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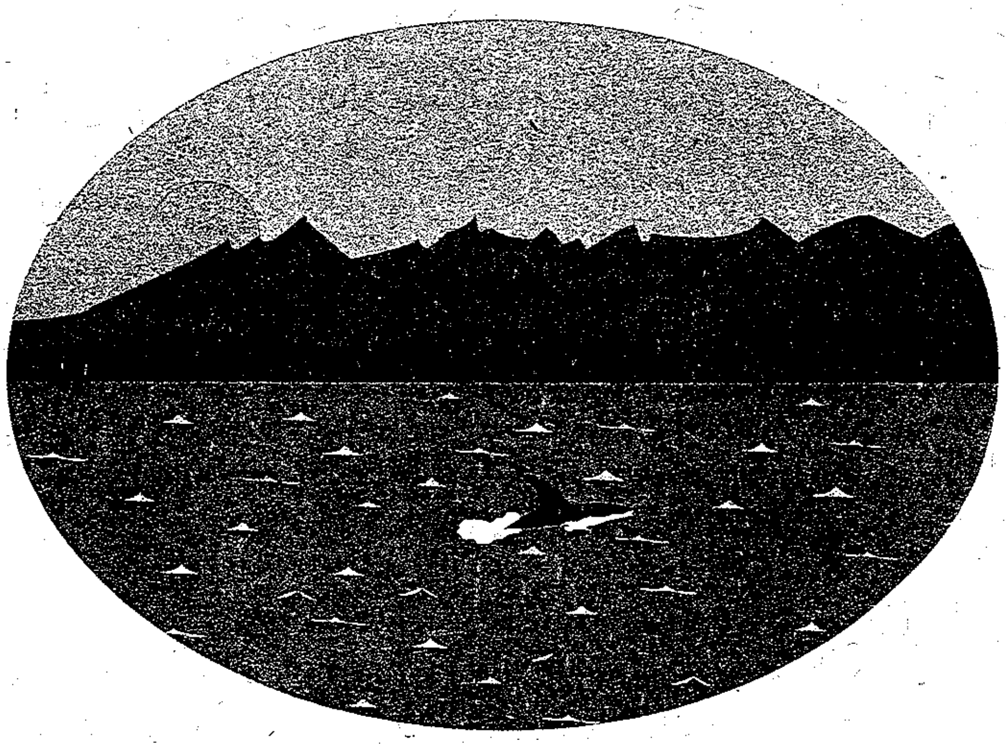
Linking Land and Water: Third National Nonpoint Source Watershed Monitoring Workshop

Proceedings

October 2-6, 1995
Seattle, Washington



Co-sponsored by
U S Environmental Protection Agency
State of Washington Department of Ecology
State of Washington Water Research Center
USDA - Natural Resource Conservation Service

In cooperation with
North Carolina State University
Oregon State University

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INTRODUCTION

Monitoring of both land treatment and water quality to document water quality improvement from nonpoint source (NPS) pollution controls is necessary, in at least a few projects, to provide information to decision makers regarding the effectiveness of NPS pollution control efforts. The United States Environmental Protection Agency (USEPA) Section 319 National Monitoring Program is designed to provide information on pollution control efforts by documenting water quality changes associated with land treatment.

The Section 319 National Monitoring Program projects comprise a small subset of NPS pollution control projects funded under Section 319 of the Clean Water Act as amended in 1987. Currently, projects are focused on stream systems, but USEPA intends to expand into ground water, lakes, and estuaries as suitable project criteria are developed. The goal of the program is to support 20 to 30 watershed projects nationwide that meet a minimum set of project planning, implementation, monitoring, and evaluation requirements designed to lead to successful documentation of project effectiveness with respect to water quality protection or improvement. The projects are nominated by their respective USEPA Regional Offices, in cooperation with state lead agencies for Section 319 funds. USEPA Headquarters reviews all proposals, negotiates with the regions and states regarding project detail, and recommends that regions fund acceptable projects using a regional 5% set-aside of Section 319 funds

Thirteen Section 319 National Monitoring Program projects and one ground water pilot project have been approved as of October 31, 1995. The thirteen surface water monitoring projects selected as Section 319 National Monitoring Program projects are Peacheater Creek (Oklahoma), Warner Creek Watershed (Maryland), Totten and Eld Inlet (Washington), Elm Creek (Nebraska), Lake Champlain (Vermont), Lake Pittsfield (Illinois), Long Creek (North Carolina), Morro Bay (California), Oak Creek Canyon (Arizona), Otter Creek (Wisconsin), Pequea and Mill Creek (Pennsylvania), Sny Magill (Iowa), and Sycamore Creek (Michigan). The fourteenth project, Snake River Plain, Idaho, is a pilot ground water project.

Each year, the 319 National Monitoring Program sponsors a conference on nonpoint source pollution and the 319 National Monitoring Program projects. *Linking Land and Water* was the Third Annual Section 319 National Monitoring Program Conference, which was held in Seattle, Washington, from October 2-6, 1995. The conference was comprised of three distinct components: project feedback, field trips, and mini-courses. The first component centered around successes and problems of the Section 319 National Monitoring Program projects: Project Planning and Management; Institutional and Social Issues; The Cooperative Effort; Water Quality and Data Evaluation; Pollution Sources — Nonpoint; and Spatial Analysis of Data. Three field trips to view either forestry, agricultural, or urban watershed projects were available. Mini-courses ranged from training in Geographical Information Systems to water quality, land treatment, and habitat monitoring. *Linking Land and Water* was co-sponsored by the U.S. Environmental Protection Agency, State of Washington Department of Ecology, State of Washington Water Research Center, and the USDA — Natural Resource Conservation Service, in cooperation with North Carolina State University and Oregon State University.

SESSION A
PROJECT PLANNING AND MANAGEMENT

Iowa's Approach to Project Planning and Management

Lynette Seigley
Iowa Department of Natural Resources-Geological Survey Bureau

Since 1991, the Sny Magill Creek Watershed has been the focus of an interagency effort to encourage landowner adoption of a wide variety of Best Management Practices and to monitor and measure the resulting improvement in water quality. The following have made the Sny Magill Project work: the interagency approach, flexibility/creativity, and communication/communication/communication.

Interagency Approach: During the planning stages of the project, all the necessary players were identified Each agency identified resources they could and would contribute to the program. Currently, 15 agencies are involved in the project

- Shared resources and budgets have enhanced project efforts more than individual resources or budgets would have allowed.
- An interagency approach has brought a variety of expertise to the project
- A common message needs to be communicated by all agencies The interagency effort to monitor a watershed forces individual agencies to think beyond their normal agency confines and to understand the project goals and how their information contributes to the big picture
- When managing large interagency projects, it is important to give credit where credit is due.
- Acknowledge the efforts of others.

Flexibility/Creativity: Iowa State University Extension developed the phrase "Manure Happens, Take Credit" as part of their manure management program. When it comes to project planning and management, the phrase could be modified to read "Manure Happens, Make the Most of It"

- Allow for flexibility in the project. Despite the best-laid efforts in planning, not everything was anticipated and not everything has gone as planned
- There isn't always adequate time when initially developing a project Understand what didn't happen in the initial stages of the project that should have How can the project implementation be adjusted?
- Allow for creative solutions to your problems. What can be tried that wasn't considered in the initial work plan? What can be done in response to the unforeseen changes that have occurred to the project?

Communication/Communication/Communication: Limit surprises.

- Good communication is needed both within the interagency group and with those outside the interagency group
- As with coordination, communication has taken an enormous amount of time, but it is time that needs to be invested for project success.
- Stress the importance of presenting project information so that others can understand it The message means little if its significance is not understood
- Communication involves both talking and listening.

Further Discussion:

- Give credit where credit is due for work performed: When a collaborating agency had done an extremely good job, project personnel designed and presented a special award to the agency.
- Be sure to distribute the work load throughout the agencies and personnel.
- Continual education of locals plus other agency personnel is essential in order to maintain the momentum of the project

- Be sure to communicate deadlines to all project personnel.
- To gain volunteer participation, use hands-on workshops. In this project, project personnel were able to train interested citizens and other agency personnel in streambank stabilization techniques. The course participants installed streambank stabilization devices within the project area and received training at the same time.
- A family education day was used to gain stakeholder support of project activities.
- To overcome producer resistance to state agency intrusion, the Iowa Department of Natural Resources has conducted residential well testing. This allowed producer and agency personnel to establish communication and begin to build trust.

General Discussion:

- Projects have learned that in some cases agencies are willing to work without funding to minimize unforeseen land use changes.
- The presenter described how a road crew had cleaned the stream near a monitoring site. When asked how this activity could have been prevented, the presenter stressed the importance of including all players that work within the boundaries of the watershed.

Successful Watershed Project Management: Lessons Learned in Long Creek

Gregory D. Jennings and Martha Burris
North Carolina State University and North Carolina Cooperative Extension Service

The Long Creek Watershed Project in Gaston County, North Carolina, is directed by a team of researchers, educators, government officials, and private interests. Since the project began in 1992, we have learned several valuable lessons about project management. Among these are:

- Teamwork. The project team must include all interested parties, including local landowners. It must work together as a unit to meet common objectives. This is sometimes difficult due to conflicting priorities among team members. The team must reach consensus on project objectives, team member roles, and operating procedures early in the project. The Long Creek Project Steering Committee has evolved into an effective management team as members have become more comfortable with their own and others' roles and abilities.
- Project Leadership. The leader must be organized, motivated, respected, responsible, team-oriented, and an excellent communicator. The leader should have local ties to the project and general knowledge of all aspects of the watershed project. The Long Creek Project Leader is Will Harman, a County Extension Natural Resources Agent. He is an effective leader because of his dedication and willingness to improve his leadership abilities.
- Objectives and Scope. These must be clearly defined and understood by all team members at the beginning of the project. Team members must know their responsibilities in meeting the objectives. The Long Creek Project team has worked to overcome early difficulty agreeing on project objectives and scope.
- Work Plan. The plan must define measurable units of work, assign responsibilities, and provide a schedule of expected accomplishments. The work plan must be flexible to account for unexpected changes in watershed land use weather conditions or project team membership. In Long Creek, we have experienced delays and problems resulting from an unclear project work plan.
- Budget. One team member must be responsible for tracking expenditures and reporting on the budget. Full funding to meet all project objectives in monitoring, land treatment, and education must be available from the beginning of the project. In Long Creek, we have spent considerable time and energy seeking additional funding to meet objectives identified by team members since the beginning of the project.
- Communication. The project leader must facilitate open communications so that team members know what is expected of them and so that problems can be addressed efficiently and effectively. The Long Creek project team communicates via bimonthly meetings, teleconferences, electronic mail discussions, and newsletters.
- Quality. Team members and funding agencies must expect quality results from the project. Members should seek expert assistance from public agencies and private sources to make the project as successful as possible. Because of the high level of government, industry, and media interest in the Long Creek Project, we have worked hard to ensure quality control in all of our efforts.

Further Discussion:

- The Long Creek project grew from a local concern about degradation of environmental quality.
- The project is managed at the local level by a steering committee. This keeps the perspective local It took a long time to coalesce the committee into a functional group. At the beginning of the project, each agency brought their own agenda into the committee. It has taken over two years to clarify project goals in order to focus people on the project and not the needs of their agencies.
- In order to reduce the time it took for the steering committee to coalesce as a group, the decision making processes should have been formalized at the start of the project.
- Subcommittees were tried and failed because everyone needed to be part of the decision making process and to have a stake in the project's success.

General Discussion:

- Most project personnel in the audience admitted that they are still struggling with BMP implementation and farmer cooperation
- An audience participant stated that although you can't control the land use activities in your watershed, you must be very certain that you document the activities so you can explain your data
- Most conference participants agreed that the 25% producer cost share contribution for BMPs is too expensive for producers to justify.

Experiences from the Elm Creek (HUA) Project

Scott Montgomery
Natural Resource Conservation Service-Nebraska

Achievements:

- Local Coordinating Committee (LCC) was established to provide a Local input process.
- Elm Creek Hydrologic Unit Area Project developed a Watershed Land Treatment Plan The Elm Creek Watershed Land Treatment Plan was provided to the Lower Republican Natural Resources District (LRNRD) for implementation
- The primary agencies (i.e. Lower Republican Natural Resource District, Nebraska Department of Environmental Quality, Natural Resource Conservation Service, Cooperative Extension, Consolidated Farm Service Agency, Local Coordinating Committee) requesting this Project reached consensus on nonpoint source pollution & runoff treatment goals and objectives Elm Creek Watershed Land Treatment Plan was a document established through team building among agencies and consensus planning.
- Almost all the funds targeted to the Elm Creek Watershed have been obligated to install conservation practices

Challenges:

- The lack of timely and adequate staffing continues to hamper project management and conservation land treatment efforts
- Lack of proper Local Coordinating Committee function, because only land owners with vested interests in the Project participated
- "Strings attached" to various funds targeted to the Elm Creek Watershed. Many owners are not willing to "jump through the hoops" to get cost-share assistance, thus limiting nonpoint source treatment opportunities
- Time limitations on how long targeted funds were/are available has lead to cost-share assistance being provided for the installation of conservation practices that cost more and yield lessor NPS pollution reduction benefits.
- Elm Creek Hydrologic Unit Area land owners, operators, and area citizens still do not recognize that Elm Creek is a very unique resource that needs protection Local "Buy-In" has not significantly occurred
- Continued insufficient funding to fully implement the Elm Creek Watershed Land Treatment Plan
- Area citizens continue to ask me "Is the water quality improvement worth what it will cost to make Elm Creek trout habitat "clean?" Agricultural production "pays the bills" and keeps the local economy going; thus many

agricultural producers in the Elm Creek Watershed have expressed concerns that this project has wasted tax money (especially if they have not received cost-share assistance).

- Various institutional pressures against the application of appropriate and cost effective conservation (i.e. CAB's, production financing, property taxes, producer's attitude, etc.).

Further Discussion:

- Local buy-in is essential and the local buy-in is usually based on the local population recognizing the value of the water resource In this project, the designated water use of the stream, cold-water fishery, is not valued by the local population.
- Elm Creek is a large watershed and, therefore, it has been difficult to show results. The Nebraska Department of Environmental Quality stated that a smaller watershed should have been chosen
- The lack of a designated project leader from the start of this project has been problematic to the success of the project.
- There is no violation of water quality standards in Elm Creek; therefore there is no impetus for producers to participate in the project. The incentive that project personnel have used to increase participation is a 75% - 100% cost share for BMP implementation from national and local sources
- When the project started, the local coordinating committee was composed largely of a diverse representation of the county population. Over time, only persons that had vested interests in the watershed continued to participate in the local coordinating committee activities. In order for the community to become vested in conserving the stream, the committee needed to be rediversified

SESSION B
INSTITUTIONAL AND SOCIAL ISSUES

Combining of Resources to Maximize Efforts

Rick Mollahan
Illinois Environmental Protection Agency

In spite of all good intentions on the part of local interests, financial resources are limited due to overall community needs and the political acceptability of increased fees on consumers. To maximize resources, the City of Pittsfield, Illinois (City), the Illinois Environmental Protection Agency (Illinois EPA), Consolidated Farm Service Agency (CFSA), and Pike County Soil and Water Conservation District (SWCD) combined efforts in a single watershed.

Lake Pittsfield was originally constructed under P.L. 566 as a flood control structure. It later served as the City's water supply as well as a recreational area. The City of Pittsfield performed a Diagnostic Feasibility Study under Section 314 of the Clean Water Act. The Illinois EPA contacted the Pike County SWCD and the City to consider a holistic approach to lake protection restoration and watershed management. Utilizing the water quality data provided in the Section 305(b) Report prepared by the Illinois EPA, the parties applied for a Section 319 grant for construction of 37 detention basins throughout the watershed, and a Section 314 grant for in-lake implementation. The Illinois EPA presented the watershed as a candidate for Water Quality Incentive Payments through the CFSA. Based on the involvement of the other organizations, the documentation of the water quality issues, and the strong local support, funding was obtained.

The City and the SWCD have also committed resources to this effort. At a cost of approximately $1 million, the City will be dredging the existing lake to remove in-place contaminants and reestablish capacity. The SWCD has committed staff time and facilities to work with the landowners in the development of extended operation and maintenance agreements with the landowners. The Natural Resource Conservation Service is preparing the designs for the detention basins, and is assisting the SWCD where needed.

Coordination of these organizations and their resources has assured a blanketed approach to correction and management of the total watershed resource concerns. Execution of operation and maintenance agreements to assure proper function of the systems will hopefully instill responsibility for the continued care of the system as well as promote positive communication between the urban and rural community.

Further discussion:

- Sediment from cropland erosion and in-stream erosion impacts roadways and recreation areas greatly.
- Soil types, slope, and land use practices were taken into consideration as decisions were made about placement of retention basins.
- The project offers 100% funding for BMP implementation (sediment retention basins). Landowners signed 10 year agreements to maintain the basins and to install and pay for the fencing Farmers have finished installing all sediment basins except the largest basin upstream of the lake
- Raw water samples, taken from the deepest lake station, near the water intake are also analyzed for Atrazine, along with other chemicals To date, the dredging of the Lake has not occurred.
- Blue Creek - Due to the construction of sediment basins and the resulting reduction of sediment loads, some bottom scouring and streambank destabilization has been noticed in the main tributaries. Due to the stream dynamics, it is not yet known if fixing one problem has created another Further analysis of the project will answer whether corrective actions will be necessary within the watershed.

General Discussion:

- Project personnel are modeling the watershed to look at hydrological changes resulting from the decreased sediment load They are looking at pool riffling as a way of addressing the hydrological changes.
- What has the effect of the hydrological changes been on the aquatic community in stream? The focus has been on water chemistry. They haven't yet looked at the biological communities. Upland streams are zero flow streams. Main stem has some water flow. They are waiting for the new system to equilibrate and then will study the biological communities.
- The question of long-term management of the retention basins was raised Farmers have signed 10 year agreements to maintain stable banks and intact fencing At 10 years, the project team intends to reevaluate functional capabilities of the basins Basins are designed for a 20 year life by Natural Resource Conservation Service. The state can recover the full costs of BMP installation from landowners if the basins are not maintained for 10 years.

Citizen Monitoring and Urban BMP Evaluation

Joan Drinkwin
Texas Watch Program

Texas Watch is the volunteer environmental monitoring program of the Texas Natural Resource Conservation Commission, supporting more than 5,000 citizen monitors throughout the state. The program was developed as an EPA approved Quality Assurance Project Plan which calls for standardized equipment, training, quality control checks, and data checks The program recently ventured into nonpoint source pollution monitoring and is currently implementing five projects funded through Section 319.

