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Water Quality in the West

Gene Reetz

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Gene Reetz
U.S. Environmental Protection Agency
Denver, Colorado

Report to the Western Water Policy Review Advisory Commission

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Gene R. Reetz, Ph.D.
U.S. Environmental Protection Agency
Denver, Colorado

Jim Berkley, Darcy Campbell, Cindy Dyballa (USBR),
Holly Fliniau, Lynnette Gandl, Carl Lucero,
Lee Roberts, Carol Russell, David Schmidt,
Ed Stearns, Mike Wireman, and Bruce Zander

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While this report was prepared by EPA staff, it should be acknowledged that this document does not necessarily represent an official EPA position on water quality in the West.

Summary

This report was developed to provide the Western Water Policy Review Advisory Commission with an overview of water quality in the West. It is based on a synthesis of existing documents and attempts to highlight water quality issues of particular significance to the West.

While historic discussions of water in the West have been dominated by the issues of water quantity, water allocation, and water development, there has been a consistently growing concern over water quality. This increased interest in water quality appears to be the result of a combination of factors including increased competition for limited supplies, changing public values and attitudes, and water quality degradation becoming more apparent.

Reviewing the historic and current information on water quality reveals consistent patterns summarized below:

- Given the natural variation in geology, soils, and climate in the West, there is a significant natural variation in water quality of both surface and ground water.

- Agricultural activities (irrigation, grazing, livestock operations) consistently stand out as a major cause of water quality impairment throughout much of the West.

- In some portions of the West, excessive sedimentation associated with forestry practices is a major concern particularly as it impacts fisheries.

- Discharges from municipal facilities can be a more local, but nevertheless significant, cause of water quality impairment.

- General growth and urbanization throughout the West is having an increasing impact on water quality.

- Hydromodification (channelization, dewatering, damming) is becoming increasingly recognized as a significant source of impairment of water quality.

- Mining (both current and historic) is a significant cause of water quality degradation in mineralized areas in the West.

Assessment of the available information on water quality suggests a number of additional observations that are critical to managing water quality in the West.

- The interrelationships between surface and ground water are being recognized but still pose challenges for more integrated water management.

- The legal and institutional separation of water quantity from water quality can add to the challenge of meeting water quality goals.

- While federal agencies clearly play a major role in water quality in the West, most water quality control programs are implemented by the states.

- Ground water use for drinking water is increasing in the West and is the sole source of drinking water in most rural areas making ground water quality an increasing concern.

- Water quality issues on tribal lands are reflective of the overall water quality issues in the West. However, resources have been more limited to assess as well as address water quality problems on tribal lands.

- The current water quality monitoring programs, while providing valuable information, make it difficult to truly assess, on a broad scale, the condition and trends of the West's surface and ground-waters.

- While there has been an increase in efforts to assess the effectiveness of various water quality control programs, documenting the "on-the-ground/in-the-stream/in the aquifer" impacts has been difficult.

A number of innovative approaches are being attempted to more effectively and efficiently meet water quality goals.

- Watershed approaches are being implemented in a number of areas and offer potential for resolving contentious issues by involving all stakeholders in a partnership process.

- On a limited basis, water quality "trading" among dischargers in a basin is being explored and has potential economic and environmental benefits.

- Ecological restoration of degraded aquatic systems is being implemented at various levels and offers considerable promise to help achieve water quality as well as other environmental goals.

- Ground-water protection programs (wellhead protection, sole source aquifer designation, aquifer vulnerability assessment) are being implemented to prevent ground-water degradation.

Contents

I. Introduction

This report is intended to provide the Western Water Policy Review Advisory Commission with a "snap shot" of the water quality conditions in the West. It is critical to recognize what this document attempts to cover as well as what it does not. This report is a summary document and clearly not a comprehensive treatise on the subject of water quality in the West. Citations are provided for those who seek additional details on the topics discussed. This report was written based on a set of assumptions including:

- The focus is on federal programs (per the general mandate to the Commission);

- The report is primarily descriptive; it is based on synthesis and summary of existing documents; and

- The report highlights water quality issues especially significant or unique to the West.

It should also be recognized that while this report was prepared by EPA staff, it does not necessarily represent an official EPA position on water quality in the West. It is also important to recognize that some water quality programs are in a state of flux and that the observations in this report are based upon the situation existing at the time the report was prepared.

The first few chapters of the report provide an overview of water quality issues associated with surface water quality, ground-water quality, drinking water, and tribal water. Following these general chapters, is an in-depth analysis of the various aspects of water quality issues such as agricultural activities, livestock, mining. The second portion of the report focuses mainly on state and federal programs and approaches to water quality problems. Each chapter contains a chapter summary that outlines the general conclusions and recommendations of the chapter.

Water in the West

In many respects, the West has been defined by its predominately arid or semi-arid climate. Consequently, it is not surprising that the focus of discussions and debates over water in the West have focused on water quantity, not water quality. The numerous classical and scholarly studies of western water have dealt almost exclusively with water quantity in terms of water allocation and water development and, with perhaps a few exceptions, the topic of water quality has received only passing attention. As observed by Getches et al, "The development and use of water in the West traditionally have been considered of paramount importance when compared to issues of water quality. Attitudes are changing as water becomes scarcer and pollution problems become more obvious." (Getches, MacDonnell, Rice, 1991: p. viii).

Increasing Concern Over Water Quality in the West

During the late 1960's and early 1970's, incidents such as rivers catching fire, fish kills, and the closing of beaches provided dramatic documentation of serious water quality problems at the national level. Prior to and during this period, the details for implementing water pollution controls rested primarily at the state level (Adler, Landman, Cameron, 1993). Congress recognized the critical condition of the nation's waters, and passed the Clean Water Act of 1972 (also referred to as the Federal Water Pollution Control Act Amendments of 1972). This Act resulted in significant revisions to the fundamental approaches to protecting water quality in the United States. In its declaration of Goals and Policy, the Act stated, in part:

> *"The objective of this Act is to restore and maintain the chemical, physical, and biologic integrity of the nation's waters."*

With this stated objective and the specific programs authorized in the Act, water quality management moved beyond the limited narrower focus on chemical water quality and was redirected toward protecting human health and the health of aquatic ecosystems.

Reflective of the increased concern over water quality was the Department of the Interior report, *Critical Water Problems Facing the Eleven Western States* (DOI, 1975). This study provided an assessment of the critical water-related resource problems in the West and noted:

> *"The West has long been noted for the beauty and high quality of its rivers and lakes. Overall, the quality of this water is still high, but in many instances it is threatened with serious degradation. Energy development, urbanization, industrial expansion, farm and grazing practices, forestry, natural resource development, and human activities of many kinds have or potentially can act to lessen the quality of water in the West. Protection of high-quality water and restoration of now inferior quality waters to a higher quality are major concerns for the West-wide area"* (DOI, 1975: p 27).

Seventeen water-related issues were identified as western water problems. Of these, four were specific water quality issues which included:

- Water quality and pollution control,
- Increasing salinity in major river systems,
- Managing waste and urban storm water, and
- Erosion and sedimentation (DOI, 1975: pp 71-152)

Shortly after the Department of the Interior study, the National Commission on Water Quality issued its report which evaluated the impacts of the 1972 Clean Water Act and made recommendations to Congress on the implementation of the Act. The Commission's recommendations basically supported the approaches defined in the 1972 Clean Water Act, but also made two recommendations particularly relevant to western water quality issues:

Redefine the goal of elimination of discharge of pollutants as one stressing conservation and reuse of resources.

Authorize flexibility in applying control or treatment measures to irrigated agriculture after an inventory of the problem, and support salinity alleviation projects to reduce salt loads from sources other than man's activities. (National Commission on Water Quality, 1976: p 5)

In 1978, the U.S. Water Resources Council published the second national water assessment, The Nation's Water Resources 1975-2000, which evaluated both water quantity and water quality issues. The report identified irrigation return flows as the most widespread nonpoint surface water pollution problem in the West (U.S. Water Resource Council, 1978: p 21).

In 1984, the U.S. Geological Survey (USGS) published its first National Water Summary - 1983 -- Hydrologic Events and Issues. This report focused on water quantity and availability, but did include discussion of water quality. The report observed:

The quality of the Nation's ground and surface water supplies generally is adequate, although numerous problems exist. Contamination of ground and surface waters is mentioned frequently in the State water-issue summaries. The sources of contamination noted most frequently include sewage- treatments plants, industrial

> *plants, coal mines, spills, urban runoff, agricultural runoff, feedlots, landfills, and naturally saline waters. The hazardous wastes most often mentioned are synthetic organic compounds and toxic metals* (National Water Summary, p.2).

The following year, the USGS published its second National Water Summary, which included a greater discussion of water quality issues. Water quality issues specific to the West included the following:

- The discovery of Selenium in agricultural drainage water in the Kesterson National Wildlife Refuge (San Joaquin Valley of California),
- The sediment load in rivers (with rivers in the Southern Great Plains and the Southwest having suspended sediment loads in excess of 6,000 milligrams per liter),
- Concern over dissolved-solids in the Colorado and Arkansas River Basins, and
- Nitrate concentrations in ground water.

The next USGS National Water Summary in 1986, focused on ground-water quality and is discussed in the Ground Water Quality section of this report. The most recent USGS National Water Summary was in 1990-91 and it addressed stream water quality which is discussed in the Surface Water Quality section of this document.

A review of the preceding documents clearly indicates an ever-growing concern over water quality in the West. As indicated above, this increased concern can be attributed in part to both a changing awareness in public attitudes as well as better documentation of water quality problems and impacts.

II. Surface Water Quality

Chapter Summary

This chapter provides a brief overview of issues in the West that affect surface water quality. The activities that lead to water quality impairment as well as the types of contaminants will be introduced. A more detailed discussion of particular water quality issues such as agriculture, grazing and mining is presented in the section entitled Water Quality Issues.

The major cause of water quality impairment in the West continues to come from nonpoint source pollution. Agriculture is the largest cause of water quality degradation through nonpoint source pollution. Although the EPA and many states have implemented programs to encourage the adoption of voluntary Best Management Practices that reduce nonpoint source pollution, it is difficult to document an overall improvement in water quality, despite their implementation. As a result, nonpoint source pollution continues to present a challenge to maintaining and/or restoring the quality of the Nation's streams, rivers and lakes.

Conclusions

Surface water quality in the West is affected by natural factors such as climate, geology, soils, as well as anthropogenic factors including a multitude of land and water use activities. Agricultural activities including irrigation, grazing and feedlots have a major impact on surface water quality. Point source discharges from municipal and industrial sources and hydromodifications are also significant sources of surface water quality degradation.

Recommendations

- More effective monitoring programs are needed to obtain a better picture of surface water quality in the West.
- Prevention of water quality problems before they occur is much more desirable than remediation of contamination problems. A proactive approach towards prevention of surface water quality problems in general can result in cost savings relative to remediation.

- There is a need to integrate ground-water management and surface water management at the state and local level. While the magnitude and nature of this connection varies, it is important to recognize the fact aquifers and streams are hydraulically connected.

- Recognition of the interrelationships between water quantity decisions and water quality protection is necessary to achieve water quality goals.

Introduction

The overall status of water quality in the West is not clearly documented. Although the federal and state governments have a number of water quality monitoring efforts underway, these programs are limited in scope and do not provide a clear picture of water quality in the West. For example, the Clean Water Act mandates that states monitor water quality and report their findings to EPA, which in turn reports to Congress. In the most recent report, only 17 percent of the Nation's waters were monitored. (EPA 1995) In the western states, only 15 percent of surface waters were monitored.

In many instances, water quality suffers from varying degrees of degradation. Energy development, urbanization, industrial expansion, farm and grazing practices, forestry, natural resource development, and human activities of many kinds have degraded, or potentially can act to degrade, the quality of water in the West (USEPA. 1995, DOI 1975).

Water quality varies throughout the West. This variation is in part due natural factors such as climate, geology and soils and to the nature, extent, and magnitude of pollutants which are discharged into surface and ground-waters from a wide range of both point and nonpoint sources (USEPA. 1995, DOI. 1975).

Surface Water Quality Conditions and Major Sources of Surface Water Contamination in the West

Water quality degradation generally occurs as a result of two types of pollution: point source and nonpoint source. Point source pollution is defined by the Clean Water Act as discharges to rivers and streams that come from a particular source or conveyance; such as a sewage treatment plant, an industrial facility or an animal feedlot. Point source pollution is generally related to concentration of human activity; i.e., urban areas, mining areas, industrial areas, and energy producing areas. Point source discharges are permitted by the EPA or states through the National Pollutant Discharge Elimination System Program (NPDES). Nonpoint source pollution results mostly from agricultural land use and includes runoff from storms as well as other types of runoff. Farming, construction, logging, grazing, roadbuilding, and mining activities all can result in nonpoint source pollution. (USEPA. 1995; DOI. 1975). Nonpoint source pollution, which is widespread and can severely impair water quality, is not regulated although the EPA and states do encourage voluntary practices to reduce nonpoint source pollution. Naturally occurring point and nonpoint sources affect water quality as well.

Water quality is affected by a number of different factors. A very critical water quality parameter for aquatic life is temperature. In both stream and estuarine areas, natural high summer temperatures may be only a few degrees below lethal limits for many fish and aquatic invertebrates. In industrial and energy producing areas, the use of water for cooling purposes can result in thermal pollution of adjacent waters.[1] Sediment washed from croplands, unprotected forest lands, overgrazed pastures, strip mines, roads and construction areas, is a serious problem in many areas throughout the western states. Sediment originating from federal lands constitutes a significant portion of the problem (DOI. 1975).

Nitrogen and phosphorus are contaminants which often originate with agricultural uses of fertilizers in agricultural applications. In the Columbia-North Pacific Region, irrigation return flows are believed to be a significant source of nutrients, especially phosphates. Pesticides are also a contributor to surface water contamination in portions of the West.

Irrigated agriculture has a major impact on salinity concentrations in western streams. A clear distinction exists between two basic causes of salinity increases in streams of arid and semiarid regions in the West. These causes may be referred to as the "salt loading" and "salt concentrating" effects. Salt loading is associated with the discharge of additional mineral salts into the stream system by municipal and industrial wastes, by water from natural sources, and by irrigation return flows. In contrast, the salt

[1] The Forestry section in the Water Quality Issues chapter expands on the issues associated with increases in water temperature.

concentrating effect occurs as a result of the consumptive use of water. No additional mineral salts are discharged and the salt load in the stream remains constant, but the salt concentration increases as a consequence of loss of water from the stream system. Irrigated agriculture often contributes to both of these types of salinity increases. Many streams in the arid and semiarid regions of the West display a progressive increase in salinity between their headwaters and mouths, especially where a large part of the total water supply is consumptively used by irrigated agriculture (DOI. 1975).

The areas most adversely affected by salinity increases from irrigation return flows are located in the lower reaches of the river systems of the Southwest. These include the Colorado River, which serves seven states and Mexico, the Rio Grande and Pecos Rivers in New Mexico and Texas, the San Joaquin River in California, the Sevier River in Utah, the South Platte and Arkansas in Colorado, and some other smaller streams (DOI. 1975).

Instream Flow

Although there are numerous existing reservoirs throughout the West, relatively few of them have water stored specifically for the purpose of augmenting stream flows to maintain or improve water quality. In some situations, the regulation of streamflow for other purposes benefits water quality control. Such benefits are often confined to limited stream reaches, since significant diversions for other beneficial uses may occur a short distance below the storage reservoirs (DOI. 1975).

Water Quality Monitoring by the U.S. Geological Survey

Additional information about the trends and indicators of western water quality is presented from excerpts from the "National Water Summary 1990-91--Stream Water Quality: HYDROLOGIC PERSPECTIVES ON WATER ISSUES" (USGS. 1993). The six parameters reviewed are:

- Dissolved oxygen
- Fecal coliform bacteria
- Dissolved solids
- Nitrate

- Total phosphorus
- Suspended sediment

The information presented in this section was culled from the above mentioned USGS national report. This information represents trends of the decade of the 1980s. These trends should be viewed with caution as the data are often limited.

Each summary below is also presented in graphical form. Although the graphics presented include the entire continental United States, the western states are easily discernible.

Dissolved Oxygen

Out of a total of 33 stations analyzed for dissolved oxygen (DO) trends in the West, 17 showed an increase in DO while 16 showed a decrease (Figure II-1). The reason for increases in DO for urban areas may be the investment in point-source pollution control in the 1980s. The appearance of "breaking even" on DO may be the result of increased pollution controls offset by an increase in population and GNP over the same time period.

Fecal Coliform Bacteria

Of the 29 locations that were sampled for trend analysis in the West, only two exhibited an upward trend. The other stations showed a downward trend in fecal coliform count (Figure II-2). This data suggests the improvement in the control of point source fecal coliform.

Dissolved Solids

Of the 37 locations in the West sampled for trend analysis, 15 sites exhibited upward trends in dissolved solids concentrations and the rest downward (Figure II-3). Dissolved solids are a historic problem that continues, especially in portions of the Southwest.

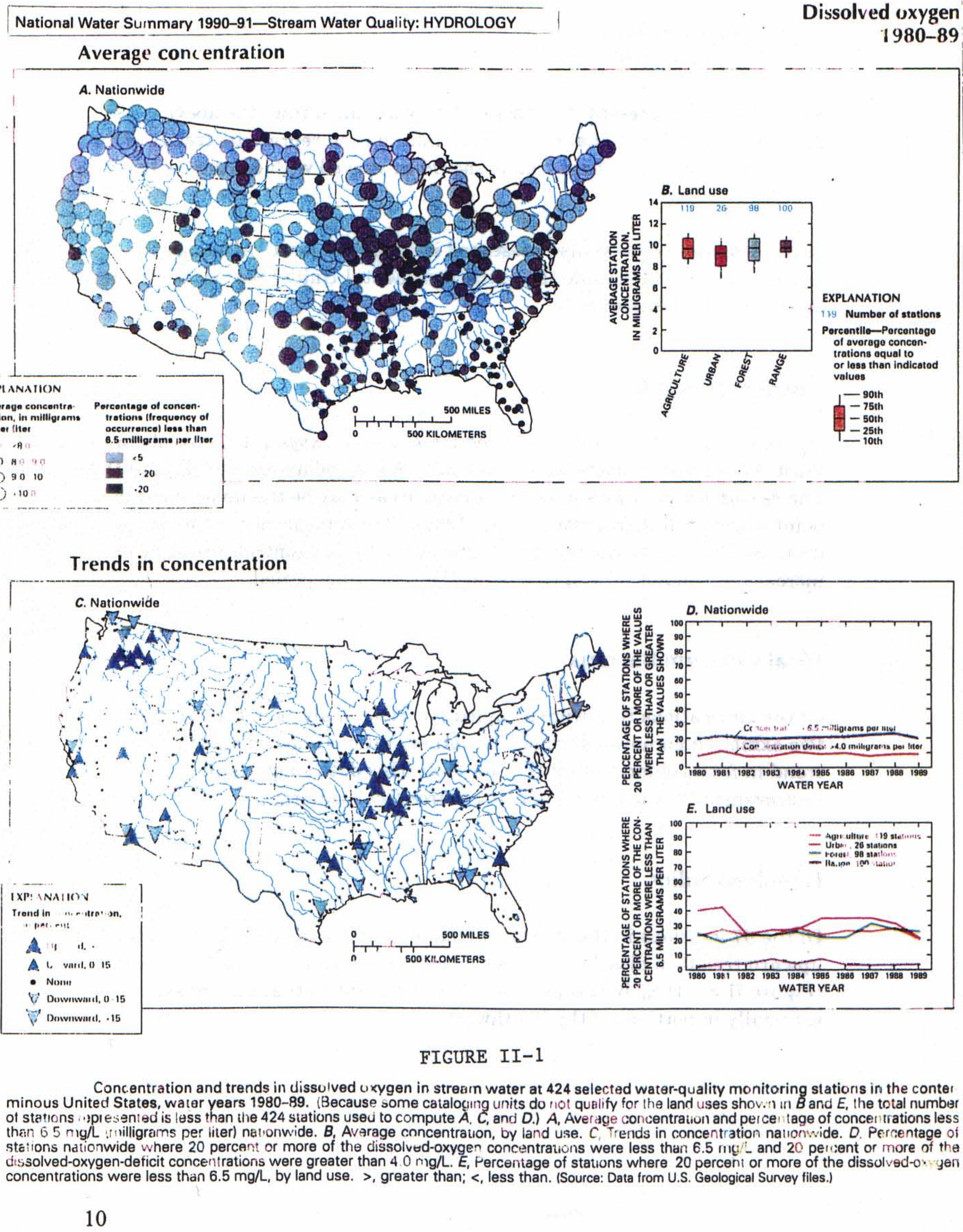


FIGURE II-1

Concentration and trends in dissolved oxygen in stream water at 424 selected water-quality monitoring stations in the conterminous United States, water years 1980–89. (Because some cataloging units do not qualify for the land uses shown in *B* and *E*, the total number of stations represented is less than the 424 stations used to compute *A*, *C*, and *D*.) *A*, Average concentration and percentage of concentrations less than 6.5 mg/L (milligrams per liter) nationwide. *B*, Average concentration, by land use. *C*, Trends in concentration nationwide. *D*, Percentage of stations nationwide where 20 percent or more of the dissolved-oxygen concentrations were less than 6.5 mg/L and 20 percent or more of the dissolved-oxygen-deficit concentrations were greater than 4.0 mg/L. *E*, Percentage of stations where 20 percent or more of the dissolved-oxygen concentrations were less than 6.5 mg/L, by land use. >, greater than; <, less than. (Source: Data from U.S. Geological Survey files.)

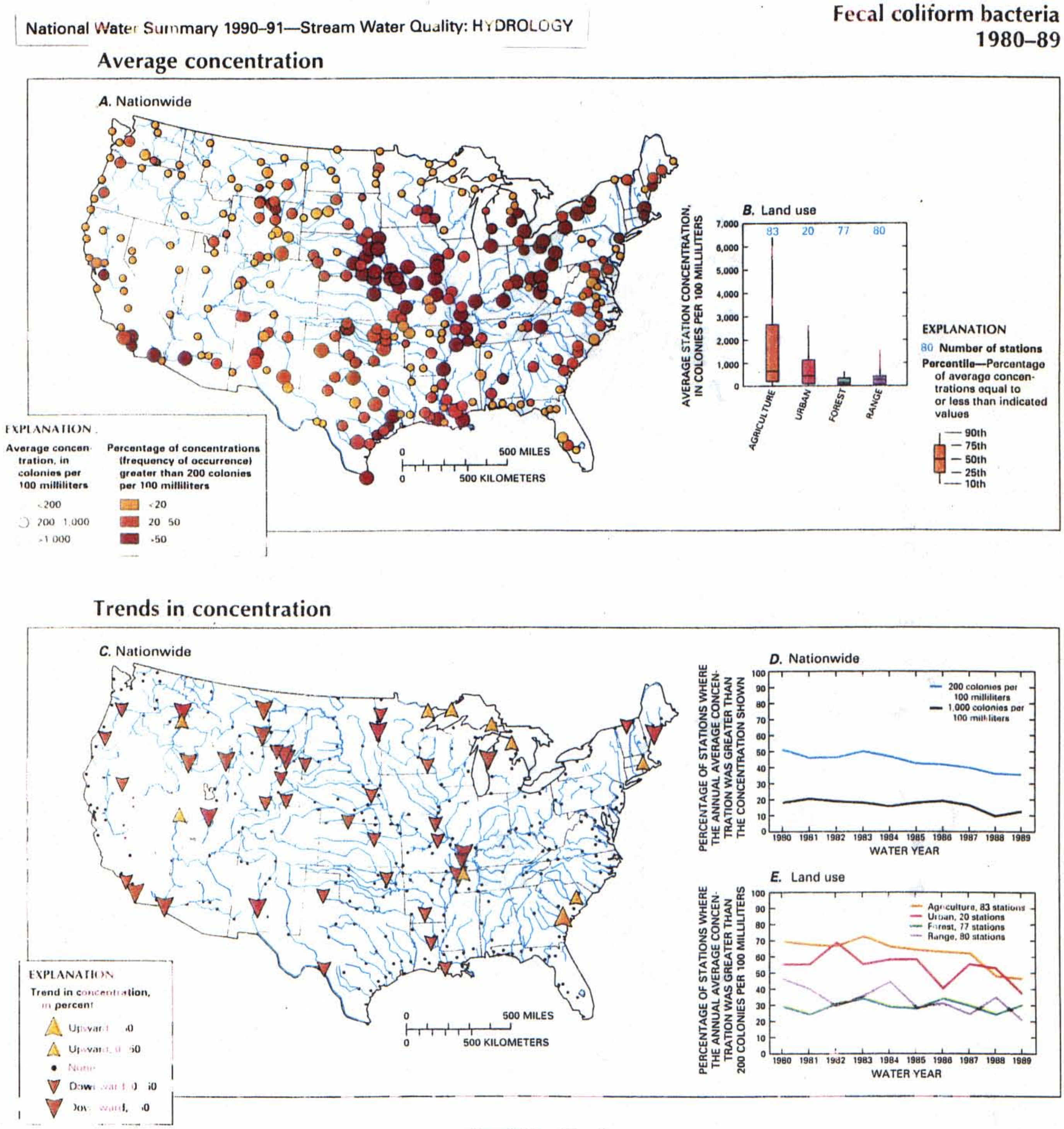


FIGURE II-2

Concentration and trends in fecal coliform bacteria in stream water at 313 selected water-quality monitoring stations in the conterminous United States, water years 1980–89. (Because some cataloging units do not qualify for the land uses shown in *B* and *E*, the total number of stations represented is less than the 313 stations used to compute *A*, *C*, and *D*.) *A*, Average concentration and percentage of concentrations greater than 200 colonies per 100 milliliters nationwide. *B*, Average concentration, by land use. *C*, Trends in concentration nationwide. *D*, Percentage of stations nationwide where the annual average concentration was greater than 200 or 1,000 colonies per milliliter. *E*, Percentage of stations where the annual average concentration was greater than 200 colonies per 100 milliliters, by land use. >, greater than; <, less than. (Source: Data from U.S. Geological Survey files.)

