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# Summary of the National Acid Precipitation Assessment Program's Watershed Coordination Workshop

Nancy S. Dailey

Environmental Sciences Division

Publication No. 2857

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ENVIRONMENTAL SCIENCES DIVISION

# SUMMARY OF THE NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM'S WATERSHED COORDINATION WORKSHOP

June 5-6, 1986

Atlanta, Georgia

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Biology Division, ORNL

Environmental Sciences Division
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ABSTRACT

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The need for, anticipated benefits of, and recommended approaches toward coordinating watershed research across the United States were deliberated at the Watershed Coordination Workshop, June 5-6, 1986, in Atlanta, Georgia. The workshop was sponsored by Task Group VI (Aquatic Effects) of the National Acid Precipitation Assessment Program (NAPAP) through the Acid Deposition Planning Staff and the Air Pollution Effects Branch of the U.S. Environmental Protection Agency. Invited representatives from NAPAP, various federal agencies, universities, and industries discussed their concerns and offered recommendations regarding the possible initiation of a nationally integrated approach to watershed research and a proposed Long-term Monitoring Program (LTMP) for acidic deposition research. This report briefly summarizes the formal presentations highlighting the status of watershed research in the United States and outlines the results of the moderated discussion periods that followed. The discussions focused on important issues related to watershed research coordination, design and implementation of a watershed research program, priorities for watershed research, design of the proposed LTMP, and suggestions to improve watershed research programs as a whole. In general, participants concurred with NAPAP on the benefits to be derived from a coordinated watershed research program and on the conceptual design

of the LTMP. However, key recommendations offered by the attendees were for NAPAP to develop scientifically sound research programs of national or regional scope and to select an appropriate agency to administer the watershed research coordination program. Additionally, for both efforts, NAPAP and the program's designated agency must demonstrate the credibility of the research design, recruit a national network of research sites and dedicated researchers, and provide long-term funding.

# 1. INTRODUCTION

The Watershed Coordination Workshop was sponsored by Task Group VI (Aquatic Effects) of the National Acid Precipitation Assessment Program (NAPAP) through the Acid Deposition Planning Staff and the Air Pollution Effects Branch of the U.S. Environmental Protection Agency (EPA). The workshop brought together a select group of watershed researchers and program managers (both NAPAP and non-NAPAP) to deliberate the need for and discuss possibilities for coordinating and facilitating watershed research activities across the United States. Invited participants included representatives from the NAPAP Office of the Director of Research, EPA, U.S. Department of Agriculture [i.e., Forest Service (FS)], U.S. Department of Energy, U.S. Department of Interior [e.g., Fish and Wildlife Service (FWS), Geological Survey (GS), National Park Service (NPS)], National Oceanic and Atmospheric Administration, Tennessee Valley Authority, academia, and industry (e.g., Electric Power Research Institute, National Council for Air and Stream Improvement). Appendix A provides a list of the participants.

The primary objectives of the workshop were to:

(1) discuss the need for coordinating watershed research activities,

(2) present the findings of a recently completed telephone survey of current watershed research in the United States,

(3) discuss emerging research priorities,

(4) propose an approach for the coordination of watershed research at long-term monitoring sites, and

(5) discuss existing and proposed watershed manipulations, including hypotheses to be tested and methods to be used.

The workshop agenda (Appendix B) included both formal presentations by invited speakers and moderated discussion periods. Opening presentations outlined NAPAP's goals and the uncertainties driving federal research through the year 1990 and highlighted NAPAP's watershed-related research efforts. Subsequent presentations addressed the preliminary results of a telephone survey of current watershed research in the United States, the proposed approach for the Long-term Monitoring Program (LTMP), the key processes designated for future watershed research, and the preliminary results of the Loch Fleet Project in the United Kingdom. Highlights of the formal presentations are provided in Section 2. Discussions centered on important issues concerning watershed research coordination, watershed research priorities, design of the proposed LTMP, and suggestions to improve watershed research programs as a whole. The workshop served as a preliminary forum for the representatives from the various federal agencies, universities, and industries to voice their concerns, interests, and recommendations regarding a nationally integrated approach to watershed research. The results of the discussions will be used to assist NAPAP in its overall watershed research planning process. As a result, this report focuses primarily on the results of the discussions (Section 3). Final recommendations are summarized in Section 4.

# 2. SUMMARY OF PRESENTATIONS

For the most part, the presentations by invited speakers addressed critical issues and future research directions for watershed research and provided workshop participants with background information for the discussion periods that followed. These presentations gave an overview of NAPAP, its research objectives, and its watershed-related research and addressed the results of a telephone survey on watershed research, the watershed processes designated for future research, and the Loch Fleet Project in the United Kingdom. The agenda for the workshop is included as Appendix B. Information on the majority of these topics is available elsewhere; as a result, only highlights of these presentations are included here. Additional information can be obtained in the following reports:

Interagency Task Force on Acid Precipitation. 1985. National Acid Precipitation Assessment Program Annual Report to the President and Congress. EOP Publications, Washington, D.C.

Radian Corporation. 1986. Summary of Watershed Research and Monitoring Activities in the United States in 1986, Vol. 1-Results. Draft report prepared for U.S. Environmental Protection Agency. Research Triangle Park, North Carolina.

U.S. EPA. 1986. Watershed Manipulation Project Research Plan. Draft report prepared for the Peer Review Meeting, June 2-4, 1986, Atlanta, Vols. 1 and 2. Washington, D.C.

