A DATA MANAGEMENT SYSTEM TO EVALUATE WATER QUALITY IMPACTS OF NONPOINT SOURCE POLLUTION CONTROL

M. D. SMOLEN
S. A. DRESSING
R. P. MAAS
J. SPOONER
C. A. JAMIESON
A. D. NEWELL
F. J. HUMENIK
North Carolina State University
Raleigh, North Carolina

ABSTRACT

The data base and data management system of the National Water Quality Evaluation Project (North Carolina State University) were developed specifically to analyze the effects of various approaches to land treatment in the context of diverse hydrologic, geologic, meteorologic, and socioeconomic factors. The data base consists of two parts: (1) an annotated bibliography and (2) a water quality project file, containing summaries of agricultural water quality projects. The project file contains subfiles for general project data, detailed descriptions of projects' water quality problems and land treatment programs, and, summaries of the projects' water quality results. Land treatment data are indexed by project code, date, and a Land Area Resource Code (LARC), and water resource and water quality data are indexed by project code, date, and a Water Resource Code (WARC). Water quality results are then related to land treatment by associating LARCs with WARCs. The data base is used to evaluate water quality projects, but future developmental effort will be directed toward a BMP-decision matrix to access all available information for making and planning nonpoint source pollution projects.

The National Water Quality Evaluation Project (NWQEP) is charged with examining agricultural nonpoint source control efforts to evaluate the efficacy of best management practices (BMPs) and implementation strategies in terms of water quality. The factors affecting water quality and the NPS control programs vary widely from one location to another. The primary problem in conducting the national evaluation is, therefore, to assemble highly diverse types of information into a common data base to compare results and methods and develop recommendations.

To address this problem we have developed a two-part data base consisting of: (1) a water quality project file to store primary information, and (2) an annotated bibliography of nonpoint source-related publications to access the relevant scientific literature. The project file is restricted to those agricultural water quality projects that include both a land treatment component and a water quality monitoring component. This restriction reduces the problem of managing a great deal of unrelated information and eliminates many demonstration projects that have implementation without water quality monitoring.

In developing a data management system, the designer needs to consider what types of data will reside in the data base, who will be the users of the data base, and what analyses will be requested. The analyses considered for the NWQEP data management system (NWQEP–DMS) included testing hypotheses concerning: project management and BMP implementation, cost of BMP implementation and cost efficiency, immediate effects on quality of runoff or ground water, and the ultimate impact on quality of an impaired water resource. For this reason, the data base includes parameters that describe each project's goals and objectives, implementation costs, cost sharing, and the value of the impaired water resource, as well as the physical setting and water quality impact.

STRUCTURE OF THE PROJECT FILE IN THE NWQEP-DMS

The project file stores NPS project information and parameters that identify other data bases for supporting information, such as individual water quality observations. The project file includes detailed information on climate, geography, land use distribution, BMP implementation goals and accomplishments, a description of the water resources of the project area, and summaries of water quality monitoring results.

The structure of the NWQEP-DMS project summary file is depicted in Figure 1. It consists of a land information file and a water information file. The land information file has three data sets: a General Descriptive Data (GDD) set containing information pertinent to the whole project area, a Land Treatment Data (LTD) set containing land use information, and a BMP data set containing information on BMP implementation goals, accomplishments, and costs.

The water information file consists of two data sets: a Static Water Quality (WQS) file and a Dynamic Water Quality (WQD) file. The static file describes the receiving water resources of the NPS project, and the dynamic file contains water quality parameters that change with time, such as pollutant concentration and loading values.

The GDD data set is indexed by Project Code (for example, R21 for RCWP 21, the Rural Clean Water Program project in Virginia). It contains such nonvarying information as the project's location (latitude and longitude), the average monthly rainfall, snowfall, and temperature, and lists land areas that contribute to each water resource within the project. Each land area is identified by a Land Area Resource Code (LARC), and each water resource is identified by a Water Resource Code (WARC). Every project in the NWQEP-DMS has one GDD file. Figure 1 shows the relationship of LARCs and WARCs in an actual nonpoint source project.

Every NPS project has at least one land area as a unique LARC. The boundaries of the LARC correspond with a natural watershed divide so that all of its surface runoff contributes to a single water resource. A single water resource (WARC) may have several LARCs, but a LARC can contribute to only one WARC. For analysis of cause-effect relationships in a project, the data from several LARCs may, therefore, be pooled if water quality data are available at few monitoring stations.

If land use and land treatment information are available for each water resource within a nonpoint source project area, the project area may be divided into subareas with different LARCs. Because the workload to provide land use and BMP implementation data on a subwatershed basis increases rapidly with the number of LARCs, most projects in the NWQEP-DMS at this time have fewer than four LARCs. LARCs range in size from about 400 ha (1,000 acres) to as much as 12,000 ha (30,000 acres).

Land use information for a LARC is placed in the LTD file, which is indexed by project code, LARC, and date. The file contains a description of the land use distribution within the specified project subarea. Each land use type is

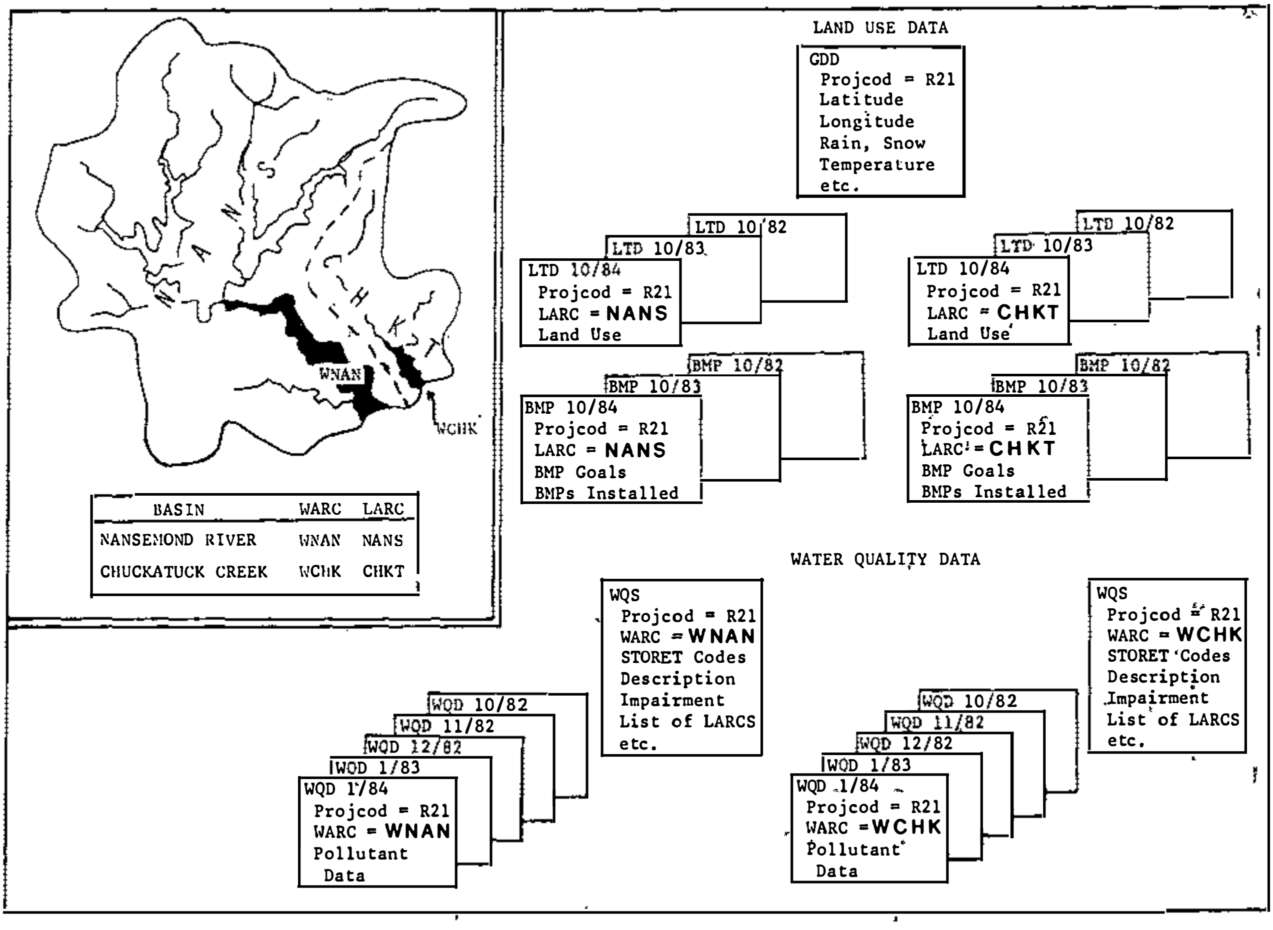


Figure 1.—Structure of the project summary file in the NWQEP-DMS.

identified by family, genus, and species. The family level refers to such classifications as agricultural, urban, or forest; the genus level to such classifications as animal operation, residential, or harvested forest; and the species level refers to such classifications as specific crop, construction, or unconfined livestock area. The area of the LARC, the percent area for each specific land use type, crop yield information, estimates of fertilizer usage by crops, and estimates of animal waste production are included. A quality parameter rates each estimate on a scale of 0 to 3 (unsubstantiated to precise and accurate).