The East Bouldin Creek BMP Implementation and Demonstration Project entails implementing non-structural BMPs, such as community education, as well as citizen monitoring. The goal of the project is to decrease the NPS pollutant load entering Town Lake from East Bouldin Creek in Austin, Texas. Citizen monitors are being trained specifically to evaluate whether these goals are being met by implementation of BMPs. Throughout the project, volunteer monitors will sample for benthic macroinvertebrates on a quarterly basis and chemical and physical variables on a weekly basis. A paired watershed design is being employed.

Working with the City of Austin is a critical element in the success of this project. While Texas Watch has been successful coordinating with the city's own monitoring program, there remain differences in monitoring techniques which will hamper data analysis. Coordinating with other city departments has been more challenging. It has been difficult, for example, to coordinate with various city departments regarding community education and BMP construction. These challenges represent institutional barriers inherent in implementing a project in an urban area.

Texas Watch has learned that you can train volunteers to conduct water quality monitoring for either community education or good water quality monitoring data. The Texas Watch program has always been focused on good water quality data.

One powerful technique for community education is using the media to get the message across. The conflict that arises is the need to promote the project in the treatment area, but not have an impact on the control area. Because of this contradiction, it is necessary to clearly explain to citizens in both control and treatment watersheds the philosophy behind the experimental design and the importance of having a control. Through successful documentation of BMP effectiveness, which requires a treatment and a control, we can gather sufficient evidence to support requests for funds for treatment in all watersheds.

Implementation of BMPs by other agencies before the calibration period for a water quality monitoring project has been completed is a problem that has been raised. Joan noted that the Texas Watch had been able to coordinate with the city's professional monitors for adequate historical data for the calibration phase. A participant noted the importance of pre-project coordination among agencies before any of the agencies implements anything in the project area. It was noted that it is important to emphasize educating the community and agencies about the value of pre-BMP monitoring.

General Discussion:

- Texas Watch has learned that you can train volunteers to conduct water quality monitoring for either community education or good water quality monitoring data. The Texas Watch program has always been focused on good water quality data.
- One powerful technique for community education is using the media to get the message across. The conflict that arises is the need to promote the project in the treatment area, but not have an impact on the control area. Because of this contradiction, it is necessary to clearly explain to citizens in both control and treatment watersheds the philosophy behind the experimental design and the importance of having a control. Through successful documentation of BMP effectiveness, which requires a treatment and a control, we can gather sufficient evidence to support requests for funds for treatment in all watersheds.

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Farmers and Cows

Summary of presentation made by

Patricia Lietman, U S. Geological Survey

(summary prepared by Judith A. Gale and Janet M. Young, NCSU Water Quality Group)

Synopsis of the Pequea-Mill Creek Basin Project (Pennsylvania)

The Big Spring Run is a spring-fed stream located in the Mill Creek Watershed of south central Pennsylvania Its primary uses are livestock watering, aquatic life support, and fish and wildlife support In addition, receiving streams are used for recreation and public drinking water supply. Sampling of benthic macroinvertebrate communities indicated poor water quality at five of six sites. Other stream uses are impaired by elevated bacteria and nutrient concentrations

Land use in the project area is primarily agricultural. Uncontrolled access of more than 220 dairy cows and heifers to each of the two watershed streams is considered to be a major source of pollutants. It is estimated that grazing animals deposit an average of 40 pounds of nitrogen and 8 pounds of phosphorus annually per animal. Pastures adjacent to streams also are thought to contribute significant amounts of nonpoint source pollutants. Therefore, proposed land treatment will focus on streambank fencing to exclude livestock from streams. This will allow a natural riparian buffer to become established, which will stabilize stream banks and potentially filter pollutants from pasture runoff.

Water quality monitoring will employ a paired watershed design in which the proposed nonpoint source control approach is implementation of livestock exclusion fencing on 100% of the stream miles in the treatment subwatershed Grab samples will be collected every 10 days at the outlet of each paired subwatershed from April through November Storm event, ground water, biological, and other monitoring is planned to help document the effectiveness of fencing in the treatment subwatershed

The Chesapeake Bay program, which has set a goal of a 40% reduction in annual loads of total ammonia plus organic nitrogen and total phosphorus to the Bay, should have a significant impact on the project. The Pennsylvania State Chesapeake Bay Program is expected to provide up to 100% cost-share money to help landowners install streambank fencing.

General Discussion:

The project team is facing challenges posed by land use changes in both the control and treatment watersheds These changes include changes in cow numbers, changes in land ownership or tenancy, an unexpected housing development, and changes in length of pasture rotations

- In response to the land use changes, the project team has installed an additional water quality monitoring station below the housing development and has negotiated the placement of 30-foot buffers around the development, in the hope that the buffers will reduce the impact of the development on water quality data. The team considered adding an extra year to the pre-BMP (best management practice) monitoring period, but was not convinced that lengthening both the pre- and post-BMP periods of monitoring would improve the water quality data, since additional land use changes are likely to take place during the post-BMP period.
- The team is considering stratifying the water quality data to allow analysis of early pasture season data separately from late pasture season data This may help decrease the impact of the changes in pasture rotations, which have generally involved some farmers not pasturing their cows until later in the summer.
- The possibility of placing another new monitoring station above the housing development was discussed, but would probably not be feasible (lack of funds) or necessary, since there are no cows in the subwatershed above the housing development.
- The differences in fecal strep data from one time to another have been as great as three orders of magnitude, making the data hard to interpret.
- The possibility of switching from a paired watershed to an upstream-downstream before-after design was discussed. It was noted that some of the land use changes may not create data analysis problems because of the built-in redundancy of the monitoring design, which includes both paired watersheds and upstream-downstream sampling.

SESSION C
THE COOPERATIVE EFFORT

Common Ground on Private Land - Is It Possible?

Rick Hafele
Oregon Department of Environmental Quality

The Grande Ronde River is a 5,265 square mile watershed in the northeastern tip of Oregon. As in most basins in Eastern Oregon, the major land uses are logging, grazing, and agriculture. In 1992, an NPS assessment and restoration project began on five tributaries to the upper Grande Ronde River Stream and site selection followed a combination of the paired watershed and upstream-downstream approaches.

Land ownership in the selected tributaries covers both U.S. Forest Service and private ranches, with Forest Service land making up most of the upper timbered portions of the watersheds and private land comprising lower elevation pasture and rangeland. Because important areas of the streams, as well as the greatest restoration opportunities, are on private land, cooperation of private landowners is critical to the overall success of the project

What have been the critical issues in dealing with the landowners? First, there are typically very different perceptions between landowners and agencies about basic ideas such as:

- Who does the land really belong to?
- What is the land used for?

Secondly, there are often differences in the levels of trust and cooperation between old landowners and new landowners. Finally, some of the basic questions and problems that have come up include many common sense, issues that are not easily addressed. For example:

- How many agencies does a landowner want to deal with?
- Clear communication of study objectives is important so that landowners understand them.
- Watersheds are generally owned by more than one owner and not all are willing to participate. Thus, entire watersheds cannot be studied and treated, and control of problems is only partial.
- Maintaining consistent land use activities in study areas throughout the life of the project is difficult since scientific controls are not considered by landowners.
- Lengthy turnaround of data and results is difficult for landowners to understand.
- What do you do when you find an endangered species?

The long term success of most NPS projects is dependent upon the attitude and cooperation of private landowners. Failure to start on the right foot can create years of difficulty and ultimately lead to a lack of improvements in land use or stream conditions.

The speaker noted the difficulty of making water quality improvements with the cooperation of landowners when upstream landowners are not interested in working on repairing the stream.

Issues

Landowners:

- Lack of consistency within and between agencies
- Too many agencies
- Too much red tape
- Data analysis takes too long to be completed and reported
- Don't trust data or recommendations
- Landowners don't trust Agencies (hidden agenda)

Agencies:

- Changing objectives and funding
- Who takes the lead (the level of communication among agencies needs to be quite sophisticated so that the objectives of each agency are articulated by the lead agency, which has direct contact with the landowner)
- Complex criteria for funding
- Land use changes take too long
- Don't trust commitment to land use changes
- Agencies don't trust landowners (hidden agenda)

Communication is the key issue for building trust between landowners and agencies. In order to successfully involve landowners, it is important to first identify and agree on problems Once problems are agreed upon, it is easier to identify and agree on solutions

The Cooperative Effort: Working With Producers

Randy Brooks
University of Idaho

The Idaho Snake River Plain Water Quality Demonstration Project staff works with over 30 producers/cooperators involved in production agriculture Many diverse crops are produced in the project area. Excessive irrigation, a common practice in the area, creates the potential for nitrate and pesticide leaching and/or runoff. Groundwater monitoring indicates the presence of elevated nitrate levels in the shallow aquifer underlying the project area. The NPS control strategy focuses on voluntary implementation of nitrogen, pesticide, and irrigation water management BMPs that will reduce the amount of nutrients and pesticides moving into surface water groundwater. Project objectives are to demonstrate these BMPs so producers will voluntarily adopt them. Getting producers to adopt BMPs on a voluntary basis, without any guarantee that the BMPs will not adversely affect yields, can be challenging. To date, this has been accomplished through cost-share incentives for record keeping. Producers are required to act on uncontrollable events which hamper the logistics of rigidly scheduled sampling activities. The number and arrangement of field instrumentation has complicated production field work as producers are forced to manipulate production equipment around monitoring instrumentation. One of the biggest obstacles to overcome while monitoring the effectiveness of implemented BMPs has been changes in the types of crops produced and the production methods employed Scheduled crop rotations designed to monitor BMP effectiveness have been changed spontaneously to meet commodity market demands. Finally, one of the largest obstacles to overcome when working with producers has been the existence of long established traditions.

While there have been several challenges to overcome, there have also been numerous achievements The greatest advancements have come in the area of record keeping and irrigation water management. With advances being made in those areas, a trend towards reductions in agri-chemical use has been noted. A trend towards reductions in groundwater nitrate concentrations has also been observed in conjunction with this. Current demonstrations and I&E efforts conducted by project staff has heightened water quality awareness not only among producers, but among the urban populations as well

Further Discussion:

- Barriers to technology transfer include: water cost, availability, and delivery schedule.
- Barriers to technology adoption include: landowner or farm manager attitudes and the level of cost-share funds available.
- Gains have been made in the Snake River Plain project in:

  1 - Irrigation scheduling: irrigating on basis of soil moisture
  2 - Recordkeeping.
  3 - Reduction in water usage.
- For a farmer, in order for a practice to be a BMP, it has to be technically feasible, economically feasible, and socially acceptable

Benefits and Disadvantages of Coordinating University Environmental Science Students for the Collection and Analysis of Water Monitoring Samples

Robin Woods
Northern Arizona University

This presentation will discuss the benefits and disadvantages of coordinating University Environmental Science students for the collection and analysis of water monitoring samples for the Oak Creek National Water Monitoring Project versus using trained professionals

The discussion will focus on three key issues:

1. Properly trained and supervised students in the collection and analysis of water monitoring sampling provides the Oak Creek National Water Monitoring Project with accurate and reliable data.
   - In August of 1994, Arizona Department of Environmental Quality engaged in split sampling procedure with the students of the National Water Monitoring Team and the results of this procedure were a 95% confidence interval
   - Data collected by Northern Arizona's National Water Monitoring Team can be used to draw correlations among the seasons, high-use periods, and a rise in pathogens.
2. Who benefits from using students as a resource for the Oak Creek National Water Monitoring Project?
   - The project benefits because a dependable trained team is created to do the sampling and analysis at a minimum of the cost.
   - The students benefit because they can receive one or all of the following benefits: the opportunity to "network" with agency representatives and receive "hands-on training" which they do not receive in classroom or lab environments; development and polishing of their skills in their selected profession; and provision of a possible stepping stone for their future careers.
3. What are the controversies over using students rather than trained professionals for the Oak Creek National Water Monitoring Project, and what tools are used to ensure that students are capable, competent, and performing to their full capacity?
   - Undoubtedly, there is a learning curve. Students have to have strict supervision and guidance. At all times there is at least one paid Graduate Research Assistant or a University Professor either present or available during sample collection and analysis.
   - There is doubt about the competency of the students because they are students rather than trained professionals. To ensure competent students are participating on the project we provide a mandatory Sampling Training Workshop in conjunction with ADEQ, we select students who have been recommended by Professors, and our Quality Assurance/Quality Control plan was designed in anticipation of using students.

<u>General Discussion</u>:

General discussion covered ways of addressing skepticism about student-collected data. One suggestion made was to include skeptics in the training sessions for the students so that the skeptics can be more aware of the quality of the training. Another participant noted that there is a double standard in this sense, because industries are allowed to conduct self-monitoring without being required to attend training sessions. The presenter followed this statement by noting that the same professional water quality sampling training workshops that are conducted for volunteers are also provided for homeowners and land facilitators, who live and work in the project area

<u>General discussion regarding Concurrent Session C, *The Cooperative Effort*, is listed below:</u>

- Get cooperators involved early in the planning process.
- Be flexible in terms of integrating cooperator comments into your monitoring plan.
- Threat of regulatory action can provide motivation for landowners or stake holders to participate in a project

- Correspond frequently with the landowners Share results with landowners because if you don't, they may suspect you're building a case against them
- Sharing results with landowners helps educate them about the limitations of scientific studies and what we can realistically expect to learn from water quality data.
- Results of data analysis should be used as part of a feedback loop for refining and improving a water quality monitoring plan
- Don't change the sampling program too quickly before you are sure that you have enough data to detect a trend, if there is one.

SESSION D
WATER QUALITY AND DATA EVALUATION

Interstitial Loadings of Fecals in the Cold Water Lotic Ecosystem of Oak Creek in Sedona, Arizona

Daniel Salzler
Hydrologist/Environmental Program Specialist
Arizona Department of Environmental Quality

The study area of the Oak Creek National Monitoring Program includes the upper reaches of Oak Creek Canyon and the cold water lotic ecosystem of Oak Creek This 12 mile stretch of the canyon is one of Arizona's most popular recreational areas Approximately 7,000,000 automobiles travel this scenic highway through the canyon every year At Slide Rock State Park and the US Forest Service's Grasshopper Point water recreation areas, approximately 550,000 people pay to enjoy the recreational experiences Oak Creek has to offer. It is estimated that another 700,000 enjoy the cold waters from junctures along the highway.

The Oak Creek National Monitoring Program has measured significantly higher levels of ammonia downstream of the water recreation area of Slide Rock State Park than upstream levels This has been attributed to human excretions of urine. Fecal coliform levels are also higher downstream than upstream Parallel complementing research has revealed significantly large numbers of fecal coliform colony forming units within the sandstone/basalt sediments of Oak Creek. The interstitial zone of the sediments appears to be the breeding ground for fecal coliforms that enter a suspended state when stirred by human activity or natural storm events

The method of determining the source of fecal coliform continues to be researched. Possible sources are warm blooded animals that live within the watershed of the canyon, human excretion by recreationists, human excrement dumped by RV tourists, and septic systems Discussion will be centered on research findings and a theory of fecal coliform reproduction

<u>Further Discussion</u>:

- Project personnel have found increases in fecal coliform from May through the swimming season.
- There are several potential sources of fecals: septic systems in adjacent residential areas, a herd of elk, intentional recreational-vehicle septic discharge, diaper disposal, recreationists relieving themselves, and dog feces
- Project personnel have found that ammonia levels increase from upstream to downstream, thus suggesting direct ammonia input into the stream by swimmers
- Project personnel efforts to explain fecal coliform data have lead them to the supposition that the fecal coliform are using nutrients within the interstitial zones of the sediment to grow or possibly reproduce.
- If the supposition is true, then how do you treat the interstitial growth of fecal coliform within the stream sediments? It was suggested that limiting nutrients would limit fecal coliform growth. However, the data does not consistently show a correlation between high nutrient concentrations and fecal coliform spikes Project personnel have tried to reduce nutrients by educating recreationists, upgrading the bathroom facilities, and other types of activities.

- Lab experiments performed using sediments from Oak Creek demonstrated continuous growth of the fecal coliform for more than 150 days. These results suggest that sediments may serve as an on-going source of fecal coliform.
- It was suggested by a conference participant that the project verify the presence of human pathogens and another participant suggested that they determine whether the fecal coliform was derived from an animal or human source.

Chumash and Walters Creek Stormwater Analysis
Morro Bay Watershed, California

Karen Worcester
Regional Water Quality Control Board
San Luis Obispo, CA
and
Dave Paradies
Bay Foundation of Morro Bay
Los Osos, CA

Storm water data was collected by Cal Poly State University over a two year baseline period (1993-94 and 1994-95) at Chumash and Walters creeks in the Morro Bay watershed, San Luis Obispo County, California. Establishing baseline flow and water quality relationships between the two creeks is a critical component of the "paired watershed" study design, and must be developed prior to implementation of Best Management Practices on the treatment watershed. In this paper, we examine the relationships between the two creeks defined by this data set, and consider the question, "How much data is enough?"

Because of low rainfall during 1993-94, only one storm data set was collected. Flow data was not yet available at the time of this storm, so data from this year is incomplete and of limited usefulness. Fortunately, the winter of 1994-95 was an extremely wet one, and provided a considerable amount of data on storms of varying intensities.

Water quality samples were collected at 30-minute intervals when flow levels rose high enough to trigger activation of automated sampling devices. Flows were also measured at 30-minute intervals, and precipitation data was collected at 5-minute intervals. Samples were analyzed for total filterable solids, turbidity, and conductivity.

Although 784 30-minute interval data records were collected in total, only 139 time based pairs could be developed between the two creeks. This resulted for a variety of reasons, including flume design errors, equipment failure, and differing equipment activation thresholds between creeks. Flow data lost when the Chumash Creek flume overtopped was simulated using the regression relationship between the two creeks ($y= 0.6958x - 2.18$; $r^2= 0.84$); 36 data pairs were recovered in this fashion. Because of the flow activated data collection strategy, lack of sample time synchronization, and loss of data records, the data stream used for analysis contains a number of time interval gaps.

A "storm event delimiter" algorithm was developed to define storm events in the data stream in a repeatable, non-subjective way. Flow, turbidity and sediment data from the control watershed were utilized in the algorithm to establish the boundaries between flow events.

Data was examined in various ways to evaluate the relationships between flow, turbidity and sediment concentration in the two creeks. Double mass curves were developed both for the entire paired data set and for individual storm events. A variety of statistical analyses were performed in order to characterize the distinction between variability in the data resulting from watershed to watershed differences versus storm to storm differences. Prior to initiating BMP treatments on the treatment watershed, we will utilize the results of these analyses to determine whether the existing data collected to date contains enough information to serve as a baseline characterization.