## 2.1 OVERVIEW OF NAPAP

Dr. J. Laurence Kulp, director of NAPAP, outlined the goals and status of NAPAP's research program. One of NAPAP's goals is to develop and progressively improve the analytical tools necessary to understand processes critical to the acidic precipitation issue. Application of

these tools contributes to an objective and comprehensive information base on acidic deposition and its effects for use by decision makers by 1990. The federal program covers seven research categories, three of which deal with environmental effects (aquatic effects, terrestrial effects, and effects on materials and cultural resources). NAPAP research is gathering information on the levels of certainty for the various acidic deposition issues, which pollutants require controls, where to control them, and how to quantify costs and benefits of controls. Thus, NAPAP's role is to provide a sound information base to decision makers who will make the necessary value judgments toward a national policy. In particular, NAPAP's watershed research activities within the Aquatic Effects Research Program (Task Group VI) will provide vital information for use in setting pollution control policy.

## 2.2 OVERVIEW OF NAPAP AQUATIC EFFECTS TASK GROUP AND WATERSHED RESEARCH

Dr. Rick A. Linthurst presented an overview of the Aquatic Effects Research Program and the watershed research sponsored by EPA for the NAPAP. The primary goals of Task Group VI (Aquatic Effects) research program are to quantify the chemical and biological effects of acidic deposition on lakes and streams of the United States and to determine the ecological consequences of remedial methods. An additional objective is to provide information necessary to improve predictions of possible changes in water quality and aquatic biota due to acidic deposition. Although the various projects under the Aquatic Effects Research Program were designed to address a particular policy question, the combined results of these projects will be used to verify the

extent of knowledge of aquatic systems and their response to acidic inputs. For example, the National Surface Water Survey (NSWS) is quantifying the status of surface water chemistry in areas of the United States that are potentially sensitive to acidification. The Direct/Delayed Response Project (DDRP) is developing methods to make predictions regarding responses of surface waters to acidic inputs. The Watershed Manipulation Project (WMP) is designed to verify projections of impacts based on experiments involving watershed processes and watershed manipulations. The LTMP, as currently being revised, will validate these projections based on detection and measurement of long-term chemistry trends of surface waters with low alkalinity. Because watershed research will be a key concern for future NAPAP activities, close coordination between the WMP, LTMP, and other projects would greatly further our understanding of the processes affecting watershed acidification.

Dr. Linthurst noted that watershed processes research has historically been funded by the FS, the NPS, the FWS, and the GS. Because research directions largely reflect the funding agency's mission(s), the approaches taken are quite diverse, and the resulting data are often not compatible. Integration of various watershed research activities (i.e., process studies funded by the FS, the GS, and the NPS; mitigation studies funded by the FWS; manipulation studies funded by the EPA; and long-term monitoring funded by the EPA) could be very beneficial. From NAPAP's viewpoint, enhanced research coordination could provide research stability, maximize research

dollars, standardize protocols, enhance data availability and compatibility, and increase the level of certainty for the research results for the participating groups.

## 2.3 WATERSHED RESEARCH TELEPHONE SURVEY: APPROACH AND RESULTS

Before proposing an integrated research effort, Task Group VI sponsored a telephone survey of current watershed research activities across the United States. The poll was conducted by Radian Corporation in April 1986. Margie B. Stockton discussed the approach and preliminary results of the survey. Its primary purpose was to obtain information on the status of research and monitoring activities currently under way at watershed sites. The survey also attempted to identify potential research sites for future watershed manipulation studies, which is an important concern of the WMP. Initial contacts involved the various agencies associated with NAPAP, but additional non-NAPAP contacts were identified in the course of the survey. Information on current monitoring activities (aquatics, soils, forests, deposition, and air quality) and on the feasibility of conducting manipulation studies on watershed research sites was obtained. Overall, the results reflect input from 154 contacts.

Ms. Stockton reported that an estimated 233 basins (representing 713 research watersheds in 37 states) were identified (Fig. 1). Primary monitoring activities in the basins include precipitation (90%), water flow (89%), and some form of water chemistry (84%). Roughly half of the basins measure some type of deposition chemistry (64%), soil chemistry (69%), and meteorology (44%). Responses to