Information on BMP implementation is contained in a BMP file, indexed by project code, LARC, and date. The file contains parameters to specify BMP reporting units, implementation goals, and implementation accomplishments. The BMP file also contains the amount of project money spent on implementation and estimates nonproject money spent on BMP implementation. New observations are added to both the LTD and the BMP files annually.

Of the two water-related information files, the WQS (Water Quality Static) file contains the descriptions of water resources such as lakes, impoundments, rivers, and aquifers, indexed by project code and WARC. The description of a water resource includes its physical and hydrological characteristics, relevant water quality standards, and parameters identifying the intended uses, the use impairments, and the type and strength of documentation available. The types of documentation include social perceptions and economic data as well as chemical, physical, and biological data. This file also contains parameters to retrieve water quality recores from the EPA STOrage and RETrieval system (STORET).

The WQS data set also includes a list of pollutants and the designated pollutant reduction goals specified by the nonpoint source project. These data may be retrieved by project code and WARC. Annual entries to this file are not anticipated.

The WQD file contains pollutant concentrations and loads indexed by project code, WARC, and date. In addition to pollutant names, such as nitrate-N, the STORET analysis code is included. Observations in the data set are entered as monthly means unless specified otherwise. Parameters are also reserved for standard deviations, medians, and number of samples. A procedure will be developed to extract monthly summary values from primary data in STORET or other sources of water quality observations to move these values into the NWQEP–DMS.

DATA ANALYSIS AND DATA SOURCES

Procedures written in the language of the Statistical Analysis System (SAS, 1982) perform data management and analysis. This system allows a high degree of programming flexibility and direct use of the data in statistical analyses.

Most of the data in the NWQEP–DMS project file were extracted from the reports of agricultural nonpoint source projects sponsored by State and Federal agency programs. These programs include: RCWP, the Model Implementation Program, Agricultural Conservation Program–

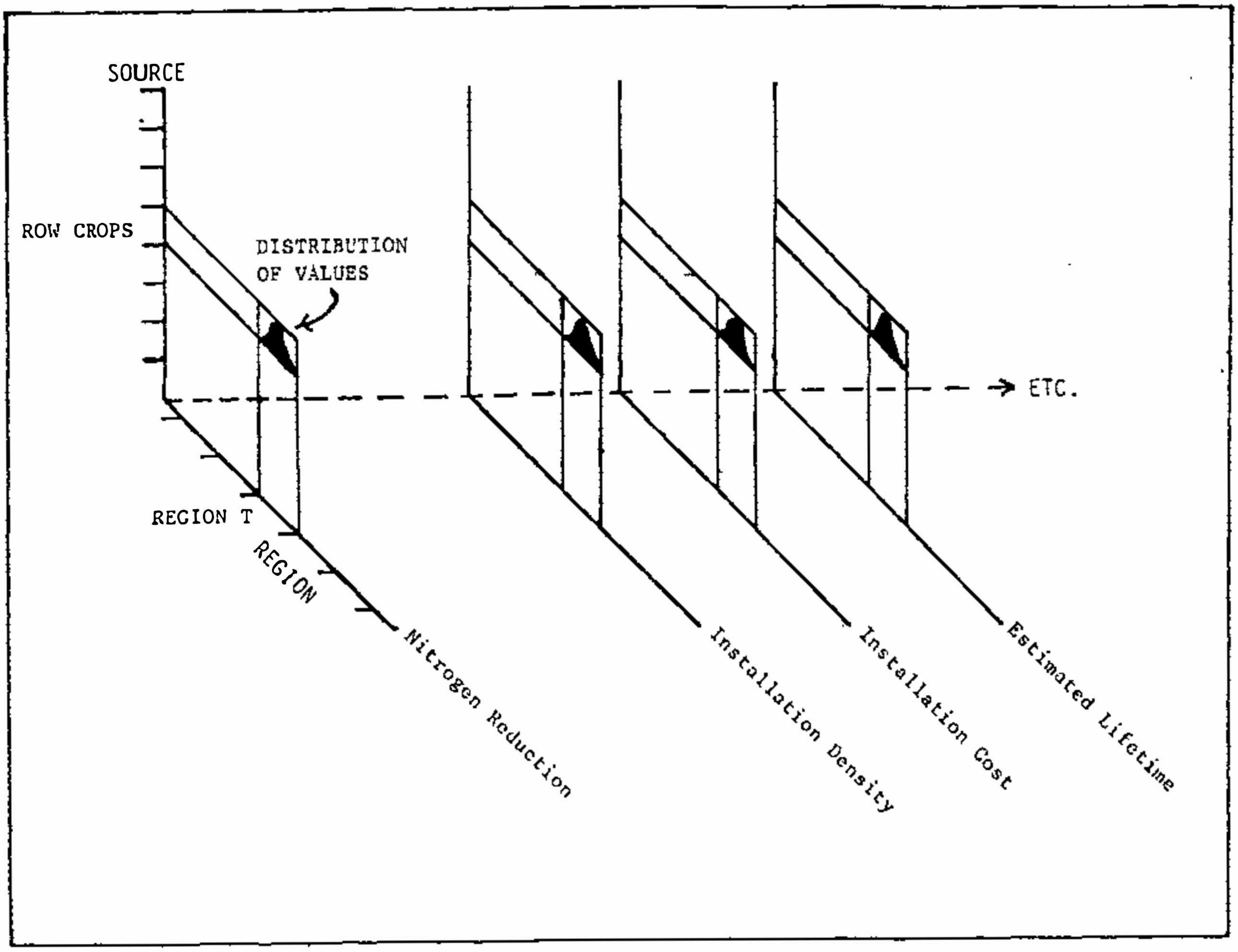


Figure 2.—Related data planes in the BMP decision matrix.

Special Water Quality Projects, the Great Lakes 108 Program, statewide 208 Programs, P.L. 566 Programs, the Chesapeake Bay Program, and others. These data will be supplemented by information from the literature, from USDA's Conservation Reporting and Evaluation System (CRES), and from any other sources we are able to identify.

DEVELOPMENT OF A BMP DECISION MATRIX

The NWQEP-DMS has been developed primarily for project evaluation. Our future goal, however, is to use the data to address basic questions about BMP's and BMP implementation strategies. Further efforts in this respect will be focused on development of a BMP decision-matrix (BMP-DM).

The BMP-DM is illustrated in Figure 2. Conceptually, it will be a multidimensional structure that may be thought of as a series of related data planes. Each cell in a data plane will contain a summary of water quality responses for the combination of indexing variables that locates the cell in the data matrix. The individual cells in the data matrix will be filled by observations from the NWQEP-DMS project file and information from the project library (accessed through the annotated bibliograpy). If one is interested in nitrogen reduction by a particular BMP on a specific crop in a specific region, the distribution of values will be retrievable from the BMP-DM as shown in Figure 2. Recommendations on application of BMP's to specific problems will be obtainable by combining the probable reduction of the pollutant by implementation with the probable implementation density. Related information on costs and expected lifetime could also be examined to identify the optimal choice of BMP's for the specific situation.

CONCLUSION

Achieving the full potential of the NWQEP-DMS and the BMP-DM will require considerably more data and a concerted programming effort. Most of the data presently in the project file are from RCWP project reports. The annotated bibliography contains about 1,800 references, retrievable by author or topic. Nevertheless, a data system like this is essential to transfer the knowledge obtained from the diverse nonpoint source projects conducted throughout the country to future nonpoint source control efforts. The efficiency of this information transfer may, to a large extent, determine how successful we are in controlling agricultural nonpoint source pollution.

REFERENCES

SAS Institute. 1982. SAS User's Guide: Basics. SAS Inst. Inc., Cary, NC.

DEVELOPMENT OF A NONPOINT SOURCE DATA CENTER

CLAIRE M. GESALMAN
The Synectics Group, Inc.
Washington, D.C.

ABSTRACT

One challenge faced by managers of nonpoint source control programs is tracking progress made in solving problems. Program managers and staff often do not have ready access to the latest information on, for example, best management practices, water quality effects and benefits, and other State programs. Such information is needed for problem assessment, designing solutions, and evaluating progress. This paper presents the design of a prototype nonpoint source data center. The center is being established based on needs identified through interviews and questionnaires and is based on data from Chesapeake Bay States. The center's information will be available to all States and local governments and to the public, and the database will be gradually expanded to cover all States. Existing data and information centers such as the Conservation Tillage Information Center were evaluated during the study to allow the new nonpoint source data center to build upon their experiences.

INTRODUCTION

There can be little argument that, in many areas, controlling nonpoint sources is the key to further water quality improvements. However, we need to be able to build on the experience and results of existing programs. Where efforts have been made to control nonpoint source pollution, it has become clear that progress is difficult to document. Furthermore, few mechanisms exist for sharing information and results among the many workers in this field.

The emphasis on cleanup of nonpoint source pollution in the Chesapeake Bay dramatizes the need for effectively documenting best management practices (BMP's) and other activities. Although an effort to coordinate the wide variety of information about the Bay is underway, the effort does not extend to the systematic tracking of BMP's, and it is only concerned with the Bay. A central point for coordinating information about all types of nonpoint source problems (not just agriculture) nationwide would serve not only the Chesapeake Bay effort, but the other nonpoint source programs underway in most areas of the country.

We need solid data sources upon which to base nonpoint source assessments. Our focus is on how decision-makers can use the data in establishing programs and assessing progress. The experiences of the Lake Erie Wastewater Management Study, for example, can be used to guide similar studies elsewhere (U.S. Army Corps Eng. 1982).