Further Discussion:

- The statistical analyses that were performed on the paired watershed data demonstrated a consistent performance between the two watersheds in terms of discharge, sediment, and turbidity. Additional sensitivity analyses need to be performed in order to confirm the suitability of the pairing.
- BMP implementation is occurring in the treatment watershed due to grant obligations to spend out the money. An additional year of baseline water quality monitoring would have been useful to establish a stronger relationship between the paired watersheds.
- The use of several statistical software packages has made data analyses difficult. Project personnel will be trying to standardize their statistical software

Evaluating Barnyard Best Management Practices in Wisconsin Using Upstream-Downstream Monitoring

Todd D. Stuntebeck
U.S. Geological Survey

This presentation discusses the results of a study by the U.S. Geological Survey, in cooperation with the Wisconsin Department of Natural Resources, to evaluate water-quality improvements that result from implementation of Best Management Practices (BMPs) at barnyards. Automated water-quality sampling equipment was used to collect discrete water samples during 10 storms at stations on Otter Creek and Halfway Prairie Creek before BMPs were implemented. On each stream, one sampling station is located upstream from a single barnyard-runoff source and the other station is downstream from that same source.

Continuous streamflow and instantaneous water-quality data were used to estimate event-mean concentrations for individual storms. Event-mean concentrations of total phosphorus, ammonia nitrogen, and biochemical oxygen demand (BOD) downstream from the barnyard at Otter Creek and Halfway Prairie Creek were generally higher than event-mean concentrations upstream from each barnyard. Paired Student's *t*-tests performed on these data indicate that average downstream event-mean concentrations of total phosphorus, ammonia nitrogen, and BOD were significantly greater than average upstream event-mean concentrations at the 95-% confidence level for both creeks. Using the pre-BMP data, an equation was developed to estimate the minimum amount of change in post-BMP average downstream event-mean concentrations necessary to be considered statistically significant. For Otter Creek, this "minimum detectable change" is 50 % for total phosphorus and ammonia nitrogen and 40 % for BOD. Minimum detectable changes of 10, 30, and 40 percent were estimated for Halfway Prairie Creek, respectively. The pollutant reductions expected from BMP implementation at each site are greater than the changes needed to observe a statistically significant improvement in water quality.

Further Discussion:

- Upstream pollutant sources may mask the barnyard sources. A good sampling design is necessary to detect water quality changes, because the upstream/downstream design is not very sensitive.
- However, for this barnyard, there is a visual difference between the upstream and downstream samples: the downstream samples were much darker
- The time at which sampling is initiated is extremely important to distinguish between the upstream water quality and barnyard runoff into the stream
- If sampling is initiated by stage, it is important to use a sufficiently low threshold to capture high initial barnyard inputs downstream. Later, downstream constituent values may be swamped by upstream concentrations. Statistical analyses were done by taking the difference between downstream and upstream water quality for all storms and determining significance. A statistical difference for phosphorus, ammonia-nitrogen and biological oxygen demand was detected

SESSION E
POLLUTION SOURCES-NONPOINT

Thurston County Intensive Dye-Trace Method for On-Site Sewage System Evaluation

Linda Hofstad and Sue Davis
Thurston County Environmental Health Division
Olympia, WA

Effluent from failing on-site sewage systems is one of the primary sources of nonpoint pollution along the shorelines of Thurston County, Washington. Located at the southern terminus of Puget Sound, Thurston County has an abundance of natural resources which includes a valuable shellfish resource—both commercial and recreational. These resources depend upon excellent water quality in order to be safe for consumption. Nonpoint pollution sources, primarily storm water, agricultural runoff, and failing on-site sewage systems, threaten these areas. As part of the coordinated effort with Conservation Districts and others to remediate the nonpoint sources, the Health Department has focused on identifying the failing on-site sewage systems, getting the systems repaired, and providing the homeowner with information on how to properly operate and maintain their systems. Blatant failures of septic systems are easy to find with most any method of sanitary survey. The intermittent and seasonal failures caused by system component problems and general subsurface failure are much more difficult, if not impossible, to find

However, in order to address nonpoint pollution remediation, these failing systems need to be identified, evaluated and repaired. Thurston County has developed an intensive sanitary survey procedure which includes a dye-trace method using small mesh charcoal-filled packets placed in probable pathways of surfacing effluent. The fluorescent dye used to establish the hydraulic pathway of effluent is absorbed onto the charcoal in the packets if the effluent surfaces. Dye concentration is measured and then fecal coliform sampling is done to confirm the presence of sewage. This method has been used in over 1600 surveys and has been proven to be a sensitive test which identifies failing sewage systems. Statistical analysis of the survey results has shown that there is little to no correlation of failure with age, type, or distance from water of the systems. A special study was conducted during the wet season 1994-95 which looked at correlations between dye concentrations and fecal coliform levels from identified failing systems. The study also considered additional parameters (nitrates, ammonia, total dissolved phosphorus, chlorides, and specific conductance) which might be better indicators of failing systems. Preliminary results will be presented at the conference.

Further Discussion:

- The study concentrated on systems within 200 feet of the shoreline. No correlation was found between septic system failure and either distance from the shoreline or antecedent rainfall. The conclusion was that nutrients were not going to help define further failures.
- The speaker indicated that types of support needed for this type of program include: a clear definition of system failure, political support, legal support, and a specific staff person assigned to follow-up with homeowners.

Challenges of Monitoring Bacteria

Thomas D. Harrison
Northern Arizona University

A spate of biological pollution incidents have occurred in numerous water recreation areas located on the southern Colorado Plateau region (AZ, NV, UT) during the past two seasons. In 1994 the Bull Head City lake area was closed because of high fecal coliform counts. One hundred and forty-three rafters developed intense gastrointestinal illness in the Grand Canyon area of the Colorado River. Nineteen Las Vegas residents died from cryptosporidia from drinking "purified" Lake Mead water. This past summer, Bull Head City was closed as was the Utah northern shore of Lake Powell as a result of high fecal coliform counts. The Oak Creek Canyon National Monitoring Project falls into this general pattern. Slide Rock State Park, the most popular water recreation area, was closed for three weeks in late summer, 1994, when fecal coliform counts reached 3400 cfu/100ml Warning signs were posted in the same area over the July 4th holiday. Coconino County Environmental Health Department closed off Grasshopper Point, a smaller water recreational area in the Canyon, on September 7, 1995.

Using the Arizona Project as a case study, this discussion focuses on basic issues entailed in attempts to remediate and to prevent these incidents from recurring:

Identifying biological pollution sources. In the case of Slide Rock, a significant amount of previous research—to a person—assumed that the water recreationists themselves were the pollution source. Results from Year I baseline study strongly suggest that:

- Fecal coliforms are introduced into the system in significant numbers above Slide Rock State Park; and
- High downstream fecal coliform counts may be the result of roiled sediment transported downstream to Slide Rock during the rainy "monsoon" season

Is the fecal coliform a valid and reliable indicator organism of the presence of other water borne pathogens? EPA selected fecal coliform as a standard indicator organism under the assumption that the organism multiplies only in the intestines of warm blooded animals.

- One season of sediment research calls this assumption into serious question.
- NAU is currently conducting experiments designed to determine if fecal coliforms do multiply in sediments under certain conditions.
- Using state-of-the-art equipment, Northern Arizona University is attempting to rapidly and reliably identify water borne pathogenic bacteria.

How does the Arizona project balance the responsibility to inform the public of potential health risks with these uncertainties?

- There are those who have financial risk in closure—concessionaires, local business people, and even state managers; others tend to overreact to a degree bordering on hysteria

Further Discussion:

- The goals of the Oak Creek Canyon project are to show success in reducing fecal coliform counts and to apply data to other problems arising in the future.
- Participants pointed out that fecal coliform counts can be high due to waterfowl and other natural sources The consensus was that much more research is needed on 1) the use of fecal coliform as an indicator variable, 2) distinguishing between human and nonhuman fecal coliform, and 3) the means by which fecal coliform multiply

Biological Monitoring in Otter Creek, Wisconsin

Roger Bannerman
Wisconsin Department of Natural Resources

Otter Creek is a low gradient warmwater forage fishery located in east central Wisconsin Dairy farming and cash grain crops are the main landuse activities in the watershed. These activities have impacted the biological integrity of Otter Creek by degrading the stream habitat and causing excessive growth of aquatic plants Evaluation monitoring of Otter Creek began in 1990, and is expected to be completed in 2001. Methodologies have been developed for sampling fish habitat and communities that provide a good balance between the precision needed to see change and the amount of field time required to collect each sample. We have published manuals describing these fish habitat and community sampling protocols A Before-After-Control Impact (BACI) experimental design is being used to determine the effect of the BMPs in Otter Creek. The specific design is called a "beyond" BACI design because multiple control sites (eight) are being used for the five test sites on Otter Creek The paired and regional control sites are located on four streams Most of the sites have a poor to fair Index of Biological Integrity (IBI) value, while the habitat ratings are more variable and they range from fair to good. Control and test sites will be compared using a two way analysis of variance having site type (control vs test) and time period (before and after) as the main effects. To date, best management practices have been installed at all critical barnyards in the Otter Creek watershed Completion of the upland erosion control practices will mark the start of the "after" watershed monitoring period.

Further Discussion:

- Heavy macrophyte growth is being caused by excess fertilization on surrounding land. Another problem is highly degraded habitat caused by siltation and bank erosion. Sources of sediment include cows in the stream and upland erosion.
- The experimental design includes five treatment sites in the Otter Creek Watershed and eight reference sites within the same ecoregion. A before and after / control and impact (BACI) design is being used with treatment and control sites.
- A fish habitat assessment protocol has been established based on the following considerations: spatial scale (including field trials to determine sampling size); sampling effort (to determine how many transects and how long a reach should be sampled); and accuracy and precision (visual measurement was determined to be acceptable in terms of accuracy).
- Quality control procedures are being critically evaluated.

SESSION F
SPATIAL ANALYSIS OF DATA

Spatial Analysis of Data: Tracking Agricultural Activity

William A. Harman III
Associate Extension Agent, Natural Resources
NC Cooperative Extension Service

The Long Creek National Nonpoint Source Monitoring Program Project is near completion of the two year background monitoring phase. Thus far, spatial analysis has included targeting critical areas for BMP installation. A few achievements are listed below. As we move into the BMP installation and post BMP monitoring phase, new opportunities and challenges arise as to tracking these BMPs and relating them to improvements in water quality.

Achievements:

- Base maps have been digitized into Atlas GIS, Strategic Mapping, Inc. including watershed boundaries, monitoring sites, soil surveys, streams, roads, land use (limited) and topography (limited).
- Implementation of the Universal Soil Loss Equation in a GIS. A graduate student from UNCC worked on this project for her MA degree in Geography. She used one of our project watersheds for a case study, providing us with a watershed scale prediction of agricultural field erosion.
- Targeting Critical Areas with Pollutant Runoff Models and GIS. The AGNPS model was used to determine critical and near critical NPS pollution source areas. AGNPS output was imported into Atlas GIS for display and georeferencing.
- GIS Procedures for the Analysis of Fecal Coliform Bacteria Transport and Fate. A Ph.D. student from NCSU is working in Long Creek to understand the mechanisms which contribute to bacterial fate (die off) and transport in the terrestrial environment, which will help in the interpretation of water quality indicators. A geographic information system (GIS) model will be used to determine the effect of temperature, exposure, rainfall, and soil type on die off and transport of bacteria.

Challenges:

- Cooperating agencies use different GIS systems, i.e. Atlas GIS, Arc-Info, Intergraph and Microstation, which can make data analysis and transfer difficult.
- Land use data at multiple scales (field to large watershed scale). What is the best source of data? How do you track detailed land use changes at a large watershed scale?
- Using GIS to integrate land use changes with BMP installations and water quality changes (spatially and temporally)
- GIS model validation. Does this map mean anything?

Further Discussion:

- How do you monitor a watershed with rapidly changing land use patterns? No one in the audience had an answer to this problem.
- You must field verify your data. For example, a piece of land on which a building is identified is insufficient data. The use of the building must be known in order to interpret the data correctly.
- Project personnel have found that fecal coliform was found to survive for up to three months in the soil system, making it difficult to track
- Everyone agreed that tracking land applications of commercial fertilizers, manure, and pesticides is very difficult. Different projects use different sources to determine land application of commercial fertilizers and pesticides: some projects use consulting agencies, some use farmer surveys, some use averaged county data, some use commodity organizations.
- How do you monitor dynamic land use changes, such as cows with free access to the stream? When the cows are in the stream there is a direct correlation with water quality parameters.

Geostatistical Sampling and Assessment of Nitrate in an Agricultural Environment

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Dr. Stanley M. Miller
Department of Geology and Geological Engineering
College of Mines and Earth Resources
University of Idaho
Moscow, Idaho

Geostatistics is an applied statistical method used to measure spatial dependence and to make spatial predictions of an attribute of interest. Geostatistical methods are being used to describe nitrate occurrence in the vadose zone at an agricultural demonstration project in southern Idaho. The goal is to assist in evaluating the effectiveness of management practices, as related to irrigation and fertilizer application, for mitigating high nitrate levels in subsurface waters. Geostatistical tools provide a means to assess the hypothesis that nitrate concentrations are spatially dependent in the vadose zone across the study site.

The initial phase of the investigation consisted of the development of a geostatistically based sampling network of lysimeters for obtaining soil-water samples, subsequent installation of the monitoring network, and collection of monthly nitrate data over the four-month growing season in 1994. Results indicated that nitrate concentrations as sampled in August and September, 1994, did exhibit some spatial dependence. The existing sampling network then was modified to better define that spatial dependence. Nitrate samples collected thus far in 1995 show some spatial dependence in July, as well as a notion of spatial anisotropy in the nitrate levels measured in the vadose zone.

Geostatistical spatial simulation procedures have been used to describe the spatial distribution of nitrate concentrations across the study site. This description includes contour maps of expected mean values of nitrate and of the probability of exceeding any specified threshold value. The overall study illustrates that the effectiveness of a geostatistical investigation depends on both the number of, and the locations of, sampling points. A multi-phase sampling program allows the development of an efficient and rationally based monitoring network conducive to an appropriate description of the spatial attribute.

Further Discussion:

- Geostatistics is being used to help evaluate BMP's for agricultural water and fertilizer applications based on improved spatial sampling design.
- Soils in the unsaturated zone across the study site were sampled for particle-size characteristics, and then geostatistical criteria were used to assign locations for lysimeters used to sample soil water at a depth of 1 m below the ground surface
- Initially, there were just barely enough lysimeters to obtain the desired spatial information, so additional lysimeters were installed for the second field season.

- Geostatistical simulations based on the field measurements of nitrate concentration verify the heterogeneity of nitrate across the site; these simulation also were used to generate exceedance probability maps for nitrate concentrations in soil water Such information will be compared to groundwater nitrate levels measured in monitoring wells at the site.

Techniques for Quantifying Nonpoint Sources of Pollutants and Tracking Land Treatment Practices

Kerry F. Rappold
U.S. Geological Survey

Landuse and land treatment practices can have a significant effect on the water quality of agricultural watersheds. Quantifying and tracking these effects is a key element of the Otter Creek (Wisconsin) National Monitoring Program project. The Otter Creek project area is part of the larger Sheboygan River watershed, which has been included in Wisconsin's Priority Watershed Program since 1985.

Constituent loadings from agricultural nonpoint sources of pollutants were quantified by a variety of techniques. These techniques rely on collection of site-specific nonpoint-source pollutant data and computation of pollutant loads from simple equations or models. The constituent-load data are used to identify critical sites that require the implementation of best management practices (BMP's). Nonpoint-source pollutant data were collected primarily by local Land Conservation Department (LCD) staff; sources not quantified by local staff or in need of updating were compiled by activities of the monitoring team.

Land-treatment practices are tracked through a cooperative effort between the monitoring team and the local LCD staff. BMP's funded by state and federal agencies are updated in the spring and fall. Maintenance of accurate and timely information on BMP implementation is crucial to interpretation of existing and new water-quality data

The data collected on nonpoint sources of pollutants and land treatment practices are maintained in a geographic information system (GIS). Spatial-data layers created within the GIS include the basin boundary, nonpoint sources of pollutants, hydrologic features, land-treatment practices, soil types and topographic features. The GIS provides a useful tool for updating information and presenting graphical depictions of the current conditions and changes occurring within the Otter Creek project area.

Further Discussion:

- Project personnel inventoried barnyard runoff, manure spreading, streambank, and gully erosion.
- Barnyard data was collected by the local LCD and estimates of pollutants were generated. They were able to estimate phosphorus deposition based on manure spreading locations.
- The LCD inventoried agricultural land use and modeled sediment deposition delivery.
- Currently the monitoring team is updating sediment delivery using a new model that allows for both in-stream sediment delivery and deposition
- Other data collected by the monitoring team demonstrated that there are insignificant gulley erosion sites.
- Few conservation practices have been implemented in the upland regions of the watershed, which is the primary source of sediment
- The land survey must be updated because some of the information and models are outdated.
- Techniques for tracking land use consist of biannual updates of BMP implementation and field surveys
- Tabular and spatial data are used in graphical representation, water quality modeling and statistical analysis.
- The inventory has allowed pollution sources to be identified and BMPs tracked. However, there is some field level information not inventoried (i.e. pesticide and nutrient application). Project personnel also have problems with incompatible data and old information

SESSIONS G1 AND G2

Use Of Spatial Data - GIS Tools

Walter Bremer
Landscape Architecture Department
Cal Poly, San Luis Obispo, CA

Session Overview

This session will familiarize participants with the use of spatial data and geographic information system (GIS) tools for manipulating and displaying spatial data related to watershed monitoring. GIS tools are becoming more and more important to watershed activities. They provide a different look at the watershed and bring many disciplines together to understand and solve problems

This session will use lecture/demonstration and discussion, together with some "hands on" interaction with GIS technology. The session will also take a peek into the future to see what new data and ways of working with data are just around the corner

Organization

The sessions will be broken into four topics:

1. Introduction - GIS for data management and use in NMP. How can GIS be used?
2. Organization of GIS data - Spatial and database organization
3. GIS Data - Representation, structure, automation, precision, display
4. GIS Tools - Overview of systems, ArcView 2.1 to access and represent data, the future

The sessions will use watershed data from the San Luis Obispo County area on the central coast of California to illustrate concepts. The watersheds include the Morro Bay Watershed and San Luis Obispo Creek Watershed, both of which have numerous ongoing projects at this time.

Group Participation

Although the format will be primarily lecture/demonstration and discussion, there will be four computers with software and data to provide an opportunity for the participants to try out the technology and to use "real" data. The computers should also be available during the breaks. The "hands on" experience will help participants to more fully understand the information

Additional information provided by the speaker

WHAT IS A GIS?