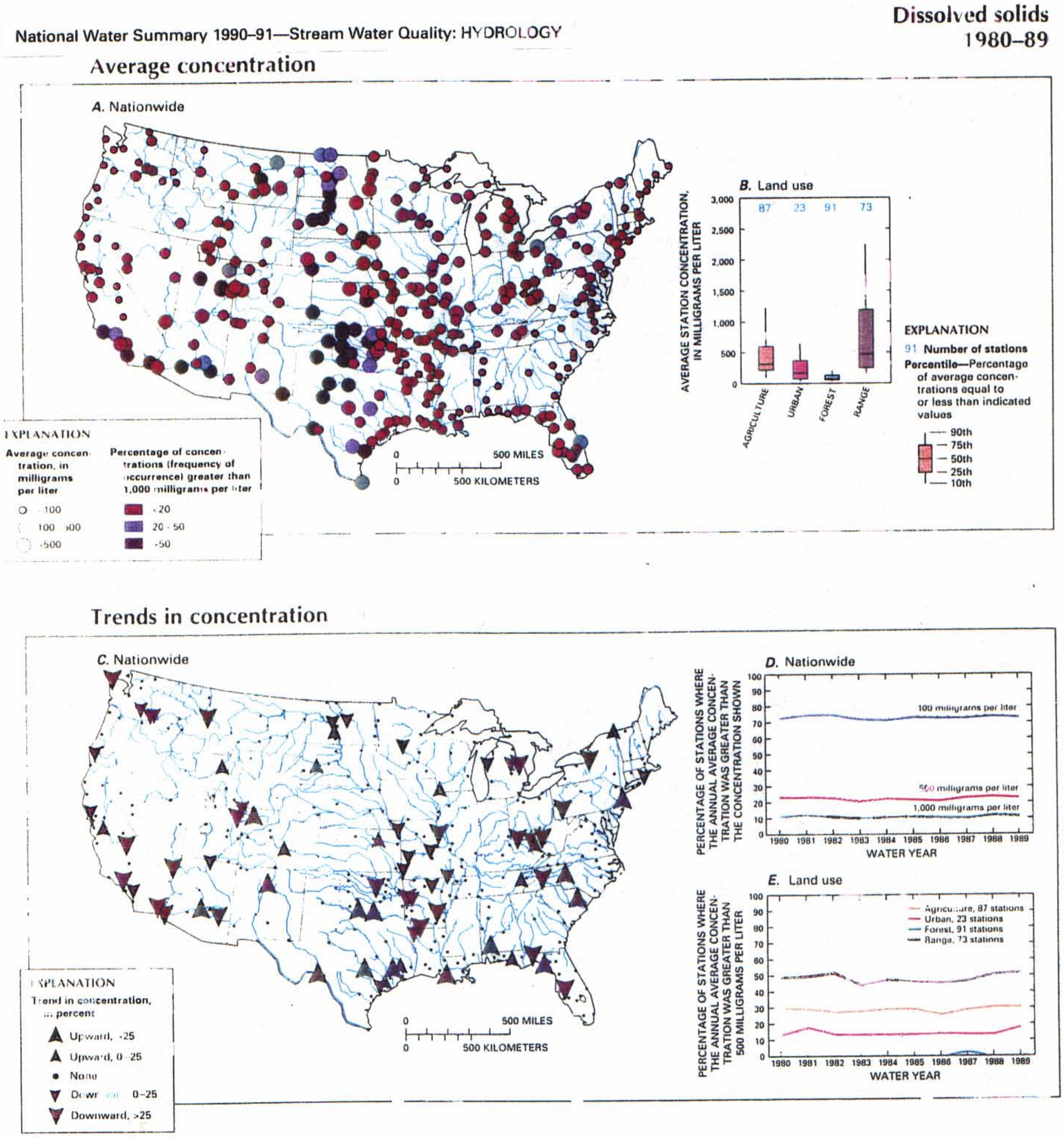


FIGURE II-3

Concentration and trends in dissolved solids in stream water at 340 selected water-quality monitoring stations in the conterminous United States, water years 1980–89. (Because some cataloging units do not qualify for the land uses shown in *B* and *E*, the total number of stations represented is less than the 340 stations used to compute *A*, *C*, and *D*.) *A*, Average concentration and percentage of concentrations greater than 1,000 mg/L (milligrams per liter) nationwide. *B*, Average concentration, by land use. *C*, Trends in concentration nationwide. *D*, Percentage of stations nationwide where the annual average concentration was greater than 100, 500, or 1,000 mg/L. *E*, Percentage of stations where the annual average concentration was greater than 500 mg/L, by land use. >, greater than; <, less than. (Source: Data from U.S. Geological Survey files.)

Nitrate

Of the 27 locations monitored for trends in nitrate concentrations in the West, 15 locations had an upward trend while 12 had a downward trend (Figure II-4). Nitrate seems to be a significant problem for portions of the West.

Phosphorus

Of the 57 stations analyzed for phosphate trends in the West, only 8 had an upward trend, the rest had a downward trend (Figure II-5). The main reason generally cited for the decrease in phosphorus is the control of point source loading for phosphorus.

Suspended Sediment

Of the 17 trend analysis locations sampled in the West, only two showed an upward trend, the rest were downward (Figure II-6). The number of locations for obtaining this data in the West were quite small relative to the other major parameters measured above, so this information should be viewed with extreme caution.

National Water Quality Assessment Program

The ongoing U.S. Geological Survey's National Water Quality Assessment (NAWQA) program is an additional source of information on water quality in the West. The NAWQA program focuses on selected watersheds throughout the United States and examines basic environmental factors such as physiography, geology, soils, and climate as well as hydrologic systems (both surface and ground water) and the natural and anthropogenic factors influencing water quality in the given watersheds. "The long-term goals of the NAWQA program are to describe the status and trends in the quality of a large, representative part of the Nation's surface water and ground-water resources and to provide a sound, scientific understanding of the primary natural and human factors affecting the quality of these resources." (Leahy et. al. 1993).

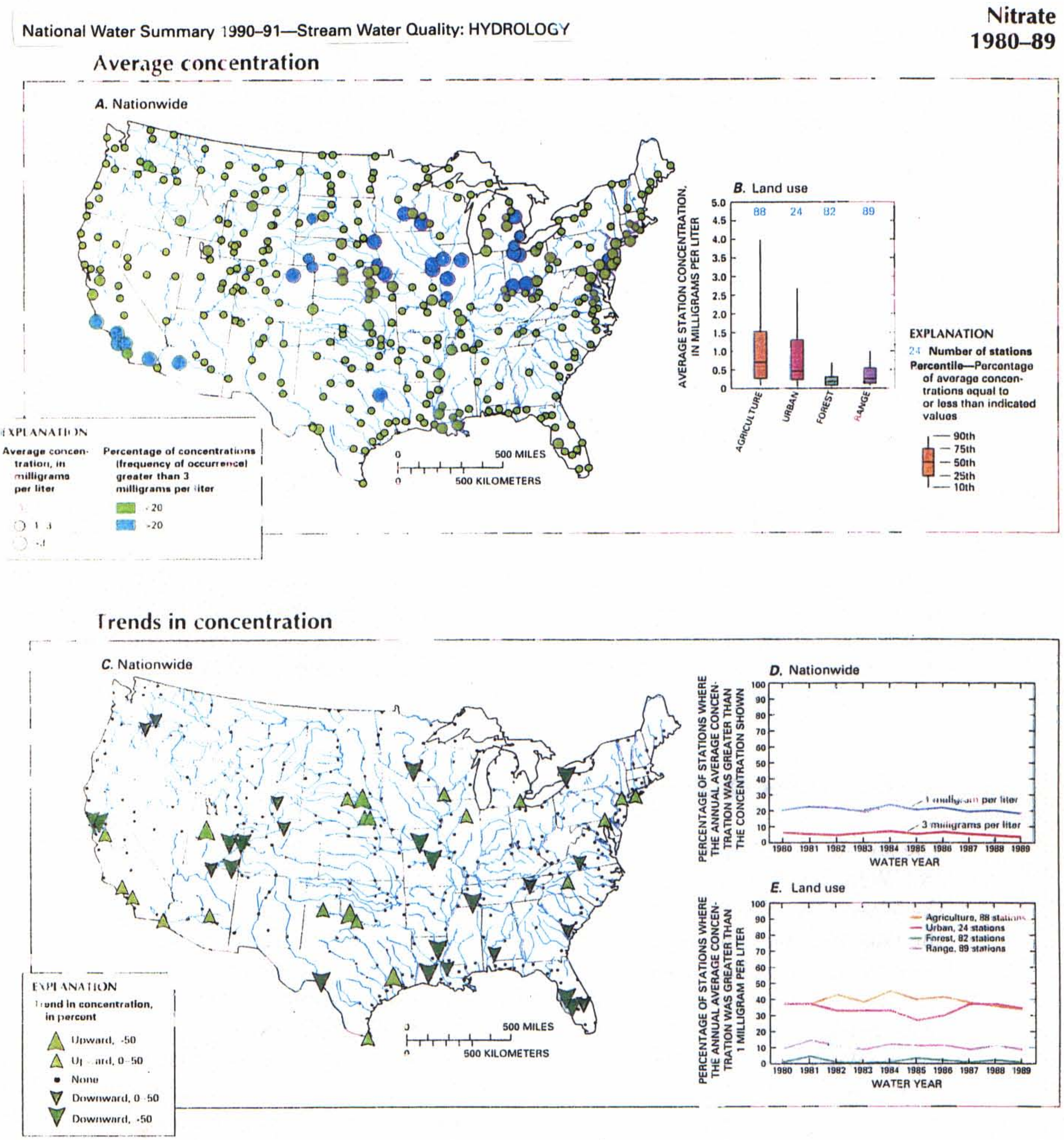


FIGURE II-4

Concentration and trends in nitrate in stream water at 344 selected water-quality monitoring stations in the conterminous United States, water years 1980–89. (Because some cataloging units do not qualify for the land uses shown in *B* and *E*, the total number of stations represented is less than the 344 stations used to compute *A*, *C*, and *D*.) *A*, Average concentration and percentage of concentrations greater than 3 mg/L (milligrams per liter) nationwide. *B*, Average concentration, by land use. *C*, Trends in concentration nationwide. *D*, Percentage of stations where the annual average concentration was greater than 1 or 3 mg/L. *E*, Percentage of stations where the annual average concentration was greater than 1 mg/L, by land use. >, greater than; <, less than. (Source: Data from U.S. Geological Survey files.)

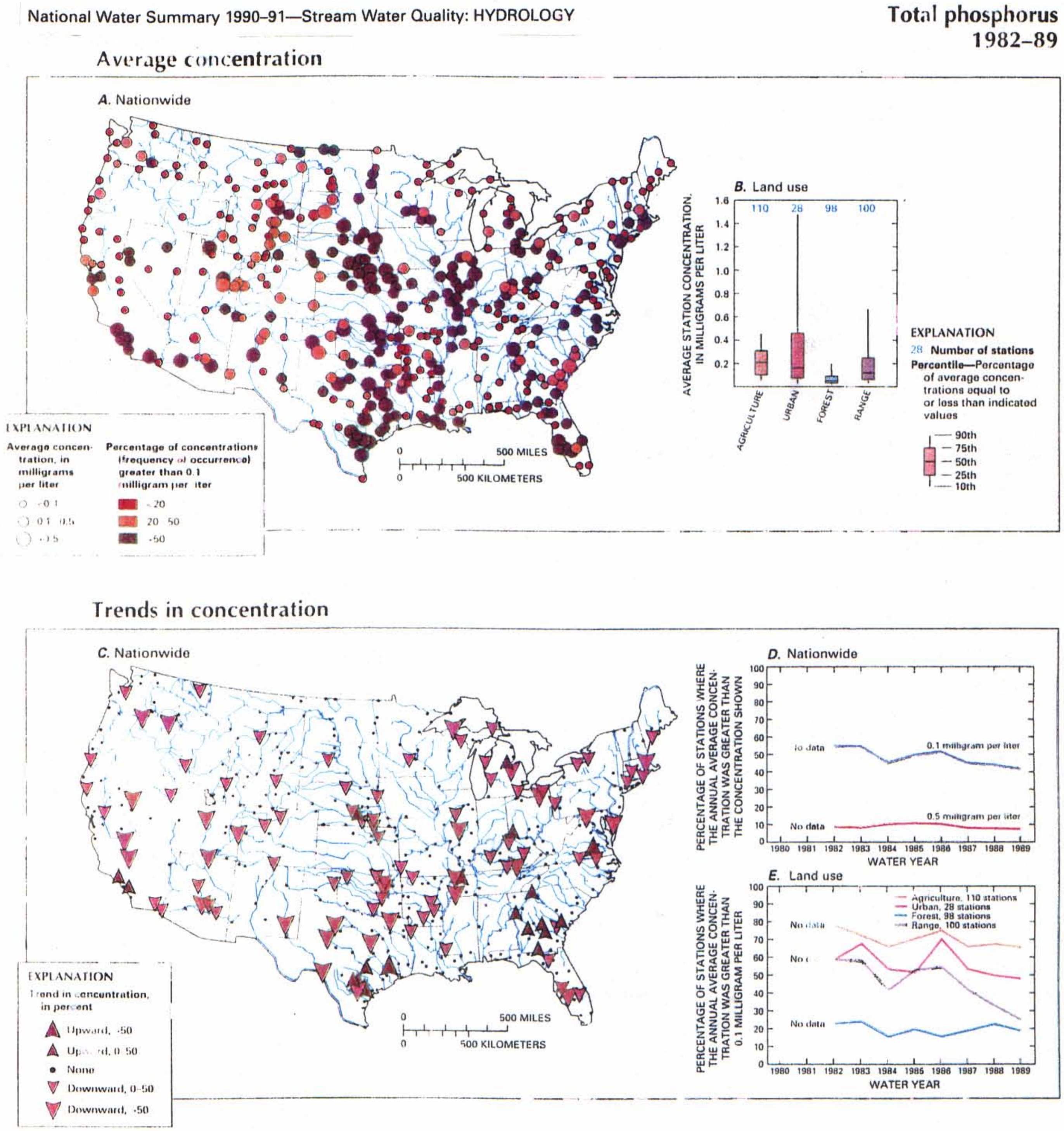


FIGURE II-5

Concentration and trends in total phosphorus in stream water at 410 selected water-quality monitoring stations in the conterminous United States, 1982–89. (Because some cataloging units do not qualify for the land uses shown in *B* and *E*, the total number of stations represented is less than the 410 stations used to compute *A*, *C*, and *D*.) *A*, Average concentration and percentage of concentrations greater than 0.1 mg/L (milligram per liter) nationwide. *B*, Average concentration, by land use. *C*, Trends in concentration nationwide. *D*, Percentage of stations where the annual average concentration was greater than 0.1 or 0.5 mg/L. *E*, Percentage of stations where the annual average concentration was greater than 0.1 mg/L, by land use. >, greater than; <, less than. (Source: Data from U.S. Geological Survey files.)

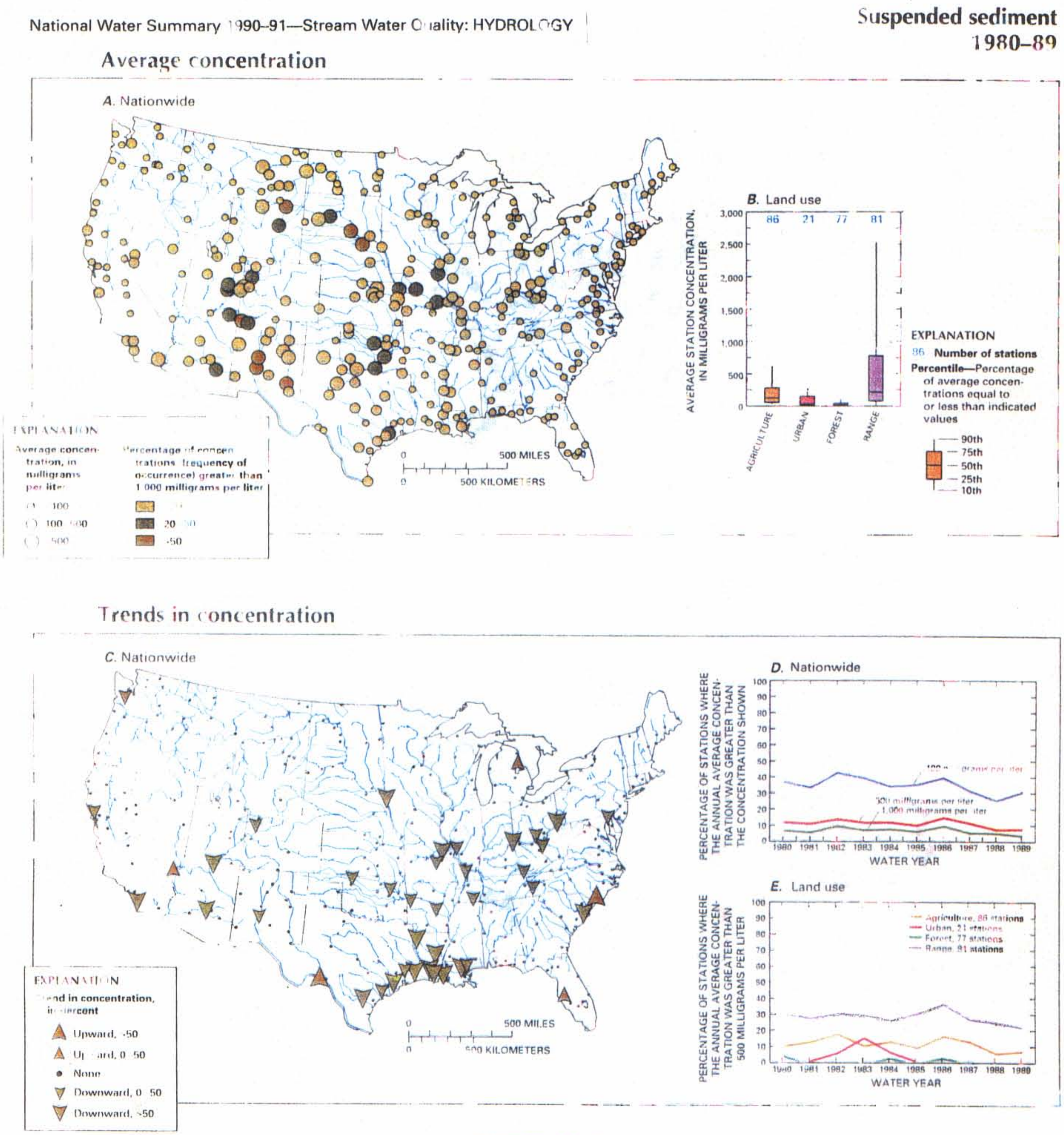


FIGURE II-6

Concentration and trends in suspended sediment in stream water at 324 selected water-quality monitoring stations in the conterminous United States, water years 1980–89. (Because some cataloging units do not qualify for the land uses shown in *B* and *E*, the total number of stations represented is less than the 324 stations used to compute *A*, *C*, and *D*.) *A*, Average concentration and percentage of concentrations greater than 1,000 mg/L (milligrams per liter) nationwide. *B*, Average concentration, by land use. *C*, Trends in concentration nationwide. *D*, Percentage of stations where the annual average concentration was greater than 100, 500 or 1,000 mg/L. *E*, Percentage of stations where the annual average concentration was greater than 500 mg/L, by land use. >, greater than; <, less than. (Source: Data from U.S. Geological Survey files.)

The following table lists additional information on water quality contaminants. The table presents the sources of the environmental contaminants as well as their impact on the environment.

Sources and environmental significance of water quality constituents

Constituent or property	Common sources	Environmental significance
Chloride	Occurs in some rocks and ground-water discharge; also in road deicers, industrial and urban waste-water discharge, and atmospheric deposition.	Concentration exceeding a natural, background level indicate contamination from human activities; can cause water to be unsuitable for public supply, agriculture, and industry; can harm aquatic organisms.
Silica	is derived from the decomposition of silicate minerals.	Can cause water to be unsuitable for some industrial applications such as boiler feed water; forms hard scale.
Dissolved solids	A result of rock weathering; also in agricultural runoff and industrial discharge.	In excess, can cause water to be unsuitable for public supply, agriculture, and industry; can harm aquatic organisms.
Nitrite plus nitrate; total nitrate	Nonpoint sources are agricultural and urban runoff; a major point source is wastewater discharge.	Plant nutrient that, in excess, can cause algai blooms and excessive growth of higher aquatic plants in bodies of water; can cause water to be unsuitable for public supply.
Ammonia	Nonpoint sources are agricultural and urban runoff; a major point source is wastewater discharge.	Plant nutrient that, in excess, can cause algai blooms and excessive growth of higher aquatic plants in bodies of water; can cause water to be unsuitable for public supply.

Sources and environmental significance of water-quality constituents

Constituent or property	Common sources	Environmental significance
Ammonia plus organic nitrogen	Nonpoint sources are agricultural and urban runoff; a major point source is wastewater discharge.	Plant nutrient that, in excess, can cause algai blooms and excessive growth of higher aquatic plants in bodies of water; can cause water to be unsuitable for public supply.
Phosphorus	Occurs in some rocks and sediments; also in runoff and seepage from phosphate-rock mines, agricultural and urban runoff, and industrial and municipal wastewater discharge.	Plant nutrient that, in excess quantity, can cause algai blooms and excessive growth of higher aquatic plants in bodies of water.
Phosphate	Occurs in some rocks and sediments; also in runoff and seepage from phosphate-rock mines, agricultural and urban runoff, and industrial and municipal wastewater discharge.	Plant nutrient that, in excess quantity, can cause algai blooms and excessive growth of higher aquatic plants in bodies of water.
Barium	Occurs in some rocks; also in mine runoff and wastewater discharge.	Toxic in larger than trace concentrations; can cause water to be unsuitable for public supply.
Iron	Occurs from the decomposition of some rocks; also in mine runoff.	Can affect the suitability of water for public and industrial water supply and can harm aquatic organisms.
Selenium	Occurs in some rocks and soils; can be leached from arid land by irrigation.	Toxic in larger than trace concentrations; can cause water to be unsuitable for public supply; can harm aquatic organisms.

Sources and environmental significance of water quality constituents

Constituent or property	Common sources	Environmental significance
Suspended sediment	A result of rock erosion; also induced by disturbances of land cover due to fires, floods, and human activities such as mining, logging, construction, and agriculture.	Can be detrimental to aquatic organisms; can fill reservoirs and impair recreational use of water.
Specific conductance (property)	A measure of the electrical conductivity of water; varies with the quantity of dissolved solids and is used to approximate the dissolved-solids content.	Dissolved solids can cause water to be unsuitable for public supply, agriculture, and industry; can harm aquatic organisms.
pH (property)	A measure of hydrogen-ion activity (acidity or alkalinity); can be affected by geologic setting, biological activity, municipal and industrial wastewater discharge, and atmospheric deposition.	Acidic water can corrode pipes and equipment; can cause the release of lead and other metals from distribution systems to drinking water; can affect wastewater-treatment processes and taste of water.
Turbidity (property)	Caused by natural or human-induced suspended matter; components include clay, silt, fine organic and inorganic matter, soluble colored organic compounds, and microscopic aquatic organisms.	Can be detrimental to aquatic organisms; can cause water to be unsuitable for recreation, industry and public supply.
Dissolved oxygen	Introduced from the atmosphere also a byproduct of aquatic plant life.	Necessary for aquatic life; deficiency can result from assimilation of organic wastes and decay of algae.
Fecal coliform bacteria	Sources include effluent from sewage treatment plants and runoff from pastures, feedlots, and urban areas.	Presence indicates contamination of water by wastes from humans or other warm-blooded animals.