This paper presents the design of a prototype nonpoint source data center and some of the information on which this design is based. In particular, the paper:

- Addresses the types of information program managers say they need,
- Reviews the extent to which some existing information systems and centers may meet needs for nonpoint source data, and
- Outlines a proposal for a new nonpoint source data and information center to provide tracking and information services.

The proposal suggests possible funding sources and staffing needs, but these are secondary to the main issues: who is to be served by the center, and how their needs are to be met.

METHODS

The National Association of Conservation Districts (NACD) studied the needs for a nonpoint source data center with the assistance of an advisory committee drawn from several Federal agencies, States, and groups working in nonpoint source control. These advisors included individuals with expertise in various types of nonpoint pollution, since the goal of such a center, if proposed, would be to include all nonpoint sources, not just agriculture. Following an initial meeting to discuss study goals and methods, we began investigating data sources, conducting interviews, and considering possible ways of structuring a data center.

The study team interviewed State water and soil conservation program managers to gather information on program needs and to test questions to be asked of key State conservation district officials and others through a written questionnaire.

Another area of inquiry was the availability and usefulness of some of the existing and planned data and information centers. The study team visited the Conservation Tillage Information Center and the U.S. Environmental Protection Agency's Chesapeake Bay Program. We telephoned others, such as the Susquehanna Basin Commission, to ask questions about the audiences reached and availability of data bases and to request copies of annual reports and lists of publications. We are currently investigating other information sources.

RESULTS: DATA NEEDS AND USERS

Do Existing Systems Meet Needs?

Participants in the interviews identified several needs for tracking capability and information handling that could be effectively served by a new data center. We also found aspects of State programs in the Chesapeake Bay area that could be adapted and used by other States, such as Virginia's system of tracking and calculating reductions in sediment and nutrients reaching water courses because of BMP installation. However, when needs are considered for the whole country, existing and planned information and data centers leave some gaps in tracking progress and coordination of information sources related to nonpoint source control.

What Needs Might Be Met by a Data Center?

Respondents described many ways a data center could assist their programs. The needs they identified spanned a wide range of topics. Some of them are discussed in the following paragraphs.

Tracking BMP Implementation and Maintenance. State program managers want to track BMP implementation and maintenance, be they publicly or privately funded. Such a system could include information on soil characteristics and biomes or biological communities that would aid in evaluating BMP effectiveness. Data must be keyed to hydrologic units as well as to specific project locations. Also, information must be coordinated and reported among States (for example, a common system for all the States in the Chesapeake Bay Basin), and data must satisfy requests from legislators and regulators.

Linking Soil Conservation and Water Quality Improvements. This item is closely related to BMP tracking. Virginia soil and water conservation officials used a model that can predict reduction of phosphorus transported to receiving waters, given sufficient knowledge of soil type and BMP effects. The Idaho batholith BMP effectiveness study by the U.S. Forest Service also demonstrates this type of linkage. Ability to link soil conservation and water quality improvements will help fill another need: that of demonstrating progress to farmers and legislators. A common database will make available progress reports in any area of interest, no matter how large or small.

Monitoring Atmospheric Deposition of Pollutants. Although it has not received much public recognition, atmospheric deposition is a major cause of water pollution and acidity in many areas. Sources include airborne soil, drift of aerially applied pesticides, and washout or fallout of pollutants from industrial emissions. Calculated loads of phosphorus from the atmosphere in the Great Lakes range from 500 to 1,600 metric tons/yr, depending on the size of the lake (U.S. Environ. Prot. Agency, 1983).

Accessing Various State Guidelines. Some States have developed guidelines for making judgments about BMP's and water quality effects of nonpoint sources. These guidelines can be adapted by other States to serve local needs. Information on measures of water quality may also be shared, for example, surrogate indicators that may be less expensive than some standard tests. Common definitions of BMP's and watershed size could be maintained by a data center to provide a uniform basis for communication. Data on the cost effectiveness of various BMP's also fall under this heading.

Sharing Research Reports. All respondents suggested that an important service of a nonpoint source data center would be to collect information on current and past nonpoint source research. Many institutions are conducting research projects, but until the results are published many others are not even aware that such projects are underway, and duplicative research might result. Early results and a central listing of projects and researchers could be extremely useful to State and local agencies.

Communicating State and Local Program Information. Many State nonpoint source programs are evolving to allow for new cost–sharing. State staff want to review the experiences of other States and choose the best for their own programs. Items needed include laws and regulations for various watershed, land use, and management situations (both actual and model), BMP success and failure stories, and evaluation of various types of incentives.

Providing Technical Assistance. Technical assistance is always identified as an important need by State and local program managers. For example, States and conservation districts want access to experts in various fields, which could be provided through an information center.

Who Will Use Nonpoint Source Data Center?

The primary users of a nonpoint source data center are expected to be State soil and water agency and local conservation district staff and managers. They have the most pressing needs for nonpoint source data and information, especially to prepare program reports for EPA and State legislatures. Conservation districts in particular serve as local nonpoint source control and management agencies with cooperation and support from groups such as the Soil Conservation Service and Extension Service. Depending on the ultimate functions supported, a coordinated data center might provide far-reaching reports and augment State staff in collecting and analyzing data. If a data center collected nonpoint source information from a wide area, it would aid each State in evaluating its program and assessing progress in nonpoint source control.

Federal agency officials would be able to use the center in developing national reports of progress in improving water quality through nonpoint source control and for developing and evaluating policies and national programs. The U.S. Geological Survey, EPA, and the U.S. Department of Agriculture are among potential users. The availability of data collected according to standard reporting items and subjected to quality assurance procedures will improve the confidence of program managers—both Federal and State—in their ability to assess progress.

The public, including farmers, homeowners, and others, is the third group that will certainly use a nonpoint source data center, both directly and indirectly. The center can answer inquiries directly, but it will also respond to State and local agencies that receive information requests from their constituencies. An important function of any nonpoint source center will be to serve as a network focus for these users and to develop effective mechanisms to inform potential users of the services and information available from the center.

Do Existing Systems Meet Some Needs?

Some existing systems do meet many needs for nonpoint source information. Four of them are described in the sections that follow. In general, though, existing systems treat nonpoint source data incompletely or lack the focus needed by decisionmakers. Many of them limit themselves to a restricted geographic area, and most are not specific in their analysis of nonpoint source issues. In most cases, scientific research related to nonpoint sources is more heavily weighted than practical field solutions; yet the latter are what most correspondents are after.

USDA Tracks Its Cost-Sharing. The Conservation Reporting and Evaluation System (CRES) is used by the Soil Conservation Service and the Agricultural Stabilization and Conservation Service. It includes information from:

- 335 counties statistically selected to report CRES data;
- P.L. 566 Watershed Protection and Flood Prevention projects;
- Resource conservation and development projects (RC&D) providing financial assistance for land treatment cost-sharing; and
- Rural Clean Water Program (RCWP) projects carrying out comprehensive monitoring and evaluation activities.

CRES is designed to produce a statistically reliable national progress report and will provide summary reports of individual P.L. 566 and RC&D projects. However, because of the statistical nature of data, analysis of smaller areas such as specific farms or counties is not valid. Also, data are reported by county, not by hydrologic unit; thus land area affected by BMP's cannot be readily tied to effects on water quality. Current reporting in CRES does not account for BMP's installed without Federal cost-sharing, although it does track technical assistance by the Soil Conservation Service.

The Chesapeake Bay Program Handles Many Inquiries. EPA's Chesapeake Bay Program and related organizations such as the Citizen's Program for the Chesapeake

Bay, Inc., provide central points of contact for information specifically related to the Bay. Activities of the Citizen's Program include publication of a newsletter. The EPA Bay Program maintains a database of the Chesapeake Bay research data, accessible through an information system called CHESSEE. This database is not designed to provide analysis of small detailed areas, such as effects of BMP implementation on a particular watershed.

EPA's Bay Program staff are developing a Bay-related network to improve coordination of information among all groups working on problems in the Bay drainage area, with the goal of making better use of existing information rather than generating new information. However, this program does not track BMP implementation and other technical data. It is also not set up to provide program progress and evaluation functions.

Susquehanna Basin Commission Serves Pennsylvania and New York. The concern of the Susquehanna Basin Commission is reflected in its name. The Commission, recognizing the contribution of the Susquehanna River and its tributaries to pollution in the Chesapeake Bay, has conducted monitoring programs to determine sources and magnitude of nonpoint source problems. However, nonpoint source pollution is only one of several mandates of this commission; and, because it is concerned with a particular geographic location, its utility is limited for program managers who consider the "big picture."

A National Water Resources Research Center and Information Clearinghouse Has Been Proposed. A study for the Council on Environmental Quality by the Chesapeake Research Consortium reported several options for research and information functions related to water resources. The information-related options include a referral center, an information clearinghouse that would obtain material for requestors, and a national coordinating center for regional or State water information clearinghouses (Chesapeake Res. Consor. 1984). Serving a very broad audience, the center would include information on all water topics, not just nonpoint source pollution. However, the information-related proposal describes a "passive" center, which would use various existing sources and not collect its own data; one research center proposal included data collection, but no plans for funding have been made by Congress yet. A nonpoint source data center would be a source on which a water resources information clearinghouse would be likely to draw for some of its information needs.

