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Invited Paper

NATIONAL WATER-QUALITY ASSESSMENT: FUTURE DIRECTIONS OF THE U.S. GEOLOGICAL SURVEY[1]

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Keynote address delivered by Philip Cohen at the Twenty-Fourth Annual American Water Resources Association Conference "Water for the Years Ahead – Quality and Quantity: 1990 and Beyond," November 6-11, 1988, Milwaukee, Wisconsin.

Ladies and gentlemen, it is a pleasure to be here today to join with you at your annual meeting and to share with you some of our thoughts on the future directions of the Nation, in general, and of the U.S. Geological Survey, in particular, in assessing the quality of the Nation's surface- and ground-water resources.

BACKGROUND

During the past two decades, Federal, State, and local governments and industry have made significant commitments to the protection of water quality. According to estimates made by the Bureau of Economic Analysis, about $184 billion was spent for water pollution abatement and control for the period 1972 to 1982. Future expenditures for pollution abatement and control through the year 2000 have been projected to be as much as $600 billion.

Given the large financial investments in water-quality management and protection already made, the potential for much larger investments in the future, and the concerns about solving myriad problems, there is considerable need for reliable and nationally consistent information on the status of and trends in the quality of the Nation's water resources, and to provide scientifically valid explanations of these conditions and trends.

NEEDS FOR WATER-QUALITY ASSESSMENT

A critical factor in understanding water quality is the ability to make comparisons, among different locations and over time. Consistent information is necessary to make valid comparisons. This has been well recognized for a long time in conducting individual water-quality studies. However, the need for *nationally* consistent information to make valid regional comparisons and national statements about current water-quality conditions and about changes in these conditions has been well recognized only recently. In fact, during the past year, new legislation has been prepared in the House and in the Senate calling for, among other things, a national ground-water assessment. HR 791, sometimes referred to as the Gejdenson bill, was passed by the House last December. A separate bill was passed by the Senate late in October of 1988. However, differences between the two bills were never resolved, and thus, no new legislation was enacted. The issue is sure to arise again in the next session of Congress.

Information on the status, trends, and causes of water-quality conditions across the country is needed to help answer some rather fundamental questions. Let me provide a few examples.

- *Are national water-quality goals being met?* How effective have the past actions been? What are the results of the billions of dollars already spent to protect water quality? What are the implications of these results for future actions?

- *How should resources be allocated among competing water-quality problems?* For example, what is the extent of various types of nonpoint-source contamination, and how does the magnitude of these problems compare to various types of point-source contamination. Remarkably, little is known in this regard from a national standpoint. Without this information, policy decisions will often be based on supposition and information from localized problems. Conversely, a lack of information may lead to a false sense that some problems do not exist.

- *What are the key substances in need of regulation and for which research is needed regarding toxicity, human*

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exposure, and drinking water treatability? For example, the 1986 Amendments to the Safe Drinking Water Act require that the Environmental Protection Agency (EPA) promulgate National Primary Drinking Water regulations for about 80 substances. Yet, there is very limited information on the occurrence and concentrations of many of these substances in the Nation's surface and ground waters. EPA also is required to identify additional substances for regulation according to a fixed schedule. There is an immense number of candidate constituents and compounds. A clear need exists for more comprehensive information, that is organized in a consistent and concise manner, about the occurrence, distribution, and behavior of various contaminants in the environment.

- *Can regulations for selected water-quality constituents be targeted to particular geographic regions or hydrologic settings?* This has become a particularly critical issue for pesticides where the simple overall banning of a pesticide may be very costly and have significant ramifications on food and fiber production. Consistent information on water-quality and geohydrologic characteristics across the Nation is needed to help determine whether there are appropriate geographic regions or hydrologic settings that can be used as a framework for establishing targeted regulations. Most characterizations of hydrogeologic regions of the United States have been made for deeper, more productive aquifers on the basis of lithologic and permeability characteristics. In many places, it is inappropriate to apply these characterizations when dealing with potential contamination of the more vulnerable shallow aquifers that overlie the principal aquifers.