Sources and environmental significance of water-quality constituents

Constituent or property	Common sources	Environmental significance
Fecal streptococcal bacteria; includes fecal enterococcal bacteria	Sources include effluent from sewage-treatment plants and runoff from pastures, feedlots, and urban areas.	Presence indicates contamination of water by wastes from humans or other warm-blooded animals.
Hardness (property)	A characteristic of water primarily related to the concentration of calcium and magnesium.	Hardness causes the formation of an insoluble residue when used with soap, and scale in vessels in which water has been allowed to evaporate.
Sodium	Occurs in some igneous rocks, evaporite deposits, and sediments; also in oil-field brines, road deicers, and irrigation return flow.	Can cause water to be unsuitable for public supply, agriculture, and industry.
Alkalinity (property)	A measure of the quantity of acid-neutralizing substances; can be affected by geologic setting, industrial wastewater discharge, waste gases, and runoff from surface mining.	Sufficiently alkaline water can be unsuitable for drinking and some agricultural and industrial uses.
Sulfate	Occurs in some rocks; also in mine runoff, industrial wastewater discharge, and atmospheric deposition.	Concentrations exceeding a natural background level indicate contamination from human activity; in excess, can cause water to be unsuitable for public supply; can harm aquatic organisms.

National Water Quality Assessment Findings for Certain River Basins

While it is not possible to review all the ongoing NAWQA studies in the West, it is instructive to summarize some preliminary findings from selected basins. The NAWQA study for the Upper Colorado River Basin concluded:

Natural and human factors affect the physical, chemical, and biological characteristics in the basin, which then affect the water

> *quality. The natural weathering processes of a variety of geologic formations in the basin add salts, minerals, radionuclides, and trace elements to the surface and groundwaters. Interbasin water transfers along the Continental Divide decrease the quantity of water in the headwater streams and the dilution capability of these streams. Water quality in the headwater streams along the Colorado Mineral belt is being degraded by past mining activities that affect aquatic life. Urbanization and recreational activities are increasing throughout the basin and have a marked effect on the quantity of water needed as well as the quality. In the lower part of the basin, agriculture has a major effect on the quality of surface and groundwaters pre-dominantly because of return flows from irrigation* (Apodaca. et. al. 1996).

Preliminary findings on the Rio Grande were:

> *Point and nonpoint sources have affected the water quality of the streams and groundwater systems in the Rio Grande Valley study unit. Nonpoint sources have affected more reaches of the Rio Grande and its tributaries than point sources. Major stream nonpoint sources are agriculture and hydromodification, whereas the major stream point source is discharges from wastewater treatment plants. The groundwater has been affected both by nonpoint and point sources. Major groundwater nonpoint sources are agriculture and household septic tanks and cesspools, and major groundwater point sources are leaking underground storage tanks, unlined or manure-lined holding ponds used for the disposal of dairy wastes, landfills, and mining operations* (Ellis. et. al. 1993).

For the South Platte River Basin, the initial summary noted, in part:

> *Anthropogenic factors such as water use, population, land use, and water management practices can have a pronounced effect on the water quality. Streams originating along Colorado's mineral belt have been and are being degraded by past mining activities affecting ambient water quality and aquatic life. Wastewater discharges from large population centers located in the central part of the South Platte Basin affect the South Platte River and its tributaries. Urbanization of watersheds in the Denver metropolitan area has accelerated eutrophication of nearby reservoirs. Industries in the Denver area are potential sources of contamination to local ground-water resources.*

Downstream from the Denver area, nitrate concentrations greater than state and federal standards have been measured in wells of several municipalities that withdraw their water from the alluvium of the South Platte River. Farther downstream from Denver, the river runs through one of Colorado's major agricultural regions, and the water quality is affected by farming and livestock feeding operations (Dennehy. et.al. 1993).

Conclusions

Surface water quality in the West is affected by natural factors such as climate, geology, soils, as well as anthropogenic factors including a multitude of land and water use activities. Agricultural activities including irrigation, grazing and feedlots have a major impact on surface water quality. Point source discharges from municipal and industrial sources and hydromodifications are also significant sources of surface water quality degradation.

Based on existing information, some long-recognized water quality problems continue to be significant, especially nonpoint source pollution from agricultural activities (irrigation, dryland farming, and grazing) as well as from historic mining activities in mineralized portions of the West. However, some new water quality concerns are being recognized such as animal feedlots as well as growth in both urban and rural areas.

Increasingly, experts and water resource professionals are recognizing that water quality and water quantity, as well as surface and ground water are all inter-related and should be managed in a comprehensive and coordinated manner in order to achieve water quality mandates. Lastly, while improvements are being made in federal and state water quality monitoring programs, existing efforts do not provide a comprehensive view of water quality conditions in the West.

Recommendations

- More effective monitoring programs are needed to obtain a better picture of surface water quality in the West.

- Prevention of water quality problems before they occur is much more desirable than remediation of contamination problems. A proactive approach towards prevention of surface water quality problems in general can result in cost savings relative to remediation.

- There is a need to integrate ground-water management and surface water management at the state and local level. While the magnitude and nature of this connection varies, it is important to recognize the fact that aquifers and streams are hydraulically connected.

- Recognition of the interrelationships between water quantity decisions and water quality protection is necessary to achieve water quality goals.

III. Ground-Water Quality

Chapter Summary

This chapter addresses water quality issues associated with ground water in the West. Because ground water is the major source of drinking water in the West, water quality issues are of particular concern.

The use of ground water for drinking water is increasing at a significant rate in most western states. The tremendous growth in the Rocky Mountain states during the 1990's has been largely supported by the increased use of ground water for drinking water supplies. The rural West depends almost entirely on ground water for drinking water.

Ground-water quality data from 1986 indicate that many of the surficial, unconsolidated aquifers in the western states are being contaminated by a variety of land uses. Waste disposal and agricultural land uses have had the greatest impact on ground-water quality. Since 1976, state and federal environmental protection agencies have implemented a variety of programs to correct past waste disposal practices and to clean up a number of existing ground-water contamination problems at some of the worst waste disposal sites. However, to date, there has not been the same success in managing nonpoint sources of ground-water contamination. Efforts to more effectively manage these nonpoint sources are just beginning and rely heavily on the use of voluntary best management practices. It is difficult to evaluate the effectiveness of such programs.

Without a concerted and coordinated effort on the part of federal, state and tribal agencies, local governments, industry and landowners to protect ground-water resources, in the future, much of the ground water in the West will likely require treatment before being used for drinking water. This will place a significant financial burden on individual domestic well users as well as communities that are dependent upon ground water.

Recommendations

- Improve agricultural practices such that application of pesticides and fertilizers does not adversely impact ground-water quality.

- Comprehensive aquifer-based ground-water quality monitoring programs should be developed and implemented at the state level.

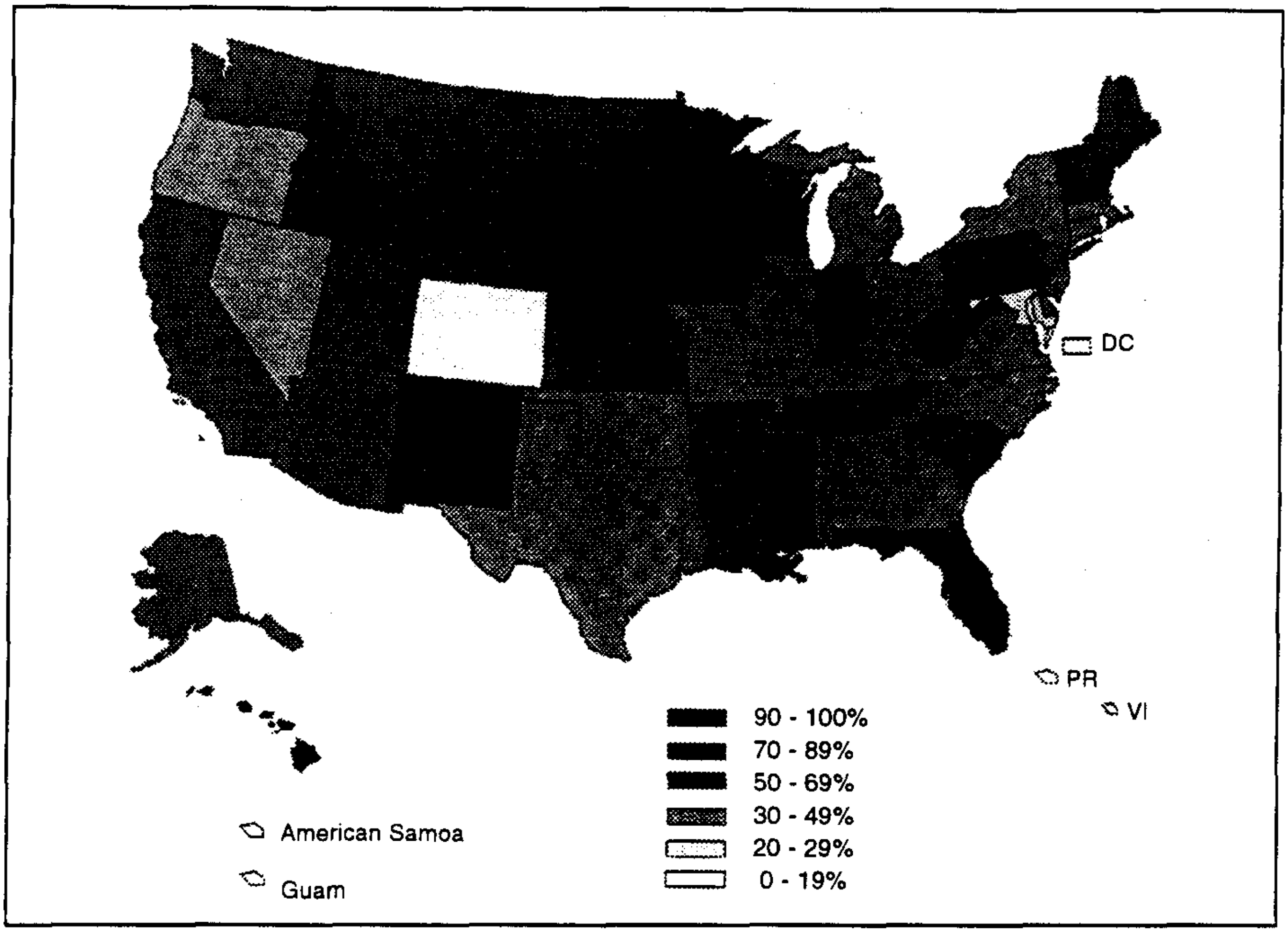
- Integrate ground-water management and surface water management at the state and local level.

- Focus management on the ground-water resource itself.
- Develop a new approach for regulating septic tank design and installation.
- Urban planning and growth should be integrated with water resource protection and planning such that increased growth does not compromise the water resources necessary to sustain it.

Introduction

Ground-water use in the western states is very significant. Many large population centers obtain municipal water supplies from ground-water sources and ground-water supplies drinking water to almost all rural residents in the western states (Figure III-1). In many states, a high percentage of the water used for irrigation is withdrawn from high-yielding aquifers (Figure III-2). Ground-water use has increased significantly during the most recent population boom in the Rocky Mountain states. Most, if not all, surface water supplies in the western states are already appropriated for use, and therefore the new growth is relying largely on ground water for drinking water supply. This is exemplified by the growth experienced in the Denver area in the past 10 years. Growth has been primarily to the south and east because there are ground-water resources available from the four major bedrock aquifers that comprise the Denver Ground-Water Basin. These aquifers pinch out to the north and west of Denver, thus limiting growth in those directions. However, these aquifers receive very limited recharge throughout the Denver Ground-Water Basin, and ground-water mining is likely to be a very real problem in the future.

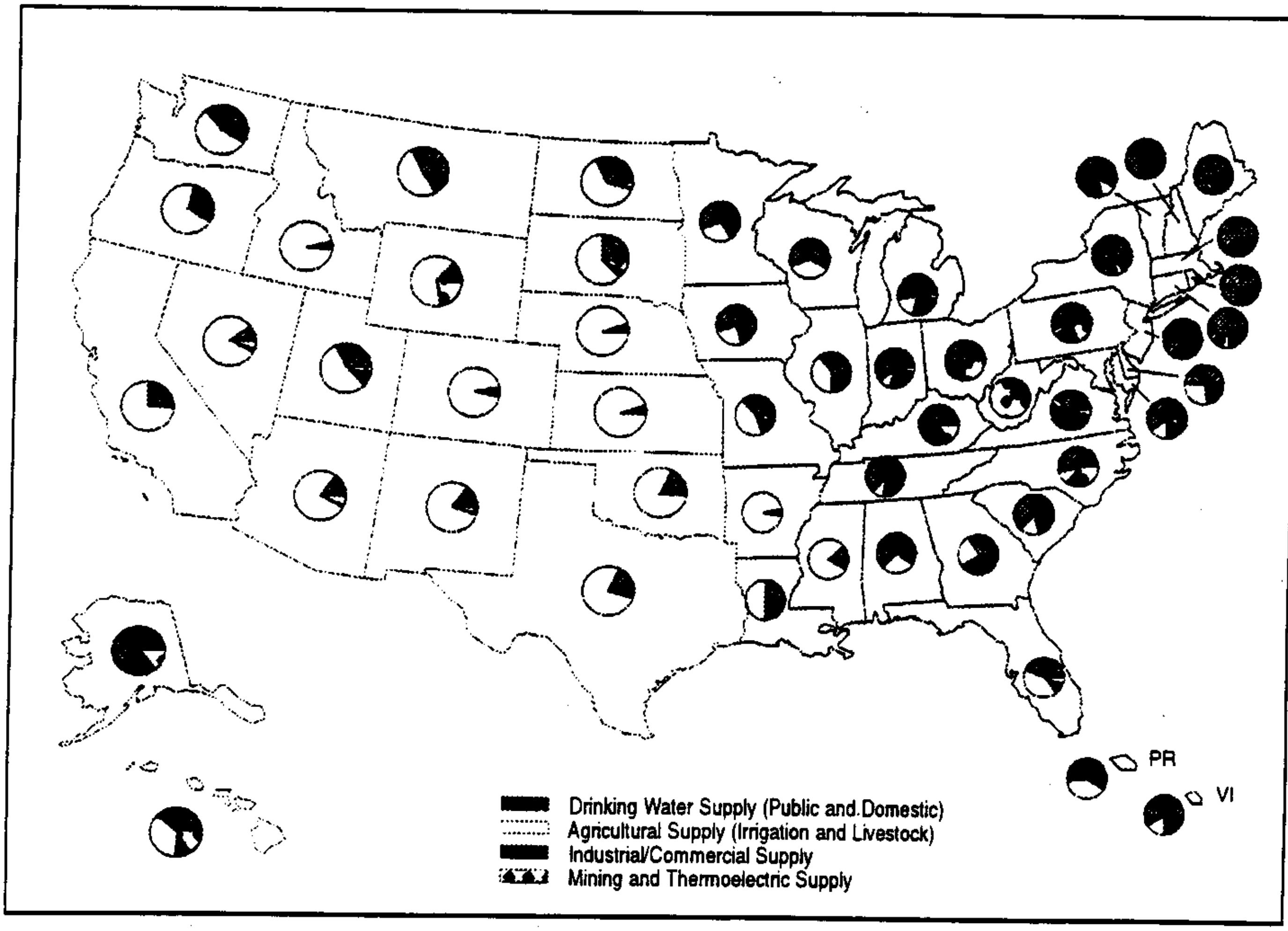
Traditionally, ground-water management in western states has focused on water quantity related to administration of water rights. In most western states, the management of ground-water quantity and ground-water quality is poorly integrated and is often split between different state agencies. To further complicate matters, hydrogeologists and hydrologists are just beginning to understand the magnitude and character of the hydraulic connection between ground waters and surface waters, and the role of ground water in maintaining surface water quality and ecological conditions. Clearly, there is a need to integrate the management of ground water and surface water.



Source: U.S. EPA (1995). National Water Quality Inventory, 1994 Report to Congress; originally from U.S. Geological Survey Open-File Report 92-63.

Figure III-1.—Percent of population dependent on ground water for drinking water in 1990.

Comprehensive characterization of aquifers and ground water has been hindered by lack of funding for monitoring. Traditionally, characterization has focused on water supply studies and new characterization techniques are only slowly being developed that are suitable for characterizing water quality, ground-water ecology and aquifer sensitivity and vulnerability. As the use of ground-water resources increases, it will become critical to better characterize ground-water resources and to implement effective ground-water protection programs.



Source: U.S. EPA (1995), National Water Quality Inventory, 1994 Report to Congress; originally from U.S. Geological Survey Open-File Report 92-63.

Figure III-2.—Distribution of ground water usage across the Nation.

Summary of Ground-Water Quality Conditions

This section of the report presents a brief summary of ground-water quality conditions and ground-water contamination problems for the principal aquifers and aquifer systems in 19 western states. Sources for the information presented in this section include the "1986 National Water Summary" (USGS, 1988) which focused on ground-water quality, and the U.S. EPA "National Water Quality Inventory--1994 Report to Congress" (U.S.EPA, 1995). Additional site-specific data on western ground-water quality can be found in other publications and state and federal water quality databases. An example would be the USGS National Water-Quality Assessment (NAWQA) Program project reports. A bibliography of current

NAWQA reports is attached in Appendix B. The NAWQA Program was initiated in 1991 and focuses primarily on assessing the quality of the Nation's surface waters. However, alluvial aquifers that are hydraulically connected to the streams and rivers included in the NAWQA Program are also being assessed. As the individual NAWQA studies are completed, new data will be available for assessing the quality of ground waters in selected alluvial aquifers. Both the USGS and the USEPA maintain large databases with ground-water quality data. The USEPA SDWIS database includes limited data on regulated parameters from public water systems including ground-water systems. Since the mid 1970's, the USGS has maintained the WATSTORE database. All ground-water quality data collected by the USGS is entered into this database.

The USGS "1986 National Water Summary" provided a snapshot of water quality conditions in the major aquifers or aquifer systems within each state.[1] Information is provided on the existing water quality as of 1986. This is the most recent data available as a national summary. Parameters used to describe water quality include selected major ions and, in some cases, trace elements. Individual state summaries are presented in Appendix C in alphabetical order for ease of reference. For each state, a one- to two-page summary is provided which includes information on ground-water use, water quality conditions in the principal aquifers and aquifer systems, and significant ground-water contamination resulting from human activities. It is important to note that the information and data presented in the 1986 National Water Summary is dated and the accuracy with regard to current conditions is unknown.

Data and information for Arizona was checked and updated for this report (Osborne, 1997). For Arizona, the data in the 1986 Summary greatly understated the magnitude of ground-water contamination resulting from human activities. Despite such discrepancies, the USGS National Summary provides useful information regarding the geology, location and use of the major aquifers and aquifer systems. However, the snapshot of ambient water quality conditions and the magnitude of ground-water contamination resulting from human activities is based on very limited data and may be misleading.

[1] There are typically 4 to 7 major aquifers or aquifer systems within each state.

Major Sources of Ground-Water Contamination in the West

This section summarizes the results of the 1994 U.S. EPA National Water Quality Inventory (U.S.EPA, 1995), and information on ground-water contamination from the USGS National Water Summary (USGS, 1988) for the 19 western states.

In the "National Water Quality Inventory," the U.S. EPA summarized the states' identification and ranking of specific sources of ground-water contamination. The information was obtained from the Clean Water Act section 305(b) reports from 48 states, 5 tribes, and 2 territories. Rankings were based on the best professional judgment of the state ground-water officials. The officials took into account the following factors:

- Number of each type of source in the state

- The location of the various sources relative to ground water used for drinking water purposes

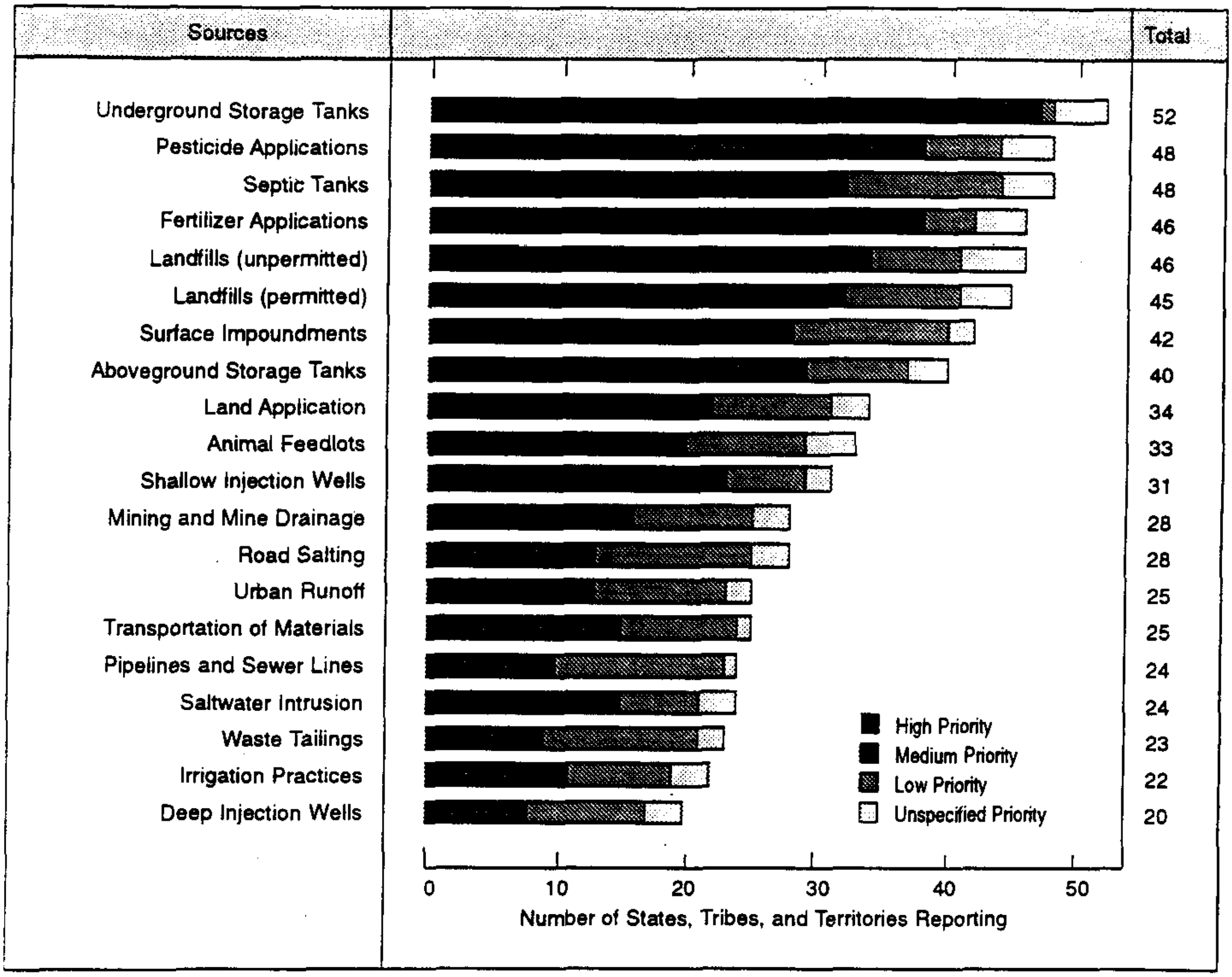
- The size of the population at risk from contaminated drinking water and risk posed to human health and/or the environment from releases

- Hydrogeologic sensitivity (the ease with which contaminants enter the subsurface and travel downward to an aquifer)

- The findings of the state's ground-water protection strategy and/or related studies

Figure III-3 lists ground-water contaminant sources ranked according to the number of states that identified each source as a high, medium, low or unspecified priority. Figure III-3 includes information from all 50 states. A review of the individual states indicates that in the 19 western states, the following sources are considered to be more important than in the eastern states:

- Pesticide applications
- Fertilizer applications
- Mining and mine drainage
- Waste tailings
- Irrigation return flow



Source: Modified from U.S. EPA (1995), National Water Quality Inventory, 1994 Report to Congress.

Figure III-3.—Ground water contaminant sources prioritized by States.

Contamination of Ground-Water Supplies as Reported by States

Most states reported that leaking underground storage tanks (USTs) are a major source of ground-water contamination with 41 states ranking USTs as a high-priority source in the 1994 305(b) reports. Montana indicated that there have been 963 confirmed releases from USTs and that half of these releases impacted ground-water resources. Montana indicates that new reports of leaking USTs come in at a rate of 20-30 per month. In general, most USTs are found in the more heavily developed urban and suburban areas of a state. They are primarily used to hold petroleum products. Ninety-five percent of the USTs in Texas contain petroleum products.

Septic tanks and shallow injection wells were listed as the third and eleventh most common sources of ground-water contamination, respectively. Shallow injection wells[2] inject fluids into or above underground sources of drinking water. A March 22, 1991 report prepared for EPA entitled "Drinking Water Contamination by Shallow Injection Wells" estimated that shallow injection wells contaminated the drinking water of approximately 1.3 million people.

