.D., M.P.H. DEC

Executive Director  
Utah State Department of Health  
P.O. Box 45500  
Salt Lake City, Utah 84145-0500 Ei,,,-

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RE: Establishment of a Task Force to Address Acid Deposition in Utah

Dear Dr. Dandoy:

*Because of the potential policy implications and impacts of the acid deposition legislation currently proposed for consideration by Congress, the State of Utah should investigate the issue of acid deposition. Facts concerning the potential impacts of acid deposition in Utah are needed so we can provide information on impacts from acid rain within Utah to the Congress and the Legislature, and so we can evaluate the effects of national legislation related to acid deposition. Therefore, Utah experts should assess these issues and provide recommendations on acid rain policy at both the State and National level.*

*It is requested that the Utah Air Conservation Committee, in cooperation with the Utah Water Pollution Control Committee, review the acid deposition problem in Utah and prepare policy recommendations to address this issue. To assist the Committees in this effort, I am directing the Department of Health to form a technical advisory task force to assist the Committees in compiling the scientific and technical data which may be available and/or needed to develop policy recommendations. I believe that the issue is sufficiently significant so*

*that all State and Federal agencies within the State which have interest or expertise in this area as well as the academic community should be encouraged to contribute to this effort.*

*Suzanne Dandoy. N.D., M.P.H.*

*Page 2*

*November 27, 1985*

*Policy formulation with respect to the air pollution aspect of acid deposition rests squarely upon the shoulders of the Utah Air Conservation Committee and upon the Water Pollution Control Committee for the water pollution aspects. These two committees will review the technical information developed by the technical task force and formulate policy recommendations for the State. Your assistance in this important venture will be greatly appreciated.*

*Sincerely,*

*/s, f)*

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**No@** gerter  
Governor

NHB: bcb

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13 October 1986

Mr. Mark T. Ellis

Bureau of Air Quality

,VR Q,,; W  
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Department of Health

288 N. 1460 W., P.O. Box 16690

oCr 16 1986

Salt Lake City, UT 84116-0690

Dear Mr. Ellis:

Due to the preliminary nature of our data, the values that we previously provided for alkalinity in the soil solution in the Mirror lake watershed are too high. The lysimeters have now been in the ground for about a year and are providing more reliable data. We have also altered our placement technology and appear to be getting more realistic numbers from placements that have not equilibrated for a year. Nevertheless, all of these data are to be considered preliminary until we have accumulated enough data to examine temporal trends.

With these caveats in mind, the alkalinities that we see in the soil solution range from approximately 100 microequivalents per liter to approximately 500 microequivalents per liter. These values are about  $\frac{1}{4}$  that of the previous values. Since the lake averages about 110 microequivalents per liter in alkalinity, these are still significantly high. In fact, these values should allow a much easier calibration of the ILVM model.

Since you attended our small acid rain conference in Park City, then you know that our values for soil Base saturation are also subject to doubt. This is a result of standard agricultural analyses for base saturation. The standard method is accomplished at a buffered soil pH of approximately 8.2. Virtually all of the central Rocky Mountain soil analyses (from different investigators) have been done with the standard method and are likely in error. The true Base saturation may be two or more times greater than the 25% that we observe and that others also observe. Thus, the lowered soil alkalinities combined with the likely higher Base saturation, still provides quite a bit of buffering capacity in the soils. The Base saturations are currently being recalculated under a new method. My apologies if our preliminary data produced any misconceptions. Reliable field data simply require several years to obtain.

Sincerely,

P &/@,

Ronald P. Neilson, Ph.D.

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inTERmountAin Power PROJEC(T

August 5, 1986

Mr. Mark T. Ellis  
State of Utah  
Department of Health  
Bureau of Air Quality  
288 North 1460 West  
Salt Lake City, Utah 84116

Dear Mr. Ellis:

Acid Deposition Technical Advisory Committee (ADTAC)

Thank you for inviting our Mr. Naim Syed to make a presentation before the ADTAC regarding Intermountain Power Project's (IPP) acid deposition position and to provide related technical information. Unfortunately, we are unable to make such a presentation at this time; however, we would like to take this opportunity to share with your ADTAC the following information.