PROPOSAL: SPECIFICATIONS FOR NONPOINT SOURCE DATA CENTER

What Structure and Functions Should the New Center Have?

Location of a Center

A nonpoint source data center could be established in several ways, each with its own advantages. The center could be:

- Sponsored by a private organization,
- Established in conjunction with a State water resource center, or
- Located at a Federal or State agency.

A nonpoint source data center established as a component of a private organization would have the advantage of equal access to all. It would be independent and would be supported by a board of directors representing a cross-section of interests concerned with nonpoint source abatement. Even if supported financially by some of its constituent groups, having many sources of support would tend to dilute the possible influence of any one group on policy or activities.

A center established at a State water resource center could easily tap existing data systems. The process of beginning operation might be eased, presuming appropriate space is available at the State center. However, State-related information and problems might predominate, particularly if some staff are shared between the two centers.

Located at a Federal or State agency, a nonpoint source data center would have access to some necessary expertise. However, by establishing close ties to that agency it might lose objectivity in data collection and analysis.

Funding and Staffing

A nonpoint source data center could be supported in a variety of ways and probably should rely on a combination of sources. The potential availability of these sources has not been evaluated, so they are merely listed here: government grants, corporate contributions, and membership fees.

The staff should include individuals with experience in nonpoint source control, information management, and computer data analysis; they could be hired full- or part-time, or as consultants. Staff could be assigned from Federal agencies, as has been done with the Extension Service and the Conservation Tillage Information Center.

Center Functions

The study has identified several key needs that a new nonpoint source data center could fill. Some of the functions are currently handled in States and other centers, but existing mechanisms often serve only one State or limited geographic area. If a State or other group has an effective method of data collection or analysis, the nonpoint source center would try to use or adapt it. Although we cannot go into all aspects of the institutional structure of a nonpoint source data center here, the results of this study show that such a center should include at least the following functions to be responsive to existing needs:

- Actively seek information on current research projects and reports of completed work, and maintain bibliographic access systems (including information on atmospheric deposition);
- Gather information on State nonpoint source programs and develop fact sheets and analyses to facilitate access to the information;
- Compile State and local laws and regulations and case studies of BMP successes and failures;
- Provide technical assistance to users through literature searches, advice on BMP's, assistance with development of pollution potential maps, and other projects;
- Develop the capability to analyze BMP information and provide reports on water quality and other effects to State agencies, Federal agencies, individuals, and interested groups;
- Work with EPA to create or adapt a computer-based system to track BMP implementation in selected areas; and
- Perhaps most important, develop effective mechanisms to inform potential users of the information and services available from the center.

CONCLUSIONS

There is a need for a nonpoint source information center, probably including a data component, although the latter may be difficult and expensive.

A new nonpoint source data center should probably be separate from existing and proposed water resource or water quality centers. Some economies are associated with integrating the new functions into an existing institutional setting; however, such economies are outweighed by the need for increased visibility of and emphasis on nonpoint source pollution. Historically, nonpoint source concerns have received lower priority than other water quality programs. Establishment of a separate data center devoted to nonpoint source concerns would help raise the level of awareness about this issue.

A nonpoint source center must focus on information and data for program management and decisionmaking, as opposed to the strict research orientation of most existing and proposed data resources. In addition, it should eventually collect and analyze data and produce reports to meet the needs of its clients.

As outlined above, its functions may be an ambitious undertaking, but they need not be accomplished simultaneously. At first the center might concentrate on serving a limited area and on only one source (e.g., agriculture or siliviculture). In developing a final proposal for a center, the need for various activities will be assessed, and the top one or two will be initiated, with others to follow as resources allow. Thus, a center can be developed and grow in a planned, logical way.

ACKNOWLEDGEMENTS: The author thanks Bob Williams and Mary Garner of NACD for their assistance during the project and their comments on this paper. This project is supported by a grant from the U.S. Environmental Protection Agency. The ideas presented here are those of the author and various interviewees and do not necessarily represent the views of the author.

REFERENCES

Chesapeake Research Consortium. 1984. Alternatives for a National Water Resources Center and Information Clearinghouse. Pub. No. 120 CRC, Inc., Gloucester Point, VA.

U.S. Army Corps of Engineers. 1982. Lake Erie Wastewater Management Study. Final Rep.

U.S. Environmental Protection Agency. 1983. Region 5 Environmental Management Report, Parts 1 and 2.

WATER QUALITY DATA AND URBAN NONPOINT SOURCE POLLUTION: THE NATIONWIDE URBAN RUNOFF PROGRAM

DIANE NIEDZIALKOWSKI
DENNIS ATHAYDE
U.S. Environmental Protection Agency
Washington, D.C.

ABSTRACT

Prior to 1960, concerns about urban stormwater were related primarily to flooding and drainage problems. More recent studies have focused on characterizing and quantifying pollutants in stormwater or developing methodologies for reducing loads. While such research contributes to understanding urban nonpoint source runoff, it does little to illuminate the cause/effect relationship between stormwater and associated water quality of the receiving water. Water quality planners need information to guide their stormwater management decisions to help them determine: (1) if there is a problem; (2) the significance of the problem; and (3) whether they need to do anything about it. Lack of good data and appropriate methodologies have often been cited as the reason it is difficult to relate stormwater runoff to the water quality associated receiving waters. This paper describes the Nationwide Urban Runoff Program (NURP) sponsored by EPA which was undertaken to respond to these needs by providing support, data, and methodologies for urban nonpoint source problem assessment and water quality planning.

INTRODUCTION

The reduction of pollution from industrial and municipal point sources has been the main regulatory focus of water pollution control efforts since the passage of the Clean Water Act in 1972. Less emphasis has been placed on nonpoint source pollution; those pollutants mobilized by storm events and transported by runoff across the land surface. Point source pollution controls alone are insufficient to meet the objectives of the Clean Water Act. Research by Gianessi and Peskin (1981) shows that for some waterbodies, nearly all of the phosphorus and nitrogen, more than half of the biochemical oxygen demand (BOD), and many toxic substances are contributed by rural and urban nonpoint sources. In their most recent biannual reports to the U.S. Environmental Protection Agency on progress toward achieving water quality objectives and designated uses, the majority of the States have identified nonpoint sources as the principal cause of remaining water quality problems (U.S. Environ. Prot. Agency, 1985).

The focus of this paper is on the Nationwide Urban Runoff Program (NURP), a data collection effort sponsored by the Environmental Protection Agency from 1978 to 1984 to improve the information available for assessing urban nonpoint source pollution.

NONPOINT SOURCE POLLUTION

General Overview

The nature of nonpoint source pollution makes it more difficult to characterize, quantify, and control than pollution from point sources. Even so, the following characteristics are associated with both rural and urban nonpoint sources of pollution:

1. Pollution is generated by a wide variety, and large number, of activities rather than discrete, identifiable sources.
2. Pollution is conveyed to surface waters by runoff, stormwater culverts, or groundwater percolation.
3. Pollution is intermittent because of its relationship to storm events and the hydrologic cycle.
4. Pollution is difficult to detect because of the low frequency and short duration of storm events.

Urban nonpoint source pollution is a widely occurring problem, estimated to affect 20 percent of the river miles located in more than half of the watersheds in the United States (U.S. Environ. Prot. Agency, 1984).

The predictability and uniformity of effluents from point sources (particularly discharges from sewage treatment plants) allow end-of-pipe technologies to be used for meeting effluent discharge limits. However, because urban runoff is associated with storm events and the hydrologic cycle, it is generated in pulses. Therefore, no "technological fix" can be uniformly applied to reduce nonpoint source inputs to receiving water, even though nonpoint source runoff may include many of the same pollutants found in point source effluents.

Urban Runoff: Quality and Quantity

Urban development generally results in changes in land use that reduce the land surface area, allowing water to infiltrate while increasing impervious surface areas such as roof tops, streets, and sidewalks. For a given storm event, an urban area will contribute a larger volume of runoff more quickly than an undeveloped area. Such increases in runoff rate and total volume often considerably effect erosion, flooding, and the quality of the receiving water. Thus, urban runoff can be viewed as a two dimensional problem resulting from the *quantity* and *quality* of runoff produced by storms.

Effects on Water Quality

Many of the pollutants commonly found in stormwater runoff, including sediment, nutrients, metals, toxics, and bacteria can affect the quality of urban streams and lakes. Sediment and silt are carried in runoff from streets, construction sites, and eroding land. The pollutants associated with the sediments from these sources and urban activities are generally not as benign as the natural mineral sediments that result from soil erosion. Sediment is often the major pollutant in urban runoff, and is associated with the following problems: (1) decreased carrying capacity in storm water sewer systems, resulting in greater flood potential; (2) increased dredging costs for maintaining navigation channels; (3) higher pretreatment costs for municipal and industrial users depending on sources affected by runoff; (4) aesthetic degradation; and (5) transport of phosphorus, pesticides, and toxics.

The effects of surface particulates (from tire wear, auto exhaust, and road deterioration) on receiving waters tend

---

The opinions expressed in this paper are those of the authors and do not necessarily reflect any policies or decisions of the U.S. Environmental Protection Agency.

to be more chemical than physical. Nutrients, particularly phosphorus and nitrogen, are contributed to runoff by fertilizers applied to parks and lawns. Additional sources of nutrients (and bacteria) are pet wastes and malfunctioning septic systems. In some areas, atmospheric deposition is a significant source of phosphorus. Heavy metals, such as lead, copper, and zinc are not uncommon in urban runoff. Although heavy metals and organic chemicals do not usually produce an acute and immediately observable impact, such as a fishkill, these pollutants may accumulate in living tissue or sediment and may have long term detrimental effects on individual organisms and ecological communities.