Figure III-4 includes information on ground-water contaminants prioritized by the states. The greatest number of states cited petroleum compounds as a high-priority contaminant in their ground water. Petroleum compounds are generally associated with underground and above-ground storage tanks. Nitrate was the second most common ground-water contaminant cited in state 305(b) reports. Twenty-four states indicated that nitrate was a major concern. Sources of nitrate include fertilizer, domestic wastewater and sludge, and septic tanks. The U.S. Geological Survey (USGS) evaluated nitrate concentrations on a national basis, looking at 12,000 wells and springs in 18 of the 20 Study Units of the National Water Quality Assessment Program and five supplemental study areas. (Figure III-4) The following results were obtained: 22 percent of wells in agricultural areas exceeded the drinking water standard for nitrate (10 mg/L), 9 percent of private wells and 1 percent of public supply wells exceeded the drinking water standard for nitrate, 16 percent of irrigation and stock wells exceeded the drinking water standard for nitrate.

The U.S. Geological Survey last summarized ground-water quality for the Nation in 1986. The following descriptions of ground-water sources are excerpted from the National Water Summary (USGS 1988). The state summaries included in Appendix C are also based on this report. While somewhat dated, these assessments of the principal sources of ground-water contamination in the western states are still considered to be accurate.

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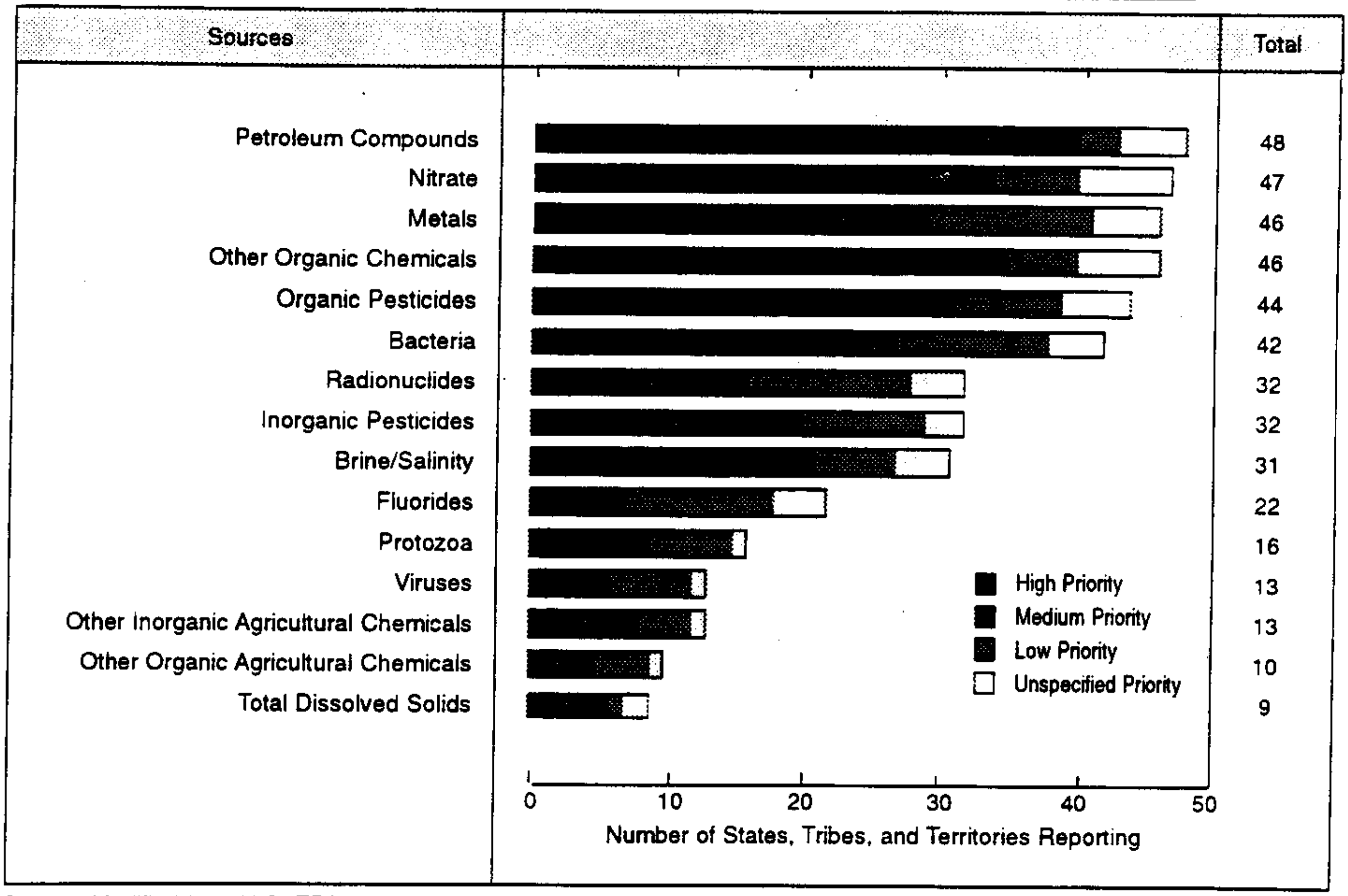
[2] These wells are classified as Class V wells in the Underground Injection Control Program.



Source: Modified from U.S. EPA (1995), National Water Quality Inventory, 1994 Report to Congress; originally from U.S. Geological Survey Open-File Report 92-63.

Figure III-4.—Ground water contaminants prioritized by states.

Naturally Occurring Sources.—In some locations, ground water contains one or more naturally occurring chemical constituents, leached from the soil or rock by percolating water, that can exceed federal or state drinking water standards or otherwise impair use.

Nationally, one of the most common ground-water quality concerns is the presence of dissolved solids in concentrations exceeding 500 mg/L, which is the recommended maximum limit in the secondary drinking-water standards. Ground water with natural concentrations of total dissolved solids (TDS) concentrations in excess of 500 mg/L is found toward the seaward ends of coastal aquifers, and is common in aquifers at depths greater than a few hundred feet below the land surface in many parts of the U.S. Although such water is not recommended for drinking under federal guidelines, some western states such as Nevada and Texas do allow a maximum of 1,000 mg/L dissolved solids in drinking water. Despite the higher TDS content, water exceeding these drinking water standards may be suitable for other uses such as the irrigation of salt-tolerant crops, industrial cooling, and livestock watering.

Although not toxic, iron and manganese in concentrations greater than 300 $\mu g/L$ and 50 $\mu g/L$ respectively (the limits recommended for secondary drinking-water standards), can impair the taste of water, stain plumbing fixtures, glassware and laundry, and form encrustations on well screens, thereby reducing well-pumping efficiency. This is a relatively common problem in western states.

The information presented in this section is based on the state summaries of ground-water quality compiled by the USGS (1988). It is anecdotal in nature and does not represent a comprehensive list of the problems in each state. The sources are based on the USGS' understanding of the primary problems in each state and the selected site-specific studies.

Causes of Ground-Water Contamination

Under this classification, the sources of contamination most frequently mentioned in the state summaries of ground-water quality include, in order of frequency (see Appendix C for individual state summaries):

- Landfills
- Agricultural application of fertilizers and pesticides
- Septic systems
- Underground storage tanks
- Surface impoundments
- Saline intrusion
- Accidental spills

Organic Chemicals Frequently Detected in Well Water

In addition to common inorganic constituents and heavy metals, the state summaries include about 100 organic chemicals (including 49 pesticides) that frequently are detected in well water. The most frequently reported chemicals, in decreasing order of occurrence, were:

- Trichloroethylene (TCE)
- Benzene
- Tetrachloroethylene (PCE)
- Phenolic compounds (general)
- Toluene
- Chloroform
- Pentachlorophenol
- Creosote
- 1,1,1-trichloroethane
- Xylene

Most of these substances are found in solvents. They have very low health advisory levels and are difficult and expensive to characterize and remediate.

The following is a general description of common sources of ground-water contamination in all 50 states (USGS, 1988):

Storage and handling of waste materials results in ground-water contamination owing to leaks from both above-ground and underground storage tanks, accidental spills during handling of chemicals and wastes or from poor housekeeping practices on industrial and commercial sites. Underground storage tanks appear to be a leading source of ground-water contamination from benzene, toluene, and xylene, all of which are organic compounds contained in diesel and gasoline fuels. Although leaking underground storage tanks are reported in many states, contamination generally is localized.

Oil and gas production can contaminate ground water by a variety of mechanisms. During production, oil wells produce brines that are separated from the oil and stored in surface impoundments. EPA estimates that there are 125,100 brine-disposal impoundments that might affect the local ground-water quality by seepage and 161,400 EPA Class II brine injection wells. Also, if a well is abandoned and is not properly plugged, contaminated water can move vertically from one aquifer to another.

Other sources mentioned in the state summaries include atmospheric deposition, surface water/ground-water interactions, and saline intrusion, which is the most frequently mentioned (29 states). The encroachment of saline water into the freshwater parts of aquifers is an ever-present threat when water supplies are developed from the highly productive coastal plain aquifers or from aquifers underlain by saline water in the interior of the country.

Significant Sources of Ground-Water Contamination in the 19 Western States

The following sources of ground-water contamination are important in the 19 western states:

Agriculture is the most widespread of human activities that directly affects ground water. Fertilizer applications (resulting in nitrate contamination) and pesticide applications are among the most common sources of contamination described in the state summaries (44 states). The most frequently mentioned pesticides detected in ground water were the fumigants ethylene dibromide (EDB), and 1,2-dichloropropane, the insecticides aldicarb, carbofuran, and chlordane, and the herbicides alachlor and atrazine. In the western U.S., agricultural chemicals are applied to millions of acres across many hydrogeologic settings.

Waste disposal of liquid or solids in or on the earth is perhaps the best-known source of ground-water contamination. Waste disposal can take a number of forms: septic systems, landfills, surface impoundments, waste-injection wells, the direct application of stabilized waste to the land (land farming), and illegal dumping.

Onsite sewage disposal from septic systems is the largest source, by volume, discharged to the subsurface. Nearly any household chemical poured down the drain of a home served by a septic system can find is way into the local ground-water system. Organic solvents, such as trichloroethylene, which are used for cleaning septic systems, are frequent contaminants.

Landfills are a traditional method of disposing of solid waste. Although facilities can be engineered to prevent migration of contaminants, precipitation and storm runoff can still percolate through most landfills and leach contaminants from the wastes into the underlying ground water.

Surface impoundments are another common form of waste storage or disposal. Some impoundments are lined to prevent seepage, and the liquid fraction of the waste evaporates. In most impoundments, however (including the arid West), some of the liquid fraction discharges to streams or seeps into the aquifer below the impoundment.

Mining of precious metals, coal, uranium, and other substances and the disposal of related mine spoil can lead to ground-water contamination in a number of ways. Underground mining leaves shafts and tunnels that can intersect aquifers and collect and transmit water. Exposing the pyrite- (iron sulfide) bearing ore to oxygen in the atmosphere can lead to the formation of sulfuric acid, low pH waters, and dissolution of heavy metals. In addition to the mine workings, piles of tailings left after mineral extraction can be exposed for many years to leaching by precipitation. Contaminants such as arsenic, copper, iron, zinc, lead, manganese, radium, selenium, and sulfate can leach from the waste piles and infiltrate local aquifers. The addition of a high concentration of heavy metals to streams can significantly degrade aquatic resources. In the Rocky Mountains, there are hundreds of large active mines and tens of thousands of inactive mine sites. At many of these sites surface water runoff and ground water with low pH and high concentration of heavy metals discharge to mountain streams.

Urban activities that contribute to ground-water contamination include the use of septic systems, underground storage tanks and surface impoundments, the application of fertilizers and pesticides to lawns, parks and golf courses, accidental chemical and other hazardous waste spills, commercial and industrial waste disposal and sewer systems. The state summaries frequently provide examples of ground-water contamination related to high population density and urban and industrial land uses.

Conclusions and Recommendations

1. The use of ground water for drinking water is increasing at a great rate in most western states. The tremendous growth in the Rocky Mountain states

during the 1990's has been largely supported by the increased use of ground water for drinking water supplies. The rural west is almost 100 percent dependent on ground water for drinking water.

2. The major aquifers and aquifer systems have been delineated in most of the western states. The geology and hydrology are fairly well characterized. However, much remains to be done to fully characterize ground-water quality conditions and ground-water/surface water interaction for the principal aquifers and aquifer systems.

3. Surficial, unconsolidated aquifers have been the most extensively developed in the western states. This is because it is cheaper to develop shallow aquifers and these aquifers are typically more productive. The recent growth in the West has led to increased development of deeper bedrock aquifers.

4. Ground-water quality data from 1986 indicate that many of the surficial, unconsolidated aquifers in the western states are being contaminated by a variety of land uses. Waste disposal and agricultural land uses have had the greatest impact on ground-water quality. Since 1976, state and federal environmental protection agencies have implemented a variety of programs to correct past waste disposal practices and to clean up a number of existing ground-water contamination problems at some of the worst waste disposal sites. However, to date, there has not been the same success in managing nonpoint sources of ground-water contamination. Efforts to more effectively manage these nonpoint sources are just beginning and rely heavily on the use of voluntary best management practices. It is difficult to evaluate the effectiveness of such programs.

5. There is much commonality among the western states with respect to the types of land uses which have the greatest impact on ground-water quality: agricultural land use, waste disposal practices, mining and urbanization are the land uses which have the greatest impact.

6. Ground-water management has traditionally been done at the local level. Local governments historically have had difficulty adequately managing many land uses which can damage ground-water quality. This has been the case, particularly in the West.

7. Without a very concerted and coordinated effort on the part of federal, state and tribal agencies, local governments, industry and landowners to

protect our ground-water resources, in the future, much of the ground water in the West will likely require treatment before being used for drinking water. This will place a significant financial burden on individual domestic well users as well as communities dependent upon ground water.

Recommendations

Aquifer Management.—Ground water should be managed, or at the least management should be coordinated, on an aquifer and aquifer-system basis. Aquifers are the natural unit of management for ground water just as a watershed is a natural unit of management for surface water. Management of small portions of aquifers by different jurisdictions with different management objectives has resulted in a fragmented, nonresource-based approach to ground water. There is enough knowledge and understanding of aquifers and aquifer systems to make this change in approach.

Prevention, Not Remediation.—Due to the difficulty in remediating aquifers after they are contaminated , it is clear that the sensible approach is to try to prevent contamination rather than try to clean it up (NRC, 1994). This is particularly important when considering new information on how aquifers are contaminated by dense non-aqueous phase liquids (DNAPLs) such as pure trichloroethene (TCE) or tetrachloroethene (PCE). DNAPLs are a problem in ground water at many Superfund, Resource Conservation and Recovery Act (RCRA) and Underground Storage Tank (UST) sites. Even a very small amount of one of these compounds (e.g., 5-10 gallons) can contaminate an entire aquifer. Scientists are now finding that, in many cases, the aquifer cannot be cleaned up after such contamination. This results in treatment forever, if the water is to be used.

Federal and state governments spend tens of millions of dollars per year on ground water remediation, and a few million dollars per year on prevention of contamination. The average cost of a Superfund ground-water remedy is $20-40 million. Significantly more money should be allocated to prevention efforts, including: education of the public regarding the sensitivity and vulnerability of ground water, how it becomes contaminated, and how to protect it, well head protection and ground-water sensitivity vulnerability studies, and ambient monitoring to detect water quality trends.

Other specific steps that should be taken in each state are: strict regulation of USTs, RCRA sites, Superfund sites, and underground injection wells. These programs may not be successful in remediating aquifers, but the deterrent effect on potential polluters is great. Proper closure of abandoned wells should also be strictly enforced.

Home Water Testing and Remediation .—There is a need for affordable water quality testing methods for domestic well owners, preferably home testing methods. Currently the cost of a laboratory analysis for the suite of common contaminants is at least $2000. Domestic well users need affordable home treatment units for contamination by nitrates, pesticides, and volatile organics. At some Superfund sites, home owners are using home air stripper units, and activated carbon to pretreat water.

Ground-Water Monitoring.—In the authors' opinion, there are insufficient data to truly determine the status of ground-water quality in the western states. There are many monitoring efforts (see Section VIII), but there is little consistency in monitoring programs, data are not shared among the programs, various entities are often not aware of monitoring by other entities, many of the data are not entered on computer databases, and databases are not compatible. Also, the amount of monitoring is very limited when considering how vast the resource is. An up-to-date assessment of the current data is needed. Note that many of the data used in this report are from 1986, which is the date of the last national assessment by the USGS.

The U.S. Geological Survey's NAWQA Program and other water quality studies should be fully supported. The bibliography in Appendix B shows the reports generated by the program. The U.S. Geological Survey in cooperation with the USEPA should prepare National Water Summaries for ground-water quality on a regular and timely basis (the last assessment was in 1986). No other organization appears to be looking at ground-water quality nationally. Ground-water quality is changing rapidly enough to warrant this type of effort.

Each state should have a comprehensive ground-water monitoring network. Monitoring should include analyses of a much expanded list of parameters than has previously been done. These include: volatiles, semivolatiles, pentachlorophenol (PCP), polycyclic aromatic hydrocarbons (PAHs), dioxins, polychlorinated biphenols (PCBs), petroleum hydrocarbons, benzene, toluene, ethyl benzene and xylenes (BTEX), pesticides, pathogens, and nitrate (examples given by EPA, 1994, page 123), metals and radionuclides.

Less expensive methods to sample and analyze ground-water supplies are needed. New methods such as temporary wells (Hydropunch and Geoprobe, e.g.) are helping to bring costs down for sampling. Analytical methods that are relatively inexpensive and that work in the field, such as fiber optics or immunoassay tests, should be supported and funded by necessary research. (Please see Section VIII-K, Water Quality Monitoring, of this report for further recommendations on monitoring.)

EPA 1994 Recommendations to Congress.—The EPA made the following recommendations in its 1994 report to Congress (U.S. EPA 1995):

- Pesticides and fertilizers should be applied appropriately
- Site-specific assessment should be conducted to accurately target and protect vulnerable ground water
- Ground-water recharge areas and wellhead areas should be identified and protected
- Flood irrigation should be used more carefully

Ground-Water Management.—Integration of ground-water management and surface water management at the state and local level is critical. This is necessary to recognize the fact that aquifers and streams are hydraulically connected. The magnitude and nature of this connection vary, but it is important for aquifers and watersheds of all scales.

Federal, state and local ground-water management is very fragmented. There is a need to focus management on the ground-water resource itself instead of including a small ground-water component in numerous waste management, agricultural, resource extraction and water supply programs.

Septic Tank Management.—Currently, individual septic tanks are ineffectively managed. With the recent growth in the West, the number of septic tanks is increasing dramatically and many local Health Departments are concerned about this issue. There have been few advances in septic tank design to customize design to hydrogeologic setting or aquifer type. There seems to be a "one-size-fits-all" approach. Data indicate that many individual septic tanks fail and result in localized ground-water contamination. There is a need to develop a new approach for regulating septic tank design and installation.

IV. Drinking Water

Chapter Summary

This chapter discusses the Safe Water Drinking Act and its mandate to EPA and states. Issues of particular concern to the western states are briefly discussed, followed by recommendations.

Challenges

The quality of drinking water in the West varies. It depends as much on the financial capability and technical knowledge of the drinking water facility, as it does on the quality of the source water which the facility utilizes. For the very large majority of people, however, water quality in the West is very good and presents minimum risk to consumers.

The following activities represent particular challenges to drinking water quality in the western states. Because a large number of western states depend upon ground water for drinking water supplies, many of the water quality concerns stem from contamination of ground-water supplies.

- Agricultural activities that lead to nitrate contamination of ground-water supplies.
- Volatile organic compounds from petroleum products seep into ground-water supplies.
- Naturally occurring contaminants in ground-water supplies.
- Remoteness of certain water systems make proper monitoring unfeasible.
- Colonias settlements have severe drinking water quality problems.
- In some areas, pumping of ground water in excess of natural recharge has impaired the overall quality of the ground water resulting in poor drinking water supplies.

Recommendations

In order to improve the drinking water quality problems mentioned above, a number of activities should be undertaken.

- Maintain adequate funding and promote implementation of 1996 SDWA amendments

- Conduct studies to better understand private domestic well use, demographics, needs and availability of technical assistance

- Improve access to drinking water quality statistics and information on a state-by-state basis

- Modernize the federal data tracking system to house drinking water quality information for specific water supply systems and require states to input complete data

- Improve coordination among federal agencies involved in tribal water system

- Consider appropriate responses in situations where tribal systems do not meet federal standards

Introduction

When discussing the quality of drinking water in the West, it is important to make a clear distinction between raw water quality (the quality of lakes, rivers, and streams from which water supplies are drawn) and treated water quality (the water that comes out of the tap). Analyses required by federal and state drinking water programs are performed on *treated* water. The Safe Drinking Water Act (SDWA) is the federal statute that authorizes a national drinking water program. (42 U.S.C. §300g-1)

The SDWA was originally passed in 1974, had a major reauthorization in 1986, and again in August of 1996. The Act requires that public water systems meet the following basic requirements for water quality:

- (a) perform periodic analyses of the quality of the water being served consumers, and

- (b) if those analyses show violation of a health-based standard, the system must either treat the water or provide an alternate source of water that meets the standards.

Numerous provisions under the most recent reauthorization of the Act pertain to issues of drinking water quality in the West. These activities are elaborated in the recommendations section at the end of the chapter.

As the regulations that govern public water systems increase under the Safe Drinking Water Act Amendments of 1996, compliance rates for these systems will vary. As regulations become more stringent, some systems that were previously in compliance may no longer meet the legal standards. The fact that EPA and states work with water systems to help them meet new compliance requirements, helps assure that consumers receive drinking water of high quality. Additionally, new programs under the 1996 Amendments, such as the state revolving fund, source water protection, consumer confidence reports and operator certification will go a long way toward providing continued improvement in infrastructure support, consumer awareness and water quality.

Treatment of Drinking Water

For the most part, drinking water is treated by chemical or physical means, or a combination of both. The treatment process, whether simple or sophisticated, requires operation and maintenance by a knowledgeable individual. In addressing drinking water quality issues, therefore, the 1996 SDWA amendments direct that fiscal, managerial and administrative factors affecting plant operations be integrated into the program in addition to environmental considerations.

The biological and chemical makeup of raw untreated water dictate the treatment processes (and, thus, the costs) required to make that water safe to consume. While little can be done to prevent contamination of source waters by naturally occurring factors, more and more federal, state and local dollars will be spent in the next decade trying to protect source water areas (watersheds and aquifers) from manmade threats of contamination.

Most of the issues addressed in this report will focus on public water systems that are governed by federal legislation. The SDWA and its regulations define a public water system (PWS) as ". . .a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves an average of twenty-five individuals daily at least 60 days out of the year" (40 C. F. R. 141.2). A public water system is either a "community water system," serving a resident population, or a "noncommunity water system," serving transient populations, schools, and businesses.

Individually owned water supplies, such as shallow wells, that are not served by public water systems, are not governed by the SWDA and are not the subject of this report. Although no statistics could be found for the western states, it is estimated that while there are 94,600 community water system wells in this country, there are an estimated 10,500,000 rural domestic wells (EPA, 1990).

How Drinking Water Issues Differ Between the West and the East

The western and eastern parts of the United States share many of the same threats to drinking waters supplies. Aging infrastructure of water systems, increased development and intensified land use near water sources, and rising demand due to population growth are just a few of the common problems that face water suppliers on either side of the Mississippi.

Many differences, however, make numerous drinking water issues unique to the West. These issues, both environmental and socioeconomic, include natural water chemistry, scarcity of water, agricultural practices, mining practices and unique communities of people. These issues are discussed below under the heading, "Areas of Concern."

Another issue unique to the West is the development of so-called "rural water systems." Due to the large distances between small communities, and the need for both drinking and agricultural water, federally-subsidized rural water systems extending hundreds of miles have become common in several states. For example, in South Dakota there are currently more than 30,000 miles of pipelines serving approximately 20 rural water systems. One out of five South Dakotans drink rural water and the Nation's largest rural water system is currently under construction in that state. The South Dakota Association of Rural Water Systems estimates that by the year 2002, over one half of all South Dakotans will be served by large rural water systems.

Anecdotal data does show that many small communities that had poor drinking water quality and were targeted for enforcement action by the state or EPA, are now being provided high-quality water that meets all current drinking water standards.

This report does not contain a state-by-state breakdown of the number of contamination incidents or the number of water systems in violation of federal and state drinking water requirements. Instead, this section focuses on specific issues confronting numerous western water systems and communities that may be at risk of being exposed to drinking water that does not meet national standards.

Areas of Concern

Agricultural Activity

The use of fertilizers and pesticides has impacted drinking water quality throughout the West. Wherever these chemicals are used, stored or transported, there is a risk of potential contamination. Pesticides such as atrazine have been detected in drinking water sources from the corn belt to the island of Kauai. EPA's National Pesticide Survey showed the following chemicals to be most frequently found in drinking water sources.

Pesticides most commonly found in drinking water:

- Dacthal acid metabolites (DCPA)
- Atrazine
- Simazine
- Prometon
- Hexachlorobenzene
- Dibromochloropropane (DBCP)
- Dinoseb (EPA, 1990)

The use of nitrate in fertilizers has made it one of the most common contaminants found in both public and domestic wells. While detection of nitrates at insignificant levels is common, EPA estimates that over 50 percent of both community and domestic wells have concentrations below the health standard of 10 milligrams per liter. (EPA, 1990) EPA estimates that 1.2 percent of community wells and 2.4 percent of domestic wells have levels at or above the health standard. Nitrates, while relatively harmless in adults, can cause deadly methemoglobinemia (blue baby syndrome) in infants.