IPP is an environmentally responsible Project whose commitment to maintain good air quality is reflected by its investment in air pollution control equipment which accounts for about 25 percent of the power plant's cost. This air pollution control ' equipment will remove 98 percent and 90 percent of the particulate and sulfur dioxide emissions, respectively. Based on the results of modeling analysis conducted to issue the IPP Air Quality Approval Orders, IPP is confident of meeting prevention of significant deterioration increments.

In addition, upon commercial operation of Unit II, IPP will provide post-construction ambient air quality monitoring data to the Utah Bureau of Air Quality (BAQ). This monitoring data will be collected at three monitoring stations, one of which is located in the U.S. Fish Lake National Forest. Voluntarily, IPP has agreed to provide the BAQ with one year of fine particulate (PM 10 ) and upper-level atmospheric data.

IPP suggests to the **ADTAC** to consider costs and benefits in its technical recommendation to the Statutory Committees.

Mr. Mark T. Ellis  
August 5, 1986

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**For additional information, please contact Mr. Syed at (213) 481-5699.**

Sincerely,

*JA4X,40 /-/*

**JAMES H. ANTHONY    0**  
Project Director  
Intermountain Power Plant

cc: **Mr. Brent Bradford State of Utah**  
**Department of Health**  
**Bureau of Air Quality**



**Mr. Naim Syed**

Colorado River  
Wildlife Council

F,ESCLUTION-86-1

RESOLUTION OF THE  
COLORADO RIVER WILDLIFE COUNCIL  
RELKTIVE TO THE MONITORING OF  
ACID R.A\_ IN TN THE WESTER-N  
UNITED STATES

WHEREAS, the destructive effects of acid rain are well known, and the occurrence of acid rain is widespread, and has been well documented in the northeastern United States and southern Canada; and

WHEREAS, there have been areas identified in the **western United States--most notably** the Sierra Nevada and Rocky Mountain **raages-of high susceptibility** and sensitivity to acid precipitation; and **the U.S. Forest Ser-vice has recently** documented aci@-; precipitation on **national forest lands in the Colorado River Basin**; and

**WHEREAS, eventual natural- resource damage resulting from acid precipitation includes, but is not limited to acute and chronic acidification**

**of lakes with subsequent and profoun4 losses of sport and uongame fishery values; and**

WHEREAS, the basis for decision making and action plans to combat **the** occurrence of acid rain and its resulting environmental **damage** is the **analysis** of sound scientific data collected in areas of known susceptibility and

sensitivity throughout the potential range of acid rain occurrence in the United States;

BE IT THEREFORE RESOLVED, that the Colorado River Wildlife Council at its April 7-8, 1986 meeting in Las Vegas, Nevada, does urge and request the U.S. Environmental Protection Agency to include representative waters in the western United States having existing sport and endemic fisheries in the Phase I and III monitoring programs of the National Watershed Survey; and ,

BE IT FURTHER RESOLVED, that the Colorado River Wildlife Council **does** also request the inclusion in the Phase III monitoring program of **at least** four high mountain lakes with sport and endemic fisheries, **one lake each from** the Sierra Nevada Mountain Range in California and Nevada and **the** Rocky Mountain Range within the Colorado River Basin.