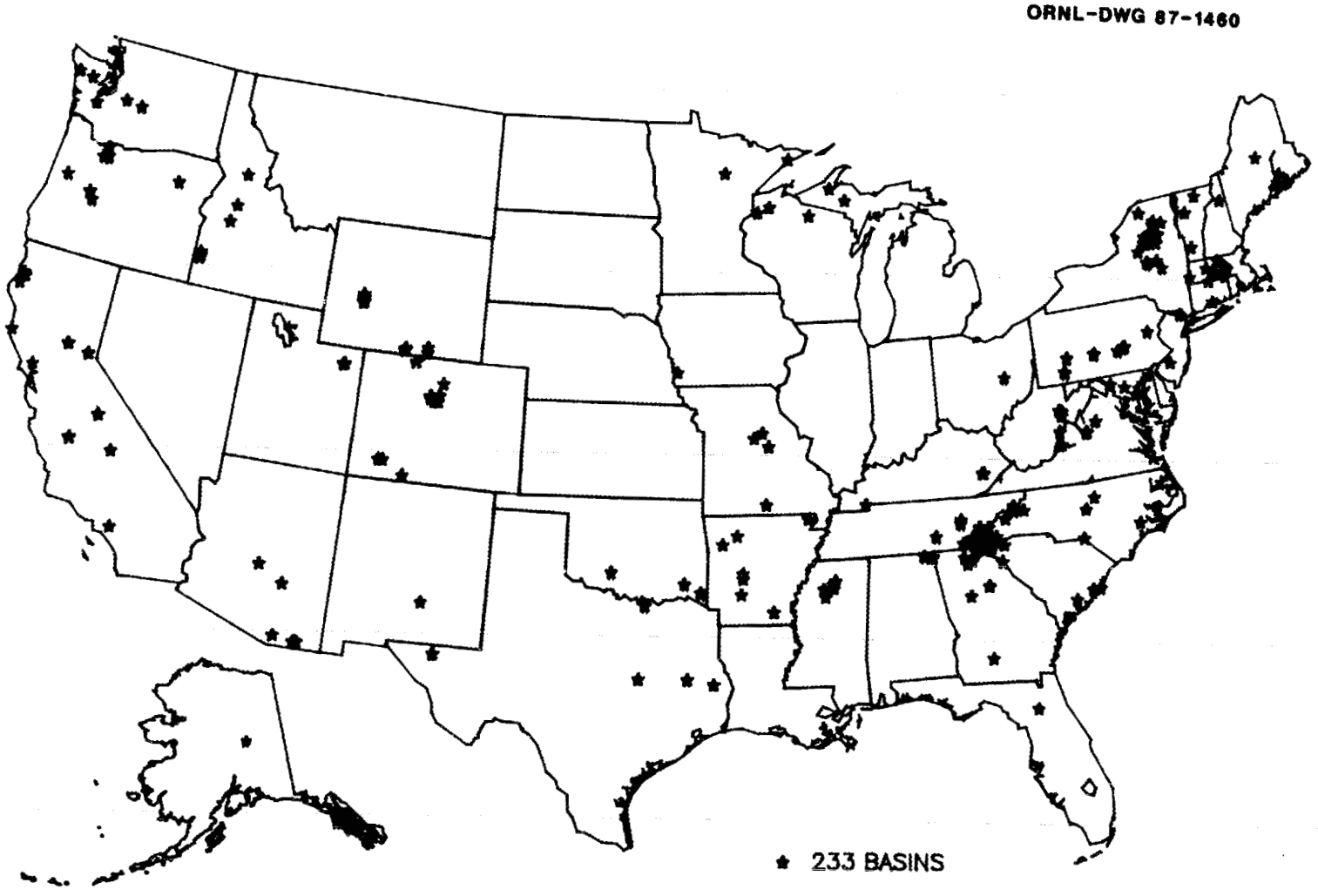


Figure 1. Locations of watershed research sites that were identified in the telephone survey. From: Radian Corporation. 1986. Summary of Watershed Research and Monitoring Activities in the United States in 1986, Vol. 1-Results. Draft report prepared for U.S. Environmental Protection Agency. Research Triangle Park, North Carolina.

forestry-related questions were untabulated as yet. Responses to the questions concerning watershed manipulation experiments were less definitive in that one-third to one-half of the contacts did not know if manipulation studies could be undertaken at their site(s). Manipulation studies were deemed feasible by survey respondents for roughly one-third or fewer of the basins (liming 39%, acidification 24%, and radioisotope tracking 19%). Table 1 summarizes the basic statistics derived from the survey.

Subsequent to the Watershed Coordination Workshop, representatives from several NAPAP agencies identified potential problems with the nomenclature used to conduct the survey. The terminologies they questioned were basin and watershed. Commenters indicated that not all of the so-called basins and watersheds identified in the survey were actually basins and watersheds under the strictest definition. Some of the indicated basins may actually be watersheds within a basin or individual water bodies (e.g., lakes) within a watershed, and some of the identified watersheds may actually be individual water bodies within a watershed. Ecological systems described in the survey were originally categorized according to the descriptions provided by the coordinators who were contacted. Because there appear to be inconsistencies and errors in the identification of some systems, the summary statistics (i.e., both relative percentages and absolute numbers) in Table 1 may be incorrect and potentially misleading. Work is under way to correct these inconsistencies.

Table 1. Summary of statistics derived from the telephone survey of watershed research

| | Number | Percentage |
|---|---|---|
| Contacts | 154 | -- |
| Basins identified | 233 | -- |
| Watersheds | 713 | -- |
| Monitoring | | |
| Precipitation | 209 | 90 |
| Deposition chemistry | 148 | 64 |
| Flow | 207 | 89 |
| Water Chemistry | 196 | 84 |
| Acid neutralizing capacity | 139 | 60 |
| pH | 182 | 79 |
| Sulfate | 166 | 71 |
| Nitrate | 184 | 79 |
| Other | 221 | 95 |
| Individual episodes | 134 | 58 |
| Soil chemistry | 161 | 69 |
| Cation exchange capacity | 151 | 64 |
| pH | 161 | 69 |
| Percentage base saturation | 126 | 54 |
| Sulfate isotherms | 37 | 16 |
| Meteorological data | 102 | 44 |
| Air quality | 33 | 14 |
| Ozone | 19 | 8 |

Adapted from: Radian Corporation. 1986. Summary of Watershed Research and Monitoring Activities in the United States in 1986, Vol. 1-Results. Report prepared for U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

## 2.4 LONG-TERM MONITORING PROGRAM

Dr. Kent W. Thornton presented the conceptual plan for a revised LTMP. The initial LTMP sponsored by EPA addressed lakes; the current conceptual plan reflects an attempt to expand and improve the research design. The overall goals of the program are to monitor the chemical and biological status of surface waters, to quantify and characterize what proportion of the population is changing, and to determine how rapidly the changes are occurring in order to be able to respond to these changes in a timely manner.