Mining

Although mining impacts on drinking water in western states are not a widespread risk to public health related to drinking water, areas with significant mining activity are faced with a variety of contamination problems from abandoned mining activities. The main reason for this is that mining operations generally impact streams, rivers and lakes (surface waters) and, as previously stated, the large majority of drinking water systems utilize ground water as their source. Contaminated water from mines and mining operations, nevertheless, can percolate down into groundwater supplies posing contamination problems.

In locations where current or former mining operations exist, water systems that use surface water must guard against potential contamination from sudden or long-term threats from mining activities. Heap-leach operations, like those that utilize cyanide to extract gold from rocks in South Dakota and other states, are one such threat. Ground-water collecting in abandoned mine tunnels in Colorado can seep and flow into creeks and rivers that serve as water supply sources miles downstream. These contamination problems can be costly due to the additional treatment required.

Volatile Organic Chemicals

The use of volatile organic chemicals (VOCs) is ubiquitous throughout the West, as well as the rest of the country. VOCs such as benzene and xylene, which are components of gasoline, can potentially threaten a drinking water well in any small town that has a corner gas station. Other chemicals, such as trichloroethylene (TCE), are used as solvents in many light industries and manufacturing plants. These chemicals can severely impact ground-water resources because very small amounts can impair an entire aquifer requiring costly treatment of the water.

Remote Alaskan Villages

The cornerstone of the national drinking water program is routine sampling that provides consumers and state officials with information about the quality of the water being consumed. Many of these samples, especially those for microbiological quality, need to be analyzed within a certain period of time. For example, the analysis for bacteria must be performed within 24 hours. Another foundation of a good state program is the technical assistance that is given to small water systems. The smallest systems may lack the funding or a trained operator who can assure the water system is functioning properly.

In the State of Alaska, there are many remote small native villages that can only be reached by plane. These villages, designated as public water systems, are unable to perform the routine drinking water monitoring required. The state agency that administers the program is unable to provide adequate technical assistance because of limited resources and the great distances that need to be traveled. The people in these villages receive a lower level of public health protection than the majority of Americans.

Arid Environment and Natural Ground-Water Chemistry

The majority of water systems in the United States depend on ground water for their drinking water supplies. In many parts of the arid West, ground-water is more difficult to find, pump and treat than in other parts of the country. Naturally occurring minerals or contaminants that do not necessarily pose a risk to human health can negatively effect the aesthetic quality of water, sometimes making it non-drinkable. High levels of chloride, iron, manganese, sulfate, sodium and other total dissolved solids (TDS) are common in the West. They not only make the water unpalatable, but increase treatment costs and shorten the life of plumbing fixtures.

Other contaminants found in ground water that increase the risk to human health, such as arsenic, fluoride and selenium, are also found in many western states. The treatment methods best suited for small water systems to remove these contaminants may be water intensive. For example, arsenic is best removed by reverse osmosis, which typically can "waste" 10-50 percent of the water being treated. This rate of loss may present real problems in the West.

Colonias

Residents of colonias (unincorporated settlements along the U.S.-Mexico border) are exposed to some of the worst drinking water quality in the West. In 1995, the Texas Water Development Board estimated that of

1,436 colonias, 275 of them (serving a population of 87,251) lack adequate water supply. The 1990 Census indicated that 23 percent of owner-occupied units in colonias had no treated water in the house. In some cases, "water for bathing, washing, and even drinking may be drawn from drainage ditches where sewage and agricultural chemicals collect." (Lyndon B. Johnson School of Public Affairs, 1996).

Tribal Water Systems

There are hundreds of federally recognized tribal water systems in this country. EPA has primary enforcement responsibility for the drinking water programs on tribal lands.

Tribal water systems face a number of unique problems that can have an impact on the quality of the system's drinking water. These problems include:

- Inadequate communication among federal agencies. A number of federal agencies (EPA, Indian Health Service, Bureau of Indian Affairs, Bureau of Reclamation) often do not adequately communicate or work together in attempting to address tribal infrastructure and technical assistance needs.

- Lack of qualified system operators and high turnover rates. Frequent turnover rates (sometimes due to tribal council elections) result in a new slate of employees that are often under or non-qualified.

- Inadequate maintenance of water system equipment.

- Lack of a fee system for water services that would result in a capital reserve to be used for maintenance and improvement, and

Assessment of the Program's Effectiveness

The Safe Drinking Water Act (SDWA) and its implementing regulations define and mandate the Federal Public Water System Supervision (PWSS) program. The U.S. Environmental Protection Agency and states have responsibility for ensuring the program is implemented.

Since the passage of the Safe Drinking Water Act in 1974, criticism has been leveled against the national drinking water program by various groups. Environmental groups, often using EPA's own data, have castigated the Agency for being ineffective in holding states accountable for proper implementation of the program. States and municipalities, on the other hand, have often criticized EPA for developing complicated regulations that require water systems to perform costly analyses for contaminants unlikely to be found.

The U.S. General Accounting Office (GAO) has performed several studies on the effectiveness of the PWSS program. Some of the findings are as follows:

- Many small community public water system supplies are not meeting the drinking water quality standards and are not being tested as required by federal regulations (GAO, 1982),

- As defined in the Act, the effectiveness of the public notification process in informing drinking water users of violations is questionable (GAO, 1982),

- The gap between the "needs" and "available resources" of state drinking water programs, estimated in the hundreds of millions of dollars annually, has severely affected states' capabilities to conduct sanitary surveys (inspections) on drinking water system plants (GAO, 1993a),

- Several barriers hinder states' efforts to develop and implement Wellhead Protection programs, including:

    (1) Opposition at the local level against states' enactment of land-use controls, and

    (2) A general lack of public awareness about the vulnerability of drinking water to contamination and about the need to protect wellhead areas (GAO, 1993b),

- The number and complexity of the requirements that states must adopt have expanded significantly (without a corresponding increase in federal or state resources) and many states have found it increasingly difficult to fulfill their responsibilities in enforcing primary drinking water regulations (GAO, 1993c),

- The efforts EPA and the states have made to increase technical assistance to small water systems have generally been ineffective, in large part because of the vast number of small systems that need support (GAO, 1994), and

- Many states lack the resources needed to identify nonviable water systems and ensure that they are brought into long-term compliance with drinking water standards (GAO, 1994).

Recommendations

Implementation and Funding of the Safe Drinking Water Act Amendments

1. The 1996 Amendments to the Safe Drinking Water Act include several provisions that, if appropriately funded and properly implemented , would go a long way in addressing numerous drinking water quality issues that face public water systems in the West. These provisions are delineated in (a)-(h) below. References to relevant sections of the 1996 Amendments are cited.

   (a) EPA must identify technologies that are affordable and which achieve compliance for categories of systems serving fewer than 10,000 people (Sec. 105). The majority of water systems in the West serve fewer than 500 people.

   (b) EPA, in cooperation with either the National Academy of Sciences (NAS) or the Centers for Disease Control (CDC), must perform additional studies on the risks and health effects of exposure to arsenic, sulfate, and radon (Sec 109a & b). Radon is common in western states, and arsenic and sulfate are largely exclusively western problems.

   (c) States are required (with substantial federal funding provided) to develop source water quality assessments that: (i) delineate the boundaries of the areas providing source waters for public water systems, (ii) identify the origins of contaminants in the delineated area, and (iii) to determine the susceptibility of public water systems to contamination (Sec. 132(a)). This requirement will go far in assessing the threats to western drinking water supplies.

(d) States will be required to implement operator certification programs that meet national guidelines (Sec. 123). Nearly all western states currently have operator certification programs; however, many tribal operators do not participate.

(e) The Amendments have created a Drinking Water State Revolving Fund (SRF) similar to the Wastewater SRF that has successfully operated for years under the Clean Water Act. Once implemented, the Drinking Water SRF will be used for loans, loan guarantees, source of reserve and security for leveraged loans, and other uses as allowed under the Act to support broadened state drinking water program activities (Sec. 130). This provision will help many small western water systems acquire the funds they need to make capital improvements to aged or inadequate collection, treatment and distribution systems.

(f) EPA must establish an occurrence database that will contain information on regulated and unregulated contaminants found in drinking water supplies (Sec. 126). This database will aid in assessing contamination occurrence and risk in the West, as well as the rest of the country.

(g) EPA is authorized to make $15 million in annual grants to the State of Alaska to pay 50 percent of the cost of improving sanitation for rural and Alaska Native villages (Sec. 303). Grants are used for development and construction of public water and wastewater systems and also for training, technical assistance and educational programs. These grants have been provided since FY 1995 and are included in the President's FY 1998 budget as they have been in past years. These resources improve infrastructure and assistance to small and remote villages.

(h) EPA and other appropriate federal agencies are authorized to award grants to Arizona, California, New Mexico and Texas to provide assistance (up to 50% of project costs) to colonias where the residents are subject to a significant health risk attributable to the lack of access to an adequate and affordable drinking water system (Sec. 135). These funds will be critical to improving the drinking water quality of the colonias along the Mexican border.

Data Collection and Accessibility

- There is little information on the number of people in the West who use private domestic wells. A study that addresses private well demographics, associated health risks and the availability of technical assistance should be undertaken.

- Easy-to-access information regarding drinking water quality issues on a state-by-state basis is inconsistent or nonexistent. This information would be useful to many groups, including the public, environmental groups, public health interests, and the federal government. States should be encouraged to produce periodic reports that assess statewide (public and private) drinking water quality and that delineate the state's short and long-term strategies to protect public health. The SDWA requirement for an annual report (Section 300g) will help meet this need.

- Prior to the amendments in 1996, the Federal Safe Drinking Water Act did not provide authority for EPA to obtain the data for a tracking system able to provide national, state specific and water system specific information on drinking water quality and enforcement. Now that the law does so, EPA should continue to support and improve the Safe Drinking Water Information System (SDWIS). As the law now also provides, states should put mandatory data into the SDWIS until it becomes a useful tool for all levels of government, groups, and citizens interested in drinking water.

Coordination

- Coordination among federal agencies providing technical assistance to tribal water systems on Indian reservations needs to be improved. In order to better serve the tribes, EPA, IHS, BIA and BOR, plus any other players, need to increase communication and cooperation at both the local and Headquarters levels.

V. Tribal Water

Chapter Summary

The Environmental Protection Agency and other federal agencies have made substantial progress in assisting Indian tribes to develop water quality capabilities. Yet, much work remains to be done in terms of water quality monitoring, funding and technical assistance. The overall status of water quality on Indian lands cannot be well-documented. Despite significant recent increases in EPA's support for tribal multimedia and specific water programs, many western tribes still face enormous challenges in building strong programs for water quality monitoring and pollution prevention and control. EPA needs to implement its Indian Policy and increase environmental protection in Indian country. This can only be achieved through a concerted outreach program and continued efforts to provide tribes the opportunity, as EPA has provided the states, to receive assistance as they build their water quality protection programs.

In addition, other federal agencies must be encouraged to assist in attaining environmental protection in Indian country. For water quality, the sharing of monitoring and special studies data would help to better define tribal water quality needs. Coordinated approaches with the tribes, other federal agencies, and the EPA could serve in conserving scarce water quality resources.

A number of specific activities could address these problems and should be incorporated into current federal efforts to work with tribes to address water quality issues.

- Revise EPA's funding strategies so that funding resources are directed to the tribes with the greatest need.

- Tribes should be required to monitor water quality and report the results under Section 305(b) of the Clean Water Act.

- EPA should provide more direct technical assistance to Indian tribes.

- EPA should determine the best methods and practices, especially in terms of enforcement and compliance, that enable tribes to meet tribal water quality needs.

- Tribal water quality should be a major component in the Tribal-EPA Environmental Agreements.

- Federal agencies, like the Bureau of Indian Affairs and the U.S. Geological Survey, need to be more involved in assisting Indian tribes in water pollution prevention and control as part of each agency's trust responsibilities.

- A database relating to tribal water quality should be developed as a means of increasing tribal and EPA's understanding of water quality impairment.

Social and Economic Geography

Introduction

This section provides background information on Indian tribes in the West, and will outline where tribes are located, the general attributes of reservations and tribal water resources and quality. It then outlines the role of EPA and other federal agencies in assisting Indian tribes with water quality issues, programs, and progress towards meeting the broad goals under the Clean Water Act.

Materials and reports of the U.S. Congress, the EPA, the Department of the Interior, and other federal agencies have been reviewed to formulate the report. Other documents found at the National Indian Law Library in Boulder, Colorado, have been used to augment the report.

Native American Tribes, Reservations and Pueblos

Table V-1 below, and Table V-2 and Map V-1 on the following pages illustrate the distribution of federally recognized tribes in the United States. There are an estimated 264 Indian reservations, rancherias and trust areas (referenced hereafter as reservations) in the western United States. Indian reservations in the West make up an estimated 40.7 million acres, or nearly eighty percent of all Indian land in the United States (excluding Alaska). Reservations range in size from a few acres to one rivaling several eastern states. The Berry Creek Rancheria in California, for example, contains thirty-three acres while the Navajo Nation has over 16.2 million acres that sprawl over the states of Arizona, New Mexico, and Utah. The largest reservations are found in Arizona, Montana, North and South Dakota, Idaho

Table V-1.—An estimate of Indian reservations in the West

EPA region	States	No. of reservations
6	OK, NM, TX	67
7	IA, KS, NB	8
8	CO, MY, ND, SD, WY	27
9	AZ, CA, NV	74
10	CA (rancherias)	58
	ID, OR, WA	30

Source: U.S. Department of the Interior, Bureau of Indian Affairs, 1992. Indian Land Areas, Map, U.S. Government Printing Office: Washington.

and Washington, while California has most of the smaller reservations—primarily the numerous rancherias dotting the coastal range and interior valleys. California also has the highest number of reservations although the sizes of these reservations are small in comparison with other reservations (USDOI-BIA 1992).

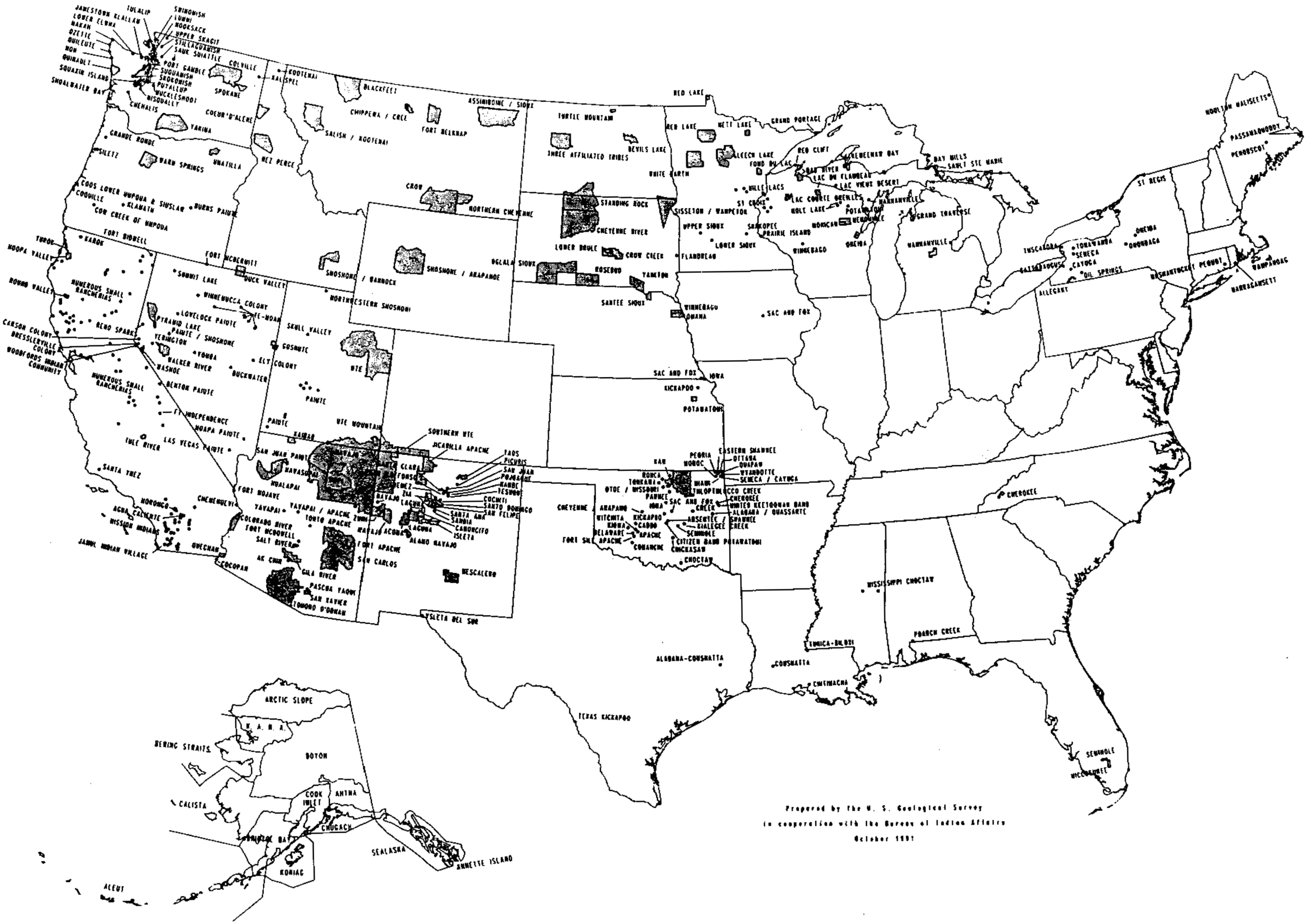
The expansion of the United States in the eighteenth and nineteenth centuries resulted in the creation of Indian reservations. Generally, reservations were created by the United States through treaty, executive order, or legislative act for the exclusive use and occupancy of Indian tribes. Other federal acts expanded or diminished Indian reservations.
The Indian Allotment Act of 1887 was a vehicle that allowed for Indian individuals to receive allotments for agricultural purposes. While treaties established reservations for tribal use and occupancy by Indian tribes, the reservation system often resulted in the removal of Indian people from traditional homelands (Washburn 1973, p. 2267; Deloria 1973, p.1-4; AIPRC 1976, Vol. 1).

From 1892-1917, the federal Indian policy pertaining to Indian lands went hand-in-hand with the policy of assimilation. Once the allotments were completed, the remaining "surplus" lands were opened to non-Indians for sale and settlement. The effects were the expropriation of millions of acres of tribal trust lands, and a checkerboard pattern of land ownership within many Indian reservations (Collier 1947, pp. 244-246). While the allotment process ended with the enactment of the Indian Reorganization Act (June 18, 1934, 48 Stat. 984), federal policies of the 1800's were devastating to the tribes, leaving in the wake an estimated 53 million acres of tribally owned land (AIPRC 1977, Vol. 1).

Table V-2

AMERICAN INDIAN POPULATION AND RESERVATION LAND (Selected Tribes and EPA Regions)													
INDIAN TRIBES			POPULATION				RESERVATION LAND (in acres)						
EPA REGION	STATE	INDIAN RESERVATION	INDIAN	OTHER	TOTAL	TRIBALLY ENROLLED	ALLOTTED	FEE	OTHER	TRUST	TRIBE	TOTAL
6	OK	Cherokee - TJSA	66,456	333,029	399,385							
	NM	Acoma	2,551	39	2,590	5,902				364,809	377,794	378,114
		Isleta	2,699	216	2,915	4,538						211,045
		Zia	637	0	637	750						121,611
		Zuni	7,073	339	7,412	9,582	2,213	2,213			461,057	463,271
7	NE	Winnebago	1,156	1,184	2,340			23,282	429		4,241	27,537
8	SD	Cheyenne River	5,100	2,643	7,743	9,841	503,483			1,419.504	911,467	1,419,504
	MT	Fort Belknap	2,338	170	2,508				25,535	427,580	162,993	654,000
	ND	Fort Berthold	2,999	2,396	5,395	8,500				500,000		1,000,000
	MT	Fort Peck	5,782	4,813	10,595						935,000	2,093,318
	SD	Lake Traverse	2,821	7,912	10,733	9,894	80,269		425		26,976	107,245
	SD	Lower Brule	994	129	1,123							240,000
	MT	Northern Cheyenne	5,100	2,643	7,743	9,841	503,483			1,419,504	911,467	1,419,504
	SD	Pine Ridge	11,182	1,033	12,215	17,775					707,246	1,771,082
	MT	Rocky Boy's	1,882	72	1,954							120,000
	SD	Rosebud	8,043	1,653	9,696	15,438				954,572	409,321	954,572
	CO	Southern Ute	1,044	6,760	7,804	1,252	4,200		207		301,867	818,000
	SD	Standing Rock	4,870	3,086	7,956		542,701		10,258		294,840	847,799
	SD	Yankton	1,994	4,275	6,269		23,000		394,932		17,000	434,932
9	CA	Benton Paiute	52	11					3	160		163
	CA	Berry Creek Rancheria	2	0	2	304					65	65
	CA	Cabozon	20	799	819	25						1,706
	AZ	Colorado River Tribe	2,345	5,520	7,865	3,098					269,921	261,921
	CA	Colusa Indian Communi	19	3	22	55				273	300	573
	NV	Ely Colony	52	7	59	268					100	100
	AZ	Hopi	7,033	299	7,332	7,785					1,561,213	1,561,213
	CA	Hoopa	1,733	410	2,143		2,250				83,798	85,446
	AZ	Hualapai	802	20	822	7,872			738		991,680	992,463
	NV	Navajo	143,405	5,046	148,451		762,749		431,761	385,500	15,622,107	16,224,896
	CA	Pyramid Lake	959	429	1,388	1,776					476,689	476,689
	AZ	Rincon	379	973	1,352	651	7		150		3,975	4,276
	AZ	San Carlos	7,110	184	7,294	10,500					1,853,841	1,853,841
	CA	Santa Rosa Rancheria	284	39	323	408						170
	CA	Susanville Rancheria	154	300	454	373						151
10	WA	Colville	3,788	3,169	6,957	7,995			7			1,400,000
	ID	Fort Hall	3,035	2,079	5,114	3,593						544,000
	WA	Quinalt	943	273	1,216	2,410	124,000					208,150
	OR	Umatilla	1,029	1,473	2,502	1,500				18,211		172,140
	OR	Warm Springs	2,820	256	3,076	3,200	47,345				596,290	643,570
	WA	Yakima	6,307	21,381	27,688	6,315			380	90,000		1,372,000

FEDERALLY RECOGNIZED INDIAN TRIBES



With some exceptions in Arizona, California, New Mexico and Washington, Indian reservations lie in remote regions. Some are endowed with range and farm land, timber, water, and extractive minerals (e.g., coal, uranium, oils and gas). As a result, tribal governments have oriented economic development toward the resources which provide the greatest income and numbers of jobs. Farming (dryland and irrigated), grazing, timber harvesting, mining and mineral extraction, and milling are the chief economic pursuits on most of these lands.

Socioeconomic Conditions

Indian country population varies by state with the largest number of Indians found in Arizona, California, New Mexico, and Oklahoma. Indians live on reservations, in reservation border towns, and in cities of the West. The 1990 Census estimates that there are 808,163 American Indians and Alaska Natives in the western states with about one-half of these people found on the reservations (Bureau of the Census 1991). Many tribes question the Census estimates and fear a serious under-counting by as many as 2 million people.

The U.S. Department of the Interior periodically lists tribal entities recognized by the Bureau of Indian Affairs. Federal recognition by the Department is "a prerequisite to the protection, services, and benefits from the federal government available to Indian tribes" (58 FR 54366, 1993). The Bureau also recognizes "new" tribes under its rules for federal recognition. Accordingly, non-federally recognized tribal groups may petition the Secretary of the Interior to be added to the list of federally recognized tribes. Upon gaining federal recognition, a new tribe may function as a government and enjoy the protection, immunities, and services that are normally provided to other federally-recognized tribes (Ibid).

Indians are employed in most economic sectors, including agriculture, commerce, government, mining, and milling. For most reservations, job opportunities are limited and seasonal, so that on-reservation unemployment rates peak in the winter months and often exceed sixty percent. Because of this, Indians tend to migrate between reservation and nearby cities to find employment. However, a low educational attainment most often prevents them from competing with a more "sophisticated" urban labor force, leading to a return to the reservation.

To reduce unemployment, some tribes have developed light industry and are capitalizing on the Minority Business (8a) Program of the Small Business Administration for federal contracts. An example of this is the A&S Industries[1] operated by the Assiniboine and Sioux tribes on the Fort Peck Indian Reservation which contracted with the U.S. Department of Defense for manufactured goods (AIPRC 1977, Vol. 1). Other tribes are investing in casinos under the Indian Gaming Regulatory Act as a means of generating income and jobs. While somewhat successful, it is too early to tell what the advantages of Indian gaming approaches will be.