**STATE OF NEVADA:** Department of Game and Fish, Division of Wildlife Resources, 1500 South Virginia Street, Las Vegas, Nevada 89102  
**COOPERATING FEDERAL AGENCIES:** Bureau of Land Management, 1615 North 2nd Street, Reno, Nevada 89501  
 Division of Game and Fish, 1500 South Virginia Street, Las Vegas, Nevada 89102  
 U.S. Forest Service, 1615 North 2nd Street, Reno, Nevada 89501  
 U.S. National Park Service, 1615 North 2nd Street, Reno, Nevada 89501

Approved: \_\_\_\_\_, Director, Division of Game and Fish  
 Approved: \_\_\_\_\_, Director, Bureau of Land Management  
 Approved: \_\_\_\_\_, Director, U.S. Forest Service  
 Approved: \_\_\_\_\_, Director, U.S. National Park Service

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Aug-UST 6, 1986

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I am Joan Auger, Natural Resources Chair of the League of Women Voters of Utah. We appreciate the opportunity to address this committee and to present the League's position on the Problem of acid deposition. We commend the governor and the Department of Health for organizing this task force to examine acid deposition in Utah and we appreciate the committee's review of scientific and technical data from various areas of research.

The League in Utah has been concerned about air pollution for some time. The Salt Lake League was one of the first leagues in the country to identify air pollution in 1965. The Utah League worked for the passage of the Air Conservation Act in 1967, and the first chairman of the Utah Air Conservation Committee was a League member. Local leagues have considered updated reports on air quality several times through the years, and acid-deposition is a topic of concern for League members today.

In the area of natural resources the goal of the League of Women Voters is to promote an Environment beneficial to life by preserving the physical, chemical, and biological integrity of the ecosystem. Acid rain, unlike some other forms of air and Water pollution, is not easily visible. Because it is not obvious it can cause damage in insidious ways. As this committee knows the Acid Rain is not limited to lakes devoid of fish and aquatic life, but it includes deteriorating and dying forests, changes in the soil, the mobilization of toxic metals into the water. These changes may take a long time to occur, but they are serious and may be permanent.

Acid rain has been considered in the past to be a regional problem affecting primarily the North and Canada. The Lewis and Clark Is concerned, as are many others, that the West is especially vulnerable to the effects of acid deposition. Kau high altitude lakes in the Rocky Mountains, the Cascades and the Sierra Nevada were identified by EPA as sensitive to acidification. The

League supports additional study to clarify the problem of acid deposition in the West. We need more fundamental, well-argued research and a continuation of the cooperation among the western states. The solution, however, is technically difficult, expensive, and can take *Years* to complete. Here in the West we have the opportunity to avoid the effects occurring in the East by taking action now.

The League's environmental protection and antipollution goals are to prevent ecological degradation and to reduce and control pollutants at their source, both stationary and mobile. The League wants to see current legislation enforced and strengthened and opposes extensions of deadlines to comply with the Clean Air Act. Usually the league supports the legislation being considered in Washington, R.R. 4567 the Acid Deposition Control Act of 1986 and Senate Bill 2203, which call for reductions in sulfur dioxide and nitrogen oxide emissions.

Environmental protection and pollution control should be considered a cost of providing a product or service. The League believes that in general the polluter should pay for the costs of cleanup. Consumers, taxpayers, and ratepayers must foot the bill of these costs.

The League believes that action to reduce sulfur dioxide and nitrogen oxide emissions is the most prudent course to follow to prevent acid rain damage and to improve air quality.

## APPENDIX B

### Glossary of Terms

ACC- Air Conservation Committee; an eleven member body established by Utah law to officiate in air quality laws, regulations, policy, etc.

ANC- acid neutralizing capacity; the amount of buffer available in soils for neutralization of acids.

acid- any substance which produces more hydrogen than hydroxide ions in water.

acid deposition- commonly referred to as acid rain, acid deposition is the phenomenon of atmospheric acids being deposited on the earth's surface in wet or dry forms.

acidobiontic- diatoms which occur at a pH below 7 and develop best below pH 5.5.

acidophilous- diatoms which occur at around pH 7 and develop best below pH 7.

alkalibiontic- diatoms which occur above pH 7.

alkalinity- the capacity of a solution to neutralize acid. Alkalinity is normally reported as calcium carbonate.

alkaliphilous- diatoms which occur at around pH 7 and develop best above pH 7. anion- an ion with a negative charge.