A *Geographic Information System* is a form of Information System utilizing geographic data

- System - group of components working together, e.g., stereo components forming a system
- Information System - set of processes (components) executed on raw data to produce information useful in decision making

GIS - uses geographically referenced and non-spatial data and includes operations for spatial analysis to:

aid in decision making, managing land resources, transportation, oceans, anything spatially distributed.

A **GIS** System is:

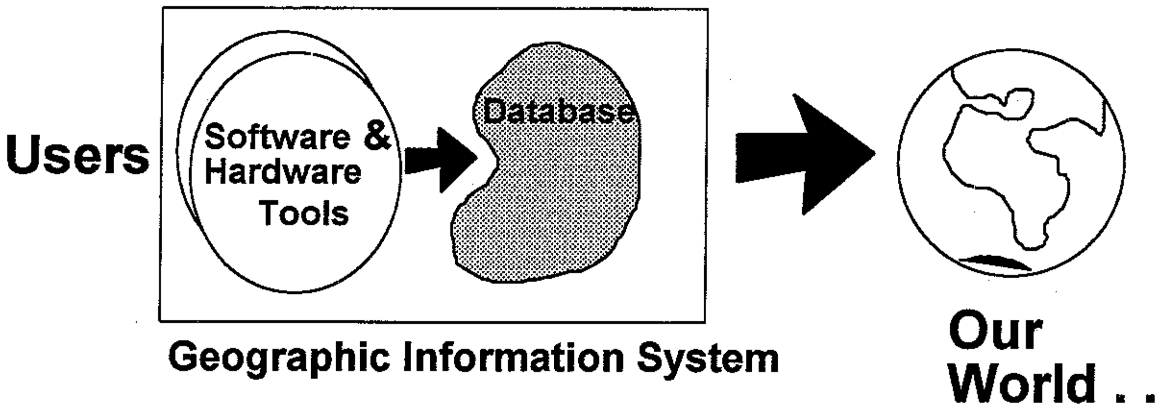
An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently

capture,
store,
update,
manipulate,
analyze, and
display

all forms of geographically referenced information." Environmental Systems Research Institute

or

"A computer system capable of holding and using data describing places on the earth's surface." Environmental Systems Research Institute



WHY IS GIS IMPORTANT?

"GIS technology is to geographical analysis what the microscope, the telescope, and the computer have been to other sciences... (It) could therefore be the catalyst needed to dissolve the regional-systematic and human-physical dichotomies that have long plagued geography" and other disciplines which use spatial information." Dangermond

GIS:

- integrates spatial and non-spatial data into one system
- enables us to look at data geographically, and gain new insights, explanations, connections
- enables us to look at geographic proximities, i.e. what land uses are within 1/4 mile of Diablo Canyon

*Why are computers used for **GIS**?*

- computers are fast
- computers are accurate
- computers are able to store lots of information, efficiently

*Types of questions **GIS** can answer:*

- location - What is at...?
- condition - Where is it...?
- trends - What has changed since...?
- patterns - What spatial patterns exist...?
- modeling - What if...?

A GIS is not:

- just a system for making maps
- just a system for storing conventional maps

Types of databases:

- environmental/ natural resources
- land records
- transportation facilities
- military
- etc.

GIS IS AN INTERDISCIPLINARY ACTIVITY

Traditional disciplines are brought together. The related disciplines offer the techniques which make up GIS technology: some emphasize data gathering, others analysis.

GIS brings together disciplines by emphasizing:

- integration
- modeling
- analysis
- display/ communication

DATA IN GIS

SAMPLING DATA

- The world is infinitely complex.
- The database represents a particular view of the world.

Representing Reality

- A database consists of digital representations of discrete objects.
- Many features on a map are fictitious and do not exist in the real world.
  boundaries, contours, direction of slope, etc
- Contents of the database include:
  digital versions of real objects, e.g. roads
  digital versions of artificial map features, e.g. contours
  artificial objects created for purposes of the database e.g. cells

Spatial Data

- Geographic phenomena can be observed on 3 "modes" or can have 3 characteristics:
  Spatial (locational) characteristic
  Descriptive (attribute) characteristic
  Temporal (time) characteristic

Types of Geographic Data

- Line, point, area

Measurement Scales

- It is important to recognize scales of measurement used in GIS to determine the kinds of mathematical operations which can be performed.

- Scales of Measurement
  - **Nominal**
    - name, establish identity
  - **Ordinal**
    - numbers establish order
  - **Interval**
    - the intervals or difference between numbers is significant
    - subtraction makes sense but division does not
  - **Ratio**
    - measurement has an absolute zero, and the difference between numbers is significant
    - division makes sense

Errors and Accuracy

- There is a tendency to lose sight of errors when any data are in digital form
- Types of errors

  Original Sin
  - errors in sources of the data; maps, etc.

  Boundaries
  - lakes fluctuate, soil boundaries are transition zones, etc.

  Classification errors
  - wrong attributes, particularly in tabular data

  Data capture errors
  - manual data input can induce error, e.g. in digitizing

DATA INPUT

- Data input is the largest task (time & $) in the application of GIS technology
- Costs can consume 80% or more of project costs
- Data input is labor intensive and prone to error
- Activities include encoding of both locational (spatial) and descriptive (attribute) data
- Modes of data input:

  keyboard - usually only attribute data but also some coordinate entry
  manual locating devices - digitizing
  automated devices - scanning
  conversion - from other digital sources, e.g. magnetic tape

Digitizing

- uses cursor
- points interpreted as x and y coordinates
- table uses grid of wires to generate electromagnetic field, detected by cursor
- $500 - $5,000
- process:

  map taped to table
  three or more control points digitized
  stream mode - points captured at set time interval
  point mode - operator identifies points to be captured; most common mode
- time/cost - industry "rule-of-thumb" is *one boundary* (polygon) *per minute*

Scanning

- Video scanners - *(the kind we will use)*
  - black and white, or color
  - fast and inexpensive - $500 - $10,000
  - typically have poor geometrical and radiometrical characteristics

- Electromagnetic scanners
  - accurate and expensive $6,000 - $100,000
  - resolution of up to 25 microns
- Requirements for scanning
  - clean documents
  - lines at least 0.1 mm wide, and crisp
  - contours cannot be broken with text

Other Sources of Data

- USGS digital products
  - DLG's Digital Line Graphs - roads, hydrography, boundaries
  - DEM's Digital Elevation Models - elevation
- DIME & TIGER - census data
- CAD/ CAM systems (DXF, IGES)
- LANDSAT, SPOT satellites
- Other GIS products

DATA STRUCTURES - GRID & VECTOR

- A GIS database consists of digital representations of discrete objects
- Current GIS's differ in the way they organize reality
- Through the **data model** - **GRID/RASTER** or **VECTOR** - each type of model tends to fit certain types of data and applications

  - A **GRID/RASTER** model indicates *what occurs at each place* in the geography (landscape) - occupies space

    - A grid can be thought of as
    a special case of point sampling where the points are regularly spaced
    a special case of the same size zones

  - A **VECTOR** model indicates *where every object occurs* in the geography (landscape) - location of objects

GRID Data Model

- Process for converting data map into GRID format:

  1. Overlay uniform grid (cells) registered to the earth
     - high resolution means small cells and large grid (overall grid)
  2. Assign values
     values representing measurements, i.e. elevation
     values as "pointers", (e.g. 1 = deciduous forest; 2 = grassland
     usually one value per cell)
  3. Arrange in map layers - THEMES *(from other readings)*

- Cell Size
  Resolution of data
  Types of analysis and modeling
  Personnel and equipment limitations
- Coding Rules
  Predominant type
  Presence/ absence
  Percent
  Centroid

VECTOR Data Model

- Based on vectors, with the fundamental unit as a point *(a primitive)*
- Points are connected with straight lines
- Areas are defined by sets of lines
- Process for entering VECTOR data
  1. Georeference with coordinates (x, y)
  2. Map is digitized by recording points and lines to define general data types:
     - points
     - lines
     - areas *(polygons)*
  3. Edit line work
  4. Label, or attach attribute data to points, lines, areas
- Types of storage:
  1 "POLYGON" Storage
     - every polygon stored as sequence of coordinates - all internal shared polygon boundaries digitized twice, once for each adjacent polygon
     - used in some current GIS's, many automated mapping packages

  2. "ARCS" Storage
  - "smart" - have attributes which identify polygons on either side
  - digitizing *direction* is important
  - areas "built" by linking arcs, calculating the relationships between points, lines, areas and to the RDBMS (e.g. INFO, Oracle)
  - only one version of internal shared boundary is input and stored
  - used in most current vector-based system
- Database
  - Attribute data - description of what the points, lines, and areas represent
  - Often a RDBMS - relational data base management system

MAP PROJECTIONS

A map projection is a system in which locations on the curved surface of the earth are displayed on a flat sheet or surface according to some set of rules

Relevance to GIS

Maps are a common source of data input
Often the size of our study site is large enough that the earth's curvature is significant

Distortion Properties

- angles, areas, directions, shapes and distances will become distorted when transformed from sphere to a plane, to a flat map
- map projections attempt to represent these surfaces but a single projection cannot keep all properties undistorted
- usually, a projection can keep one property from being too distorted but the other properties become very distorted

Universal Transverse Mercator (UTM)

- UTM provides georeferencing at high levels of precision for the entire globe
- established in 1936 by the Union of Geodesy and Geophysics
  - adopted by the US Army in 1947
  - adopted by many national and international mapping agencies, including NATO
  - is commonly used in thematic and topographic mapping, for referencing satellite imagery

Transverse Mercator Projection
- results from wrapping a cylinder around poles rather than the equator
- the central meridian is where the cylinder touches the sphere

Zone System
- to reduce distortion, 60 zones, 6 degrees of longitude wide
- each zone is further divided into 8 degree strips of latitude

Coordinates
- coordinates in meters
- eastings (x) are displacements eastward
- northings (y) are displacements northward

- advantages
  UTM is frequently used
  consistent for the globe
  a universal approach to accurate georeferencing

- disadvantages
  full georeferencing requires zone, easting, northing
  adjacent zones are skewed with respect to each other

State Plane Coordinates (SPC)

- SPC's are individual coordinate systems adopted by the US state agencies
- each state's shape determines the projection
- projections are chosen to minimize the distortion
- units are in feet
- advantages
  SPC may give better representation than UTM for the state's area
  coordinates may be simpler than UTM
- disadvantages
  SPC are not universal from state to state
  problems may arise at the boundaries of projections

North American Datum

- NAD 27 - 1927
- NAD 83 - 1983 (current datum for many projects)

THE FUTURE

Although there are many changes or trends in GIS in the near future, the following are some related to watershed monitoring projects.

GPS - Global Positioning Systems
quicker and more accurate determination of locations

More Network Access
acquisition to existing data (World Wide Web - WWW)
provide access to information by others

3D Visualization
visual understanding and display of phenomenon

Multilayer Views Of Data
better understanding of complex systems

More Portable/Laptop Support
better field access to GIS

Better, Easier To Use GIS Tools
better user interfaces
easier to use modeling and display tools

Access To GIS By Non-Technical Users

REFERENCES

Geographic Information Systems, An Introduction, Star, Estes, 1990
NCGIA Core Curriculum Lecture Notes, 1990
Understanding GIS: The ARC/INFO Method, ESRI, 1990

SESSIONS H1 AND H2

BIOLOGICAL MONITORING TO PROTECT WATER RESOURCES

James R. Karr and Leska S. Fore
Institute for Environmental Studies, U. of Washington

Since the Clean Water Act amendments of 1972, federal and state agencies have been mandated to monitor the chemical, physical and biological integrity of rivers and streams The emphasis until recently has been on chemical criteria such as nitrogen, phosphorous, and dissolved oxygen Continued loss of aquatic species and degradation of aquatic resources has shifted the focus of monitoring to biological criteria.

To assess the biological integrity of Northwestern streams, we collect benthic invertebrates to evaluate the species richness and composition of the biota Sites with high numbers of mayfly, stonefly, and caddisfly taxa, for example, indicate excellent in-stream conditions. These invertebrates require conditions that are also favorable to salmon— cool, clean, fast-moving water with complex cobble substrates. Juvenile salmon also favor these organisms in their diet Stream sites that have been damaged by timber harvest, grazing, and urbanization have higher proportions of tolerant organisms such as soft-bodied flies (tipulids and simuliids), worms, some snails, and small crustaceans (amphipods). We evaluate attributes of invertebrate (or fish) assemblages and score them in reference to minimally disturbed sites Attribute scores are then integrated into an overall numeric index, the index of biotic integrity (IBI), that is used to rank streams or stream reaches according to their biological condition IBI scores reflect, for example, logging and road building in forested watersheds, the effects of impervious surface area in urbanized watersheds, and agricultural practices in agricultural landscapes.

Participants in this workshop will evaluate data from Puget Sound lowland streams. We will construct testable hypotheses about how invertebrates respond to human-induced degradation and test them with real data. We will construct an index and test its relationship with impervious surface area. In conclusion, we will present evidence of IBI's ability to respond to other types of degradation

Additional information provided by the speakers

Existing water-quality programs have made substantial progress in improving the quality of water resources in the United States, especially in controlling point sources of contamination. But inadequacies in analysis of the effects of nonpoint sources, and in their management, result in continued degradation of water resources. The most important gap between accomplishments and legislative intent is in the area of biological integrity.

Three problems are responsible for the gap; all deserve increased attention First, we have used a conceptual framework to control contamination based on point-source strategies that is not effective in controlling nonpoint sources Second, the primary focus on chemical water quality has allowed other factors responsible for water resource degradation to go unchecked. Third, we undervalue the importance to society of healthy biological systems and, as a result, biological integrity continues its steep decline.

A broader conceptual framework is needed if we are to attain the goals of the Clean Water Act because biological resources are not being protected by current programs.

Humans influence the biological integrity of water resource systems by altering: 1) water quality, 2) habitat structure, 3) energy sources, 4) flow regime, and 5) biotic interactions. Biological integrity is the sum of the elements of biological systems (biodiversity) and the biological processes that generate and maintain those elements Until programs to protect and improve the quality of water resources focus on all those factors, water resource degradation seems inevitable.

Several years ago EPA called for states to develop narrative and numeric biocriteria. Substantial progress has been made by some states but others are just initiating biocriteria programs. Early efforts to focus on rapid assessment are changing. Effectiveness rather than speed should be the core of biological monitoring Costs of implementation of biocriteria are very competitive with chemical evaluations and they provide a more comprehensive assessment of resource condition.

Bioassessment can be accomplished using any major taxonomic group (e.g., fish, benthic invertebrates, algae). The primary limiting factor is the nature of the ecological insight that goes into the study design, data analysis, and project synthesis. In the Pacific Northwest, we focus on invertebrates, but earlier work in the Midwest concentrated on fish Salmon, or other fish, may be the primary focus of society but invertebrates provide a better approach to evaluate biological condition in Northwest streams because they are resident year around, are easier to sample, and are present in a diverse array of species. In addition, the process involved in obtaining sampling permits is simplified with invertebrates relative to the many endangered stocks of salmonid fishes.

Both managers and researchers have successfully used biological monitoring and assessment to evaluate the condition of water resources Ohio EPA uses both invertebrates and fish in their monitoring programs while other states use only one or the other Linda Deegan at Woods Hole has developed a prototype IBI for estuarine environments, and John Lyons has adapted the fish IBI for use in Wisconsin. Many other water resource managers and scientists have developed approaches that are reliable in their regions.

An early step in the design of an effective program is to generate hypotheses about the relationship between human actions and the condition of the aquatic biota. Work throughout North America has demonstrated the generality of patterns, such as the total number of taxa and the number of stonefly taxa decline as human actions increase within a watershed. We have used a variety of measures of human influence: percent impervious area in urban environments; grazing intensity in rangeland; percent of watershed logged in forested areas; and condition of riparian corridors in a number of areas. By plotting, for example, taxa richness (number of kinds of fish or invertebrates in a stream sample) against a measure of human influence (% impervious area) one can document very robust indicators of water quality.

The following metrics work well in the Northwest as measures of biotic integrity of streams:

Metric	**Response**
Taxa Richness	
Total number of taxa	decrease
Number of Ephemeroptera taxa	decrease
Number of Plecoptera taxa	decrease
Number of Trichoptera taxa	decrease
Number of long-lived taxa	decrease
Number of intolerant taxa	decrease
Number of sediment intolerant taxa	decrease
Community Structure	
Percent predator individuals	decrease
Percent tolerant individuals	increase
Percent sediment tolerant individuals	increase
Percent dominance (3 most common species)	increase

Workshop participants were given sample data (benthic invertebrate samples) from six lowland streams in Puget Sound Streams were selected to represent the range from the best to worst streams in the region along a gradient of urbanization. The metrics listed above were calculated for each station and scoring criteria were developed to define each site based on the range of values within the data set. These metrics are essentially hypotheses about the effects of human activities on invertebrate assemblages. After each site was evaluated and scored for each metric, an IBI was calculated for each stream and the ranking of streams was compared to the conditions within each watershed (as ranked by % impervious area). This IBI is referred to as B-IBI (benthic IBI) to distinguish it from the original IBI based on fish assemblages. B-IBI values were ranked according to impervious area, indicating the ability of biological data to reflect watershed condition.

Although the influence of human activities varies from watershed to watershed in the region, analysis of invertebrate data demonstrates that diverse human actions (e.g., forestry, grazing, urbanization, and the cumulative impacts of these and other actions) have predictable and easily detected influences on benthic organisms. Conversely, sampling aquatic organisms provides a convenient and reliable evaluation of the condition of streams and the landscapes they drain. Biological integrity varies in predictable ways with measures of the extent of human influence within a watershed (e.g., percent impervious area, percent of watershed logged, grazing intensity, or chlorine concentration in effluent water). Other factors that also influence biotic integrity include time since logging, drainage from mined lands, presence of wetlands or intact riparian areas, and number of stream crossings by roads in areas involving timber harvest.

Some states begin by establishing a set of reference stations to define reference condition. We do not begin with reference streams per se. Rather, we identify and sample the full range of stream conditions in the sample region. By sampling the best and worst and a range of intermediate streams, we can observe which biological attributes vary as a function of intensity of human activity, that is, along a gradient of human influence. One cannot discover how biology changes (i.e., which components of biology provide signal about biological integrity) by only measuring reference streams. By integrating the results of studies in grazed, logged, and urbanized landscapes, biologists can develop a general B-IBI useful in watersheds with diverse cumulative impacts.

Success in use of the multimetric IBI has changed the framework of monitoring and analysis of water resource condition in many states. Use of biological monitoring has been limited in the past, in part because of the following factors: 1) dominance of water pollution engineers; 2) lack of a defensible definition of biological integrity; 3) lack of standardized field methods; 4) lack of indexes successful in measuring attainment of biological integrity; and 5) misconceptions about the cost of biological monitoring. The development of multimetric approaches like IBI clearly demonstrates that these problems have been overcome.