The proposed approach, as described by Dr. Thornton, was designed to optimize the detection of trends in surface waters over broad geographic regions. The hierarchical structure would involve four tiers (or levels) of research: regional, seasonal, intensive, and special studies. Regional studies, the first tier, would obtain an annual index of key chemical variables (such as base cations, anions, pH, acid neutralizing capacity, dissolved organic carbon, silica, conductivity, and color) for approximately 100 systems. Samples would be taken during stable periods such as fall overturn in lakes and spring baseflow in streams to detect changes over a three- to five-year period. Two types of lakes would be of particular interest at the regional level: early indicators (for either increased acidification or recovery) and "typical" lakes within specified subpopulations. From the regional group, selected systems would be sampled seasonally for both chemical and biological indices to characterize the seasonal patterns. The third tier would consist of intensive watershed studies (i.e., forests, lakes, streams, soils, etc.) on a smaller subset of

systems. The final tier would involve special studies, possibly resurveys, of a few key systems. Integration of the research program requires consistent methodologies, selection of a central laboratory, coordination of quality assurance and control, and development of a database management system. Dr. Thornton suggested that coupling of the LTMP data with those from the DDRP, the NSWS, the WMP, and other watershed research programs could offer significant gains for evaluating the integrated response of forests, soils, and watersheds. At present, implementation of the revised LTMP is scheduled to begin in 1988.

## 2.5 WATERSHED MANIPULATION PROJECT

Dr. Daniel H. McKenzie presented an overview of the WMP being conducted by the EPA Environmental Research Laboratory/Corvallis. The research plan for the WMP was approved in the Peer Review Meeting held June 3-4, 1986. The primary goal of the WMP is to test and validate the three DDRP models: Trickle-Down, MAGIC, and ILWAS. The objectives of the WMP are to observe watershed response to manipulation, use the data collected from the manipulation experiments to test model predictions, improve the scientific understanding of watershed processes, and refine the watershed models. The WMP is based on two assumptions: that long-term acidification is sulfur driven and that the important processes controlling acidification are known.

At present, task and site proposals are under peer review, and the supporting documents (quality assurance, data quality objectives, and field implementation plans) are being prepared. Site selection will be

based on applicability to policy concerns regarding acidification impacts, short-term responsiveness to manipulation, and representativeness of typical watershed characteristics, which should improve the linkage between the WMP and other watershed research programs. The first site will be in Maine. The remaining sites may be located in the Southeast, the Mid-Atlantic, the West, and the Adirondacks. Manipulations will involve three different scales of field studies -- catchment, hillslope, and plot -- and laboratory studies. The experiments will use sulfuric acid, sulfur, or ammonium sulfate with or without radioisotope tracers. Thus, the WMP research will support model testing to determine the bounds or uncertainty of the DDRP models and to evaluate the processes associated with acidification.

## 2.6 RECOMMENDATIONS FOR RESEARCH ON WATERSHED PROCESSES

### 2.6.1 Base Cation Resupply Processes

Cation mobilization and resupply processes were reviewed by Dr. Jerry S. Schnoor. His recommendations for future research included:

(1) laboratory, plot, and field experiments (in particular, hydrologic processes, fractional weathering, ion exchange, selectivity coefficients, replacement of the exchange complex by weathering, biocycling, and organic reactions) to lend credence to the formulations in the DDRP models;

(2) determination of the amount of chemical weathering and resupply to the exchange complex on the soils; and

(3) continuation of baseline watershed monitoring, including such parameters as trace metals and pesticides.

### 2.6.2 Sulfur and Isotope Tracers

Dr. Dale W. Johnson summarized a few of the basic issues that sulfur tracers (radioactive or stable) could address, and Dr. Myron J. Mitchell summarized the use of sulfur isotopes to study cycling. Research has concentrated on the sulfate component of the sulfur cycle, but most of the sulfur in forest ecosystems is in the organic form. Thus, one major uncertainty that should be addressed is whether the sulfur mobilization and mineralization reactions are in steady state. Sulfur adsorption is ecologically important because of its impact on soil leaching. Delayed effects from sulfur inputs can be expected if sulfur is strongly adsorbed into soils. The use of sulfur isotopes [radioactive ($^{35}S$) and stable isotopes ($^{32}S$ and $^{34}S$)] in watershed manipulation experiments could provide significant insights into the role of sulfur in watersheds. This is because sulfur isotopes are incorporated into the various sulfur pools within a short period of time. Isotopes could be used in laboratory, plot, and watershed level studies of environmental acidification. Suggested areas for research were:

(1) measurement of dry deposition and foliar exchange,

(2) identification of soil sulfur sinks (organic versus inorganic),

(3) measurement of total sulfur using a mass balance approach,

(4) evaluation of hypotheses on sulfur dynamics (loadings versus losses), and

(5) refinement and testing of biochemical and geochemical relationships.

### 2.6.3 Nitrate Mobility and Nitrogen Cycling

Dr. Knute Nadelhoffer discussed the basis for nitrogen/nitrate research within the NAPAP effort. He explained that inputs of nitrogen in any chemical form in excess of biological demand are more powerful acidifying agents than sulfur. Key areas for additional research were:

(1) identification of the controls on nitrification rates in the field,

(2) prediction of nitrate assimilation capacities of representative ecosystem types and individual species,

(3) identification of the fate of nitrate and associated hydrogen ions and base cations that are exported from forests to surface waters including an examination of their interactions in surface waters, and

(4) incorporation of biological controls of nitrate production and assimilation into watershed level models.