anthropogenic- originating from the activities of man.

back trajectory analysis- a method of tracking air pollutants from a receptor to the area of origin. Radiosonde weather records of upper air flow patterns are used to track the path of an air parcel backwards in time for several days to find its probable area of origination.

benthos- organisms on the bottom of a lake or stream.

buffer- any substance that reacts to neutralize acid.

cation- an ion with a positive charge.

chlorosis- the yellowing of a leaf from any form of physiological stress.

chemocline- a chemical gradient in a lake.

circumneutral- diatoms which develop best around pH 7.

crustal material- material found on the earth's surface. In the context of this report, crustal material normally refers to windblown dust.

deposition- the process of airborne materials falling to the earth's surface.

denuder- a device used to sample gases in the atmosphere.

(i)

diatom- single cell algae with a siliceous cell wall and belonging to the class Bacillariophyta.

dolomite- a mineral consisting of calcium magnesium carbonate.

dry deposition- atmospheric particles deposited in the earth in the absence of precipitation.

dystrophic- the state of a lake where there is a large amount of organic matter in the water, but the productivity of the lake is **low**.

epilimnion- surface layer of water in a lake.

eutrophic- a high nutrient state of a lake which has high productivity. Such a lake frequently experiences deoxygenation in the lower layers of the lake.

frustule- the siliceous cell wall of a diatom.

**gneiss**- a metamorphic rock similar in composition to granite or feldspar.

**hydrophytes**- aquatic plants.

hypolimnion- bottom layer **of** water in a lake.

lacustrine- originating from a lake.

lichen- a plant resulting from the symbiotic relationship between fungi and algae.

littoral- zone of shallow water in a lake typified by high biological activity.

loess- windblown dust originating from a plain or valley floor.

mesotrophic- a moderate nutrient state of a lake which is moderately productive.

mycorrhizae- fungi which **have** a symbiotic relationship **with** the roots **of** seed plants.

NADP- National Atmospheric Deposition Program; a nationwide precipitation monitoring network with over 190 sampling sites.

oligotrophic- a low nutrient state of a lake which is characterized as pristine and has low productivity.

oxidant- substances which act as chemical scavengers. Atmospheric oxidants include **ozone**, hydrogen peroxide, etc.

ozone- a molecule consisting of three oxygen atoms.

pH- a measure of hydrogen ions which roughly equates to acidity. pH is measured on a scale from 1 to **14**, where 7 is neutral. The smaller the **number**, the more acidic the substance.

(ii)

PSD- Prevention of Significant Deterioration; an area of attainment of air quality -standards.

precipitation- rain, snow, sleet or other forms of moisture falling to earth

from the atmosphere.

rime ice- ice formed onto objects from the moisture in clouds or fog.

receptor- any point which is influenced by the emissions of a source of pollution.

retrofit- to rebuild existing equipment to meet new specifications.

sensitivity- as used in this report, sensitivity is the vulnerability of a watershed or water body to the effects of atmospheric acids.

synergis,T.- the cooperative effects of two or more agencies such that the total effect is greater than the independent effects taken separately.

thallus- the plant body of a lichen.

threshold- as used in this report, threshold refers to the maximum annual loading of an air pollutant to a receptor which is thought to produce no detrimental environmental effects.

throughfall- material deposited on trees or another substrate which is collected in wet collectors located beneath the substrate during precipitation events.

transformation- as used in this report, transformation refers to the chemical change of an acid precursor to an acid in the atmosphere. This process is normally applied to anthropogenic acids.

trophic status- the amount of organic or nutrient matter found within a lake system which influences the productivity of the lake.



visibility- as used in this report, this refers to visibility impairment. Any small particles in the air which reduce visual range, color, contrast or tincture of a scene.

WPCC- Water Pollution Control Committee; a nine member body established by state law to officiate in water pollution laws, regulations, policy, etc.

wet deposition- atmospheric constituents entrained in precipitation before being deposited on the earth's surface.

(iii)