Societal well-being has long been evaluated by examination of the health of individual humans. In recent decades, economic health has been the focus of efforts to assess societal well being. IBI provides a way to assess ecological or environmental health, upon which both human health and economic health ultimately depend.

SESSION K1 & K2

APPLYING THE PAIRED-WATERSHED AND UPSTREAM-DOWNSTREAM MONITORING DESIGNS

Moderators: Pat Lietman, U.S. Geological Survey, Lemoyne, PA
Jean Spooner, NCSU Water Quality Group, Raleigh, NC
Jack Clausen, University of Connecticut, Storrs, CT

Paired Watershed Study Design

Jack Clausen, University of Connecticut, Storrs, CT

The criterion of a paired watershed study design will be described. Jack's own *Fruit-of-the-Loam* presentation will be included. Statistical analysis approaches will be summarized. An example from a conservation tillage paired watershed site in Vermont will be used.

Discussion:

Experimental Designs

Single Station Design: a single station below the treatment area compares baseline and post-treatment data. The major disadvantage is that the cause of water quality changes can't be isolated; results may be due to BMPs or to climatic factors.

Above and Below — Before and After: analysis can be similar to the paired watershed design.

Above and Below Design: monitoring occurs on receiving waters both above and below the treatment area The major disadvantage is that the cause of water quality changes can't be isolated; results may be due to BMPs or to inherent differences in the watershed between above and below positions (e.g., geology). The exception to this is the case of above and below design with both before and after sampling, allowing two periods of comparison.

Two Different Watersheds: comparison of two watersheds with different land uses (e.g., agriculture and forestry), where one receives BMP implementation and the other remains the same. The major disadvantage is that the cause of water quality changes can't be isolated; results may be due to BMPs or to the inherent differences in the watersheds There are many examples of these flawed studies in the literature.

Paired Watershed Design: two similar, nearby watersheds are used. A calibration period occurs where the watersheds are treated the same in terms of land use and management From this a regression relationship is developed for their hydrology. The watersheds do not need to be identical, they just need to respond similarly to rainfall. Regression relationships are compared between the two watersheds before and after land treatment, based on slope and intercept.

The advantage of this method is that rather than performing a comparison of absolute parameter values, changes in the relationship of values between the two watersheds are analyzed. The method factors out confounding variables, narrowing the cause of water quality changes more closely to the treatment BMPs One weakness of this method is the lack of replication (such as is used in plot- or field-scale efforts).

Nested Watershed Design: this method is useful where there are distinct geological zones within a basin (e.g., coastal plain, piedmont, and montane) Analysis is similar to the paired watershed design The treatment area is a subwatershed in the head waters The larger watershed outlet is monitored to evaluate relative change in the smaller subwatershed

Multiple Watershed Design: the use of numerous watersheds within a basin allows a substantive understanding of the basin-wide big picture.

Paired Watershed Issues

The prior existence of water quality-oriented BMPs in the control watershed should not be considered a disqualifying factor. Prior level of BMP use is not as important as a lack of change in BMPs in the control watershed during the 6 to 10 year monitoring period. This feature is attributable to the comparison of relationships between watersheds, not simply values. Ideally, both watersheds should have the same land uses, but they can be different provided land uses don't change during the project. Watersheds with significantly different land uses will show different hydrologic responses, but as long as the relationship between them is established, the design can be workable

In an above/below — before/after watershed design, the control watershed may be more desirably located up- or downstream, depending on the treatment. For example, the "anti-BMP" of spreading manure on frozen ground should be done downstream from the control, whereas restoration of riparian areas should occur upstream of the control

A completed case study of a paired watershed in Starksboro, VT was presented. The project evaluated the effects of conservation tillage on pesticide movement in surface water. Conservation tillage was defined in terms of residue management, the leaving of at least 30 % residue on the surface. The design actually used paired fields of approximately 2 ha in size. H-flumes collected surface runoff In evaluating pesticides, the desired focus is on the decay in pesticide movement in runoff over time following application. Use of paired watersheds allows this comparison of temporal effects because the effect occurs on both watersheds The calibration period was 19 months, the treatment period 30 months. A useful method of evaluating the data involved generating plots of residual errors for the treatment vs. the control. In this example, plots represented the observed deviations from predicted total mass export of atrazine based on the control watershed, and provided a visual illustration of the change in that deviation over the project's lifetime. The individual errors in these plots could be summed to give the total reduction in mass export of atrazine for the given time period due to the treatment

Downstream-Upstream Study Design - Long Creek Watershed, 319 NMP, North Carolina Case Study

William A. Harman, North Carolina Cooperative Extension Service - Gaston County, Dallas, NC
Jean Spooner, NCSU Water Quality Group, Raleigh, NC

Monitoring data from a management area of the Long Creek, NC project, which has an upstream-downstream monitoring design, are presented to illustrate various aspects of water quality data analysis. One of the preliminary, but important, steps in the analysis of monitoring data is to plot the data in different ways such as upstream parameters versus downstream parameters, all parameters versus covariates, and all parameters versus time. Plots of the data from our project indicated that concentrations of total Kjeldahl nitrogen (TKN), nitrite+nitrate (NO_2+NO_3), total phosphorus (TP), and levels of fecal coliform bacteria (FC) were generally greater at the downstream (site E) compared to the upstream (site D) sampling station; however, considerable variability was apparent

Observation and then regression analysis showed a relatively strong (r^2=0.64) linear relationship between upstream and corresponding downstream concentrations of NO_2+NO_3 Further statistical analysis will be discussed to test sample frequency requirements, minimum detectable change that will be required in the post-BMP period to document a change in water quality, length of pre-BMP monitoring, and usefulness of storm water samples for trend analysis.

Workshop Discussion:

Long Creek drains a 28,500 ac mixed agriculture/urban watershed in southwestern piedmont North Carolina, and serves as the primary water supply for a small city of 5,000. Water quality problems include high sediment, bacteria, and nutrient levels, and sections of the Creek are listed as support-threatened.

The study was designed as an upstream-downstream study. The upstream watershed contains pastures, single family homes, and apartments. Extreme bank and bed erosion is occurring within upstream pasture area that supports 300-400 dairy cows. Major sediment transport action causes filling in behind the weir that was established for the upstream sampling site, compromising stage-discharge relationships. The weir is a v-notch to allow accurate gauging of low flows, but it also lends to sediment accumulation. The downstream or treatment watershed contains a milking barn and a loafing area which receives heavy use. Land management focuses on reducing erosion, largely from streambanks, by providing alternative watering sites and by fencing and restoring riparian corridors.

The current dilemma is two-fold: 1) whether to approach the project as a paired watershed design with the control upstream instead of as an upstream-downstream arrangement, and 2) whether to fence the entire study area stream corridor, both up- and downstream, or fence only the treatment area corridor. On the first question, a paired design could give more valuable results. On the latter question, there is a concern that sediment loading from the upstream watershed is so great and highly variable that it will not only compromise the stage-discharge relationship at the upstream weir, but also that sediment values at the downstream station will be swamped.

The concern was expressed that changing practices upstream by fencing the riparian area, while acceptable for upstream-downstream design, would nullify a paired approach. Given that results under any approach might be difficult to interpret if upstream fencing doesn't occur because of swamping of downstream values, some felt that upstream-downstream and complete fencing was a good alternative. Mr. Harman pointed out that considering practical realities, the farmer would very likely want to fence all of the corridor, given the short-term availability of 75% cost-share. While discussing the experimental design concerns and the fact that most of the pollutant source was below the upstream and downstream monitoring locations, the general consensus was to minimize treatment above upstream site D and to maximize treatment below the 2 monitoring locations.

A separate issue involves an inconsistent relationship among the nitrate data. At low flows, downstream values are lower than upstream, while at high flows, downstream values become higher. Some discussion focused on minimizing variability in the data. The suggestion was made to stratify the data seasonally, and to factor out flow. The upstream weir was identified as another potential source of data variability; under high flows it could become a sediment source as opposed to a sink at low flows.

Changes to the upstream weir design were discussed, such as modification to a rectangular notch with a v-cut, to allow sediment to pass while retaining the ability to gauge low flows for a rating curve and mass load calculations. The use of different upstream (weir) and downstream (culvert) structures was identified as undesirable and a potential source of data variability. The upstream weir could actually act as a BMP. As long as there were no significant defined inputs between up- and downstream, and given the relatively short flow distance of approximately two hundred yards between sampling sites, it was suggested that the downstream stage relationship be used for the upstream site as well, and that the upstream weir be removed.

Paired Watershed Study Design - Sny Magill Watershed, 319 NMP, Iowa Case Study

Lynette Seigley, Geological Survey Bureau, Iowa City, IA

Data from the paired watershed study in the Sny Magill Watershed, Iowa project will be examined. Two large watersheds are being used for the paired watershed study. Sny Magill watershed consists of 22,780 acres; the Bloody Run Creek watershed is adjacent and drains 24,064 acres. Preliminary data analysis will be presented, using one year as the pre-BMP data set and two years as the post-BMP data set. The challenges and benefits of utilizing a short pre-BMP period and having large watersheds will be discussed.

Workshop Discussion:

Sny Magill is a paired watershed design, with Bloody Run as the control. This example illustrated the issues of appropriate watershed size (keeping them as small as possible) and minimum sufficient baseline data. At 34 and 27 mi^2, respectively, both Bloody Run and Sny Magill watersheds are extremely large, and therefore hard to control in terms of unwanted land use changes during the study. Implementation of BMPs over a significant portion of the treatment watershed is a real challenge. Also, 70 to 80% of the flow out of the watersheds is base flow.

Another complicating factor was the ability to collect only one year of baseline data before BMPs had to be implemented due to time limitations on the HUA cost-share moneys. Regarding the question of minimum sufficient baseline data, Jack Clausen provided some guidelines. He stated that the calibration period ends when:

- a significant regression relationship is obtained. It may not be obtained for all constituents, and it may be obtained for mass load but not concentration. While the F statistic is important, a reasonable r^2 for water quality work was felt to be in the .6 to .7 range;
- regression errors are less than BMP effects. Two means of measuring this are confidence intervals and minimum detectable concentration;
- there is a sufficiently large sample size; and
- the full range of anticipated values for each parameter has been spanned by data points (the high end being of concern)

Jack Clausen also gave some guidance on improving the correlation coefficient of regressions to improve baseline calibrations:

- paired observations may not show a significant relationship in concentration, but be acceptable in terms of mass load;
- perform flow adjustment of concentration, if concentration varies in some way with flow;
- aggregate the data. Use means or totals, use weekly or monthly aggregation;
- stratify the data - by season (e.g., 4 seasons, or ice and non-ice, or planting and non-planting) or by process period (e.g., separate initial spike in values due to ephemeral flushing associated with BMP installation from later stabilization of values);
- use multivariate regression and add explanatory variables (covariates).

Sharing the Paired Watershed Experience

All session participants will be encouraged to briefly describe problems and success with their paired watershed studies Pat Lietman, of USGS (PA), shared the results of her study with the group, as summarized below:

This is a paired watershed design with watersheds of 1.48 and 1.8 mi2, much smaller and more manageable than the Sny Magill areas. Pat Lietman made a brief presentation to illustrate the effects of sampling design on parameter values obtained. Graphs of various parameters were shown, obtained from time-based (@10 day intervals) instantaneous samples contrasted with those obtained from composite grab samples. Significant differences were apparent in concentration between the two methods for all constituents. Poor regression relationships existed for the time-based composite data, while the storm composite sample regressions showed r2 values in the 0.6 to 0.7 range. She then illustrated use of the EPA factsheet, *Paired Watershed Study Design*, on the Mill Creek site.

SESSIONS I1 AND I2

LAND TREATMENT MONITORING: DATA NEEDS, COLLECTION, AND MANAGEMENT

Jack Clausen, University of Connecticut
Kathleen Kilian, NRCS Liaison to EPA Region 10

Objectives

1. Participants will be able to develop a land use monitoring plan.
2. Participants will interact with others having similar issues in land use monitoring

Process

This session is intended to give hands-on experience in developing a land use monitoring plan for water quality monitoring projects The session will be highly participatory and involve group activities

Agenda

I. Facilitators give lecturette on land use monitoring (30 min.)
II. Facilitators divide the entire group into smaller groups of five members each with similar interests. (15 min.)
III. The groups will begin the first of three exercises. (30 min.)
IV. Groups will report their findings.
V. Break
VI. Groups will begin the second of three exercises
VII. Groups complete the exercises.
VIII. Groups present results of their plans

Group Findings

A land use monitoring program for a watershed project was developed by each group. The following information was compiled:

Information Needed

- Base map
  - hydrology: surface and groundwater; soils; cover type
- Current and projected land use
- Historical data - water quality and biological
- Water quality standards: criteria and biological
- Inventory of farm practices
- Runoff
- Upstream contributions
- Manure (nutrient) application
  - timing of application
  - location of application
  - rate of application
- Crop type and rotations
- BMPs
- Irrigation methods
- Spatial land use / cover
- Critical site selection
- BMPs (current and historic) data
- Determine the water use
- Characterize leachate
- Soil type / leaching interactions
- Names of land managers and operators
- Current list of management units
- BMPs applied
  - EIS documents
  - Consult literature reviews, theses, and on-line computer data
  - Pump logs (existing monitoring wells and ground water data)
  - Determine leachate
  - Select pilot project sites

Method

- Personal observation of site characteristics
- Field logs
- Stream monitoring data
- Conservation districts, NRCS
- Field surveys
- Operator interviews
- Remote sensing: NRCS, FSA
- On-site visits
- Previous data - USGS
- Other agency files and data
- Field logs
- Follow-up with personal interviews
- Follow-up with agencies
- Personal contact with the county government (tax lots), NRCS, FSA
- Ground tracking - interview local specialists
- Build on existing data
- Quad maps - USGS
- Contact the Forest Service, local universities, and data archives
- Build trust through personal contact: interview local agencies
- Time log
- Cost vs benefits

Data Management

- Dedicated staff
- Dedicated resources
- Dedicated technology (spreadsheets, Access databases)
- Photographs
- Spreadsheets
- GIS and AutoCad
- Acetate overlays
- BIA GIS for existing physical and chemical characteristics, and monitoring well and pilot project locations
- Personnel
- Existing university agencies
- Communities
- Coordinators
- GIS - store spatially and temporally
- Contractor for format (in-out), trend analysis, evolution of data
- GIS - Macintosh software
- Buy information
- ArcInfo

SESSIONS J1 AND J2

LINKING LAND TREATMENT WITH WATER QUALITY AT THE WATERSHED LEVEL

Don Meals, University of Vermont

OPENING DISCUSSION (first 20-30 minutes of J1)

I Spatial and temporal issues at the landscape/watershed level
  A. Scale issues: edge-of-field vs. watershed
  B. Factors influencing pollutant delivery to watershed outlet
    1. Hydrologic system
      a. Where do pollutants come from? Possibilities include highly erodible land, areas that receive manure, and riparian zones
      b. How do pollutants get there? Variable Source Areas - runoff contributing areas (consider rainfall and soil conditions for surface water) and ground water flow systems.
      c. How long do pollutants take to get there? Consider ground water time of travel.
    2. Pollutant behavior
      a. Nutrients - phosphorus sorption to soil or sediment particles, erosion transport, bioavailability
      b. Bacteria - sources; die-off
      c. Pesticides - toxicity, partition/leaching potential, persistence
    3. Flow collector processes
      How do pollutants get from where they are generated to the stream?
    4 In-stream processes
      How are materials processed (physical, biological processing of nutrients) once they are in the stream?
    5. Management
      What actions are taken to influence supply, availability, and losses?
      What BMPs are used to manage these sources? NOTE: Management is only one factor influencing what you see at the watershed outlet
      Good news: most other factors are relatively constant, within some bounds
      Bad news: other factors are often unknown or unknowable.

II Measures of land treatment/management to relate to water quality
  A What are the independent variables of interest? They are not the amount of dollars spent or the number of structures built, but are the activities that affect pollutant inputs, generation, availability, transport, or delivery.
  B. Arithmetic measures - variable selection exercise:
    1. Hypothesize potential relationships
    2. Hypothesize mechanisms
    3 Select variables and measurement scales
  C Spatial measures
    1. Cookie-cutters (e.g. all corn land, 100 m. buffer around streams, aquifer recharge area)
    2. Runoff contributing areas
    3 GIS applications
      a Designation of Hydrologic Response Units - land areas having similar response to precipitation/snowmelt based on combination of physical properties (e.g. altitude, slope, aspect, soil, cover, and climate).
      b Mapping critical areas (e.g. erosion rates as a function of a soil and cropping system)
      c Integrating distance/attenuation factors regarding pollutant export.
      d Riparian condition map based on slope, vegetation, and bank conditions.
      e Air video and GIS for mapping watersheds and identifying riparian condition.
  D Temporal measures
    1 Timing of management activities
    2 Timing of storms
    3 Trends through time

III. Linking land treatment and water quality
   A. Constraints
      1. Differences in scale/precision of data
      2. Confounding interactions
         a. Obvious: hydrologic variations, e g. precipitation, seasonal differences.
         b. Subtle: weather vs. agricultural activities, e.g. manure vs. spring runoff, bacteria vs. pasture season or temperature.
      3. Unknown landscape-level influences
         a. How does position affect influence on water quality?
         b. Landscape level processes - phosphorus and nitrogen attenuation, wetlands, storage.
   B. Possible approaches
      1. If variables and covariates are chosen carefully, association will equal correlation and regression
   C. Examples of success and failure
      1. Success: TVA Watershed Index of Pollution, Pennsylvania RCWP lag, Vermont RCWP (animals and bacteria)
      2. Failure: Manure applications and phosphorus, pasture and bacteria

GROUP EXERCISE (remaining time of J1 and continuing through J2)
Participants divided up into groups of 6 to 10 people
Each group was provided with a unique scenario, including:

- watershed baseline description
- water quality problem statement
- water quality monitoring system
- hypothetical "rules" governing pollutant behavior, land treatment, practice efficiency, hydrologic system, etc. in their watershed
- limited amount of money

Each group did the following:

1. Sketched out their land treatment program and land treatment monitoring program.
2. Formulated their hypothesis on the effect(s) of their land treatment program on water quality.
3. Bought land treatment implementation and positioned it within the watershed (within the typical limitations and constraints of a voluntary program).
4. Bought land use/land treatment information/data.
5. Bought analytical tools such as maps, spreadsheets, and GIS.
6. Made choices regarding measures of management to use, how to quantify and display, and how to relate to water quality.
7. Reported back to entire group

<u>Team Project Reports</u>

Team #1:

- Planning process: This project team operated at the direction of watershed people. They collected, reviewed, and analyzed information related to watershed. Problems were identified and water quality monitoring information, land use, and existing farm practices were reviewed.
- Goal and objective: To improve and enhance the water quality of the watershed. The main focus was on the lower portion of the watershed and on direct BMP application. Prioritization of actions and educational development was also important.
- Specific project elements: A map was developed, indicating the problem areas treated. Farm practices were focused upon. All money was spent on implementation and restoration activities. It was discovered that the main contributor to load degradation was livestock. One-hundred % of the problem areas received BMP implementation. Two stream crosses were eliminated and ten crossings were armored. All pastureland and those areas with degraded streambanks were fenced. There was intensive management on pasturelands. An educational outreach program was implemented, with the hope of changing cultural viewpoints of current residents and those arriving in new housing developments. There was enough funding to complete stream restoration on three kilometers of degraded streams.