Tribal Water Quality Programs Administered by the Environmental Protection Agency

Tribal Views on Environmental Protection

EPA's involvement with Indian tribes is recent and has focused partly on defining tribal needs, and removing legal and institutional barriers to tribal program implementation. As part of this process, Indian environmental organizations have proven instrumental in articulating tribal environmental needs. A survey (conducted in the mid-1980's) by Americans for Indian Opportunity (AIO) showed that out of 74 Indian tribes in the survey, only 28 tribes were implementing environmental protection programs. The AIO report qualified tribal responses in that "environmental protection" within tribal government should be interpreted broadly, and under the aegis of natural resources management. Thus, many tribal programs were self-supported, or were receiving limited funds for environmental protection from other federal agencies. EPA's role in these programs was not fully documented although the tribes indicated some involvement by the Agency (EPA, 1986).

Of the programs developed by tribes in the report, twenty-seven (27) had implemented water quality monitoring programs. Less that one-half of the tribes (31) were enforcing water quality standards. Tribes stated that water quality and emergency preparedness were their highest priorities. Eighteen (18) respondents revealed that they had agreements with federal, state, and county governments for the development of and enforcement of water quality standards. Survey respondents found that irrigation return flows, grazing,

[1] A&S Industries is no longer in operation due to declining contracting opportunities with the Department of Defense.

industrial development, and mining were the land uses mostly responsible for water quality impairment. Many tribes were in the process of planning or implementing programs to control impacts from these activities (Ibid). The reader should recognize that this survey was conducted over 10 years ago and provides a historical perspective.

EPA Indian Policy

The EPA Indian Policy, which guides EPA's interactions with Indian tribes, recognizes tribal sovereignty, and the special relationships that tribes have with the federal government. Under the national policy, further articulated by President Clinton in 1993, the federal government has committed to work with tribes on a "government-to-government" basis in order advance tribal issues and concerns (President's Message, April 29, 1994). Moreover, Congress has recognized tribal sovereignty on numerous occasions, and has enacted laws to protect the interests of all tribes.

In 1984, the EPA adopted an Indian policy relating to the manner in which the Agency would provide environmental protection in Indian country.[2]

The purposes of the policy were to:

- Consolidate and expand on existing EPA Indian Policy in a manner consistent with the overall federal position in support of tribal self-government, and
- To improve environmental quality on reservation lands.

Moreover, the policy recognizes Indian tribes as the appropriate government to carry out environmental protection in Indian country. Nine themes exist in the policy.

- The Agency stands ready to work directly with Indian tribal governments on a government-to-government basis, rather than as subdivisions of other governments.

[2] The EPA Indian Policy is developed in two separate documents. *EPA Policy for the Administration of* Environmental Programs on Indian Reservations, Nov. 8, 1984 and *Indian Policy Implementation Guidance* Memorandum from the Deputy Administrator, Nov. 8, 1984.

- The Agency will recognize tribal governments as the primary parties for setting standards, making environmental policy decisions, and managing programs for reservations, consistent with agency standards and regulations.

- The Agency will take affirmative steps to encourage and assist tribes in assuming regulatory and program management responsibilities for reservation lands.

- The Agency will take appropriate steps to remove existing legal and procedural impediments to working directly and effectively with tribal governments on reservation programs.

- The Agency, in keeping with the federal trust responsibility, will assure that tribal concerns and interests are considered whenever EPA's actions and/or decisions may affect reservation environments.

- The Agency will encourage cooperation between tribal, state, and local governments to resolve environmental problems of mutual concern.

- The Agency will work with other federal agencies which have related responsibilities on Indian reservations to enlist their interest and support in cooperative efforts to help Indian tribes assume environmental responsibilities for reservations.

- The Agency will strive to assure compliance with environmental statutes and regulations on Indian reservations.

- The Agency will incorporate these Indian policy goals into its planning and management activities, including its budget, operating guidance, legislative initiatives, management accountability system and ongoing policy and regulation development processes (Ibid).

In 1994, EPA Administrator Carol M. Browner reaffirmed the EPA Indian Policy. Following this reaffirmation, a plan entitled the "Tribal Operations Action Memorandum" (July 12, 1994) established specific steps to attain the goals in the EPA Indian Policy. A central concept in the Action Memorandum was the development of the Tribal-EPA Environmental Agreement which specifies programs oriented specifically to individual tribal needs. The overall responsibility for implementation of the Action Memorandum was placed in the newly created American Indian

Environmental Office. In the EPA Regions, Regional Indian Workgroups began to review programs and resources for tribal implementation. A result of this process was the formulation of the Region 8 Indian policy clarifying interactions with tribal government. Under the policy, jurisdiction, capacity building, and protocol (how Region 8 staff relate to tribal administrations) are the benchmark for the attainment of the national EPA Indian Policy (EPA Region 8, March 1995).

Following the Indian Policy adoption, the major EPA focus was in seeking amendments to environmental statutes which clarified the role of Indian tribal governments; outreach activities, and incorporating responses to tribal environmental problems into the broader EPA management approaches (EPA 1987, p. 2).

With the enactment of the Water Quality Act Amendments of 1987, Indian tribes gained the opportunity to develop water quality programs. While the EPA Regions had competent water quality staff, very few were available to assist the tribes with the development of tribal programs.

Tribes as States Under the Clean Water Act

The 1987 amendments to the Clean Water Act were particularly important for tribal governments in that Section 518 provided opportunity for tribes to establish their own programs under the Clean Water Act in a manner similar to the role of states under the Act. Section 518 also directed the Indian Health Service and the EPA to assess tribal wastewater treatment needs and identify a manner that best addresses these needs. In the Act, a tribe is defined as:

> *"any Indian tribe, band, group, or community recognized by the Secretary of the Interior and exercising governmental authority over a Federal Indian reservation" (33 U.S.C. 1251-1377, 1988).*

The recognition of tribal governments is found in Section 518(e), and allows the EPA to treat Indian tribes as states to carry out eleven major Clean Water Act programs. In 1988, Congress expanded Indian eligibility under Section 518 to include the former reservations of Oklahoma, and Alaska Native villages as defined in the Alaska Native Claims Settlement Act (P.L. 92-203, as amended). Thus, Oklahoma tribes and Alaska Native villages and corporations were provided with a mechanism for water quality protection similar to other tribes. To qualify for treatment as a state under Section 518, a tribe must satisfy three basic criteria:

- The Indian tribe must have "...a governing body carrying out substantial governmental duties and powers..."

- "The functions to be exercised by an Indian tribe pertain to the management and protection of water resources held by the tribe, held by the United States in trust for Indians, held by a member of an Indian tribe if such property interest is subject to a trust restriction on alienation, or otherwise within the borders of an Indian reservation..." and

- The Indian tribe is reasonably expected to be capable..."...of carrying out the functions to be exercised in a manner consistent with the terms and purposed of this Act and all applicable regulations..." Clean Water Act, § 518(e), 1989).

The amendments have made it possible for tribes to receive grants for water quality programs. By 1997, over 129 Indian tribes had met eligibility requirements under the Act to initiate water quality programs.[3] Fifteen tribes including Isleta Pueblo in New Mexico and the Confederated Salish & Kootenai Tribes of the Flathead Indian Reservation in Montana, applied and have been approved for a water quality standards program to develop standards for tribal waters (EPA Fiscal Year Report 1992).

The City of Albuquerque and the State of Montana both filed separate law suits against EPA on the approval of the Water Quality Standards Program of Isleta Pueblo and the Confederated Salish and Kootenai Tribes respectively. The Courts have ruled that EPA acted correctly in approving the standards program for both tribes, and the Supreme Court has let stand the lower court decision in the Isleta case. These lawsuits reflect the seriousness of the jurisdictional issues involved in tribal environmental management.

[3] EPA Memorandum 1996, Terry Williams to Assistant Administrators.

Water Quality Concerns on Tribal Lands

Water quality impairment, a reservation management problem, is attributed to population increases, water resource demands, and on- and off-reservations land uses. Many Indian tribes have sought to improve management programs for protecting and preserving reservation water resources. In the Northwest, the tribes that are economically reliant on fishing have blamed poor land use practices as the cause of habitat losses and poor water quality. Irrigation, grazing, logging, and mining have shared in the overall blame for water pollution (Daddow, et al.; 1996; Butler, et al. 1993; Rinella, et al., 1992).

Most of the literature is inconclusive in portraying overall water pollution in Indian country. The data that exists suggests that pollution is primarily related to the rural qualities of Indian Country, and the economic activities found there. For example, irrigation on the Yakima Indian Reservation is part of the Yakima River basin, one of the largest and most intensively irrigated regions in the United States (Renella, et al., 1992, p.1). Other Indian irrigation projects on the Colorado River, Crow, Flathead, Wind River, and San Carlos Indian reservations show similar results. In addition, ranching is a significant activity, particularly on larger reservations of the western interior and contributes to reservation nonpoint source pollution problems.

Federal Studies on Tribal Water Quality

Tribal water quality needs have triggered responses from several federal agencies. The U.S. Geological Survey (USGS) together with the Bureau of Indian Affairs (BIA), have examined water resources on over twenty Indian reservations. The purpose of these studies was "...to determine if irrigation drainage has the potential to affect human health, fish and wildlife or has affected the suitability of water for other beneficial uses (Butler, et al. 1996). EPA has also performed reviews of streams for metals contamination in western South Dakota under its enforcement authority (EPA 1971, 1973).

The United States Geological Survey studies involving Indian lands have revealed a number of specific water quality problems. These studies tend to concentrate on the spatial and temporal variability of dissolved-solids and nutrient concentrations. The investigation of the Yakima River basin and the Pine River Project in Southwest Colorado (Butler, et al. 1993) suggest that dissolved-solid concentrations result from irrigation practices. Ammonia concentrations in the Yakima exceeded EPA's chronic life criteria for salmonid and other cold water species. At one site, nitrite-nitrate concentrations were above the maximum contaminant level (10 mg/L as N.) for drinking water (Renella 1992). Selenium, and traces of cadmium, manganese, lead, and mercury were discovered in surface water, sediment, and vegetal samples from the Pine River Project in Colorado (Butler, et al. 1993). Another investigation of the Wind and Popo Agie Rivers in Wyoming note that increases in dissolved solids might be attributed to contacts with and seeps from marine shales, but that rivers are recharged largely by irrigation return flows (Daddow 1996).

Mining impacts in the Cheyenne and Belle Fourche Rivers in Western South Dakota were investigated by the EPA in the early 1970s. These systems drain large areas of the Black Hills, and are important water sources for many small towns and the Pine Ridge and Cheyenne River Indian Reservations. The investigation was spurred by a U.S. Food and Drug Administration (FDA) report (1970) that mercury exceeding its recommended levels had been found in fish from the Cheyenne River arm of Oahe Reservoir. An investigation by the EPA and the South Dakota Department of Health in 1971 supported the FDA report. A subsequent investigation in 1973 documented the extent of metals contamination from the mining. The average daily discharges from the Homestake Mine revealed 2,735 pounds of suspended solids, 312 pounds of cyanide, 72 pounds of copper, and 240 pounds of zinc. An addition 9.5 tons of arsenic were being released in the form of arsenopyrite and arseno-iron (EPA 1973, p. 2). Tailings containing lead and other metals similarly were found in the King Creek drainage of Little People's Creek on the Fort Belknap Indian Reservation in North Central Montana (Main Video 1993).

EPA Water Programs and Tribal Governments

Funding for Tribal Water Quality Programs

The elimination of barriers as previously cited was a key factor in the tribes becoming eligible for water program funding. Each EPA Region (except for Region 3 which has no reservations) was involved in funding tribal water quality programs.

One hundred twenty-nine tribes have sought and received approval for various programs since the 1987 amendments of the Clean Water Act. Of these, about 59 tribes in the western states have received EPA approval to administer the Water Pollution Prevention (Section 106), Clean Lakes (Section 314), Nonpoint Source (Section 319), and Water Quality Standards (Section 303) programs. Another 17 tribes have applied for one of the programs and are awaiting EPA approval pursuant to Section 518. Table V-4 below illustrates the programs that have been approved for tribes and have begun to develop water quality management programs.

Table V-3.—EPA water program funding: 1985-93

			SDWA					
	CWA		UIC		PWSS		GWP	
Year	WY	$	WY	$	WY	$	WY	$
1985	1.3	1791.6	17.9	203.5	9.7	531.8	0	0
1986	1.6	535.0	13.3	240.4	7.3	311.7	0	0
1987	1.5	498.8	18.4	340.3	10.1	382.8	0	0
1988	12.0	2876.0	27.3	453.0	8.5	307.4	0.6	75.0
1989	—Data not available—						0.5	75.0
1990	21.0	15009.9	23.8	482.5	7.8	485.2	0.2	75.0
1991	19.7	10387.1	0	0	0.6	8.0	0	0
1992	20.1	15623.2	30.1	747.9	15.1	256.3	6.9	27.0
1993	22.6	15750.5	24.0	575.6	17.9	1076.2	7.3	35.9

Legend: CWA = Clean Water Act
GWP = Ground-Water Program
PWSS = Public Water Supply Supervision
UIC = Underground Injection Control
WY = Work Year

Source: EPA, 1985-93. *Environmental Activities on Indian Reservations, Fiscal Year Reports*, Washington: Office of Federal Activities.

Table V-4.—Tribal approvals for EPA water quality programs

EPA region	Programs approved for tribes under the CWA					
	Sec 106	Sec 314	Sec 319	Secs 303/401	Sec 404	Total
6	13	2	1	8	0	29
7	4	0	1	0	0	5
8	21	5	1	2	0	29
9	38	2	1	2	0	43
10	21	6	2	3	0	32
Total	97	15	6	15	0	133

Source: EPA, American Indian Environmental Office, September 1997.

Although the CWA amendments were enacted in 1987, the regulations for Section 518 were not enacted until 1989, and then only for the Section 106 Program. At that point, the tribes began to apply for the Section 106 Program funding which allowed for the monitoring of tribal waters (EPA 1990).

The Section 106 Program also allows funds to be used for capacity building. In that regard, tribes can employ staff, purchase equipment, develop sampling and analysis plans, and establish quality assurance and control plans for surface water quality monitoring. The EPA Regions also turned their attention to correcting water quality violations that had long occurred on reservation lands. The enforcement of NPDES and 404 permit violations on Warm Springs (Oregon) and Crow (Montana) Indian Reservations alerted the regulated communities that environmental laws would be enforced on Indian reservations (EPA 1987).

Given the substantial variation in geography, types of water resources, and tribal government structure, implementation of Clean Water Act programs varies considerably among tribes. Most tribes have established water quality monitoring programs and are now characterizing tribal waters in terms of beneficial uses. In addition, some tribes are assessing wetlands and NPDES permit programs under Section 104(b)(3) to determine the best manner to manage these resources. Preliminary data from tribal monitoring and assessment programs seem to support the contention that the major reservation pollution problems are from nonpoint sources. However, ground-water studies reveal bacterial contamination and problems from leaking underground storage tanks (UST). As an example, the Pine Ridge Indian Reservation has instituted the clean-up of contaminated soils and ground water from leaking USTs in Pine Ridge Village .

EPA has not required that tribes report the attainment of Clean Water Act objectives under the Section 305(b) reporting requirements. Rather, reporting by the tribes has been on a voluntary basis. In the National Water Quality Inventory (EPA 1994), only six tribes contributed information on the status of their reservation water quality. These tribes were from the semi-arid regions of Arizona and California, and indicate that reservation waters are partially to fully supporting designated uses. (EPA Ibid, p. 187-199).

Summary, Conclusions and Recommendations: Tribal Water Quality Needs

To summarize, pollution from nonpoint sources appears to be the greatest water quality concern to Indian tribal governments. Tribal governments have articulated the concern that agriculture, grazing, and mining impact water quality, which appears to be supported in the USGS and EPA studies relating to tribal lands. However, the extent of pollution from these sources is difficult to document and suggests the need for additional water quality monitoring and management in Indian country. In addition, tribal water quality programs should be included in the reporting requirements under Section 305(b). EPA and other federal resource management agencies must support the tribes through grants and technical expertise so that the tribes are better prepared to assume the responsibility of managing their resources.

EPA and Indian tribes in the West have made substantial progress in determining the quality of tribal waters. These efforts have been enhanced through the efforts of other federal agencies including the U.S. Geological Survey and the Bureau of Reclamation. Because most tribal water quality monitoring programs are relatively new, there are some problems relating to reservation water quality that should be addressed. The following summary provides a general overview on the directions that should be taken.

Defining the Water Quality Problem

Tribes, EPA and other federal agencies have a general understanding of tribal water quality problems and needs. Reservation waters have not been completely characterized in terms of beneficial uses, attainment of water quality goals and standards, or the impacts which stand in the way of attainment. The monitoring programs for Indian tribes, however, are too new to identify the specific water quality trends and problems. Moreover, many tribes require technical assistance in designing monitoring programs which are appropriate to tribal systems. Closely aligned with these problems is that fact that reliable data for all reservations either does not exist or is widely scattered which limits its utility for water quality management. Because of these problems, EPA and other federal agencies have no way of determining the extent of reservation water quality problems, or allocating resources in logical, planned approaches. Based on these concerns, specific actions are needed for better tribal planning, including:

- EPA and other federal agencies should work more closely with tribal water quality programs. Technical assistance should be oriented to defining tribal water quality monitoring and approaches, and in enhancing the quality and validity of data gathered by the tribes.

- Reports called for under Section 305(b) of the Clean Water Act should be applicable to Indian tribes. In particular, the tribes that have been monitoring for longer periods of time, or have set water quality standards, should provide data pertaining to the attainment of water quality standards.

- EPA should provide direct technical assistance to Indian tribes. It is not enough to provide tribes with funds for water quality monitoring. Rather, the tribes need to know which monitoring activities to develop in order to maximize the limited grant funds they receive.

Funding Needs For Water Quality Management

Indian tribes have expressed their concerns over the adequacy of funding for water quality monitoring. There is validity in their concerns both in terms of the amount of funds provided to Indian tribes, and in EPA's ability to meet tribal grant requests. In both instances, inadequate funding is in part the result of a formula devised by EPA to ensure tribal participation in Clean

Water Act programs. While changes in the formula for FY 1995 have enabled funding increases for Indian tribes, funding still falls short in meeting tribal monitoring needs. The suggested approaches to improve this problem are, as follows:

- Once better data are available on a national basis to identify tribal water quality problems, revise the EPA funding strategy so that funding resources are directed to the tribes with the greatest need. Consideration should be given to pollution problems, vulnerability and threats, and land mass, stream, lake and wetland resources, and the value of the resources.

- The Tribal-EPA Environmental Agreement (TEA) process articulated in the Administrator's reaffirmation of the Indian Policy offers a significant opportunity to assist the tribes in meeting water quality needs. EPA must consider approaches that make the process less bureaucratic and easier to implement if it is to serve the intended purposes.

- Tribal water quality should be a major component in the TEA's. TEAs should specify ways that tribes can protect and improve reservation water quality.

- Indian tribes must be encouraged to move beyond water quality monitoring, and undertake pollution abatement approaches that pertain to specific reservation circumstances. For example, if nonpoint source pollution is a problem (as most data suggests), then the tribes need to develop management approaches that curb the problem. Moreover, EPA needs to provide funding and technical expertise to the tribes that will help them choose an appropriate approach.

- Other federal agencies, like the Bureau of Indian Affairs and the U.S. Geological Survey, need to be more involved in assisting Indian tribes in water pollution prevention and control as part of each agency's trust responsibilities. Moreover, BIA and USGS should coordinate their activities with EPA water quality staff so that the understanding of tribal water quality needs is broadened and addressed in a more comprehensive and coordinated fashion.

- A database relating to tribal water quality needs to be developed as a means of increasing tribal and EPA's understanding of water quality impairment. Pollution prevention and protection approaches of the Agency should be based on needs and oriented to meeting the broad goals of the Clean Water Act.

In conclusion, while EPA and other agencies have made substantial progress in assisting the tribes to develop water quality capabilities, there is much work remaining to be done. The EPA Indian Policy requires the Agency to increase environmental protection in Indian country. This can only be achieved through a concerted outreach program, and in better allocation, distribution, and utilization of the available resources.

In addition, other federal agencies must be encouraged to assist in attaining environmental protection in Indian country. For water quality, the sharing of monitoring and special studies data would serve in better defining tribal water quality needs. Coordinated approaches with the tribes, other federal agencies, and the EPA could serve in conserving scarce water quality resources.

VI. Federal Water Quality Programs

Chapter Summary

While many federal agencies have programs addressing various aspects of water quality management, it appears that the Environmental Protection Agency and the Departments of Agriculture and the Interior have primary responsibilities.

The large number of water quality programs in various agencies raises a question as to what extent the various efforts could improve their effectiveness through better coordination. Resolving this question, however, was beyond the scope of this report. One activity shared by multiple agencies is water quality monitoring which is discussed in the section on Water Quality Issues.

Another aspect of water quality programs that must be noted is the critical role played by states, especially programs delegated under the Clean Water Act. This topic is discussed in the section on state programs.

This chapter presents a list of water quality-related programs managed by various federal agencies. Only a general description of the program objectives is presented. Analysis of the effectiveness of the programs was beyond the scope of this inventory.

Recommendations

In order to better understand and coordinate the various programs that address water quality issues, a comprehensive review of the program goals, scope, funding and coordination should be undertaken.

Introduction

The purpose of this chapter is to identify the federal departments and agencies that have programs for water quality protection and improvement and to provide a list of those programs. Because of the wide variety of existing programs, only a brief description of the each program and its objectives is provided. Additional information about individual programs can be obtained by contacting the responsible agency or referring to the literature reviewed in preparing this section.

In order to identify the relevant programs, the authors reviewed the literature, documents, program information, and past reports that discuss water quality issues. The primary sources of information were the GAO Report to Congressional Committees, "Water Quality, A Catalog of Related Federal Programs", June 1996 GAO/RCED-96-173 and EPA's "Guide to Federal Water Quality Programs and Information", February 1993, EPA-230-B-93-001. This is not an exhaustive review but should be considered an overview of the relevant federal programs. Federal programs range on a continuum of policy options from totally voluntary actions to prohibition of activities. Following is a table showing the range of policy options. An expanded listing under each types of policy are the federal agency actions and requirements.

Table VI-1.—Examples of Federal Water Quality Programs

Policy	Action	Statute	Agency
Education	University	Cooperative State Research, Education and Extension Service Prohibition	USDA
Research	Grants	National Oceanic and Atmospheric Administration Appropriations Act	NOAA
Planning	Technical assistance	Wild and Scenic Rivers Act	NPS
Incentives	Money for better farming practices	Colorado River Basin Salinity Control Program	BOR
Disincentives	Property transfer	Base Realignment and Closure	DOD
Certification	Operator certification for public water systems	Safe Drinking Water Act	EPA
Registration	Pesticide labeling	Federal Insecticide, Fungicide, and Rodenticide Act	EPA
Permitting	Discharge of fill material	Clean Water Act (sec. 404)	COE
Prohibition	Pesticide bans	Federal Insecticide, Fungicide, and Rodenticide Act	EPA

Education/Public Involvement

Council on Environmental Quality

The Council on Environmental Quality is required by the National Environmental Policy Act of 1969 to report to Congress on the status and the condition of the environment.

U.S. Department of Agriculture

The Natural Resources Conservation Service (NRCS) provides conservation technical assistance through local conservation districts to individuals; communities; watershed groups; tribal governments; Federal, state, and local agencies; and others. The NRCS staff at the local level works with state and local conservation staff and volunteers in a partnership to assist individuals and communities to care for natural resources.

Environmental Protection Agency

Since the majority of EPA programs are discussed in other sections of this report, EPA activities will not be outlined in this chapter. However, the legislation creating EPA programs will be listed at the end of this chapter.

Research

Interagency

The National Acid Deposition Program/National Trends Network is the only U.S. network to monitor precipitation chemistry on a national scale.

National Aeronautics and Space Administration (NASA)

NASA maintains a global change master directory of data sets that are of potential interest to the research community.

U.S. Department of Agriculture

Through the Cooperative State Research, Education and Extension Service usually associated with each states' land grant college, the National Research Initiative Competitive Grants Program supports research on key problems of national and regional importance in biological, environmental, physical and social sciences relevant to agriculture. Scientists at all U.S. academic institutions, federal research agencies, and private and industrial organizations and institutions are eligible for these grants.

The Agricultural Research Service and the Economic Research Service provide information on agricultural activities such as pesticide and fertilizer use as well as land use effects on water quality and research activities on water quality protection.

The U.S. Forest Service under the Resources Planning Act conducts research into the present situation and outlook for water quality on lands it manages.

Department of Commerce

The National Oceanic and Atmospheric Administration conducts extensive water quality and biological research in estuarine and coastal areas contained in the Earth System Data Directory, the Climatic Data Center, the National Oceanographic Data Center, and the National Environmental Data Referral Service.

The Bureau of the Census provides detailed data regarding on-farm practices as well as annual operating costs and capital expenditures for pollution abatement activities in manufacturing industry.

Department of Energy

Through the national labs, the Department of Energy conducts water quality research and data collection.

Department of Health and Human Services

Since 1971, in cooperation with EPA, data has been tabulated concerning waterborne disease outbreaks in the United States.