Effects From Quantity of Runoff

The potential impacts urban runoff volumes on receiving water, particularly on streams, equal the water-quality effects in importance. Increased flow and velocity in streams from stormwater inputs can erode streambanks and resuspend bottom sediments, increasing turbidity in the receiving water. Disturbed sediments may also increase the availability of sediment-bound phosphorus, encouraging algal growth and accelerating eutrophication. Toxic substances, which may be relatively innocuous when bound to undisturbed sediments, can become available when resuspended.

The volume of runoff and corresponding pollutant load is related to a number of factors, including intensity and duration of the storm, length of time since the last storm, and land use. Urban activities that disturb land cover and alter natural drainage patterns also affect urban runoff. Figure 1 from the Results of the Nationwide Urban Runoff Program; Vol. 1—Final report (U.S. Environ. Prot. Agency, 1983) illustrates the relationship between paved land area and runoff. As the percentage of paved surfaces in a given area increases, the rate of runoff and corresponding pollutant load also increases.

THE NATIONWIDE URBAN RUNOFF PROGRAM (NURP)

Early Urban Runoff Concerns

Drainage, be it nuisance flooding of basements or catastrophic floods resulting in loss of life and property, has historically been the primary concern in urban runoff. Recently, concern has expanded to include the potentially deleterious effects on water quality. Many of the early 208 Areawide Water Quality Management Plans from the 1970's indicated that urban runoff contributed to water quality degradation. However, because data were not often collected during the development of 208 plans, the relationship between urban runoff and water quality was often difficult to assess. Where data were available confounding, physical and chemical reactions in the receiving water caused additional complications. In those communities where urban nonpoint problems had been clearly identified, reluctance to commit money for control devices of questionable effectiveness understandably existed.

The NURP Program

In 1978 EPA responded to the need for consistent and verifiable data on urban runoff by initiating a multiyear study called the Nationwide Urban Runoff Program (NURP). NURP had three major objectives: (1) develop consistent and verifiable data on the quality of urban nonpoint source runoff and the effects on the receiving water; (2) develop practical data on the relative costs and effectiveness of control measures; (3) respond to Congressional concern over whether urban runoff was a large enough problem to mandate a control approach similar to that in the Construction Grants program for treating stormwater.

Data were collected at 28 separate project sites, chosen from among the 1976 Areawide Plans that had identified

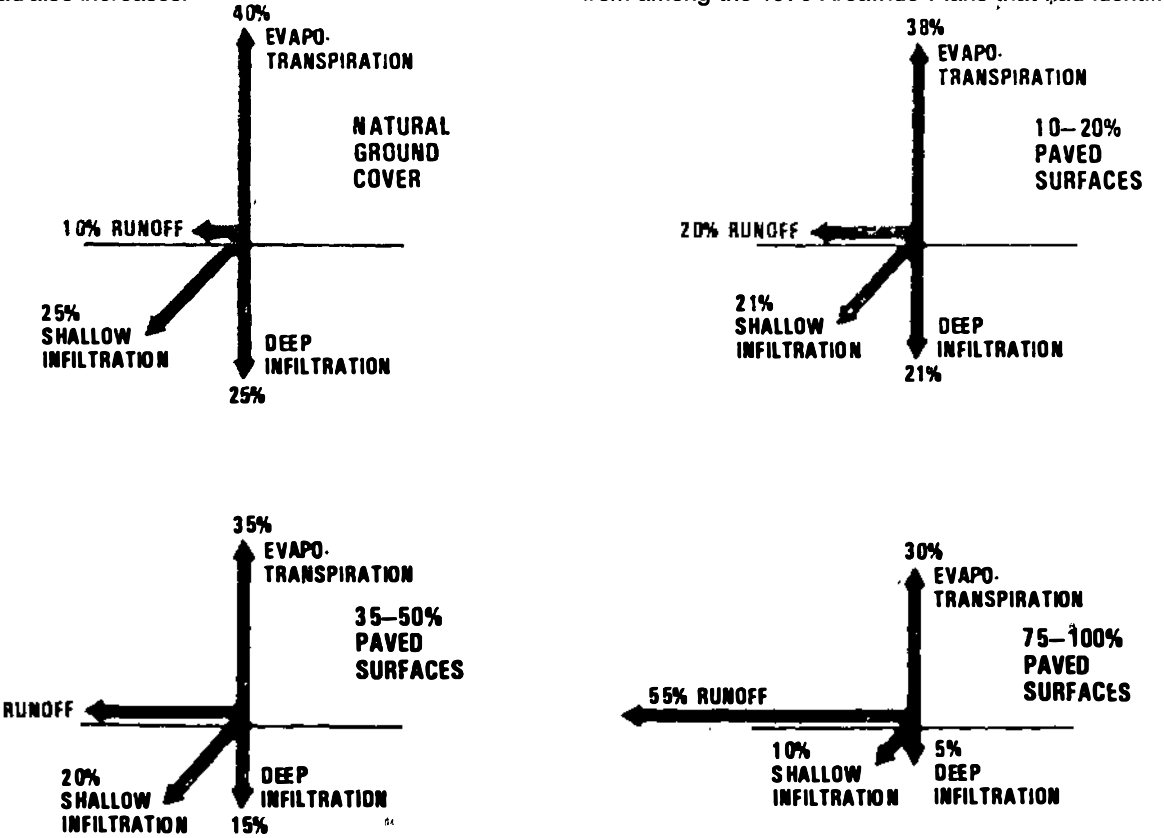


Figure 1.—Typical changes in runoff flows resulting from paved surfaces.

Source: J.T. Tourbier and R. Westmacott, *Water Resources Protection Technology: A Handbook of Measures to Protect Water Resources In Land Development*, p. 3.

urban runoff as a significant problem (Fig. 2). The projects were geographically dispersed throughout the United States in an attempt to collect representative data on climate, soils, geology, and other factors which interactively affect the quality and the quantity of runoff from the Nation's diverse urban areas. Each NURP project was managed independently at the local level with oversight and technical assistance in developing standard data collection methodologies from EPA Headquarters. Consistency in data collection ensured that differences in data among the projects were related to the urban area, not methodology.

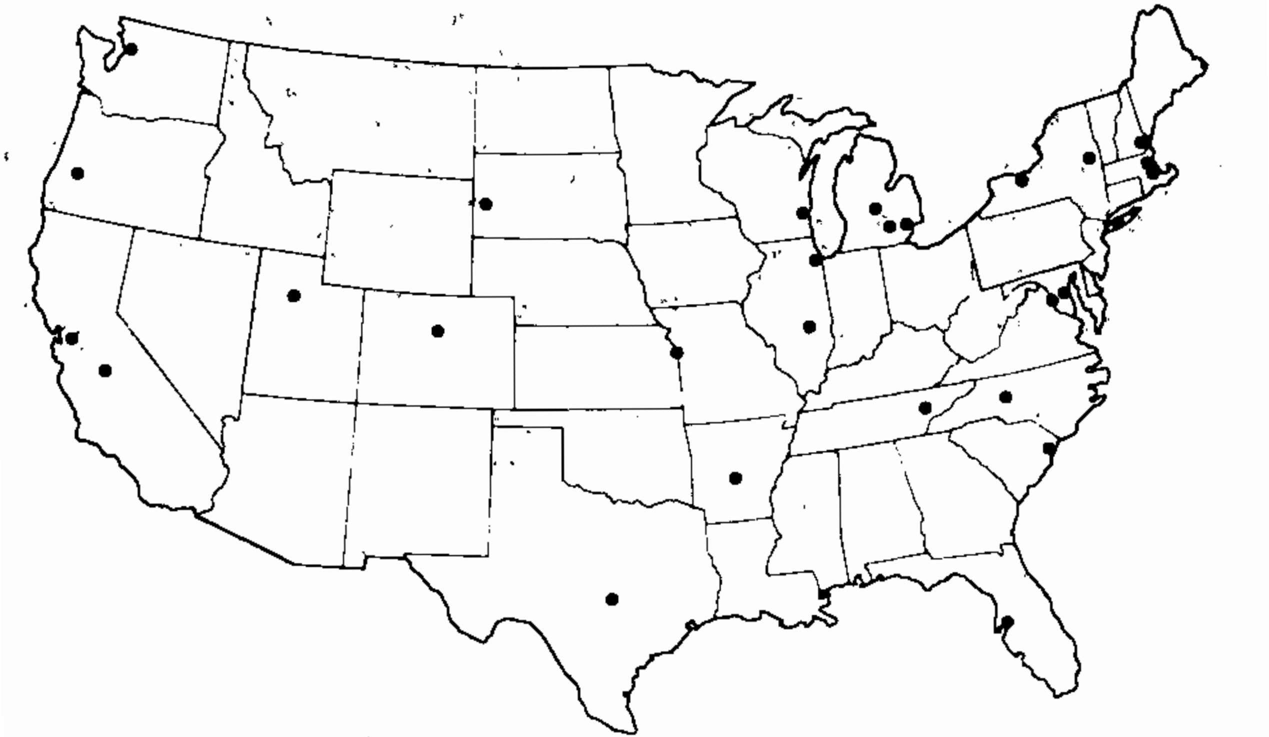
Five categories of standard pollutants were monitored in stormwater runoff and ambient receiving water at each of the 28 NURP sites (Table 1). At 20 of these locations, samples were also collected for priority pollutants, including pesticides, metals, PCB's, and organics. Nine of the projects collected engineering and economic data on best management practices (BMP's), and BMP systems for controlling runoff. Data were collected on wet and dry detention basins, street sweeping, and two "living filter" approaches—grassy swales and wetlands.