### 2.6.4 Watershed Aluminum Chemistry

The effect of acidification on biogeochemistry of aluminum and the status of research on aluminum cycling in the environment were reviewed by Dr. Charles T. Driscoll. Aqueous aluminum was deemed environmentally significant because it buffers pH, affects nutrient cycling, and can be toxic to aquatic organisms. At present, fractionation can be used to measure levels of aluminum (i.e., nonlabile monomeric, labile monomeric, and acid soluble aluminum), and equilibrium models can describe the concentrations of aluminum in the environment fairly well. Future research should:

(1) evaluate the extent of the interaction of the various pools of aluminum,

(2) identify which forms (organic vs inorganic) regulate aluminum concentrations, and

(3) determine how aluminum cycling is affected by strong acid inputs.

### 2.6.5 Hydrologic Pathways and Residence Times

Hydrologic process (groundwater transport, overland flow, subsurface flow, baseflow, etc.) information is needed to test the DDRP models in order to improve predictions related to acidification. Dr. George M. Hornberger reviewed current research into hydrologic processes and offered recommendations for future hydrologic research. He suggested that initial studies should look at the processes in a controlled situation and then attempt to infer what role the hydrological processes play in determining stream water chemistry. For example, experiments should assess macropore flow (both vertical and lateral) characteristics and should determine other preferred flow paths in a catchment. He also advocated the use of tracers to facilitate hydrologic analyses.

## 2.7 LOCH FLEET PROJECT

Dr. David J. A. Brown summarized the research design and preliminary results of the Loch Fleet Project. This five-year effort (1984-1989) is jointly funded by the Central Electricity Generating Board, the South of Scotland Electricity Board, the North of Scotland Hydro Electric Board, and the National Coal Board. Loch Fleet Lake is a small acidic (pH $\leq$4.5, 21 ha) lake in Galloway, Southwest Scotland, that once supported a healthy trout population. No fish have been

caught since 1960. The underlying geology is granite, covered by a thin sandy loam and peat. In 1961, about 12% of the catchment was afforested with Sitka spruce and lodgepole pine trees. The area receives high levels of rainfall and acidic deposition; yet the lake is more acidic than the rain falling on it. Diatom analyses suggest that acidification started around 1965.

The objectives of the Loch Fleet Project are to (1) demonstrate that the water chemistry can be made suitable to support trout by one or more treatments of the Loch Fleet catchment (110 ha) or of the water and (2) demonstrate the suitability of the waters for a self-sustaining trout population. Treatments include the addition of basic minerals to soil and/or water, manipulation of hydraulic contact with natural or added minerals, or manipulation of the ion exchange system (i.e., burning). The research will be conducted in six phases: baseline data collection, laboratory and field manipulations, treatment, post-treatment monitoring, fish stocking, and post-stocking monitoring. At present, data are being collected on aquatics (chemistry, flow, biota), soils, deposition, and land use. The catchment has been divided into thirteen subcatchments, and nine lake embayments have been installed. Selected subcatchments will be treated with limestone or burned. Subcatchment VII was treated with 4 t/ha of limestone in April 1986. Preliminary results suggest that aquatic pH and calcium levels increased and that aluminium and sulfate levels decreased slightly following the treatment. Additional studies are under way.

## 2.8 INTERNATIONAL ACTIVITIES

Recent discussions concerning international research priorities and important issues related to environmental acidification were summarized by Dr. Rick A. Linthurst. NAPAP monitors international agreements, policy discussions, and research developments dealing with acidic deposition. NAPAP uses this information to guide the direction of its research and to develop appropriate schedules and budgets. Future international activities will emphasize additional problem definition types of work (i.e., identifying specific questions that must be answered, identifying realistic assessment targets, etc.).

At present, the key international issues include: nitrate saturation in forests, long-term monitoring, and watershed research coordination. Initial cooperative efforts will involve identification of key scientists interested in each of these topics, promotion of information exchange on current research efforts, and identification of target questions for cooperative research activities. Subsequent cooperative efforts may involve providing support to collect samples and data or to analyze and review the data collected. Research proposals covering targeted topics, database management, quality assurance and control, etc., are being prepared. Sweden is leading the forestry effort, Germany and Canada are jointly leading the long-term monitoring effort, and the United States may lead the watershed coordination effort. These internationally defined proposals will be used to help define, refine, and set standards for NAPAP's research in these areas.

## 3. SUMMARY OF DISCUSSIONS

The presentations on NAPAP-sponsored watershed research and results of the telephone survey suggested that some coordination of the research was needed. In particular, the survey suggested that researchers and their research sponsors are probably missing some real opportunities due to the lack of coordination and information exchange in current efforts. Many contacts expressed interest in participating in a cooperative research effort. In all, the respondees suggested that a collaborative watershed research program would be beneficial for all parties involved.

The workshop's initial discussions focused on watershed research coordination. Participants identified possible benefits of a cooperative program, suggested which aspects of watershed research could be coordinated, recommended what level of coordination could be achieved, and discussed possible strategies or implementation plans. Attendees also addressed the willingness of their federal agencies to cooperate in the coordination effort or even to provide financial support, assuming NAPAP would formulate a sound plan that focused on certain key issues. In the subsequent discussions, participants commented on the conceptual plan for the LTMP and offered general suggestions to improve watershed research programs as a whole. Results of the discussions follow.