- Team summary: The requirements for monitoring effectiveness became academic. A windshield survey was implemented, all farmers complied, and there was a 90% reduction of loadings, 75% reduction in phosphorus and 90% reduction of e. coli.

Team #2:

- This group focused on fencing units, armored crossings (eliminating one), and stabilizing streambanks.
- Land use monitoring: By looking at discharge and storm events, it was determined that the sources identified would not account for loads. Farmer log books, interviews, photographs, and windshield surveys were used to get information about potential sources in the watershed. A GIS approach was used for analyses (ARCINFO, SAS, etc.)
- Effectiveness: Calculations showed a 20% reduction in phosphorus.

Team #3:

- Goals were discussed as to reduce or eliminate impairment for fishing, swimming, and aesthetics. The major pollutants were sediment, phosphorus, and e. coli.
- BMPs: Cost, effectiveness, and land use considerations were discussed. There were correlations among land use, riparian conditions, and targeted areas where BMPs should be implemented. It was decided that BMPs would not be used for corn land. While looking at the upstream distribution of stream crossings, it was determined that one stream with less priority should be eliminated. A secondary targeting process began, based on BMP effectiveness. Two additional crossings were eliminated, nine crossings were armored, and four kilometers of fencing, six rotational grazing packages, and two kilometers of streambank restoration packages were purchased.
- Budget: The allotted money was spent first and documented later. Site specific and overall reductions of parameters were made. There was an eight percent reduction in phosphorus and a ten percent reduction in e. coli. Focus was aimed on smaller areas of the watershed. In some areas, loading was reduced by 100%.
- Monitoring plan: The money was targeted on aerial photography, GIS, and education and outreach. The photography was downloaded into GIS and used as an educational tool.
- One farmer pulled out of the program. The remaining money was used to bring the farmer back to make the program more effective and to expand the outreach program to other farmers. A conclusion was not drawn on how to quantify the level of treatment because the team believed the data to be insufficient.

Team #4:

- Total suspended solids, total phosphorus, and e. coli loadings were calculated by adding stream meters on a map
- The allotted funds were spent on eliminating 2 allowable crossings and armoring 11 others, fencing 5.6 kilometers of streambank, stabilizing 4 kilometers of streambank, and converting 8 pastures to rotation grazing. ArcInfo was also purchased
- The group was successful in reducing pollutants. One armored crossing was lost, and one farmer dropped out. Extra efforts were made to have close farmer contact for cooperation.

Team #5:

- Budget: The allotted money was primarily used on streambank fencing. Armored crossings were installed and one was eliminated. All riparian areas were fenced.
- Education in the watershed: GIS and ArcInfo were used to generate reports to show farmers that their actions benefited the entire watershed. These reports would be presented annually. Log books were provided for the farmers, aerial photographs were taken, and annual interviews were done. The aerial photographs were used to show where fencing was in place.
- After data analysis, the group discovered that total suspended solids were reduced by 85%, total phosphorus by 55%, and e. coli by 80%.

<u>Session Leader's Observations:</u>

- Goal setting and assessments were utilized, prioritizing the target, and pollution reduction percentages were targeted. Information on how to measure the extent of land treatment and how it affected water quality was not presented.

- For future use, it should be noted, with emphasis, that not every problem has a regulatory or mandatory solution Perhaps some loaded questions should be included, but don't include all information.

SESSIONS L1 AND L2

STATISTICS: CONCEPTS AND APPLICATIONS

Pete Richards, Heidelberg
John McCoy, Maryland Department of Natural Resources

The title first suggested for this session was "Statistics Made Easy", but we decided that statistics really cannot be made easy, and we might just as well admit it In fact, applying formal statistics correctly is difficult without advanced training, and knowing that you've applied statistics correctly is even more difficult Most of us do not have that level of training, and should acknowledge this reality and consult with experts when we need to.

One thing that is considerably easier to do without advanced training is to explore your data and find many of the patterns in it. Once the patterns are discovered and documented graphically, formal statistical treatment may not be necessary. Or, if it is, the appropriate techniques will be more apparent, and consultation with a "real" statistician will be more efficient Throwing statistical tests at a data set without a prior notion of what the patterns are and what you want to evaluate is like fishing without bait - it's usually not very successful, and if you do come up with something, it may well not be what you were after!

We support the two-step approach first suggested by Tukey: exploratory data analysis followed by confirmatory analysis. Exploratory analysis seeks to identify patterns and leads to the generation of hypotheses; confirmatory analysis applies formal statistical testing to evaluate the probability that the patterns represent something real, rather than being a result of random variation alone. Many programs for exploratory data analysis are now available for personal computers, offering a number of features which make the exploration process an easy and powerful one. Most programs also offer formal statistical tests.

This session will be an introduction to techniques of exploratory data analysis on personal computers, using a MacIntosh program as an example of the kind of tools available. We will present a step-by-step approach to exploring a data set, seeking whatever stories it may have to tell After a short introductory presentation, we will interactively explore three data sets, at least two of them from NMP projects, and including ground and surface water data. In the second half, we will explore another NMP data set, and consider some of the special issues related to load estimation and working with Biomonitoring results. **Audience participation is expected and will help make this session successful as well as take it in directions where it can do participants the most good.**

Some Useful References:

Helsel, D R and R M Hirsch. 1992. *Statistical Methods in Water Resources* Elsevier Studies in Environmental Science 49. (Exploratory data analysis, non-parametric statistics, and other novel approaches applied specifically to water resources questions. A very valuable guide, worth even Elsevier's price.)

Hoaglin, D.C. and D.S. Moore, Eds. 1992. *Perspectives on Contemporary Statistics.* Mathematical Association of America Notes #21. (See especially Chapter 2 on Data Analysis You'll recognize the source of some of our introductory remarks.)

Hoaglin, D C , Mosteller, F , and J W Tukey, Eds 1983 *Understanding Robust and Exploratory Data Analysis* John Wiley & Sons. (The basic introduction to exploratory data analysis approaches, more technical and theoretically oriented than the other two references.)

(The following pages are copies of overheads used during this presentation.)

STATISTICS: CONCEPTS & APPLICATIONS

aka

~~Statistics Made Easy~~
Approaches to Data Analysis

Linking Land And Water: 3rd National NMP Workshop

"We got all this data and
we gotta
do some statistics on it..."

NMP Project Director?
I hope not...

R. Peter Richards • Heidelberg College Water Quality Laboratory

Philosophy I: What is "Doing Statistics"?

Is this?

Var	n	mean	std dev
Syn 1	50	1.703	1.050
Syn 2	50	2.087	1.174

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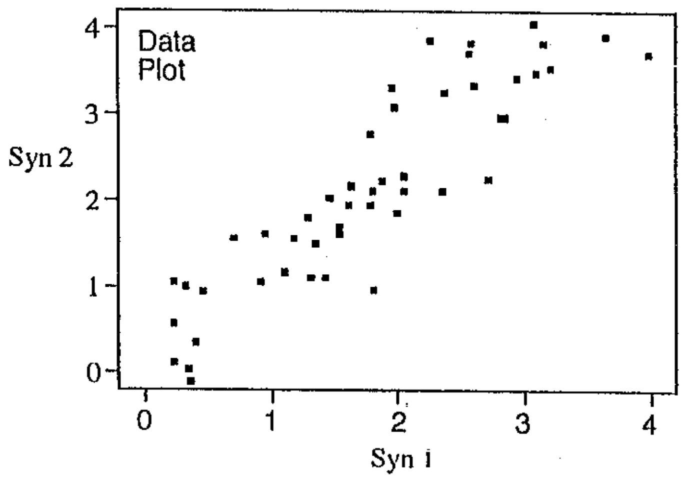
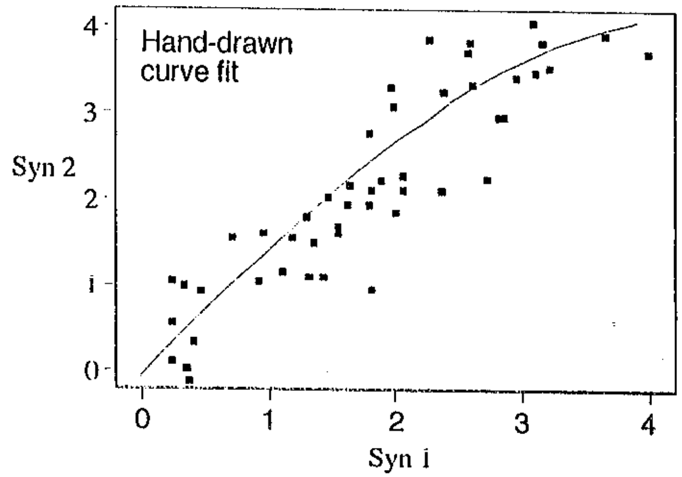
Philosophy I: What is "Doing Statistics"?

Is this?





Var	n	mean	std dev
Syn 1	50	1.703	1.050
Syn 2	50	2.087	1.174

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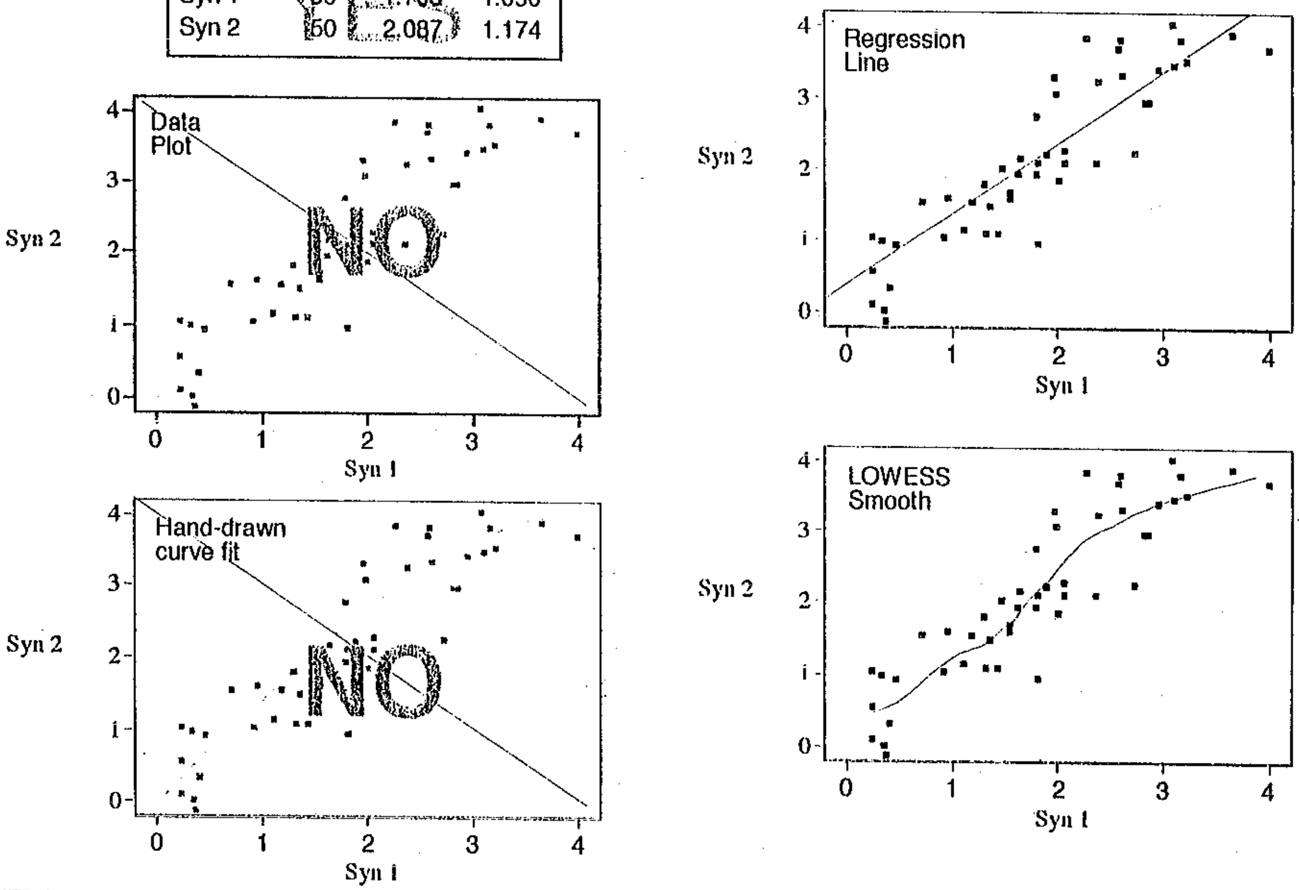
Philosophy I: What is "Doing Statistics"?

Var	n	mean	std dev
Syn 1	50	1.703	1.050
Syn 2	50	2.087	1.174

YES

Is this?



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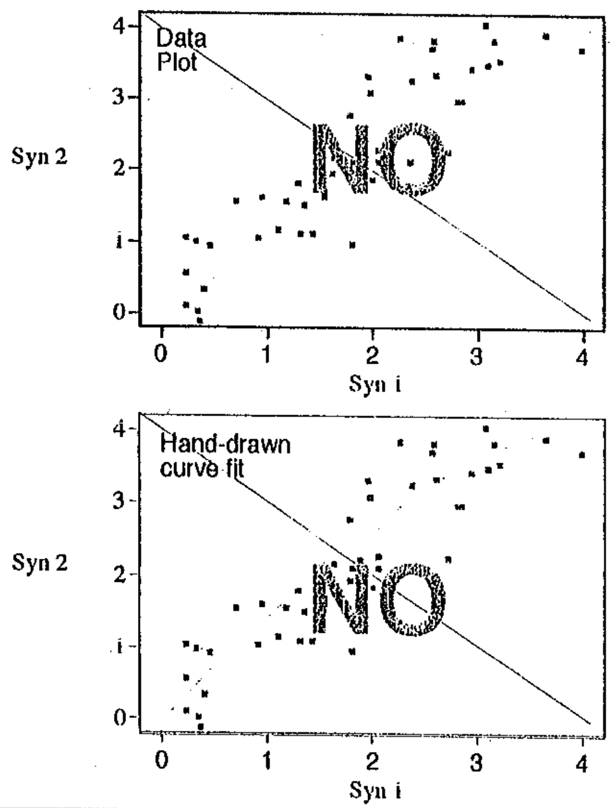
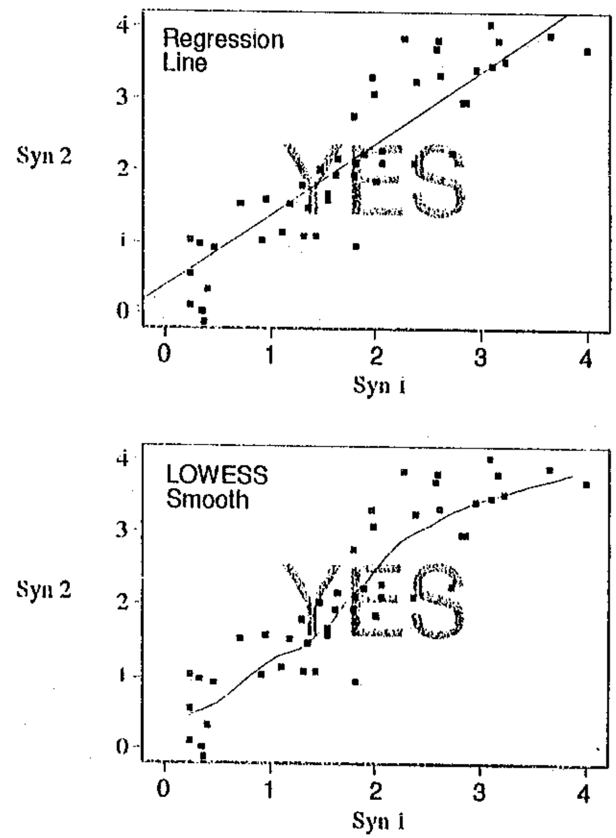
Philosophy I:
What is "Doing Statistics"? And WHY?

Var	n	mean	std dev
Syn 1	50	1.703	1.050
Syn 2	50	2.087	1.174



Is this?



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"Doing Statistics" is...

... applying any of a number of objective procedures to:

• describe one or more sets of data,

• usually to make inferences about the total of all possible observations of which the actual data is a part, and

• often to evaluate the probability that two or more sets of data are from different populations or universes.

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Fundamental Choices for Confirmatory Statistics

Parametric, Non-Parametric, Parametric on Ranks

To Transform or Not To Transform...

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Different Uses of Statistics

- Characterize the center and spread of a set of data.
- Make inferences about the "universe" of possible data of which our particular data is a sample
- Test hypotheses about one or more sets of data:
  - these two samples are different (trivial),
  - these two samples are drawn from different universes
  - there is a (linear) relationship between these two samples
- Extrapolate/interpolate from existing data
  - trend studies
  - modeling

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Philosophy II: The Appropriate Use of Statistics...