- *How should monitoring designs and requirements for surface- and ground-water quality differ in different areas of the country (in terms of constituents, sampling locations, sampling frequency, and timing of sampling)?* The design of a surface- or ground-water monitoring network is a highly complex undertaking. Because of the high cost of field work and laboratory analyses, small differences in design can result in large changes in monitoring costs. A national water-quality assessment program could provide considerable benefits by providing a large-scale framework for State and local monitoring programs.

- *What type and degree of water-quality protection are appropriate for different aquifers?* For example, the EPA Ground Water Protection Strategy and the EPA Pesticide Strategy are built on the concept that vulnerability should be considered in setting levels of protection. However, the state of knowledge about vulnerability is limited and largely qualitative. Many of the factors that influence vulnerability – depth to water, texture of the material in the unsaturated zone, geochemistry of the aquifer material, and organic content of soils – are known to be highly variable over small distances. There is a critical need for verified methods for assessing vulnerability and for mapping vulnerability at a meaningful scale. These assessments and management strategies need to be developed with appropriate "ground truth" provided by geohydrologic and water-quality data.

CURRENT ASSESSMENT-TYPE ACTIVITIES

Given the needs for water-quality assessment information, it is natural to ask what is currently being done. Concomitant with the billions of dollars spent on water-quality protection, considerable sums of money also are being spent on water-quality data collection for a host of purposes, including compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research to advance our understanding of water-quality processes. Unfortunately, despite these expenditures and the considerable utility of many of these data to meet their intended purpose, only a small part of the data collected can be used to assess the status, the trends, and the causes of water-quality conditions on regional and national scales.

For example, recently we took a comprehensive look at the water-quality data collection activities of Federal, State, and local agencies in two States: Colorado and Ohio. On the basis of this study and some simple screening criteria, it was determined that only about 10 percent of the approximately $63 million spent during 1984 on laboratory analyses in these two States would be potentially applicable for regional, ambient water-quality assessment.

The idea of an assessment of the Nation's water resources is, of course, not new. Two ongoing water-quality programs should be highlighted. The most comprehensive of these is the biennial National Water-Quality Inventory prepared by the U.S. Environmental Protection Agency in accordance with Section 305(b) of the Clean Water Act. This report consists of a set of State reports, prepared by the States themselves, and an overview analysis prepared by the EPA.

The U.S. Department of Agriculture conducts a generalized national water-quality assessment every five years as required under the Soil and Water Resources Conservation Act of 1977. The first two assessment reports covered a wide range of natural resource topics including soils, major land uses, water resources, and public attitudes.

Each of these assessment efforts has contributed to the understanding of water-quality conditions in the country. However, these assessments have not provided the kinds of information necessary to answer the types of regional and national policy and management questions that are facing the Nation. One of the shortcomings of these assessments is that they are based on existing information from a wide variety of sources. Those of you who have attempted to use existing information for large-scale assessments are familiar with some of the difficulties. In particular:

- Field sampling and laboratory analytical procedures commonly differ between agencies and with time;

- Water-quality sampling sites commonly are clustered around known or suspected areas of contamination; thus, assessments based largely on these data have a potential for substantial bias;
- Few sites have been sampled long enough and on a consistent enough basis to assess trends; and
- Historically, there is a paucity of data for potentially toxic trace elements, pesticides, and other organic compounds that are of more recent concern.

In addition to these assessment efforts, there are several national water-quality monitoring programs that contribute to the understanding of current water-quality conditions and trends. I will address my comments to examples of those that measure the quality of freshwater rivers and aquifers.

With regard to surface water, I will discuss three national networks; two maintained by the U.S. Geological Survey, and one maintained by the U.S. Fish and Wildlife Service. The first network, the Hydrologic Benchmark Network, consists of 53 surface-water stations operated by the Geological Survey in relatively small, pristine watersheds. The network was established in the early 1960's and provides information about "near natural" water-quality conditions where humans have little direct influence on the water resources. Data from the network recently were used to examine the effects of atmospheric deposition on water quality. Of particular interest were the relatively strong correlations between long-term trends in sulfate concentrations in streams and regional trends in sulfur dioxide emissions.