## 3.1 WATERSHED RESEARCH COORDINATION

### 3.1.1 Benefits

Most participants agreed that a coordinated effort would be very useful, but several noted that it would be difficult to implement. Obvious benefits that could be derived from such a program include:

(1) enhanced communication and cooperation between researchers at various sites,

(2) better comparison of data between sites and extrapolation between basins,

(3) facilitated identification of regional differences, and

(4) a general enhancement of research efforts currently under way or planned.

Participants recognized that additional benefits could be derived from the collaborative testing of hypotheses. For example, both NAPAP and forestry groups are concerned with evaluating sulfur cycling in forest ecosystems.

NAPAP could minimize difficulties in implementing the program through extensive planning. Attendees recommended that NAPAP and the program's funding agency should identify appropriate research sites and locate researchers who are interested in completing the work. Funds alone, they emphasized, would not always generate interest or desire to complete the work. A number of specific concerns were voiced that would affect a researcher's willingness to participate. For example, it was suggested that NAPAP must first define its own needs and decide how it will use the information to answer basic questions of regional or national concern. NAPAP must also identify and emphasize potential

uses for the consistent and conforming information. Participation in the effort would also be affected by the complexity of the protocol and its frequency of use. Thus, overall success would require difficult, judicious choices and thorough planning by NAPAP and the agency administering the program.

### 3.1.2 Aspects Needing Coordination

Participants were undecided concerning which aspects of watershed research could be coordinated. Design and implementation of a standardized protocol for the program were identified as a key concern, but opinion was divided as to whether such a protocol could be enforced. Some participants felt that standardization could be assured if adequate funds were provided; others were very skeptical. However, attendees noted that any standardization attempt should be preceded by an analysis of the available information for groups or clusters of watersheds. This analysis would indicate the size and nature of the problem.

Two approaches were suggested to standardize the program's results:

(1) periodic distribution of sample kits that would be returned to a specified (quality-assured) laboratory for subsequent analysis, and

(2) distribution of blind samples for on-site analysis to attempt to measure variability in quality assurance.

The first approach would be valid only for parameters where collection methods, preservation methods, and shipment were not important. It was noted that even this low-level participation

would be highly dependent on the availability of base funds to operate each participating station over the long term. In conjunction with the second approach, NAPAP or the program's funding agency could distribute information regarding its needs and state-of-the-art techniques. Moreover, the blind sample approach could also be used in conjunction with the first approach for measurement of parameters deemed sensitive to shipment, etc.

Other participants were skeptical noting, that personal preferences and ideas would always surface and would hinder any attempt to standardize or coordinate research at any level. Other problems could arise from the availability of funds to purchase and maintain the necessary equipment. To this end, establishing a massive program, such as the NSWS, was suggested as the best method to ensure standardization.

### 3.1.3 Level of Coordination

Several suggestions were offered concerning what level of coordination could be implemented. Initial coordination efforts undertaken by NAPAP or the designated funding agency for the program could simply be to promote information exchange. Data such as those from the telephone survey conducted by Radian and from the Acid Deposition Data Network (ADDNET) at Oak Ridge National Laboratory could be used to formulate a directory of research and researchers. The directory could serve as the basis for a contact network for individual researchers to compare and contrast data as needed. ADDNET could also facilitate the transfer and analysis of data between researchers.

Next, participants recommended a two-level approach for the coordination program. The first level could involve a large number of sites all across the nation testing nationally important hypotheses. Given that cooperation and standardization would probably be limited at this level, the research tasks and input/output requirements should be minimized. The program should support baseline research at the selected watershed sites and allocate funds for the purchase and/or reformatting of data sets available at these sites. At the second level, more detailed, process-oriented research could be conducted at a small number of select sites. One important factor to consider in site selection for the detailed research effort would be researcher interest, as this is often a key to programmatic success. The program must provide travel funds for the key scientists to visit other research sites and to attend relevant technical meetings. Granted, the increased financial support required at the second level could mandate stricter standards for participants to follow, but they noted that it would still be important for the program to foster creativity and ingenuity.

### 3.1.4 Strategy/Implementation Plans

Recommendations for implementing the coordinated research effort were very general in nature. Group participants recommended that the overall program should be interactive with the principal investigators at the various sites. They suggested that NAPAP or the program's funding agency should sponsor annual meetings and allocate sufficient

travel funds for all principal investigators to attend. Important issues that should be addressed in concert with principal investigators include quality assurance, quality control, and database management.

The group suggested that NAPAP and the program's funding agency must also examine other important issues. Ownership of the research and the resulting data and the program's ability to provide continuity of both research direction and support were two issues needing consideration. Moreover, since researcher participation may be influenced by past experiences with federal agencies, NAPAP must carefully select the agency to administer the program.

In cases where the program would require a specific measurement in conflict with established procedures at a site, then program funds should support the second measurement, both in staff time and equipment. Moreover, NAPAP must recognize that most sites can no longer volunteer free support for programs, such as was done for the National Atmospheric Deposition Program and the Long-term Ecological Research Program. Yet participants acknowledged that protocols developed for these programs could serve as good examples for NAPAP to follow.

### 3.1.5 Agency Participation

Discussions on possibilities for agency participation were based on the assumption that NAPAP would formulate a scientifically sound coordination program that focused only on certain aspects of watershed research or on important, answerable questions of wide concern.