Department of the Interior

The Bureau of Reclamation collects data and conducts research on water quality. Specifically, the Water Treatment Technology Program provides research on cost reduction of water treatment and desalting technology in partnership with the private sector, academia and communities in the seventeen contiguous western states.

The U.S. Fish and Wildlife Service provides research on the effects of contaminants on biological resources on and off Fish and Wildlife Service lands such as the National Contaminant Biomonitoring Program and the National Wetlands Inventory.

The U.S. Geological Survey collects and analyzes water quality information and researches water quality impacts from specific land uses.

The National Park Service has a park-based watershed protection program.

The Department of Transportation

The U.S. Coast Guard collects data on pollution incidentals in the coastal zone.

National Science Foundation

Grants made by the National Science Foundation to individuals in non-profit organizations are primarily made through either the Division of Earth Sciences or the Division of Environmental Biology. The grants emphasize three major areas: environmental geochemistry and biogeochemistry, hydrologic science, and water and watersheds.

Planning

U.S. Department of Agriculture

Through river basin surveys and investigations, the Natural Resource Conservation Service provides planning assistance to federal, state, and local agencies for the development of coordinated water and land resource programs. Priority is given to solving upstream flooding of rural communities, improving the quality of water from agricultural nonpoint sources, wetland preservation, drought management and assisting state agencies in developing strategic water resource plans. In addition, the Watershed Protection and Flood Prevention program provides studies, monitoring, loans, technical assistance and cost-share to governmental entities in order to improve water quality and solve problems caused by flooding, erosion and sediment damage.

The U.S. Forest Service, under the Federal Land Policy and Management Act, must develop plans and programs to manage natural resources on public lands including water quality.

Department of Defense

Under a mandate from the Water Resources Development Act of 1992, the U.S. Army Corps of Engineers provides planning and design of water-related infrastructure to eighteen specific communities and to states, Indian tribes and the trust territories. The Corps of Engineers also provides technical assistance on floods and actions to reduce flood damage potential through the Flood Plain Management Services.

Department of the Interior

The Bureau of Reclamation runs the Irrigation Drainage Program which provides studies, monitoring and technical and engineering support to water districts that are in violation of the Endangered Species Act or the Migratory Bird Treaty Act. The purpose of this assistance is to develop coordinated remediation plans where irrigation drainage has affected endangered species, migratory birds or water quality problems. The General

Investigations Program develops feasibility studies to meet current and future water quality, quantity, and environmental needs through structural and nonstructural means. The Native American Program provides technical and engineering support for the development and management of water resources. The Wastewater Reuse Program provides research grants, feasibility studies and technical and engineering support to investigate and identify opportunities for reclamation and reuse of municipal, industrial, domestic and agricultural wastewater.

The National Park Service through its Rivers, Trails and Conservation Assistance Program provides planning assistance for the assessment of resources, identification of land protection strategies, and organizational development for community conservation efforts including river restoration and water quality enhancement.

The Fish and Wildlife Service provides technical and engineering support under the Migratory Bird Conservation Act to individuals and organizations to satisfy requirements for federally funded projects or federally authorized permits. Fish and Wildlife also provides technical assistance under the Fish and Wildlife Coordination Act to protect, restore and enhance fish and wildlife habitats affected by energy and water resource development. Specific assistance is provided under this Act for 11 priority coastal ecosystems.

The Bureau of Land Management and the National Park Service under the Federal Land Policy and Management Act must develop plans and programs to manage natural resources on public lands which should include water quality.

Department of Transportation

Through the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the Department of Transportation provides technical assistance and education to state and local transportation departments on the adverse impacts to water quality and wetlands from the surface transportation system.

Incentives

U.S. Department of Agriculture

The Natural Resources Conservation Service and the Farm Services Agency provide financial and technical assistance to private landowners to accomplish program conservation goals. The 1996 Farm Bill ushered in a new era of incentive-based conservation programs.

The Conservation Reserve Program (CRP) offers landowners an opportunity to enroll or re-enroll environmentally sensitive land into the program. The CRP provides direct cost-share payments, annual rental payments, and technical support to help landowners improve their land, water, and wildlife resources. Both re-enrolled and new CRP acres will have an average Environmental Benefit Index (EBI) score that is 46 percent higher than the average for the acreage currently enrolled.

The three primary goals of the CRP are erosion reduction, improvement of water quality, and the enhancement of wildlife habitat. During the 15th signup conducted in March of 1997, 16.1 million acres of environmentally sensitive cropland were enrolled in the new CRP. Signup 16 will take millions of environmentally sensitive acres out of production. The law allows a maximum enrollment of 36.4 million acres. CRP payments will be about $1.8 billion for fiscal year 1997.

The Environmental Quality Incentive Program (EQIP) was also established in the 1996 Farm Bill to provide a single voluntary conservation program for farmers and ranchers to address significant natural resource needs and objectives. Nationally, it provides technical, financial, and educational assistance—half is targeted to livestock-related natural resource problems and the other half to more general conservation priorities.

EQIP also represents the USDA's commitment to streamlining and improving its conservation services. Four of USDA's conservation programs are combined in EQIP: the Agricultural Conservation Program, Water Quality Incentive Program, Great Plains Conservation Program, and the Colorado River Basin Salinity Control Program.

Two hundred million dollars is authorized per year for EQIP through the year 2002. Conservation practices for natural resource concerns related to livestock production will receive 50 percent of the funding. EQIP offers 5- to

10-year contracts that provide incentive payments and cost sharing for conservation practices needed at the site. Cost sharing may be up to 75 percent of the costs of certain conservation practices. Total cost-share and incentive payments are limited to $10,000 per person per year and $50,000 over the length of the contract.

The U.S. Forest Service also has a Stewardship Incentive Program in which direct payment, technical assistance and education are provided to private landowners to manage their forest lands in ways that improve water quality.

The Rural Utilities Service of the Department of Agriculture provides loans and grants to political subdivisions for improved rural water and waste disposal facilities.

Department of the Interior

The Bureau of Reclamation administers four incentive programs. The Colorado River Basin Salinity Control Program provides construction cooperative agreements to study and implement salinity control projects. The Construction Program authorized by the Reclamation Act of 1902 provides funding and assistance to state, local and tribal governments for the implementation of structural and operational measures to improve water management. The Native American Program also provides grants, direct payment and research for development and management of water resources. The Operation and Maintenance Program provides reimbursement of operation and maintenance costs associated with federal benefits on reclamation projects. The Small Reclamation Project Program provides loans to western states and their political subdivisions for water development projects.

The Fish and Wildlife Service provides restoration of damaged watershed ecosystem functions in Oregon, Washington and Northern California to willing private landowners. Grants are also provided to the coastal states to facilitate the comprehensive restoration, enhancement and acquisition of coastal wetlands.

Department of Transportation

Formula and project grants are provided to state and local transportation departments to improve or protect water quality or wetlands from the adverse effects of highway and transit facilities.

Disincentives

This section will discuss federal programs that effectively create disincentives to pollute.

Department of Defense

The Defense Environmental Restoration Program and the Base Realignment and Closure Program promote and coordinate efforts for the evaluation and cleanup of contamination at Department of Defense installations. This can be considered to be a disincentive program in that contractors on current facilities are now more aware of environmental problems from associated activities and will be less likely to undertake activities that will exacerbate current problems or create new ones. In addition, because of the extensive database , new uses of the facilities now have an environmental baseline, again providing a disincentive to pollute.

Department of Energy

In a similar fashion, Department of Energy facilities such as Rocky Flats have an extensive intensive cleanup program required under the Federal Facilities Compliance Act.

Department of the Interior

The Fish and Wildlife Service provides funding for the assessment of natural resource damage to water quality and trust resources. On-the-ground restoration activities are paid by the parties responsible for damages from oil spills and other hazardous substances releases.

Prohibition of Certain Activities

Department of Agriculture

The U.S. Forest Service prohibits certain activities in protected areas that could impact water quality.

Department of the Interior

The Fish and Wildlife Service protects specific habitats through land acquisition, and partnerships prohibiting certain activities on these lands. The National Park Service and the Bureau of Land Management prohibit certain activities in protected areas that they manage. For example, off-road vehicle use is prohibited in wilderness areas. This prohibition may impact water quality in a positive manner.

The National Wild and Scenic Rivers System prohibits certain activities that would destroy these values.

Permitting

Department of Defense

The Army Corps of Engineers is responsible for permitting discharges of dredged or fill material into waters of the U.S. under Section 404 of the Clean Water Act.

Environmental Protection Agency Programs

The Environmental Protection Agency has programs under each of the categories listed above: education, research, planning, incentives, disincentives, prohibition of certain activities, and permitting. These programs are discussed in various chapters throughout this report and therefore only the legislation creating these programs is presented below:

- The Pollution Prevention Act (42 U.S.C. §13101)
- The Emergency Planning and Community Right-to-Know Act (42 U.S.C. § 11046)
- The National Environmental Policy Act (42 U.S.C. §§4321-4370)
- The Safe Drinking Water Act (42 U.S.C. U.S.C. §201)
- The Federal Water Pollution Control Act (33 U. S.C. §§1251-1376)
- The Coastal Zone Management Act (16 U.S.C. §1455)
- The Oil Pollution Act (104 Stat.484)
- The Toxic Substances Control Act (15 U.S.C. §§2601-2629)
- The Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. § 9659)
- The Resource Conservation and Recovery Act (42 U.S.C. §§ 6901-6987)
- The Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. §121)

Conclusions

Although many federal agencies have programs dealing with various aspects of water quality management, it appears that the Environmental Protection Agency and the Departments of Agriculture and the Interior have primary responsibilities. According to the GAO survey:

> *. . .Seventy-two federal programs and other initiatives were identified that assist states, municipalities, individuals, and others in their efforts to improve and/or protect water quality from various pollution threats. These programs and initiatives include those that were designed specifically to address water quality concerns as well as others that have different primary missions but that indirectly benefit water quality. (GAO/RCED-96-173).*

The large number of water quality programs raises a question as to what extent the various efforts are complimentary or competing. Resolving this question, however, was beyond the scope of this report. Nevertheless, efforts to coordinate and understand water quality monitoring programs are underway and are discussed in the Water Quality Issues section.

Another aspect of water quality programs that must be noted is the critical role played by states, especially programs delegated under the Clean Water Act. This topic is addressed in the section on state programs.

VII. Relationships to State Water Quality Programs

Chapter Summary

This chapter discusses the important role played by states in protecting and managing water quality in the West. States have the primary responsibility for setting water quality standards and implementing programs to control both point and nonpoint source pollution. This section will provide an overview of state point source and nonpoint source pollution control efforts. Issues particular to arid states will also be identified.

Because nonpoint source pollution—contaminated runoff associated with agricultural, urban, and other diffuse sources—was not subject to the stringent regulations imposed on point sources over the last two decades, it is now a principal cause of water quality impairment.

While the impact from individual nonpoint sources may be small, the cumulative impact from numerous unregulated activities can significantly degrade water quality.

Recommendations

Federal and state programs should be strengthened and better coordinated to increase the effectiveness of nonpoint source management programs and to speed progress towards solving nonpoint source pollution problems.

- Better environmental indicators need to be developed so that programs can focus on actions that will maximize environmental improvement.
- State legislative support for nonpoint source management must be enhanced and other resources need to be added to meet water quality goals.
- Until water conservation is institutionalized much more extensively, water quality improvements will be impaired.

Introduction

The mandate to the Western Water Policy Review Advisory Commission is clearly directed towards federal water programs. However, it is important to recognize, especially in water quality management, the critical role played by state water quality programs. The evolution of the Clean Water Act clearly indicates a Congressional intent for states to assume a leadership role in implementing many sections of the Act.

The 1987 amendments to the Act emphasize state responsibility for daily implementation more than any other amendment to the 1972 statute. For example, states can now create and manage self-sustaining revolving loan funds for municipal construction and other activities. Additionally, states have gained important new authority to manage and control toxic discharges and nonpoint sources of pollution (Water Pollution Control Federation. 1987).

Water Quality Standards

Water quality standards provide the foundation for implementing the basic goals of the Clean Water Act. It is important to recognize that states have the primary responsibility for adopting water quality standards. EPA has review and approval authority and may establish standards where a state fails to do so. The three critical elements of a water quality standard are:

- The designated beneficial use or uses of a water body,
- The water quality criteria necessary to protect the use or uses of that particular water body, and
- An antidegradation policy. (USEPA. 1994)

Water quality standards are achieved through a variety of programs to control point and nonpoint sources of pollution.

This chapter reviews state nonpoint source programs, state point source control activities, and briefly discusses some emerging "arid states" water quality issues. An important state responsibility—the development of TMDLs—is discussed in chapter VIII.

State Nonpoint Source Programs

Nonpoint source pollution has become a critical element of pollution control efforts. Because nonpoint source pollution--contaminated runoff associated with agricultural, urban, and other diffuse sources--was not subject to the stringent regulations imposed on point sources over the last two decades, it is now a principal cause of water quality impairment.

Under the Clean Water Act, nonpoint source pollution is controlled largely through voluntary rather than regulatory means. As a result, local nonpoint source management varies among states in both scope and types of controls required. Nonpoint source pollution is diffuse and highly variable, depending on climate, soils, and land use practices. Effective control of nonpoint source pollution requires changes in land use practices and in personal behavior. While the impact from individual nonpoint sources may be small, the cumulative impact from numerous inadequately managed activities can significantly degrade water quality.

Since 1990, EPA has funded projects in accordance with national and regional guidance and has supplemented states' ongoing nonpoint source management programs. EPA has completed its seventh cycle of Clean Water Act Section 319 grants, which total $470 million nationwide and over $140 million in the 19 western states as summarized in Table VII-1. But, the Section 319 program is much more than an EPA grant award. Because each grant to a state requires a 40 percent nonfederal match, Section 319 effectively leverages additional money for nonpoint source control. The western states have contributed approximately $56 million in cash, labor, materials, and other in-kind services to address the nonpoint source concerns in western part of the country. It should be noted that the dollar amounts cited here only include EPA's contribution to the states' nonpoint source program. Other federal and state agencies also participate in this program. However, those dollar amounts are unavailable at this time.

State nonpoint source (NPS) management programs have matured considerably since the passage of the 1987 amendments to the Clean Water Act. All states have approved nonpoint source programs. While we are beginning to see environmental progress, federal and state programs should be strengthened and better coordinated to increase the effectiveness of nonpoint source management programs and to speed progress towards solving our nonpoint source pollution problems.

Early last year, EPA and state cooperative efforts led to several modifications to the nonpoint source grants program. For example, since most states exceeded ground-water targets established in prior NPS grants

Table VII-1.—CWA Section 319h; 19 western states grant awards by dollar amount (fiscal year 1990 through 1996)

State	Grant amount	State	Grant amount
New Mexico	4,102,945	Wyoming	4,377,965
Oklahoma	7,621,179	Arizona	6,407,980
Texas	21,676,045	California	23,241,569
Kansas	5,247,512	Hawaii	817,538
Nebraska	8,379,325	Nevada	3,244,658
Colorado	8,189,164	Idaho	4,498,378
Montana	6,475,752	Oregon	4,890,119
North Dakota	5,471,739	Washington	7,459,120
South Dakota	8,140,846	Alaska	3,833,630
Utah	6,048,396	Total	140,083,860

guidance, EPA dropped these targets for fiscal year 1996. Similarly, targets were dropped for watershed resource restoration projects and national monitoring projects. While EPA and states recognize the continuing importance of these activities, states will be provided maximum flexibility in determining whether, and to what extent, to apply Section 319 funds for these purposes. Each state now has the discretion to use a small portion of its grant to conduct specific nonpoint source-related assessments and to revise and strengthen its nonpoint source management program.

The EPA Section 319 grant program is very diverse in its coverage. It allows for states to identify specific nonpoint source pollution activities and target those areas of higher priority. Figure VII-1 shows a breakdown of activities funded through the Section 319 grant program for the western states. Individual state breakdowns can be found in Appendix A.

The United States Department of Agriculture (USDA) plays a very active role in providing assistance to states in addressing their nonpoint source concerns as they relate to agriculture. Three USDA agencies, the Farm Service Agency (formerly Agricultural Stabilization and Conservation Service), the Extension Service (cooperating with Land Grant colleges and universities), and the Natural Resources Conservation Service (formerly Soil

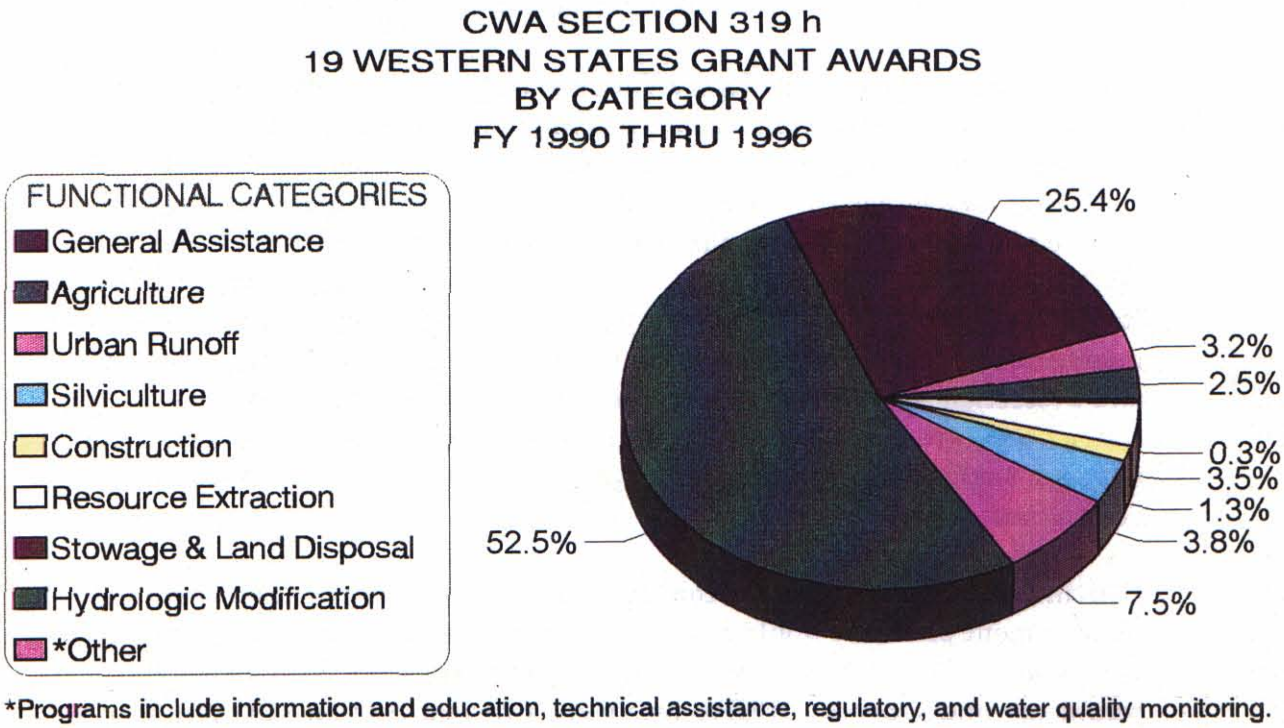


Figure VII-1.—CWA Section 319h; 19 western states grand awards by category (Fiscal year 1990 through 1996).

Conservation Service) are cooperatively providing financial, educational, and technical assistance to farmers and ranchers in order to reduce nonpoint source pollution. Through Hydrologic Unit Area (HUA) projects and demonstrations, landowners have been able to reduce their impacts to water quality and accrue long-term benefits beyond the life of the program.

Programs like EPA Section 319 Grants and the USDA HUA Projects provide seed money and act as catalysts to establish or enhance state nonpoint source programs. An anticipated outcome of these programs is that once approaches to address nonpoint source concerns are adopted, state programs will become self-sustaining. There are many examples of successful and effective nonpoint source water quality projects that, to the extent possible, document water quality improvements. In many cases these projects are ongoing and will continue for many years in order to achieve the degree of water quality improvement targeted. A few examples of successful programs are described below.

Successful Reduction of Nitrates in the Central Platte Valley

For example, in the Central Platte Valley of Nebraska, a major corn producing region, nitrate-nitrogen levels in ground water, which had increased at an average rate of 0.5 ppm per year since 1960, began declining in 1989 at an average rate of more than 0.3 ppm per year. An average decline of more than 1.0 ppm has been achieved in three years (NPS Figure VII-2). These reductions are a direct result of the Central Platte Natural Resources Districts' (CPNRD) development of a comprehensive ground-water management plan to comply with the Nebraska Ground Water Management and Protection Act of 1986. Under the plan, the CPNRD designated a district-wide ground-water quality management area where it could regulate nitrogen fertilizer application and irrigation to reduce nitrate-nitrogen accumulation.

Convincing farmers that the recommended nitrogen and irrigation best management practices would not harm their yields and would save them money in the long run was a necessary step in gaining the farmers' confidence and support. CPNRD received a five-year Section 319 grant in 1990 that supports a program to teach farmers about nitrogen and irrigation management techniques which reduce nitrate-nitrogen pollution of groundwater and yet maintain acceptable crop yields. In addition to improving the ground-water quality, these management techniques also helped farmers save money, which more than offset the added expense of soil and water testing. In 1992, district farmers saved approximately $1.6 million by applying less fertilizer and still maintained acceptable levels of crop yields. The programs success has inspired other natural resources districts to adopt similar programs.

The Bowman-Haley Watershed Project Reduces Sediment Loadings

The Bowman-Haley Watershed Project, located in southwestern North Dakota, is another example of the effectiveness of a coordinated effort to address nonpoint source pollution. Bowman-Haley Dam, constructed by the U. S. Army Corps of Engineers in 1966, was established to provide an alternative water supply, downstream flood control and recreation. Over a period of time, a noticeable decline in water quality was identified. In 1989 and 1990, evaluations of the water quality, physical characteristics, and

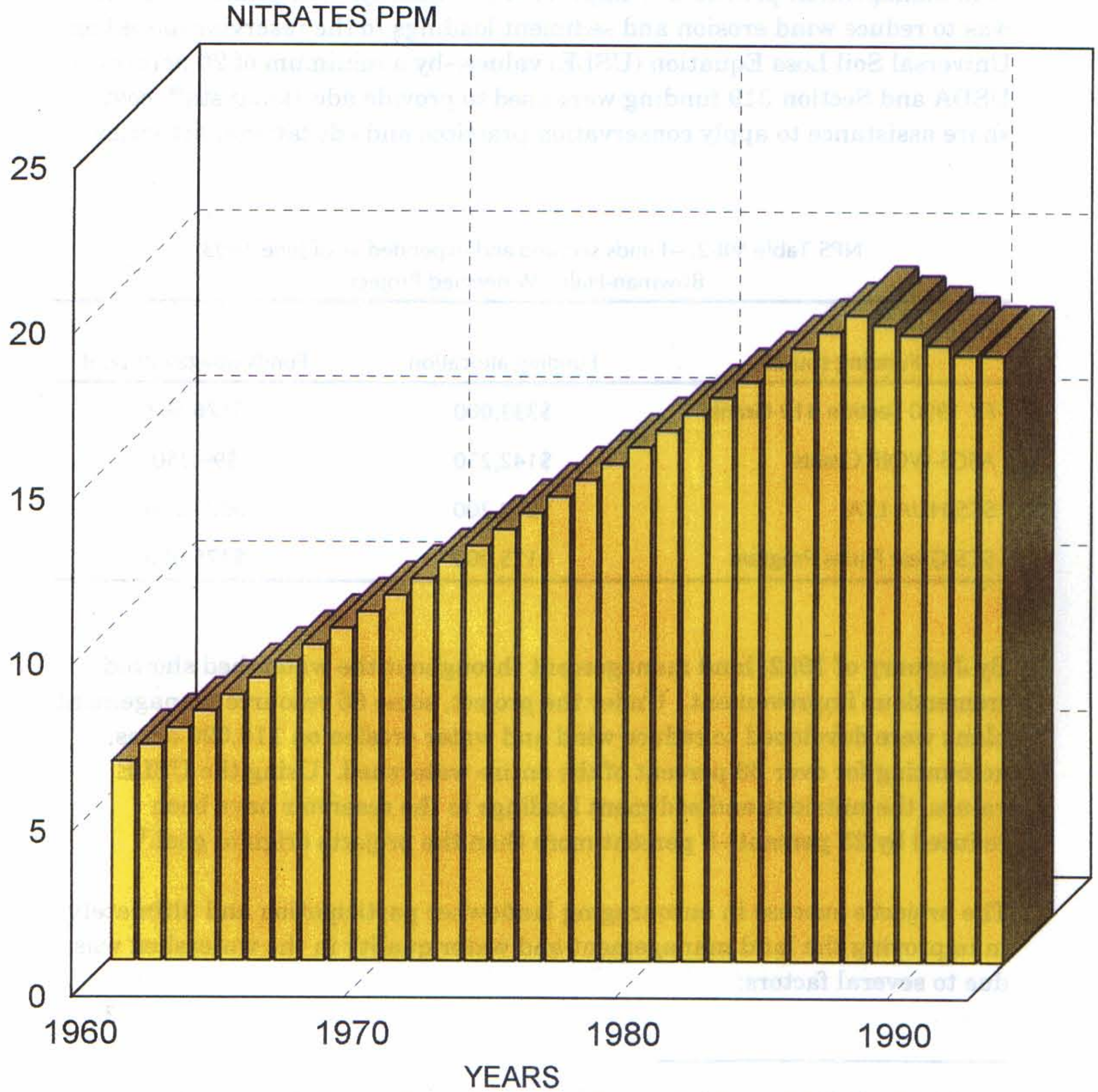


Figure VII-2.—Average nitrate levels in high nitrate areas of Central Platte Valley.

fishery by the state health agency found the reservoir was hypertrophic and nutrient rich. Nutrients and sediments from improper agricultural management were soon identified as the culprits.