The second Geological Survey network is the National Stream Quality Accounting Network (NASQAN), which began in 1972 and presently consists of 423 stations located at the mouths of most of the surface-water hydrologic accounting units in the country. NASQAN data have been used to describe a number of significant relations between water quality and human activities. Examples include relations between lead in streams and the use of leaded gasoline, nitrate in streams and atmospheric emissions of nitrous and nitric oxides, and dissolved solids in streams and climate, geology, and human population (Smith, *et al*, 1987). NASQAN data also provide extensive information on the fluxes of nutrients and metals into the Nation's estuaries and reservoirs.

The U.S. Fish and Wildlife Service maintains the third national scope surface-water-quality monitoring network. The network, known as the National Contaminant Biomonitoring Program, evolved from what was originally called the National Pesticide Monitoring Program. The current network for fish consists of about 100 stations, many of which are colocated with Geological Survey NASQAN stations. The program has provided valuable information about the occurrence of potentially toxic trace elements and selected pesticides in fish. For example, in addition to documenting the well-publicized decline in the concentrations of DDT present in fish on a nationwide basis, the program has documented that other synthetic organic compounds – toxaphene, PCB's, and chlordane, to name a few – are nearly ubiquitous. The detection of these compounds at sites far removed from sources of use or manufacture has highlighted the significance of atmospheric and hydrologic processes in the transport and fate of environmental contaminants.

Despite several important uses of these national networks, their contributions toward national water-quality assessment are limited. One of the principal reasons for this is that many of the stations in the NASQAN and National Contaminant Biomonitoring Programs are located at the downstream end of very large basins that are quite heterogeneous. Thus, it is difficult to separate the effects of different natural and human factors and to investigate associations between ambient water quality and potential sources of pollution, based only on observations at the outlets of these basins.

With regard to ground water, there are no national networks equivalent to those described previously for surface water. Within the past couple decades, there have been several short-term, specialized surveys. The most recent of these is the ongoing EPA National Pesicide Survey of drinking-water wells. The National Pesticide Survey is a snapshot survey of about 1500 wells to be sampled during 1988-90. This survey has a very specific objective. It is intended to provide an estimate of the percentage of the municipal and domestic drinking-water wells in the United States that are contaminated with selected pesticides. The National Pesticide Survey is not designed to provide an assessment of the geographic distribution of pesticide contamination in the United States and the causes of this distribution, nor is it designed to detect trends.

Thus, the present state of national water-quality assessment activities in the United States principally consists largely of two assessment programs that rely on existing information from a wide variety of sources, a few diffuse surface-water monitoring networks, and a one-time sampling survey of pesticides in well water. These activities, by themselves, do not provide a consistent description of the current status and trends in water quality across the Nation and insight on the major factors that control water quality in different regions. They do not allow the Nation to adequately assess the results of past multi-billion dollar expenditures, and to maximize the effectiveness of future expenditures of the same or greater magnitude. The acquisition of information in support of these goals is the focus of the U.S. Geological Survey's proposed National Water-Quality Assessment Program.

NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Beginning in 1986, the Congress has annually appropriated funds for the U.S. Geological Survey to test and refine concepts for a National Water-Quality Assessment Program. The goals of a full-scale program would be to:

- Provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources;
- Define long-term trends (or lack of trends) in water quality; and
- Identify, describe, and explain the major factors that affect observed water-quality conditions and trends.

The best method of conducting such an assessment is not easily determined. The difficulty is due to a number of considerations: the multiplicity of water-quality constituents, large water-quality variations in time and among locations, and the high cost of collecting and analyzing samples. At present, the program is in a pilot phase. Seven pilot projects, representing a diversity of hydrologic environments, were selected to test and further refine the assessment concepts; four projects focus primarily on surface water and three projects focus primarily on ground water (see Figure 1).

A decision about proceeding to full-scale implementation will be made in 1990. The decision will be influenced by an ongoing evaluation of the design and potential utility of the program by a committee of the National Academy of Sciences.