3.1.5.1 U.S. Forest Service

In general, Dr. M. Dean Knighton felt that the FS would be willing to cooperate with NAPAP in a well-planned, meaningful program. For example, he suggested that a study to evaluate the effects of ambient acid loading on surface water chemistry would be of interest to the FS. Such a study could be done on a national scale and could deal with temporal and spatial variability. On the other hand, watershed manipulation studies would be of less interest. He noted that the FS currently coordinates research among its 130 catchments. Most of these sites have been in operation for 20 to 25 years, although some have operated for almost 50 years. Surface water chemistry and deposition are monitored at most of the sites. Thus, the FS has demonstrated that a national program is feasible and that it has the experience to direct long-term efforts such as this.

However, FS participation in a NAPAP effort would depend on several additional factors. First, NAPAP would need to incorporate additional catchments to supplement the FS program and, thus, complete a national network that could meet the criteria established by NAPAP and the FS. He noted that the FS sites could easily form the core of the network. Next, NAPAP must identify meaningful hypotheses to be tested and demonstrate that the program is technically sound. Furthermore, the program's sponsor must demonstrate its willingness to provide solid financial support.

3.1.5.2 U.S. Geological Survey

Dr. Owen P. Bricker indicated that the GS would probably be supportive of a NAPAP coordination effort if it were based on a

well-formulated plan and if it involved the testing of clearly defined, relevant hypotheses. The GS watershed research program, which involves 17 sites, was initiated in late 1982. Surface water quality and flow information are available for all sites; additional information on soils and throughfall are available at some of the sites. The GS watershed research group meets once a year. Methodologies have been fairly well standardized. However, Dr. Bricker added that anticipated budget reductions may force the GS to terminate some of the watershed research unless additional funding is obtained.

3.1.5.3 U.S. National Park Service

Dr. Robert Stottlemyer felt that the NPS would probably support efforts to coordinate watershed research. Like the FS, the NPS has its own watershed research program involving 20 watersheds. A central quality assurance/quality control plan has been adopted. The research has emphasized water quality, but some data on soils and vegetation are available. Approximately three to five years of data are available for these sites. Dr. Stottlemyer attributed the success of the NPS program to the involvement and commitment of key, interested researchers.

## 3.2 LONG-TERM MONITORING PROGRAM

The conceptual design of the EPA/NAPAP LTMP was largely supported by the workshop participants, although some voiced concern over problems arising from having gaps in the data at some of the present LTMP sites. Other points of discussion on the LTMP centered on the issue of variability, the possible inclusion of streams in the program, and the duration of the proposed research.

Most attendees agreed that the tiered design was useful if adequate, multiyear funding were available for the intensive research sites. To that end, it was strongly recommended that the EPA and other federal agencies should begin to consider future environmental issues, such as pesticides or heavy metals, that long-term monitoring research could also address. Design of a broad-based program at a core of research sites could supply data to any number of environmental issues of interest to EPA or other federal agencies. However, long-term funding for core sites would need to be assured in order to protect the integrity and continuity of the data.

Participants noted that the LTMP must also take into consideration the amount of change that must be detected in order to contribute to policy decisions. Research to detect a 1 to 2% change would be very different from that to detect a 10 to 20% change. Preliminary analyses by EPA have suggested that a 10 to 20% change per year may be needed, but further analyses are needed to estimate the actual limit of detection. Research costs must also be factored into this analysis to identify reasonable detection limits.

Several participants questioned the ability of the LTMP to detect regional trends within three to five years. However, the pressing need for long-term data sets on watersheds for future analyses and the need for manipulations to determine cause and effect relationships were recognized.

The issue of determining intrayear variability versus interannual variability was brought out in the discussion. Participants suggested

that analyses of trends derived from long-term data sets (e.g., Hubbard Brook or Sudbury) should be compared with results of analyses of trends using only selected points from these data sets. In this manner, one could estimate the amount of error in projections derived from point sampling. They noted that estimation of year to year variability itself could be an important step in the detection of long-term trends. Moreover, statistical approaches to detect change or trends are different from those used to estimate subpopulations based on surveys or even to analyze subpopulation characteristics. The variability could be so great that the analyses would only be interpreting random chance. Certainly, the analyses of trends would require data from a large number of sites over a long period of time, probably 20 to 30 years. Most participants agreed that one or two samples per year would be sufficient to characterize most lakes. Small headwater lakes and seepage lakes were deemed the most sensitive to change and were recommended to serve as indicators.

Characterization of streams based on periodic samples was not recommended. Streams cannot be so simply characterized, due to their highly variable nature. A large part of this variability is derived from the amount and timing of snowmelt and precipitation; in some regions there is no winter baseflow. Thus, seasonal baseflow can be extremely variable. In other regions, discharge can be relatively stable yet discharge chemistry can be highly variable. Any research effort must take factors such as these into account and would, therefore, have to differ from site to site. For the most part, stream characterization would require long-term, continuous or at least weekly

sampling. Detection of the effects of variations in meteorology and climate versus long-term depositional changes would require long-term continuous data sets. Providing supplementary funding to GS benchmark stations on small watersheds was suggested as a possible compromise to keep streams in the LTMP. Still, detection of trends within the time frame of the LTMP even using benchmark station data was deemed difficult at best because data for the benchmark stations go back only 15 years.

Another suggestion was to sample first- and second-order catchment sites because these are typically more sensitive to change than are lakes and because the linkage between terrestrial and aquatic systems can be better assessed at that level. Again, five to ten years of data would be needed to separate out climatic variability within these first- and second-order catchments.