RESULTS

Objective I: Data Base Development

The first objective of NURP was met by developing a data base for characterizing urban runoff and evaluating the impacts of runoff on receiving waters. Data were collected from 2,300 separate storm events, at 22 NURP sites, in 81 drainage basins within the NURP sites. Pollutant concentrations were represented as averages using a summary statistic called an "event mean concentration" (EMC), chosen to meet NURP's objective of characterizing runoff by a pollutant's average value for a given storm and site, not its fluctuations within that storm event.

Urban runoff is stochastic and is generated in pulses in association with unpredictable storm events. The data were analyzed using an innovative statistical approach that explicitly considered the inherent variability of the runoff data. This methodology is similar to that used in predicting the frequency of occurrence of floods. The NURP data base was used to develop a screening model for



EPA Region	NURP Code	Project Name/Location	EPA Region	NURP Code	Project Name/Location
I	MA1	Lake Quinsigamond (Boston Area)	V	IL1	Champaign-Urbana, Illinois
	MA2	Upper Mystic (Boston Area)		IL2	Lake Ellyn (Chicago Area)
	NH1	Durham, New Hampshire		MI1	Lansing, Michigan
II	NY1	Long Island (Nassau and Suffolk Counties		MI2	SEMCOG (Detroit Area)
	NY2	Lake George		MI3	Ann Arbor, Michigan
	NY3	Irondequoit Bay (Rochester Area)		WI1	Milwaukee, Wisconsin
III	DC1	WASHCOG (Washington, D.C. Metropolitan Area)	VI	AR1	Little Rock, Arkansas
	MD1	Baltimore, Maryland		TX1	Austin, Texas
IV	FL1	Tampa, Florida	VII	KS1	Kansas City
	NC1	Winston-Salem, North Carolina	VIII	CO1	Denver, Colorado
	SC1	Myrtle Beach, South Carolina		SD1	Rapid City, South Dakota
	TN1	Knoxville, Tennessee		UT1	Salt Lake City, Utah
			IX	CA1	Coyote Creek (San Francisco Area)
				CA2	Fresno, California
			X	OR1	Springfield-Eugene, Oregon
				WA1	Bellevue (Seattle Area)

Figure 2.—Locations of the 28 NURP projects.

Table 1.—Standard pollutants and bacteria adopted by the NURP study to characterize the pollutants in urban runoff.

1. TSS—Total Suspended Solids
2. BOD—Biochemical Oxygen Demand
3. COD—Chemical Oxygen Demand
4. TP—Total Phosphorus (as P)
5. SP—Soluble Phosphorus (as P)
6. TKN—Total Kjeldahl Nitrogen (as N)
7. N—NO_2 + NO_3 (Nitrite + Nitrate) (as N)
8. Cu—Total Copper
9. Pb—Total Lead
10. Zn—Total Zinc
11. Total Coliform
12. Fecal Coliform

predicting instream concentrations of pollutants contributed by urban runoff. Data from 30 to 40 storm events, 50 years of streamflow, and 50 years of rainfall are needed to use the model as a screening tool. The reliability of the model was tested at the NURP site in Rapid City, South Dakota. The test results found the model very accurate in predicting in-stream pollutant concentrations that approximated the concentrations actually found in the monitored samples.

The data showed that geographic location, land use category, and other factors such as slope or population density cannot be used to predict pollutant concentrations in runoff. However, land use category was useful for predicting the volume of runoff generated since it was shown to be a function of the percentage of paved or impermeable surfaces in a given land area.

Oxygen-demanding substances and total suspended solids were usually present in runoff, sometimes in concentrations comparable to effluents from secondary sewage treatment plants. Nutrients were generally present, and with few exceptions, the concentrations were found to be insignificant compared to other pollutants.

Those sites monitoring runoff for priority pollutants found that heavy metals, particularly lead, copper, and zinc, were by far the most frequently detected priority pollutants. Acute water quality criteria were exceeded for copper in 47 percent of the samples, and for lead in 23 percent. Exceedences of chronic water quality standards for priority pollutant metals were detected in 94 percent of the samples for lead, 82 percent for copper, and 77 percent for zinc. These data represent *runoff* characteristics, and do not necessarily imply that an actual violation of ambient water quality standards occurred.

Objective II: BMP Costs and Effectiveness

The BMP's that were evaluated in the NURP program can be grouped in four categories: (1) detention devices; (2) recharge devices; (3) street sweeping; and (4) other, which included the "living filter" approach—grassy swales and wetlands. Local participants choose which BMP control options to study. Their choices reflect local perceptions of what may be feasible and practical to implement.

Six NURP projects evaluated detention devices. Adequately sized wet detention basins demonstrated removal efficiencies in excess of 90 percent for particulates, total suspended solids, and lead. Biological processes produced significant reductions (50 percent or more) in soluble nitrates and phosphorus. Dry basins, designed to attenuate peak runoff, and therefore, only briefly detain stormwater, are ineffective in reducing pollutant loads. Approximate costs for wet ponds sited within urban areas with relatively small populations ranged from $500 to $1500 for each acre of urban area served. Offsite ponds serving larger urban areas were slightly less expensive, ranging from $100 to $250 for each acre of urban area served. The differences in costs relate to the economies of scale for larger ponds.

The possible contamination of ground water by control measures that enhance runoff infiltration has caused some concern. Ground water was monitored from aquifers underlying urban runoff detention basins on Long Island, New York, and in Fresno, California. Monitoring data showed that heavy metals, organic priority pollutants, pesticides, and coliform bacteria were attenuated in the soil matrix and prevented from reaching the ground water.

Street sweeping was evaluated at 5 of the 28 NURP projects to determine the effectiveness in reducing the accumulation of contaminants on streets. A statistical analysis of the data showed no significant reduction in the event mean concentration for lead, total suspended solids, or chemical oxygen-demanding substances between swept and unswept streets for four of the sites. At one site with pronounced wet and dry seasons, sweeping just prior to the rainy season possibly reduced accumulated pollutants and lessened the pollutant load washed off streets in runoff. The unit cost of operating a sweeper varied from $16.80 to $45.45 per hour of operation; and from $5.95 and $23.36 per curb mile swept.

The two living filter approaches to urban runoff management studied were grassy swales and wetlands. Grassy swales were studied in two NURP projects. At one project, monitoring data from three swales showed no effect in attenuating pollutants. At the second site, a carefully designed artificial swale reduced heavy metal pollutants by approximately 50 percent. Chemical oxygen-demanding pollutants, nitrates, and ammonia were reduced about 25 percent. These NURP results suggest that grassy swales are a practical and potentially effective technique for managing urban runoff if they are designed carefully. Wetlands are considered by many to be a promising technique for control of urban runoff water quality. One project monitored a natural wetland, but the investigation was not adequate to identify wetland characteristics or artificial wetland design specifications with performance capability.

Objective III: Need for Another Construction Grants Program

The third objective of the NURP study was to respond to a Congressional concern of whether urban runoff was significant enough to mandate a stormwater treatment program on the magnitude of the Construction Grants program.

An analysis of rainfall records for a wide distribution of locations across the United States showed that storm events that produce urban runoff only occur about 10 percent of the time, even for the wetter parts of the country. Pollution from runoff is only a problem for a few hours per month, at intervals of every several days or longer, depending on the season and geographic location. The NURP study concluded that urban runoff was not a high priority problem needing a construction grants approach because of the infrequency of storm events, the short duration of the individual storm events, and the relative harmlessness of runoff compared to other sources of water pollution.

CONCLUSIONS

Since nonpoint source pollution is site-specific, a case-by-case evaluation is needed to pinpoint problem areas and identify solutions. The screening model developed during the NURP study provides a tool for local planning agencies to use with their own monitoring data to identify the most significant runoff problems. The monitoring data can be used with the model to simulate the effects of alternative strategies on the pollutant concentrations in the receiving waters. Local governments can use this information to develop urban nonpoint management strategies that are the most environmentally sound and cost-effective solutions to the site-specific problems.

The NURP project has precipitated a number of issues and questions that warrant further investigation. Uncertainties remain about the relationship between sources of pollutants, their fates, and downstream impacts. The potential long-term cumulative effects of nutrients and toxic pollutants in the sediments or urban lakes and streams also warrants further investigation.

The NURP database, which is being put into a more useable format contains a wealth of information that could provide insights to these uncertainties. Specific areas of future investigation might include:

- Is there a relationship between the pH of rainfall, the pH of urban runoff, and the concentrations of certain pollutants? What does this relationship tell us about acid precipitation?
- What are the historical trends in pollutant concentrations between basins at a given site, and among NURP sites nationwide?
- Is there a relationship between lead levels in runoff and consumption of lead-free gasoline?
- What are the long-term effects of priority pollutants that exceed acute and chronic freshwater criteria?