For those of you that have interest, let me know, and we will send you a copy of a report (Hirsch, *et al.*, 1988) that will be published in the next couple weeks that describes in some detail the concepts for a National Water-Quality Assessment Program. But, let me take a few moments to briefly describe for you some of the key features and the general approach that would be used for the assessment.

The program will focus on water-quality conditions that are prevalent or large in scale and persistent in time. Regional degradation of water quality, such as occurs from nonpoint sources of pollution or from a high density of point sources will be emphasized.

The proposed program is national in scope, but will *not* be conducted through a diffuse national monitoring network. As presently envisioned, it will be accomplished through investigations of about 120 study areas – aquifer systems and river basins – that are distributed throughout the Nation and that incorporate about 80 percent of the Nation's water use. Organization into these discrete study units will enable examination of the causes of observed water-quality conditions, which is vital if the program is to be useful to managers and policy makers at Federal, State, and local levels.

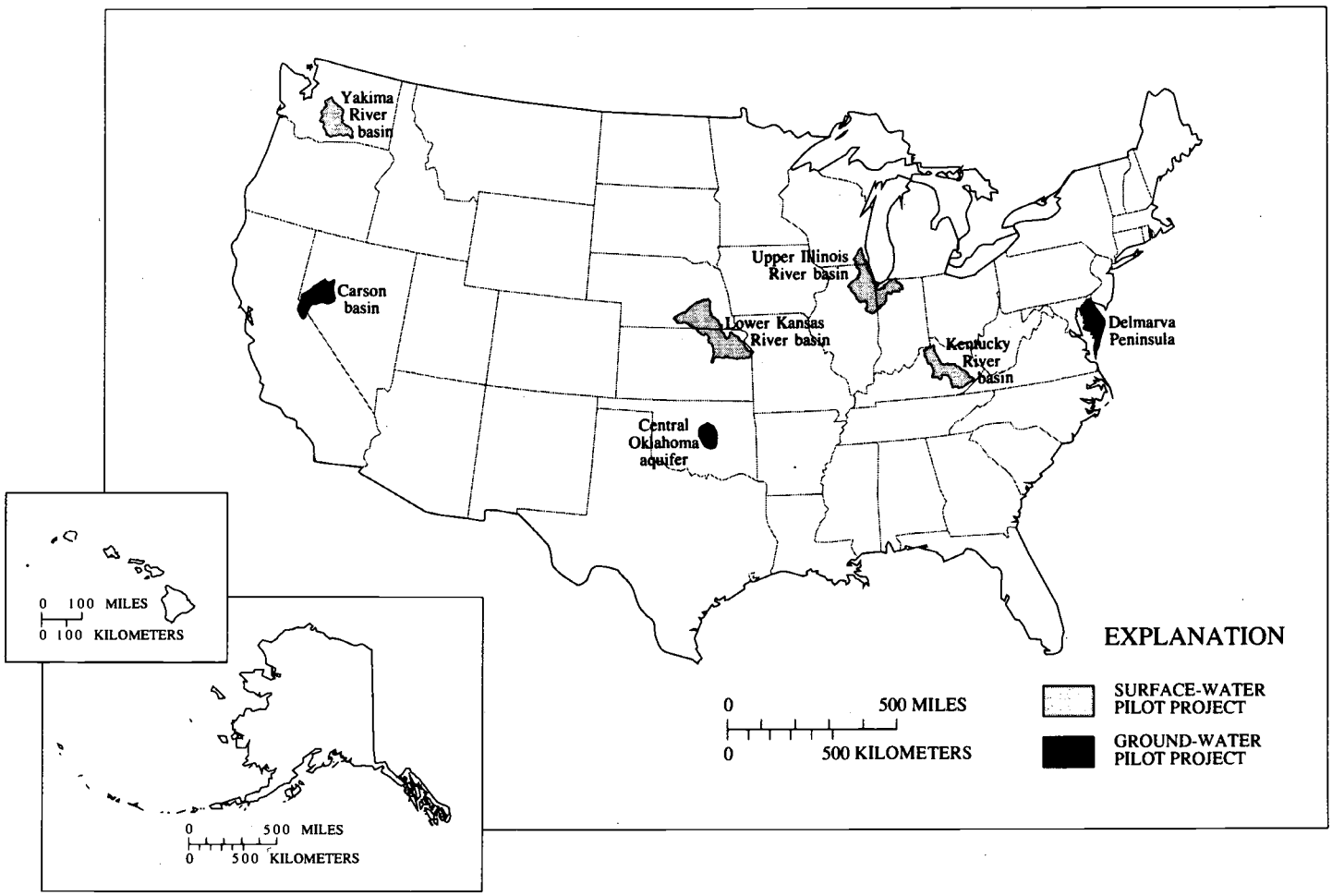

Figure 1. Locations of the Pilot Projects of the National Water-Quality Assessment Program.

The collection of data and the interpretation and communication of findings will be conducted by small teams of individuals familiar with the study areas. Having the same team of individuals responsible for the collection and interpretation of data is an important feature of the program that will help ensure that the data are of high quality and that they lead to relevant and meaningful interpretations.

The study units will be linked together in several ways to form a national program.

- A prescribed set of study approaches and protocols for sample collection, sample handling, laboratory analysis, and quality assurance will be followed;
- Data will be collected and interpreted on a nationally consistent set of water-quality constituents;
- Consistent records of ancillary information will be recorded on streamflow and basin characteristics, well and aquifer characteristics, and land use and other measures of human activity;
- Written reports will contain similar information for each study unit; and finally,
- Data will be stored in national data files, where they will be available to the user community upon request.

Because of the emphasis on trends in water quality, the program needs to be perennial. The program will evolve with time as a result of changes in knowledge of hydrogeology, improved methods of measurement, and changes in the types of contaminants of concern. However, the program will place a substantial emphasis on repetition of measurements with time and on documentation both of the locations and the characteristics of data-collection sites and the methods of data collection and analysis.