# 4. CONCLUSIONS AND RECOMMENDATIONS

The workshop served as an open forum for representatives from NAPAP, various federal agencies, universities, and industries to discuss their concerns and offer their recommendations regarding the initiation of a watershed coordination program and a LTMP for acidic deposition research. The select group of watershed researchers and program managers in attendance provided expert counsel and offered fundamental advice concerning the primary issues facing watershed research across the nation. Furthermore, the workshop initiated pointed discussions on the need for coordinating watershed research activities, the proposed design of the LTMP, and other emerging watershed research priorities. At the same time, attention was directed to the status of and conditions at existing watershed research sites across the nation. The results of the workshop will be used to assist NAPAP in its overall watershed research planning process.

In general, participants concurred with NAPAP's viewpoint that a coordinated watershed research effort could be beneficial. Development and implementation of the program, however, would require extensive planning and would demand difficult, judicious choices. Willingness to participate at both the individual and federal agency level would be very dependent on NAPAP's ability to:

(1) develop a scientifically sound research plan dealing with issues of regional or national concern; and

(2) select an appropriate agency to administer the program.

Participation would also be dependent on the program's ability (via both NAPAP and the designated funding agency) to:

(1) demonstrate a long-term commitment for adequate support,

(2) identify and recruit a national network of research sites, and

(3) enlist the support of dedicated researchers at those sites.

Given that the above requirements were met, representatives from the FS, the GS, and the NPS indicated that their agency would probably support the program.

Designing and ensuring the use of a standardized protocol were identified as a key issue. Opinions were strongly divided as to whether or not standardization could be implemented at any cost. Participants suggested that NAPAP should examine the information available from selected groups of watersheds to estimate the size and nature of the problem during the early phases of the design of the program.

Initial coordination efforts undertaken by NAPAP or the program's funding agency should simply promote information exchange between the various agencies and watershed researchers via development of a contact network and sponsorship of meetings at least annually. The program itself should incorporate two levels of research:

(1) a nationwide network of sites gathering baseline data to support nationally important hypotheses, and

(2) a lesser number of select sites conducting detailed, process-oriented research.

Research tasks and requirements should be minimal at the national level but should be fairly strict at the process-oriented level. The program would need to provide funds to support research (staff and equipment) and data management at both levels; purely voluntary cooperation could not be expected.

The participants largely approved the conceptual, two-tiered design of the LTMP. They recommended that EPA provide multiyear funding and that the program should not be limited to acidic deposition monitoring. Important issues that must be addressed by the program's designers include:

(1) the amount of change needed to develop national policy,

(2) the reasonable length of time needed to detect regional trends, and

(3) the determination of intrayear variability versus interannual variability.

Participants agreed that periodic sampling of lakes was adequate. They recommended that small headwater lakes and seepage lakes be used as indicators. However, most believed that streams could not be adequately characterized based on periodic sampling. They offered two suggestions that might enable streams to be included in the program:

(1) provide supplementary funding to GS benchmark stations on small watersheds, or

(2) limit sampling to first- and second-order catchment sites.

Overall, participants favored NAPAP's development of a coordinated watershed research program and EPA/NAPAP's conceptual design of the

LTMP. Most of the recommendations for the two programs offered by the attendees stressed the need for EPA and NAPAP to:

(1) demonstrate scientific relevance and credibility of the research design, and

(2) provide long-term funding for both efforts.

# APPENDIX A

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# APPENDIX B

## AGENDA

Watershed Coordination Workshop
Atlanta, Georgia
June 5-6, 1986

### Thursday, June 5, 1986

| | | |
|---|---|---|
| 8:30am | Introduction | John Malanchuk |
| 8:40 | Overview of NAPAP | Larry Kulp |
| 9:00 | Overview of NAPAP Aquatic Effects Task Group and Watershed Research | Rick Linthurst |
| 9:30 | Workshop: Scope and Objectives | John Malanchuk |
| 9:45 | Break | |
| 10:00 | Watershed Research Telephone Survey: Approach and Results | Margie Stockton |
| 11:00 | Discussion: Survey Interpretation and Implications for Coordination | Rick Linthurst |
| 12:00pm | Lunch | |
| 1:30 | Long-term Monitoring Program | Kent Thornton |
| 2:00 | Recommendations | Kent Thornton |
| 2:15 | Discussion: Reactions to Long-Term Monitoring Proposal | Kent Thornton |
| 3:00 | Break | |
| 3:15 | Introduction: Research on Watershed Processes | Dan McKenzie |
| 3:20 | Base Cation Resupply Processes | Jerry Schnoor |
| 4:00 | Sulfur and Isotope Tracers | Dale Johnson and Myron Mitchell |
| 4:30 | Loch Fleet Project | David Brown |
| 5:30 | Social | |

Friday, June 6, 1986

| | | |
|---|---|---|
| 8:00am | Introduction: Research on Watershed Processes | Dan McKenzie |
| 8:05 | Hydrologic Pathways and Residence Times | George Hornberger |
| 8:35 | Nitrate Mobility and Nitrogen Cycling | Knute Nadelhoffer |
| 9:00 | Watershed Aluminum Chemistry | Charley Driscoll |
| 9:30 | Watershed Manipulation Program | Dan McKenzie |
| 10:00 | International Activities | Rick Linthurst |
| 10:30 | Summary and Wrap-up | John Malanchuk<br>Rick Linthurst |
| 11:15 | Adjourn | |

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