REFERENCES

Gianessi, L.P., and H.M. Peskin. 1981. Analysis of National Water Pollution Control Policies. Vol. 2. Agricultural sediment control. Water Resour. Res. 17(24): 9–27.

U.S. Environmental Protection Agency. 1983. Results of the Nationwide Urban Runoff Program; Vol. 1—Final Report. Washington, D.C.

________. 1984. Report to Congress: Nonpoint Source Pollution in the U.S. Washington, D.C.

________. 1985. National Water Quality Inventory: 1984 Report to Congress. Washington, D.C.

THE RFF NATIONAL DATA BASE FOR NONPOINT SOURCE POLICY ASSESSMENTS

LEONARD P. GIANESSI
Resources for the Future
Washington, D.C.

ABSTRACT

This paper discusses a newly developed data base for national quantitative assessments of the nonpoint source water pollution problem. A variety of methods have been used to integrate often disparate sources of information into a unified inventory of nonpoint sources. The type of quantitative information needed to locate and quantify nonpoint source levels includes a wide variety of demographic, hydrologic, meteorologic, engineering, and field measurement data. A variety of benchmark years has been employed in the various sources of data. Lack of data for certain parameters requires the assumption of average values for very large regions. While it is desirable to integrate point and nonpoint sources of water pollution into the same inventory, often this means conversion of nonpoint source data using extremely simplified procedures. The type of information required and actually used for validation of the estimates contained in the RFF data base is discussed. Finally, suggestions are made for priorities in the future collection of data and information to make it possible to improve the accuracy of the estimates.

INTRODUCTION

The Resources for the Future Environmental Discharge Inventory (REDI) describes the discharge of 17 pollutants and nonpoint sources throughout the United States: 5-day biochemical oxygen demand, total suspended solids, total phosphorus, total Kjeldahl nitrogen, chemical oxygen demand, lead, cadmium, chromium, copper, mercury, iron, arsenic, zinc, oil, PCB's, coliforms, and other chlorinated hydrocarbons.

The data reflect average daily and average annual discharge levels for a recent year, circa 1977–81. All records in the inventory are identified by county location, U.S. Geological Survey hydrologic unit location, and Standard Industrial Classification. Summaries are easily prepared at the national, State, Aggregated Subarea (ASA), USGS subbasin, and Standard Industrial Classification (SIC) level.

For point sources, these estimates are made for approximately 40,000 individual plants—municipal sewage plants and industrial facilities. In addition, urban runoff records are included for all cities in the United State with more than 10,000 inhabitants.

The data sources and methods used to make the point source and urban runoff discharge estimates have been fully described in a recent report to the USGS (Gianessi and Peskin, 1984).

This paper focuses on the methods and data used to assemble the rural nonpoint source inventory developed as part of an ongoing project sponsored by the Water Resources Division of USGS, the Soil Conservation Service of the U.S. Department of Agriculture, and the U.S. Environmental Protection Agency. The data and results support several activities included in USDA's 1985 Resoure Conservation Act Report to Congress.

SEDIMENT FROM RURAL LANDS

The major part of our rural nonpoint source discharge inventory consists of records that estimate agricultural sediment and pollutants associated with sediment that reaches waterways. The basic data source is the 1982 National Resource Inventory conducted by USDA (Soil Conservation Serv. 1984). The Inventory provides estimates of gross soil erosion (in tons of soil lost per acre) at approximately 799,000 sample points throughout the United States by using the Universal Soil Loss Equation. The sample data were statistically extrapolated to cover all nonfederal land in each U.S. county, yielding a national estimate of gross soil erosion for nonfederal cropland acreage of 1.8 billion tons per year. We used the Inventory to compute county level estimates of gross soil erosion, according to rural land use (cropland, pasture, range, woodland) and according to soil texture (sand, loam, silt, clay).

Our next step was to estimate the fraction of gross soil erosion that becomes sediment lost to waterways. For this purpose, USDA provided us sediment delivery curves that estimate the fraction of gross soil erosion that becomes sediment as a function of river basin drainage density and soil texture. The estimated sediment delivery ratios are higher for areas with more stream miles per unit of area and with finer soil particles such as clay. A comprehensive set of State drainage density estimates was provided by USDA, as derived from the Phase II, 1977 National Resource Inventory (which was not repeated as part of the 1982 Inventory). We assumed that all counties in a State have the same average drainage density as the State value. By using county estimates of gross soil erosion classified by soil texture, the county average drainage density values, and the USDA curves, we estimated sediment discharge to waterways by county and by rural agricultural land use.

For the Nation as a whole, we estimate that approximately 40 percent of the gross soil erosion on agricultural land becomes sediment lost to waterways. For nonfederal cropland, the national sediment loss estimate is 1.8 trillion pounds per year. Although these estimates may appear to be high, our concept of sediment delivery ratio differs from the definition widely used in other studies. Those studies define the ratio as the amount of sediment exiting from a basin as a fraction of the gross soil erosion occurring within the basin. Thus, deposition of soil in reservoirs and flood plains within the basin is not included in the ratio. Since our concept of the sediment delivery ratio includes *all* soil lost to waterways within a basin, our estimates will be higher.

Our next problem was to estimate the amount of pollutants associated with the sediment that moves into the waterways with the sediment. These pollutants include nutrients (nitrogen and phosphorus), organics (which account for 5-day biochemical oxygen demand) and individual heavy metals (such as lead, copper, chromium, and zinc). For this task we used two sources of data that characterize the average surface layer content of soils for Major Land Resource Areas (MLRA's) throughout the United States. The USGS has sampled surface soils throughout the country, in a systematic program to determine the normal elemental composition of surface soil (Shacklette et al. 1971). We overlaid maps of MLRA's onto the USGS survey maps and assigned each USGS sampling point to an MLRA for chromium, lead, copper, zinc, and phosphorus. Once all the sampling points were assigned to MLRA's, the average for each element in the MLRA was computed.

The second source of data was the USDA series of individual State reports of Soil Survey Laboratory Data. From this source we extracted the fraction of organic carbon and organic nitrogen at each sample point along with the identification of the MLRA where the soil survey was made. An average carbon and nitrogen value was then computed for each MLRA and for each county within the MLRA.

Several adjustments were made to the data to estimate ratios for pollutants attached to the sediment. We assigned an enrichment factor of 2 for phosphorus, organic nitrogen, and organic carbon, to estimate the higher concentrations expected in eroded soil (Tubbs and Haith, 1980). We also estimated 5-day biochemical oxygen demand as 0.1 times the soil organic matter content (Midw. Res. Inst. 1977).

The estimates of sediment-related pollutant levels for the Nation are very large. For nonfederal cropland, we estimate 8.2 billion pounds a year of BOD_5 and 6.2 billion pounds a year of nitrogen are lost to waterways. In contrast, for all points sources in the United States, we estimate 6.1 billion pounds a year of BOD_5 and 2.5 billion pounds a year of nitrogen discharged to waterways.

To complete the rural land sediment discharge inventory, we made two other sets of estimates. First, we needed to make estimates for Federal lands since the 1982 Inventory is limited to nonfederal lands only. This limitation could be significant, since some states (particularly in the West) have sizable Federal land acreage. For example, two-thirds of Utah is federally owned.

From the General Services Administration Inventory File of Property Owned by the Federal Government (Gen. Serv. Admin. 1983), we estimated Federal rural land use acreage by county. We then assumed that the county per-acre gross soil erosion and soil texture distribution estimates derived from the 1982 Inventory for nonfederal lands also applied to Federal lands in the county. Once we estimated the gross soil erosion for Federal lands by county, we followed the same steps to estimate sediment loss and estimates of sediment-attached pollutants.

We also estimated countywide sediment loss and pollutant estimates for other sources of erosion. These include streambanks, roadsides, gullies, and construction sites. Data on these sources were included as part of Phase II of the 1977 Inventory and are readily available at the State level. Again, the estimates are quite large: 1.1 billion tons a year in gross soil erosion nationally. We prorated the State estimates back to counties in proportion to area. We also extrapolated the estimates to include Federal lands in proportion to acreage. We arbitrarily assume that 67 percent of the gross soil erosion from these sources become sediment and that pollutant concentration in the eroded soil is equal to 10 percent of the level for surface soil. After all these steps, the resulting nonpoint source inventory includes estimates of sediment and associated pollutant loss from cropland, rangeland, pastureland, woodland, streambanks, gullies, roads and construction sites from both Federal and nonfederal lands for all 3,150 U.S. counties.

LIVESTOCK RUNOFF

We have also estimated the quantities of pollutants discharged in livestock runoff for all U.S. counties. To do this we used the 1982 Census of Agriculture (U.S. Dep. Comm. 1984) to estimate the number of animals by species on farms by county and multiplied the totals by USDA estimates of the quantity of waste voided by livestock and poultry species in terms of pounds per animal per year (Van Dyne and Gilbertson, 1978). USDA has also estimated for each State livestock waste loss rates resulting from volatilization, runoff, and seepage (Van Dyne and Gilbertson, 1978). By arbitrarily assuming that one-third of the loss rate is attributable to runoff to surface waters, we estimate for each State (and each county in a State) the amount of livestock waste lost to waterways. For most States the estimated livestock runoff rate is as low as 0 to 6 percent.

We use pollutant coefficients that describe the average characteristics of livestock runoff (Morton and Loehr, 1980) to estimate the amount of associated pollutants (such as organics and nutrients) carried into waterways.