Assessment activities in each of the study units will be done on a rotational rather than continuous basis. Only a subset of the units will be studied in detail at a given time. For each study unit, three- to five-year periods of intensive data collection and analysis will be alternated with longer periods during which the assessment activities will be less intensive.

Communication and coordination between Geological Survey personnel and other interested scientists and water-management personnel are important components of the National Water-Quality Assessment Program. There is a national advisory committee to advise on national aspects of the program, and each pilot project has a liaison committee to help ensure that the information produced by the program is relevant to local and regional interests. The American Water Resources Association is represented on the national advisory committee by Dr. Kenneth Schmidt.

I would like to emphasize one further point. The program that we are proposing will not satisfy all the relevant national water-quality information needs. For some issues and questions, the spatial and temporal sampling requirements, as well as sampling protocols, may be very different from those to which this program is designed to address. Information needed in connection with enforcement of waste disposal laws is a case in point.

Because of these and other reasons, even a very effective National Water-Quality Assessment Program will not and should not eliminate the need for other water-quality data-collection activities. To make best use of the resources available, it is imperative that we foster information exchange and cooperation among all relevant agencies.

SUMMARY

Throughout our history, the Nation has made major investments in assessing natural resources, such as soils, minerals, and hydrocarbons. The reason for these investments in information is that decisions our society makes about using or conserving these resources, investing in their improvement, or regulating their use are better if they are based on sound information. The maintenance and the improvement of water quality has been one of the major areas of public investment and government regulation. Therefore, it is important to understand the need for, and the effects of, such governmental actions.

Every level of government and the private sector has a role to play. One of the contributions the U.S. Geological Survey proposes to make is to provide a strong, high quality National Water-Quality Assessment Program to underpin and unify the Nation's water-quality activities. We believe that such an assessment program will satisfy a decisive share of the attainable, national scale, water-quality information objectives. As we proceed through the pilot program, we look forward to hearing your ideas and comments on our concepts and approaches to water-quality assessment.

Thank you for your kind attention and for the invitation to be here today.

LITERATURE CITED

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