- is **NOT** to grope blindly for some order in all that data
- is **NOT** to mine a data set in the search for something (anything...) impressive to put in a report
- **IS** to evaluate objectively whether an expected (hoped for?) relationship actually exists in the data, and not by chance
- **IS** to formalize a subjective understanding of a relationship perceived in the data
- **IS** to evaluate how confident we can be of a perceived relationship (if at all)
- **IS** to evaluate whether the relationship is likely to hold for the universe of which we have a sample, not just for the sample itself - i.e. separate "real" from "coincidental"

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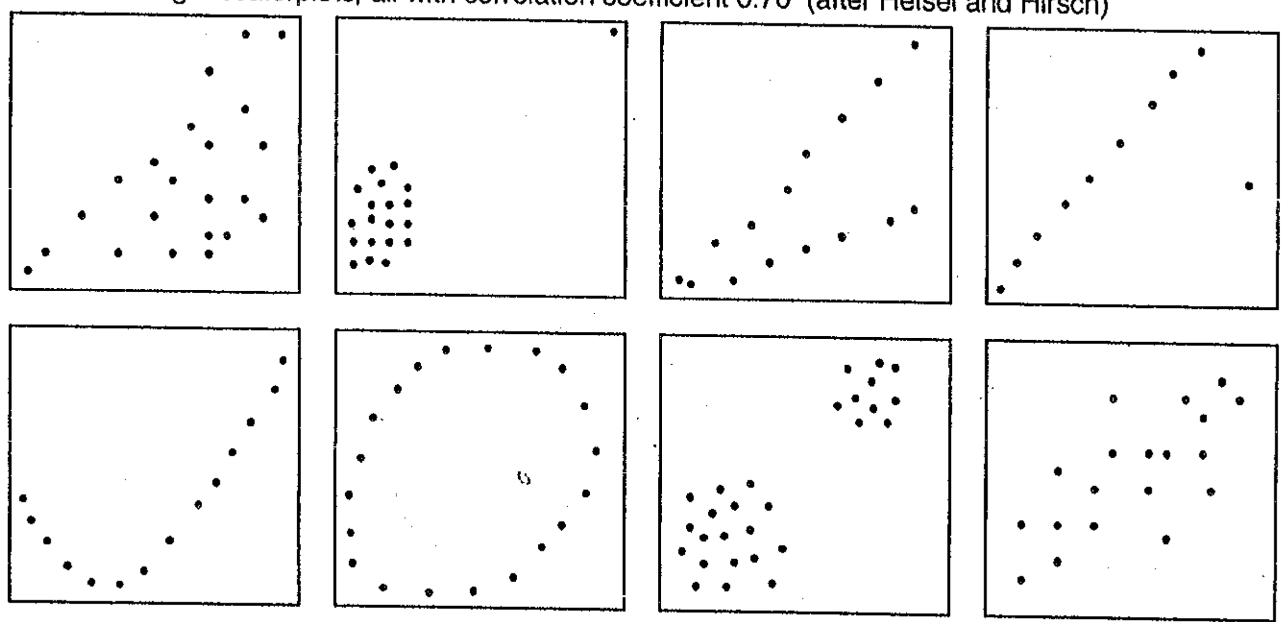
Common Pitfalls

- Can't show sameness, only difference: Cigarettes and cancer
- Correlation and causality: The Methodist Minister Syndrome and "lurking variables"
- Can get misleading results if data are not distributed as assumed

Eight scaterplots, all with correlation coefficient 0.70 (after Helsel and Hirsch)



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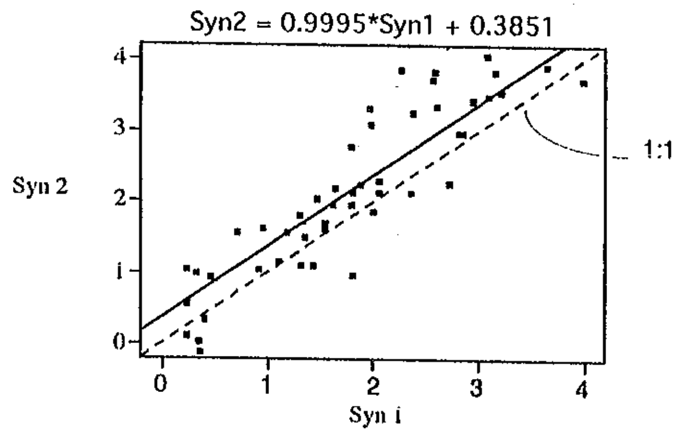
Statistical Significance
vs
Environmental Importance



- Statistical significance reflects how certain we are of a difference
- Statistical significance does not indicate how big or how important the difference is

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The Tukey Paradigm for Data Analysis

Exploratory Data Analysis
(do it yourself)

Confirmatory Statistics
(get help)

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Philosophy III: The Perspective of Exploratory Data Analysis

- We seek not just to answer questions, but to develop better questions, and maybe even new, unexpected ones. We ARE prepared to mine the data, and to let it tell its own story.

- PLOT THE DATA!

- We are probably most interested in the story that the majority of the data is telling. Remove usual observations (temporarily) and concentrate on the main pattern. Then go back and figure out what the outliers are telling us.

- Hypotheses are to be used flexibly for guidance, not tested rigidly as the goal of the process. Velleman and Hoaglin: "We prefer approximate answers to the right question over exact answers to the wrong question"

- Conventional statistics tends to be end-oriented: is the test significant or not, awready? EDA is process- and progress-oriented: try a bunch of approaches and see what you can learn. Use what you learn to guide what you do next. "Unpeel the onion".

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Characteristic Aspects of Modern Exploratory Data Analysis

- EVERYBODY PLOTS THE DATA!

- Use of interactive computer programs which allow multiple graphs which are hot-linked and self-updating.

- The four R's:
  - -Revelation: display the data in a variety of ways so that it can reveal unexpected patterns.
  - -Residuals (= data - model): remove perceived patterns and examine what remains for further patterns.
  - -Re-expression: use a scale or transformation for each variable which simplifies the analysis e.g. log transform
  - -Resistance: use approaches which are resistant to the effects of unusual observations, including removing them.

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Exploratory Data Analysis: A Sequential Approach

0. Make a list of things you'd like to know from the data, but remain open to finding things in the data you didn't expect.

1. Maximize Data Quality

2. Explore distribution properties of the data, consider transformations for convenience and enhanced display properties.

3. Look at subgroups of individual variables e.g. seasonality, different years, etc.

4. Look for relationships among variables e.g. flow & concentration, ss & tp, etc.

5. PLAY with the data - explore effects of removing extreme points, of transforming variables, of adjusting variables for the effects of other variables, etc. If there is a cluster of unusual points in one plot, see where they lie in other plots.

6. When you think you have some good understandings of what's in the data, use formal statistics to test these understandings.

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Let's Do It!!!

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SESSIONS M AND N

DECISION CASE: THE WATERING TROUGH

Jack Clausen, University of Connecticut
Don Meals, University of Vermont

"The Watering Trough" is a real Decision Case that brings out the issues of water quality monitoring to document the changes associated with BMP implementation in an agricultural watershed. A facilitator will lead a discussion of the Case. Participants will be given a few minutes to read the information presented, including a description of the Case, maps, tables, and figures.

This session will be highly participatory and will serve as a summary to most aspects of water quality monitoring, including linkages between water quality and land treatment. Participants will apply knowledge regarding water quality monitoring to a real situation and discuss alternatives.

Case Study: The Watering Trough

by John C. Clausen, University of Connecticut

It was another one of those meetings. Rob, who works for EPA, had just gotten off another road trip. He had a pile on the desk, including three letters to write for members of Congress. That project from Vermont had come in for some additional RCWP funding. They had a slick presentation with lots of slides and some pretty hot GIS maps. The room was starting to fill up. There were people from Extension, NRCS, CFSA as well as EPA. Together that group comprised the RCWP National Coordinating Committee. They would make the decision on funding, but Rob was unsure whether to support the request. There were some competing projects for the money, including one from Rob's home state. Everyone pretty much knew everyone else there. Bill from CFSA introduced the project people; there was Dick from the SCS state office and Jack and Don from the University. Oh-oh, someone invited the staffer from Sen. Leahy's office.

Dick led it off. He began, "Good morning and thank you for the opportunity to discuss the St. Albans Bay Watershed project." Dick went on to explain that they were in the tenth year of the project. The St. Albans Bay watershed is 32,000 acres in area, 65% of which is agricultural, consisting of corn, hayland, and pasture **(Exhibit 1)**. Dairy operations (102 farms) dominate the agriculture. St. Albans Bay is eutrophic due to phosphorus loading from a WWTP and agricultural runoff. In addition, high bacteria counts in the Bay closed a State swimming beach. Best Management Practices (BMPs) have been established on 76% of the critical acres in the watershed, involving 61 farms, which exceeds the original project goals. Most of the targeted farms were on contract. He showed a pretty slick GIS map of the locations of farms with BMPs, but it looked like they were scattered all over the watershed **(Exhibit 2)**. The primary BMP is animal waste management, although other practices were used, including nutrient management, streambank protection and conservation cropping **(Exhibit 3)**.

Jack described the water quality monitoring program. The paired watershed study is located within the project area and is aimed at evaluating the effects of best manure management on phosphorus export. Two small watersheds, nested with each other, are being used for the study. He mentions that the farmer could not get manure out of the pit in the winter to spread it and they had to buy some manure.

At that point Rob started to take notice. Jack went on and explained the intricacies of the paired watershed approach. Rob had trouble staying focused on what was going on and began drafting one of those letters for the Senator's constituent.

Jack also reported on the St. Albans Bay monitoring stations. There are four levels of monitoring. Level 1 is sampling within the Bay **(Exhibit 4)**. Besides chemical monitoring at the four Bay stations, plankton and chlorophyll 'a' samples are taken. Once a year macrophytes are surveyed in the Bay. Level 2 is tributary monitoring and the WWTP. Level 3 is the paired watershed study. Level 4 is the random sampling. Jack indicated that the Level 4 sampling had been terminated. They are using three times per week composite samples made up from 8 hour composites for the chemical and physical monitoring, which includes suspended sediment and total phosphorus analysis. Fecal coliform bacteria are sampled during a weekly grab sample. Benthic macroinvertebrates are sampled at the stream stations at the beginning of the project, during the middle of the study, and at the end of 10 years. Rain gauges are located in the watershed and discharge is recorded continuously at the level 2 stations.

Don stood up to explain the results from the project. Bacteria standard violations have declined in the Bay, he stated. In the tributary streams, bacteria abundance has also declined significantly. Suspended solids has declined in the streams, but there has been no reduction in phosphorus concentrations in the streams or the Bay or phosphorus loading to the Bay during the past 10 years (**Exhibit 5**). This includes the period following the treatment plant upgrade to tertiary treatment in 1987. The Bay itself continues to be eutrophic.

One of the NRCSers asked if the locations of the BMPs made a difference. Don indicated that based on the current study design, it was difficult to evaluate that question.

Jack went on to discuss the paired watershed results. He indicated that during the calibration period when both watersheds were in best manure management, significant regressions were obtained between the control and treatment watersheds for discharge, and suspended sediment and phosphorus concentrations and mass exports. Winter spreading of manure was found to significantly increase phosphorus concentrations but discharge decreased due to a mulching effect.

One of the biological types asked about the macroinvertebrates. Jack indicated that the organisms present in the tributary streams are indicative of highly polluted waters. The number of organisms have declined during the project but the species have pretty much remained the same. He also mentioned that the methods varied somewhat during the three sampling years. The biologist followed up by asking what the indices showed. Jack stated that the indices did not show any clear trends (Exhibit 6)

The guy from Extension asked what was the effect of the WWTP upgrade on St. Albans Bay. Don stood up and said that although the plant has been upgraded to tertiary treatment, and the phosphorus load from the WWTP declined by over 95%, no change in phosphorus in the Bay has been seen

Rob wondered why the nutrients didn't change in 10 years. That is such a long time. He asked why the BMPs weren't effective. Jack got up and indicated that they didn't know if the lack of change was due to whether the BMPs were not effective or if enough time hadn't been allowed to flush out the watershed. Somewhat humorously, he added that "Ethan Allen started farming in this watershed over 200 years ago. Why would we expect change in just 10?"

The staffer from Leahy's office indicated that the Senator had been watching this project closely and saw it as a landmark project in the country. He also mentioned that local residents in the Bay have seen a return of the smelt fishery to the Bay.

Dick took over the meeting again, indicating that they would like to continue the project for five more years and need additional RCWP money to do that. They also would like to add some additional BMPs and perhaps saturate one watershed with BMPs. One of the additional BMPs could be riparian buffer zones. They could also further limit the timing of manure applications. Dick mentions that a proposal outlining the extended project has been submitted to the RCWP Coordinating Committee

Rob looked up from his notes and wondered whether to support their request for funding. Recently there had been increasing pressure to show results from the RCWP to Congress. Can this project do it? Why haven't they done it already? If we give them the money what should they do?

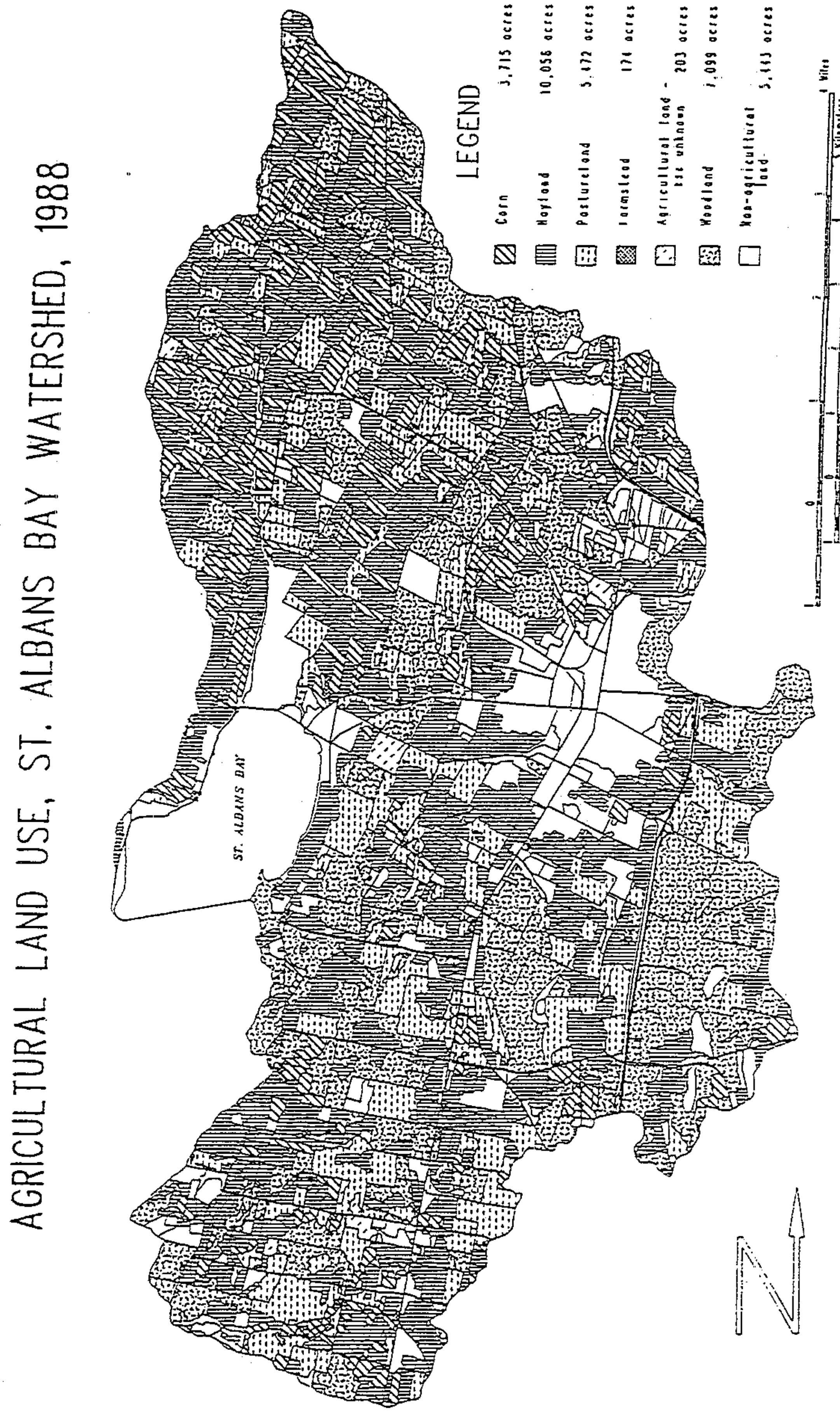

AGRICULTURAL LAND USE, ST. ALBANS BAY WATERSHED, 1988
LEGEND
Corn 3,715 acres
Hayland 10,056 acres
Pastureland 5,472 acres
Farmstead 174 acres
Agricultural land - use unknown 203 acres
Woodland
Non-agricultural land
ST. ALBANS BAY

Exhibit 1

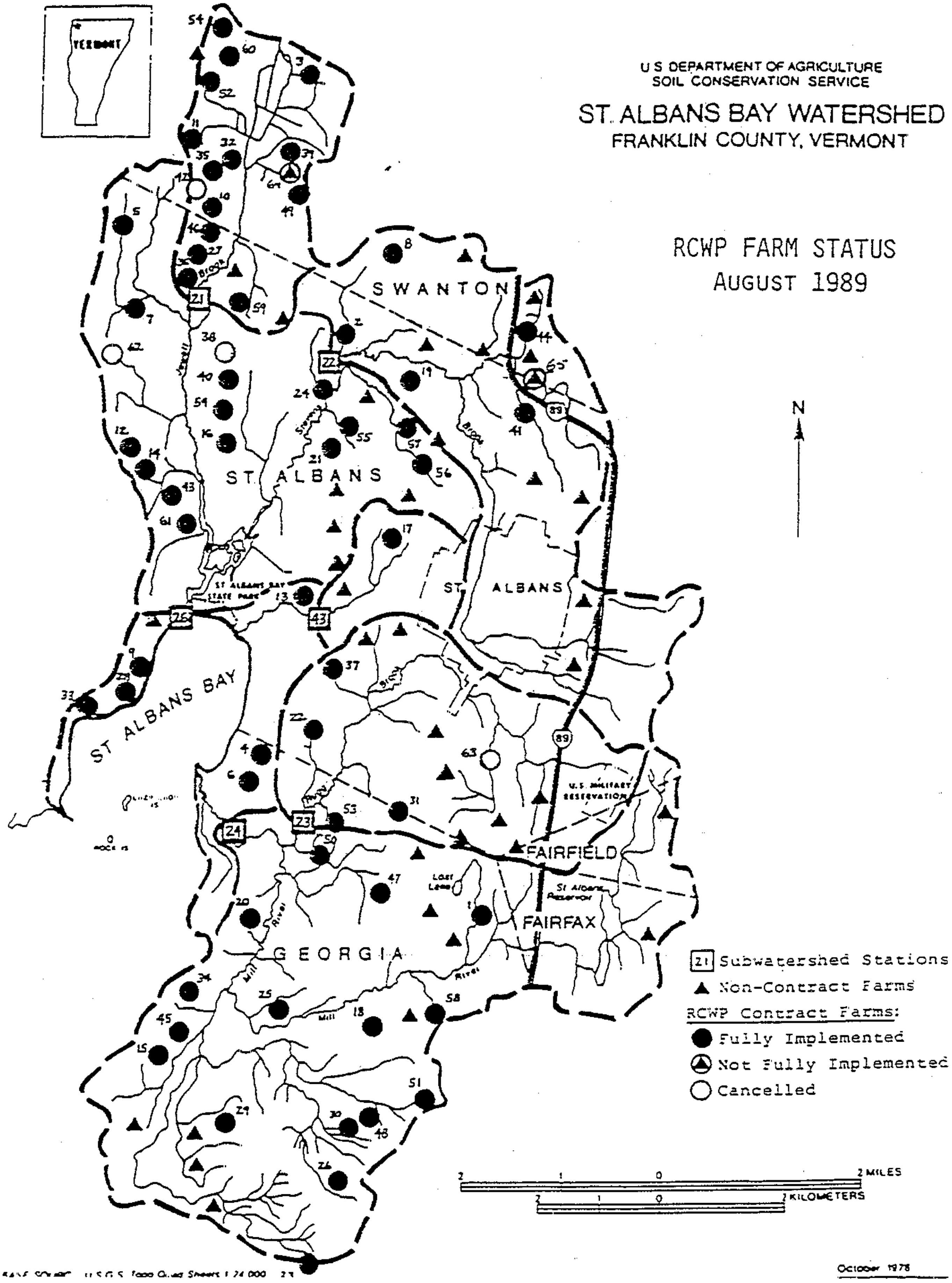

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ST. ALBANS BAY WATERSHED
FRANKLIN COUNTY, VERMONT
RCWP FARM STATUS
AUGUST 1989
N
SWANTON
ST. ALBANS
ST. ALBANS
ST ALBANS BAY
FAIRFIELD
FAIRFAX
GEORGIA
U.S. MILITARY RESERVATION
Subwatershed Stations
Non-Contract Farms
RCWP Contract Farms:
Fully Implemented
Not Fully Implemented
Cancelled
2 MILES
KILOMETERS
October 1978