Although the aggregate quantities of pollutants in livestock runoff are not as large as the quantities associated with sediment, livestock runoff accounts for almost 100 percent of the fecal coliforms discharged to waterways in rural areas.

NUTRIENT RUNOFF

We used the Cornell Nutrient Simulation Model (Tubbs, 1980) to estimate annual loading of dissolved nitrogen and dissolved phosphorus to surface waterways from cropland for the entire United States for nonsediment sources. This model estimates direct runoff, percolation, and evapotranspiration losses. It also estimates a monthly soil nutrient budget for N and P, as a function of fertilizer inputs, crop nutrient uptakes, and losses of dissolved N and P to runoff and percolation. In addition, transformation of plant nutrients from fixed to plant-available forms are estimated according to soil and meteorologic conditions.

Necessary input parameters for the Cornell model are separated into three categories: meteorologic inputs, soils data, and crop practice data. Meteorologic inputs are needed to operate the stochastic meteorologic model, and include average monthly precipitation, average number of days with precipitation by month, and average summer and annual air temperatures. These data were collected in central weather stations for each of 42 meteorologic regions.

The Cornell model was applied for a 10-year simulation of unit loadings of runoff (cm/yr) and dissolved nitrogen and phosphorus losses (kg/ha/yr) for each modeled crop in each MLRA. The results for all MLRA's were averaged into Land Resource Regions (LRR's).

Total harvested cropland acreage estimates were drawn from the 1982 Census of Agriculture for each modeled crop for all counties. Based on a counties MLRA assignment, each county was assigned to a Land Resource Region. By multiplying a county's crop acreage estimates by the appropriate LRR loading coefficients, annual runoff and loads of phosphorus and nitrogen runoff were estimated by crop. By summing across crops, estimates are made of countywide dissolved nutrient runoff losses from cropland.

The national totals for nitrogen and phosphorus dissolved in overland runoff are not large compared to the amounts of nitrogen and phosphorus attached to sediment reaching waterways. However, it is often suggested that the dissolved nutrients are almost entirely available for plant growth while the sediment-associated nutrients are not so readily available.

PESTICIDE RUNOFF

We have assembled a county-based file of annual pesticide usage estimates by crop for 184 individual widely used substances. It was necessary to develop the usage data to estimate the quantities of pesticides lost to waterways. All chemicals on the EPA list for the National Ground Water Survey and the California Priority Pollutant List are included in the inventory.

The county pesticide usage file was derived from a number of State and national usage files. The Economic Research Service of USDA (ERS) surveyed the annual amounts of individual substances used in 1982 on 13 major crops in 33 States. These crops include corn, cotton, rice, and wheat (Duffy, 1983). ERS has also compiled national estimates of individual substances used in growing potatoes, vegetables, fruits and citrus products (Ferguson, in prep.). Since the State of California was excluded from the ERS surveys, we obtained a separate study from California in which the annual quantities of pesticides applied by crop are estimated (State Calif. 1981).

Our computerized inventory covers all of the ERS and California usage estimates with the exception of minor substances, banned substances, and solvents. The estimates are by crop and by substance, either at the national or individual State level.

We used the 1982 Census of Agriculture to estimate cropland acreage at the State or national level to compute pesticide application rate coefficients in terms of pounds per acre per year. For States not included in the ERS survey, we assigned pesticide usage coefficients from neighboring States. For crops not covered in the ERS surveys, we assigned coefficients to States from the coefficients derived for the State of California. In this manner, we derived a comprehensive set of crop application rate coefficients for all States (or at the national level) for all crops. Using the 1982 Census of Agriculture data on county cropland acreage, we then estimated annual pesticide application amounts by crop and by county for the 184 substances in the inventory for all crops.

In addition to the cropland pesticide application estimates, we have also estimated the amount of pesticides applied to urban lawns and nurseries by county. The starting point for these sets of estimates was the national survey prepared for EPA's Office of Pesticide Programs, in which annual pesticide application amounts were estimated at the national level for urban lawns and nurseries (Res. Triangle Inst. 1984a, 1984b). By dividing these national usage estimates by national estimates of the number of single unit housing structures and by the number of nurseries, we computed per unit pesticide application rates for urban lawns and nurseries, respectively. We obtained county by county estimates of the number of single unit housing structures and the number of nurseries from the Census of Housing, (U.S. Dep. Comm. 1977) and the Census of Agriculture (U.S. Dep. Comm. 1982), respectively. These data allowed us to estimate pesticide application amounts by county for nurseries and housing units for individual pesticides. As a result, the pesticide inventory includes, by county, annual application estimates for 184 substances applied to individual crops, housing units, and nurseries.

The purpose in developing the pesticide application estimates was to estimate the amount of pesticides that reaches waterways. Don Wauchope of Agricultural Research Service has classified each of the 184 substances according to a runoff potential classification which estimates annual losses as a percent of amount applied. The loss rate varies from .5 percent to 3 percent (Wauchope, 1978). By multiplying the annual application amount estimate by the annual loss percent estimates, we estimate the amount of pesticides that reach waterways.

SUMMARY

The RFF Environmental Data Inventory is unique as an information source for nonpoint source policy assessments. It is the only national data base in which discharge estimates are made for both point and nonpoint sources for all U.S. counties. The same suite of 17 pollutants is accounted for comprehensively for both point and nonpoint sources. The data base allows comparisons to be made between States, water resource regions, counties, and by discharge category. EPA in a recent report to Congress used an earlier version of the data base to show States with a preponderant share of pollutant discharge from nonpoint sources (U.S. Environ. Prot. Agency, 1984).

The uniqueness of the inventory poses some constraints, however. Only small parts of the inventory can be compared to other regional data sets for verification purposes. Often such comparisons can be made for particular regions, industries, or pollutants.

Clearly many of the simplifying assumptions and methods we have used are much less sophisticated than those found in the many micro models being applied in small watersheds. Therefore, we do not advocate using our methods in doing small regional studies. On the other hand, we have found very few of the micro models that can be applied for very large regions, even for a single county. Large regional studies (such as those performed for 208 agencies) often employ methods similar to ours to make discharge estimates.

We intend to maintain and improve the inventory. One reason we try to be explicit in stating our simplifying assumptions is to elicit help, and perhaps data, from other researchers. We welcome any improvements to our estimates.

REFERENCES

Duffy, M. 1983. Pesticide Use and Practices 1982. Agric. Infor. Bull. 462. U.S. Dep. Agric., Washington, DC.

Ferguson, W.L. In prep. National Pesticide Use on Selected Crops, Aggregated Survey Data, 1977–80. Econ. Res. Serv. Staff Rep., U.S. Dep. Agric., Washington, DC.

General Services Administration. 1983. Summary Report of Real Property Owned by the United States Throughout the World as of September 30, 1982. Off. of Admin. Washington, DC.

Gianessi, L.P., and H.M. Peskin. 1984. An overview of the RFF Environmental Data Inventory: methods, sources and preliminary results. Rep. Water Resour. Div. U.S. Geolog. Surv., Washington, DC.

Midwest Research Institute. 1977. Estimation of pollutant loads from nonpoint sources using the nonpoint calculator. Draft interim rep.

Morton, J.H., and R.C. Loehr. 1980. Nonpoint source water quality problems related to animal agriculture. Prelim. rep. to U.S. Environ. Prot. Agency.

Research Triangle Institute. 1984a. National Urban Pesticide Application Survey: Final Report, Overview and Results. RTI/2764/08-01F.

———. 1984b. National Nursery Pesticide Usage Survey, RTI/2766/06-01F.

Shacklette, H.T., J.C. Hamilton, J.G. Boerngen, and J.M. Bowles. 1971. Elemental composition of surficial material in the coterminous United States. U.S. Geolog. Surv. Prof. Pap. 574-D. Washington, DC.

Soil Conservation Service. 1984. National Resources Inventory: A Guide for Users of 1982 NRI Data Files. U.S. Dep. Agric. Statis. Lab., Iowa State Univ.

State of California. 1981. Pesticide Use Report, Annual. Dep. Food and Agric. Sacramento.

Tubbs, L.J. 1980. Estimation of nonpoint dissolved nitrogen and phosphorus losses from cropland in the coterminous United States. Final Res. Rep. to Resour. Future. Washington, DC.

Tubbs, L.J., and D.A. Haith. 1980. Estimating nonpoint source nutrient loads from croplands. Rep. Dep. Agric. Eng. Cornell Univ., Ithaca, NY.

U.S. Department of Commerce. 1984. Census of Agriculture, 1982, Final County File, Technical Documentation. Bur. of Census. Suitland, MD.

________. 1982. 1978 Census of Agriculture, Vol. 5, special rep. part 7. 1979 Census of Horticultural Specialties. AC78-SR-7. Bur. Census. Suitland, MD.

________. 1977. County and City Data Book. Washington, DC.

U.S. Environmental Protection Agency. 1984. Nonpoint Sources of Pollution in the U.S. Rep. to Congress. Washington, DC.

Van Dyne, D.L., and C.B. Gilbertson. 1978. Estimating US Livestock and Poultry Manure and Nutrient Production. ESCS-12. Econ. Res. Serv., U.S. Dep. Agric., Washington, DC.

Wauchope, R.D. 1978. The pesticide content of surface water draining from agricultural fields, a review. J. Environ. Qual. 7(4): 459–72.