Exhibit 2

St. Albans Bay Watershed
RCWP Goals, Accomplishments, and Projections
August 1989

	Units	Goals	Under Contract	Completed	Projected (1990)
Critical Acre Treatment	Ac.	11,443	11,277	10,101	11,277
Critical Source Treatment	No.	64	61	62	61
BMPs					
1 Permanent Vegetative Cover	Ac.	4,500	4,021	4,021	4,021
2. Animal Waste Mgmt System	No.	70	66	66	66
	A.S.	—	9,397	9,397	9,397
3. Stripcropping System	Ac	—	0	0	0
4. Terrace System	A.S	—	—	—	—
5. Diversion System	A.S.	25	25	25	25
6. Grazing Land Protective System	No.	6	6	6	6
7 Waterway	A.S.	15	132	132	132
8. Cropland Protective System	Ac.	6,400	7,074	6,867	7,074
9. Conservation Tillage System	Ac	10	10	10	10
10. Stream Protection System	A.S.	500	483	483	384
11 Permanent Vegetative Cover on Critical Areas	Ac.	75	63	63	63
12 Sediment Retention, Erosion or Water Control Structures	No.	50	55	52	55
14. Tree Planting	Ac.	—	—	—	—
15 Fertilizer Management	Ac	7,000	7,610	7,610	7,610

*A.S = Acres Served

Exhibit 3

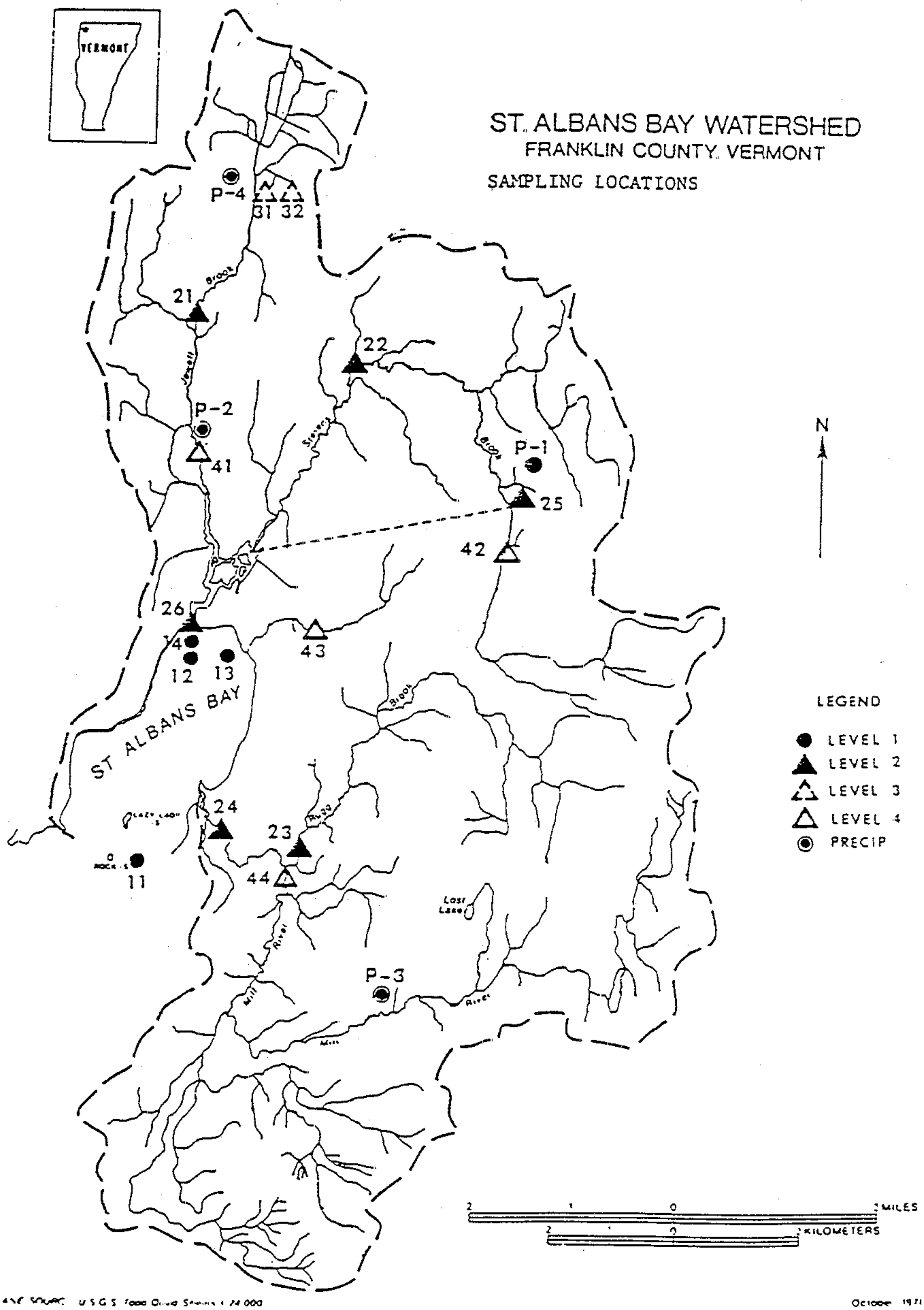
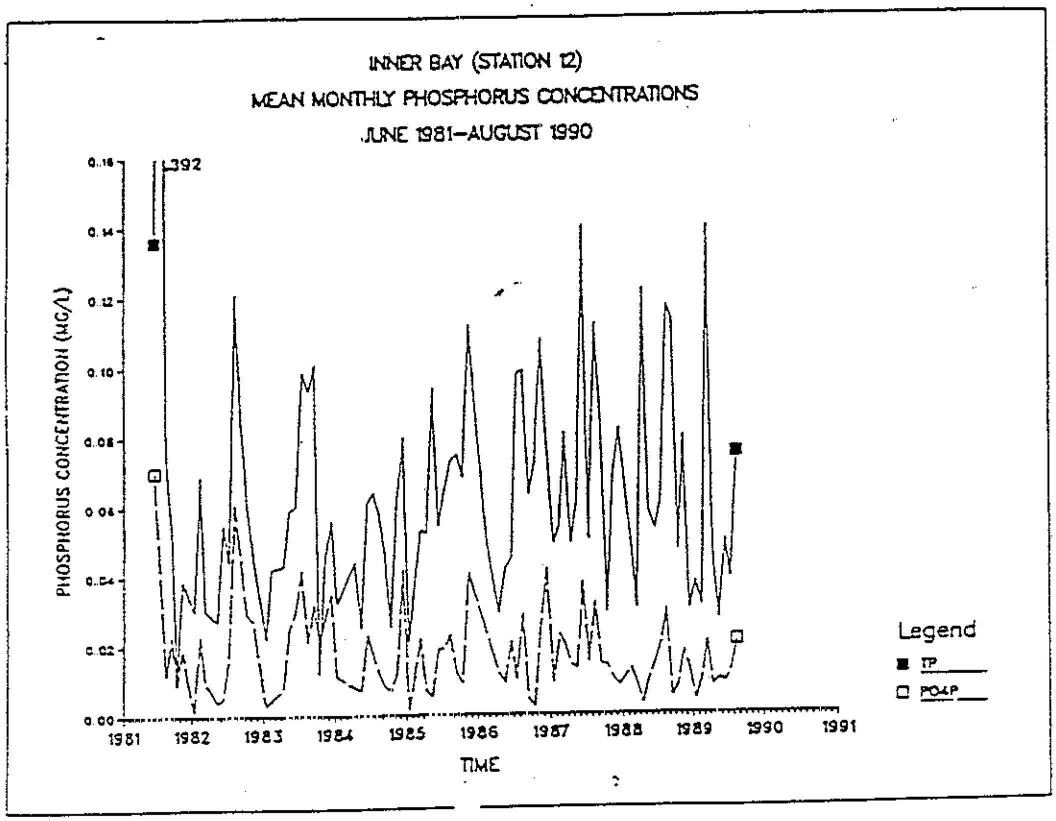

ST. ALBANS BAY WATERSHED
FRANKLIN COUNTY, VERMONT
SAMPLING LOCATIONS
VERMONT
P-4
31
32
21
22
P-2
41
P-1
25
42
26
14
43
12
13
ST ALBANS BAY
24
23
11
44
P-3
Lost Lake
Mill River
N
LEGEND
LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
PRECIP
MILES
KILOMETERS
October 1971

Exhibit 4


INNER BAY (STATION 12)
MEAN MONTHLY PHOSPHORUS CONCENTRATIONS
JUNE 1981–AUGUST 1990
PHOSPHORUS CONCENTRATION (MG/L)
TIME
Legend
TP
PO4P

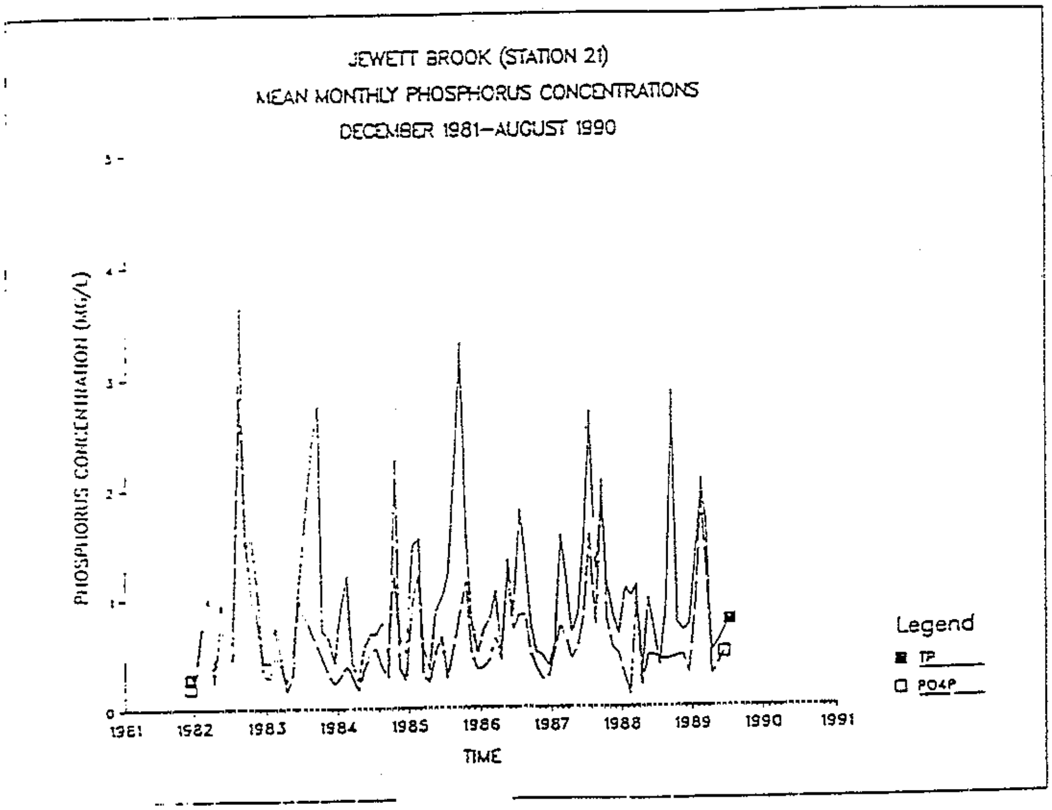

JEWETT BROOK (STATION 21)
MEAN MONTHLY PHOSPHORUS CONCENTRATIONS
DECEMBER 1981–AUGUST 1990
PHOSPHORUS CONCENTRATION (MG/L)
TIME
Legend
TP
PO4P

Exhibit 5

Table 2 Mean benthic macroinvertebrate density, biomass, and number of taxa from three samples taken at each site in the spring of 1983 and 1986. * = significant yearly difference (alpha = 05). i = significant year by site interaction (alpha = .05).

		Mill		Rugg/Mill		Jewett		Overall	
Spring		1983	1986	1983	1986	1983	1986	1983	1986
Density	Pool	13,017	3,789	34,905	2,339	25,877	1,536	24,600	2,555
	Riffle	8,041	492*	9,390	2,045*	441	2,716	5,957	1,751*I
Biomass (g/sq m)	Pool	3.57	1.72	13.69	1.25*	4.65	0.99*	7.31	1.32*
	Riffle	2.48	0.34*	3.87	0.66*	0.55	0.82	2.30	0.61*I
# Taxa	Pool	18	4*	29	10*	13	3*	20	6*
	Riffle	32	12*	28	17	7	10	22	13*I

Table 5 Values of diversity indices for fall invertebrate collections in 1982 and 1986. Each is the average of three samples. ND= No Data * = significant yearly difference (alpha = .05)
i= Significant year by site interaction (alpha = .05)

Fall		1982	1986	1982	1986	1982	1986	1982	1986
Shannon-Wiener H'	Pool	1.11	0.89	1.52	1.01	0.81	1.32	1.15	1.07
	Riffle	1.37	1.04	1.17	1.98	ND	ND	1.27	1.51
Simpson's D	Pool	0.47	0.54	0.34	0.50	0.58	0.41	0.46	0.48
	Riffle	0.41	0.46	0.53	0.18	ND	ND	0.47	0.32
Evenness, J	Pool	0.46	0.58	0.60	0.64	0.58	0.62	0.55	0.61
	Riffle	0.45	0.61	0.42	0.80*	ND	ND	0.43	0.71*

Exhibit 6

After the participants read the case study the question was asked, "should funding of this project be continued?"

Questions and comments by the audience fell into four major categories: the political/policy realm, unanswered questions that must be addressed before proceeding with project funding, concrete suggestions for improving the water quality monitoring design, and technical considerations.

Political/Policy Considerations

- It appears that Senator Leahy's staff has better information on the impaired use of Lake Champlain, and since it seems that the Senator would support additional funding, the water quality monitoring should continue.
- Many decisions are based on the politics of the situation, not the facts. Therefore, the political climate ought to be considered when making the decision about continued funding.
- The project team needs to make a better case for the public benefit of continued funding.

Answer Unanswered Questions Before Funding is Continued

- Rob can't decide because he has insufficient information.
- Monitoring should continue, but it should be targeted toward answering the unanswered questions.
- The project needs better data on pollution sources if a case is to be made for continued funding.
- Before funding the project further, wait and see or do more investigation before the water quality monitoring work is continued.
- More information is needed on the actual BMP compliance by the producers. Also, information is needed on whether or not BMPs are effective in reducing the loading of phosphorus into the streams.
- The role of non-contract farms in phosphorus loading should be determined before further money is spent on monitoring activities.
- It is important to determine whether land treatment goals (75% of the critical area) are sufficient for the change that was expected.
- It is difficult to tell if the project has met its goal of decreasing phosphorus, because the project never established a numerical value for a decrease in phosphorus concentrations. Before proceeding any further, project personnel should establish numerical goals for lowering phosphorus concentrations.
- Monitoring results so far suggest a potential ground water role in stream recharge because, although fecal coliform and total suspended solids are declining, the nitrogen concentrations are increasing. Determine the contribution of ground water to the stream system before proceeding.

Improving Water Quality Design

- Water quality monitoring should continue but focus only on the wet season.
- More intensive biological monitoring is needed, although the project had no goals related to habitat improvement nor any baseline habitat information. Further, more work needs to be done in order to determine why the macroinvertebrate community isn't thriving.
- Continue to monitor the water quality, but concentrate activities on first and second order streams.
- The water quality monitoring should be scaled back to a subwatershed scale and focused on a pollutant source assessment.

Technical Considerations

- Because of the phosphorus attached to the sediments in Lake Champlain and the associated wetland, it is unrealistic to expect to see a decrease in lake phosphorus concentration. In order to detect changes in phosphorus concentrations, long-term lake monitoring will be necessary.
- An immediate downward response in fecal coliform amounts and total suspended sediments has been seen. The lack of phosphorus response suggests that the residual phosphorus response is slower.
- Additional farms should be treated with BMPs, and monitoring should continue. However, if additional funding is approved, a better watershed plan should be developed that contains regulations for noncompliance by producers.

- After comments and questions had been received from the audience, participants were encouraged to present concrete suggestions for continuing or discontinuing funding of water quality monitoring activities Five suggestions were received from the participants and then the proposals were voted on Based on the vote, the audience recommended that funding be continued, but with some modifications to land treatment and water quality monitoring.
- Continue monitoring but at a reduced level of effort The monitoring should focus on a smaller land area. More project effort should be placed on information and outreach to landowners to ensure BMP implementation and compliance. (Received 17 votes)
- Continue monitoring at same level but redirect funds for monitoring to unanswered questions, such as how much of the phosphorus is derived from lake sediments. (Received 18 votes)
- Allocate one-half million dollars for short-term data collection. Convene a conference in November of 1996 to discuss the collected data and determine the future monitoring strategy for the project (Received 2 votes)
- Minimize the size of the watershed, in order to better control variables and continue to monitor. This smaller watershed should contain old monitoring sites in order for the project to maintain historical data The focus of the land treatment for this project should be on new BMPs. All monitoring efforts in the Bay should cease. (Received 16 votes)
- Discontinue the monitoring for a period of time and then start monitoring again in order to quantify the water quality changes that have happened over time without any additional interventions. (Received 2 votes)