In 1990, the local soil and water conservation district and water resource board took action to reverse the downward trend in water quality. (Figure VII-2.) They developed a five-year plan outlining specific agricultural land management practices to improve water quality. The plan's main focus was to reduce wind erosion and sediment loadings to the reservoir--based on Universal Soil Loss Equation (USLE) values—by a minimum of 20 percent. USDA and Section 319 funding were used to provide additional staff, cost share assistance to apply conservation practices and educational activities.

NPS Table VII-2.—Funds secured and expended as of June 1993
Bowman-Haley Watershed Project

Funding source	Funding allocation	Funds obligated/spent
FY 1990 Section 319 Grants	$333,000	$176,563
ASCS-WQIP Grants	$142,250	$94,250
SCS-HUA LTA	$232,200	$224,200
SCS-Great Plains Program	$175,000	$175,000

By January of 1992, land management throughout the watershed showed tremendous improvement. Under the project, some 65 resource management plans were developed to reduce wind and water erosion on 110,020 acres, accounting for over 36 percent of the entire watershed. Using the USLE values, the nutrient and sediment loadings to the reservoir have been reduced by 25 percent—5 percent more than the projects original goal.[1]

The project's success in encouraging landowner participation and ultimately in improving the land management and water quality in the watershed was due to several factors:

[1] Prior to 1992, watershed and water quality improvements were difficult to document because of prolonged drought conditions. During this period, many monitoring sites remained dry and virtually no water quality samples were collected. Given the limited water quality data available prior to 1993, the projects true benefits cannot be accurately documented.

- An aggressive, well-developed educational program
- Financial assistance to landowners
- A comprehensive project plan

The Chino Winds Demonstration Project Addresses the Impacts of Grazing

Grazing in Arizona, much like in the rest of the Southwest, tends to concentrate around water sources . This leads to overgrazing damage around rivers, streams and lakes. As a result, vast amounts of grazable lands located away from water sources are relatively untouched and unused by livestock. Damage to watersheds from grazing includes erosion, sediment and nutrient loadings into streams that seriously affects water quality.

Another problem in Arizona is the multiple or checkerboard pattern of land ownership, made up of an alternating mixture of publicly and privately owned lands. Added to this are the multiple jurisdictions and responsibilities of a host of federal, state, local, and private agencies and interests, which can result in deadlock in planning and using technology to remedy the situation.

The Chino Winds Demonstration Project, located on the Yavapai Ranch 26 miles south of Seligman, Arizona, is proving that these obstacles are far from insurmountable. Through the cooperation of 11 agencies and private landowners, the state currently has a project to test a holistic grazing system on multiple ownership lands to improve water quality. This project also evaluates alternative ways to measure watershed conditions and quality in arid regions that lack year-round surface water flows.

Phase I of the project started in fiscal year 1990 and was completed in 1993. A coordinated resource management plan was developed over an 18-month period by numerous groups with diverse and vested interests. Agencies responsible for developing the plan include the U.S. Forest Service, the Arizona State Land Department, SCS (now NRCS), and the Arizona Department of Environmental Quality. Also included were the University of Arizona School of Renewable and Natural Resources , the Cooperative Extension, the Chino Wind Natural Resource Conservation District, and the Arizona Department of Game and Fish.

A $90,000 Clean Water Act Section 319 grant funded phase I activities such as installing fencing, pipelines, and a water distribution system for both livestock and wildlife. State, local and private sources supplied in-kind services such as labor, equipment, and computer mapping. The University of Arizona provided watershed monitoring. Conservation groups and private citizens are converting existing fencing so that it does not restrict the movement of wildlife. A Section 319, $87,000 grant is currently being implemented for phase II.

The project is being monitored during the implementation phase to ensure that best management practices are properly installed. Baseline data was collected on initial vegetation and frequency of plant species. A survey was conducted to determine public attitudes and perceptions of grazing management efforts to improve water quality. Although the complete results of the demonstration may not be seen for 10 years, this project provides an important opportunity to demonstrate the effectiveness of best management practices on arid lands.

State Point Source Programs

Controlling point source pollution discharges from major municipal and industrial facilities has been the historic focus of water quality protection programs. This focus continues in the Clean Water Act through the National Pollutant Discharge Elimination System (NPDES).

> *"Title IV is the heart of the Clean Water Act. It contains the National Pollutant Discharge Elimination System (NPDES) that limits discharges to the navigable waters of the United States. Every point source discharger must receive a permit from either EPA or an authorized state. Thus, the permit system is the key to enforcing the effluent limitations and water quality standards of the Act. Allowances are made, however, for additional pretreatment of conventional pollutants and the establishment of a partial permit program for discharges into navigable waters. Permits for separate storm sewers are required, as are permits for dredging and disposal of dredge spoils". (Water Pollution Control Federation, 1987).*

As noted above, the NPDES program is the primary tool for controlling point source discharges. Table VII-3 below identifies western states with approved NPDES permit programs. For those states without approved programs, EPA has primary responsibility for the NPDES program.

Table VII-3.—States with approved NPDES Permit Programs

State	Approved NPDES Permit Program
Arizona	No
Alaska	No
California	Yes
Colorado	Yes
Hawaii	Yes
Idaho	No
Kansas	Yes
Montana	Yes
Nebraska	Yes
Nevada	Yes
New Mexico	No
North Dakota	Yes
Okalahoma	Yes
Oregon	No
South Dakota	Yes
Texas	Yes
Utah	Yes
Washington	Yes
Wyoming	Yes

Water Quality Issues of Particular "Arid-States" Interest

A large portion of the intercontinental West has an arid to semi-arid climate with annual precipitation of less than 15 inches. This area stretches from western North Dakota south to west Texas and westward to eastern California, Oregon and Washington. Stream flows in this region are dominated by snowmelt runoff and responses to major storm events. In the more arid portions of this region, perennial streams are the exception and ephemeral streams are more common.

Within this "arid-states" region, some local water and wastewater agencies and related interests have been raising questions about the applicability of some Clean Water Act water quality programs to the hydrologic and ecological conditions of the region. They have particularly focused on use of traditional water quality standards to ephemeral and effluent-dependent streams and ecosystems, and to constructed conveyances.

Attention has been paid to these issues on both the legislative and administrative fronts in the past few years. First, the "Reid Amendment" was included in S. 2093, the Clean Water Act reauthorization bill that passed the Senate Environment and Public Works Committee in February 1994. While the bill as a whole did not advance further through the legislative process, the Reid Amendment represents the only measure on the issue to date that reflects legislative language acceptable to these local Western interests, Western legislators, and EPA. The core functions of the amendment were to establish a research program on Western water quality and related biological issues, to direct EPA periodically to develop a certain number of new water quality criteria applicable to arid West conditions, and to have an advisory committee provide for some interim standards while new criteria were being developed. Since the amendment was developed, Congress has provided appropriations for some research which is in its initial stages.

Meanwhile, EPA has been proceeding with some administrative initiatives applicable to these arid West issues. A September 25, 1996, letter from Felicia Marcus, Regional Administrator, to John Caffrey, Chairman of the California State Water Resources Board, outlined a streamlined, categorical approach EPA Region 9 proposed to use to address the use designation issue for constructed conveyances. In this approach, the State would identify categories of conveyances based on simplified analyses of hydrologic and biological conditions and, through an expeditious and efficient process, adopt standards appropriate for each category.

Although the Region 9 proposal was offered as a pilot that specifically addresses agricultural water supply and drainage conveyances for the rice production area in California, the overall streamlined, categorical approach outlined in the letter could apply to other classes of conditions in the arid West and elsewhere. When applied in other geographic areas, the categories developed by this streamlined, categorical approach would be adapted to reflect the conditions and considerations specific to those areas.

Moreover, this categorical approach was developed in close cooperation with EPA Headquarters, and the concepts used could form the basis of a national, categorical approach. Aspects of the advance notice of proposed rulemaking on water quality standards, to be published by EPA in fiscal year 1998, are expected to reflect elements of the Region 9 categorical approach and are intended, in part, to identify and discuss programmatic means that will address these water quality standards issues of greatest interest to the arid West states.

Conclusions

It is critical to recognize the fundamental role played by states in protecting and managing water quality in the West. States have the primary responsibility for setting water quality standards and implementing programs to control both point and nonpoint source pollution.

Measuring water quality improvements from nonpoint source pollution is an elusive task. Demonstrating through actual data that conclusively shows an improvement in water quality as a result of efforts to reduce nonpoint source pollution is difficult. Best management practice activities may take decades to show a water quality improvement and in some cases may never be "proven". This is not to say best management practices are not working. But, because of the complexity of the problem and the multiplicity of highly diverse sources, it is very hard to tie a specific activity on the land to an improvement in instream water quality.

Monitoring can document an improvement in water quality, but it takes money and time to reach a conclusion relative to a best management practice. One component of the Section 319 program is monitoring and all states are utilizing it to track water quality improvements. For this reason alone, the 319 program is necessary, but the program does much more than monitor. It provides an avenue for implementation of water quality improvement activities, which is the fundamental purpose of the program.

Outreach programs are successful in raising the awareness of nonpoint source problems and have been effective in changing philosophical mindsets. Nutrient and pesticide management can reduce the amount of inputs or change the timing of their application so they are more efficiently used. Grazing management has resulted in improved streambank vegetation, less runoff and reduced sedimentation, all of which affect water quality. These activities may not be directly tied to a measurable water quality improvement, but they produce some improvements nonetheless.

Many western states such as Idaho and South Dakota have taken an aggressive approach to improving water quality and have developed successful nonpoint source programs that are supported with state and private monies. These programs would continue, although on a limited basis, without 319 grants, but some states have relied solely on 319 grant monies to support their nonpoint source program which could conceivably disappear without it.

Every state has examples of successful projects that are reducing the nonpoint source pollution problem because of federal involvement. The EPA 319 grant program and the USDA HUA projects are successful examples of federal programs providing seed money to states to accelerate and enhance state nonpoint source programs. These programs are not going to solve all water quality problems, but they are effective in providing opportunities to those who want to make a change, but lack the technical and financial resources to do so.

Recommendations

Better environmental indicators need to be developed so that programs can better focus on actions that will maximize environmental improvements.

States need to take a more proactive approach to solving their nonpoint source problems and augment federal government funding of their programs. State legislative support for the nonpoint source program must be enhanced and coordination improved among other federal and state programs so that resources can be directed to on-the-ground activities and not to basic staffing and support.

States need to improve targeting their major problems. Livestock operations in the West are a major nonpoint source problem that must receive greater attention and control. The USDA EQIP program has recognized this and is earmarking 50 percent ($100 million) of its annual budget to addressing this issue. Other programs should do the same.

The strong connection between water quantity and water quality must not be overlooked. Until water conservation is institutionalized much more extensively, water quality improvements will be impaired.

Agencies with common goals need to work closer together. Partnerships must be developed that go beyond formal agreements. Until this happens, nonpoint source solutions will continue to have fragmented success. The TMDL program is a means to do this coordination.

VIII. Water Quality Issues

Summary

This chapter contains eleven sections each addressing a particular water quality issue. The sections are presented in the following order.

A. Irrigated Agriculture

B. Livestock Production

C. Colorado River Salinity

D. Mining

E. Water Quality/Water Quantity/Hydromodification/Instream Flow

F. Pesticides

G. Forestry

H. Municipal Discharges

I. General Urban Growth

J. Total Maximum Daily Loads

K. Water Quality Monitoring

No chapter summary was written for this section as each water quality subsection has a separate set of conclusions and recommendations. The summary presented at the beginning of this report also lists the major conclusions made in this chapter.

Irrigated Agriculture

Agricultural activity is a significant contributor to water pollution. Most of the polluted surface waters in the West include rivers, streams, lakes and reservoirs are impacted by agriculture. Siltation of stream beds from accelerated soil erosion, nutrient loading (primarily nitrogen and phosphorus), and pathogens from urban and agricultural waste are the primary causes of the surface water quality impairment in the West.

Erosion

Eroded soil that reaches stream courses is detrimental to water quality through the combined effects of siltation and nutrient loading. Irrigation-induced erosion is the major contributor of sediment and associated pollutants to surface waters from irrigated cropland. Suspended sediment reduces clarity (i.e. increases turbidity), interferes with irrigation by decreasing pump life and increasing ditch cleaning costs, fills in reservoirs, increases treatment costs of drinking water, and reduces habitat for fish and other aquatic life. The major nutrients associated with sediment are forms of nitrogen and phosphorus. In high concentrations, these nutrients stimulate excessive algae or aquatic plant growth which, upon decay, may reduce oxygen to levels harmful to fish, clog pipes and ditches, and create odors.

The most serious irrigation-induced erosion is generally associated with surface application systems, primarily furrow irrigation, where the erosion process takes place within the furrow rather than across the entire soil surface. Several factors affect furrow erosion:

- Slope along the furrow
- Furrow stream size
- Residue in the furrow
- Furrow surface roughness
- The kind and amount of tillage
- The cropping sequence (Carter, 1990)

Erosion from sprinkler systems can be serious if the rate of water application exceeds the soil infiltration capacity. Application rates are most likely to exceed infiltration capacities when using center pivot irrigation systems (Carter, 1990).

Producers carrying out conservation plans have made significant progress in reducing sheet, rill and wind erosion. Between 1982 and 1992, sheet and rill erosion decreased by 19 percent across the 110 million acres of cultivated cropland in the NRCS Northern Plains Region, annually saving more than 53 million tons of topsoil. Similarly, average annual wind erosion on rangeland decreased 7.5 percent, saving nearly 47 million tons of topsoil each year. Wind erosion on cultivated cropland decreased by 30 percent.

Despite dramatic advances in efficient use of irrigation water, many producers continue to be hampered by the economic feasibility of improving irrigation practices.

Agricultural Return Flows as Nonpoint Source Pollution

Irrigation return flow is the portion of water which returns to either surface or ground water after being used to irrigate crops. An example is found in the Texas rice industry, where water is usually diverted from a river, used to flood the field and then released back into the river before harvest. The term irrigation return flow also refers to irrigation water that makes its way to any body of water after its use on crops. Irrigation return flow is an important water quality issue because of its potential to be a significant nonpoint source of pollution.

In addition to water quality concerns, irrigators should use return flow management practices to avoid wasting water. Excessive runoff is a symptom of poor irrigation system design or poor management of irrigation water and results in wasted water. Wasting water has immediate financial ramifications and threatens the long-term availability of water for irrigation and other uses.

Runoff from irrigated land is a major concern for water quality. Many of the fertilizer nutrients and chemicals used in agriculture, as well as soluble salts contained in the soil and irrigation water, are easily adsorbed onto soil particles. When runoff occurs, soil particles containing these adsorbed pollutants are picked up and transported off of the field. Eroded sediments constitute the major potential for pollution from surface return flows. In addition, soluble chemicals are dissolved by runoff and carried with the water as it flows through the soil and discharges to streams or ground water.

Another concern in some agricultural areas of the West is the potential for return flows to contain toxic constituents, such as selenium and boron, that leach from naturally seleniferous soils during irrigation. When present, this situation can create highly contaminated return flows that far exceed water quality standards.

Another example of problems with both direct runoff and underground return flows is in the Central Valley of California. In the late 1970s, irrigation return flows containing selenium and other toxic trace metals were shown to cause significant damage to aquatic life and migratory birds in the Kesterson Wildlife Refuge, which received irrigation return flows as a water source. A Department of Interior irrigation drainage program, while focusing only on federally-supplied water and federal wildlife refuges, continues to document similar conditions in numerous hot spots throughout the West.

Agrichemicals and ground-Water Quality

Agricultural chemicals can impact ground water as a result of a combination of complex factors. Some factors are related to the application of the chemical, while others are related to the soil resource, crop need, irrigation practices, and ground-water resource.

Ground-water quality is adversely impacted by irrigated agriculture when nitrates and mobile pesticides are leached below the effective crop root zone by irrigation water. Associations of pesticides and nitrate in ground water were evaluated at the national level and the results presented in the National Survey of Pesticides in Drinking Water Wells. (EPA, 1992) Although measures of agronomic activity were associated with detections at a county level, correlations at individual wells could not be made. Survey results suggested that there is a lower probability of detecting pesticides or nitrates in wells in counties that experience high levels of rainfall. In contrast, flood irrigation was associated with a greater likelihood of detection. Persistent pesticides were more likely to be detected than pesticides with short half-lives. Higher conductivity of well water was found to correspond to higher nitrate concentrations, and nitrate detections were associated with shallow, older and rural domestic wells.

Nitrogen fertilizer may sometimes be applied in excess of the actual needs of the crop. Excessive application may result in migration of nitrogen into ground water because the excess nitrogen is not used by the crop or fixed in the environment. Applying too much irrigation water can compound this problem by flushing nitrogen fertilizer past the crop root zone before the crop can use it.

The rates at which nitrogen leaches into ground water are a function of the rate and timing of irrigation and precipitation, fertilization rate, and crop uptake. Studies in Idaho and New Mexico have shown that as much as 50 percent of the applied irrigation water can leach through the soil. In these situations, nitrate concentrations in subsurface drainage water may exceed concentrations in surface runoff.

Pesticides may also impact ground-water quality. This occurs when applications are not based on crop protection needs, along with proper timing, rate, and placement factors. Uncontained releases that occur during storage, handling, mixing, loading and transport of pesticides are also potential sources of contamination.

Conclusions

Irrigated agriculture can significantly impact both surface and ground-water quality. Erosion and sedimentation, agri-chemicals (including fertilizers and pesticides), plus naturally occurring compounds (such as various salts and toxic elements) leaching from the soil in return flows can impair water quality.

Furrow erosion and soil loss can be controlled. Sediment can be trapped before entering surface waters by use of sediment retention basins, buried pipe erosion and sediment loss control systems, and vegetative filter strips. Erosion can be reduced, thereby making sediment control much simpler, by placing straw in furrows or utilizing new technologies in combination with irrigation water management and conservation tillage. Currently, conservation tillage has the greatest potential to reduce erosion and sediment loss.

Recommendations

Studies done in the Central Valley of California show that reducing irrigation return flow volume, through more efficient on-farm water use, can reduce toxic contaminants in irrigation return flows in many situations where the contamination is not severe to begin with.

The most promising practices to reduce irrigation erosion and sedimentation are conservation tillage and crop sequencing. Conservation tillage is not presently a commonly accepted practice on irrigated cropland. The reported levels of planted acres being managed with conservation tillage range from none to 19 percent averaging 7.7 percent. (National Tillage Survey, County Data, 1990).

Best Management Practices and Technical Assistance

The potential impact of agri-chemicals must be an integral part of best management practices (BMPs) addressing nonpoint source pollution on irrigated cropland. Accepted BMPs need to be reviewed and evaluated for ground-water quality benefits. It is recommended that the goal of BMPs for managing nutrients and pesticides should be to manage and maintain them within the effective crop root zone, minimizing water quality impacts.

After a farmer or landowner has installed BMPs, information, education and technical assistance should continue to help the farmer adapt to changes in cropping, economics, technology.

Agencies need to coordinate information, education and technical assistance efforts so farmers and landowners receive comparable information. The agencies must insure that farmers understand information they receive and offer them alternatives to meet minimum standards as prescribed in approved BMPs. Cooperative review, evaluations and development of mutually acceptable BMPs can help bring about this needed uniformity among agencies.

Planning for Water Quality

Future irrigated water quality project efforts will have to take a more comprehensive approach to planning and implementation and include both surface and ground-water concerns in order to be more effective. It is recommended that the entire watershed, not just the irrigation tract, be inventoried, evaluated, partitioned, and prioritized to ensure that water quality improvements can be achieved and measured.

Increased Water Quality Monitoring

Present monitoring on water quality projects is not adequate to demonstrate the water quality benefits of project actions or individual BMPs. Current levels of monitoring have not verified if projects are achieving water quality goals and if those goals are being maintained following project implementation. It is recommended that monitoring of selected projects and corresponding BMPs be conducted to verify water quality benefits and long-term effectiveness. Monitoring and evaluation should be coordinated among the local management and technical agencies.

Livestock Production

Grazing

The grazing lands of the West provide many of the panoramic vistas that are characteristic of this region of the country. Grazing lands include rangeland, pasture land, hayland, forage cropland, and grazed forest land. The forage from healthy grazing lands produce much of our food and fiber while providing an economic base for much of the rural West.

The health of grazing lands directly impacts the quality and sustenance of stream waters within many of our watersheds. The small tributaries and rivers flowing through grazing lands are water sources for agriculture, domestic and municipal uses, and power production. These waters also provide habitat for many species of fish and wildlife and are used for outdoor recreation.

Rangeland health is defined as the degree to which the integrity of the animal, soil, vegetation, water, air, and ecological processes of the rangeland ecosystem are balanced and sustained. Improperly managed grazing animals can indirectly contaminate water by damaging the vegetation such that erosion occurs. This nonpoint source pollution could have a major impact on the quality of water supplies in the West because grazing makes up a large portion of the land where water supplies originate and flow.

Sediment carried by surface water runoff is the primary water pollutant from grazing activities. Other, less abundant pollutants include chemicals absorbed on sediment particles and organic matter. Streams adjacent to areas grazed by livestock may show increased concentrations of bacterial indicator organisms such as coliform and streptococcus. However, properly managed rangeland and pasture land usually have few pollution problems from animal waste. Impact on the vegetation is the major concern.

Rangeland accounts for about 57 percent of the land (95.2 million acres) in Texas. Grazing land, classified as pasture land, includes over 10 percent of the land area (17.7 million acres) and receives more intensive management than rangeland. Most of Texas' rangeland receives low rainfall. Surface runoff from these areas may be infrequent. However, when runoff does occur, it is usually the result of a high intensity thunderstorm that may create significant surface runoff (Welch et al., 1991). These intense rainfall events can cause considerable sediment movement particularly if vegetation cover is poor.

Rangeland in the Northern Plains region comprises 43 percent of the landscape and is nearly one-third of all rangeland in the contiguous U.S. Of the total acreage of rangeland in the region, (180 million acres) 26 percent is associated with soils of high wind erosion potential. Over 40 percent of the rangeland occurs in association with fragile soils (Stover, 1996).

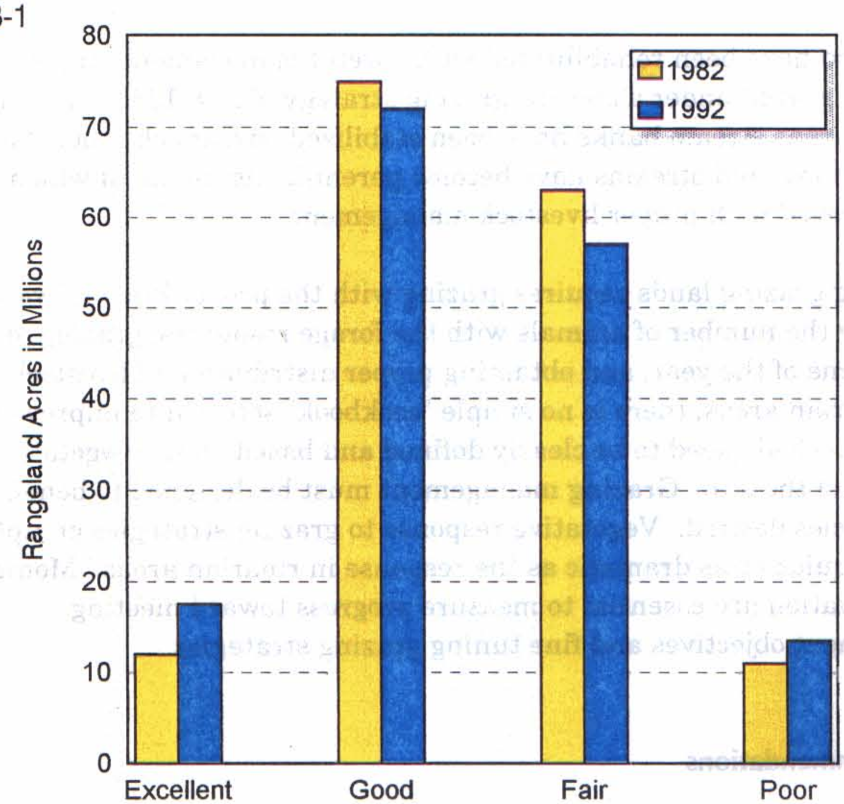
Range condition data show that 71 million acres of rangeland in the Northern Plains are in poor or fair condition. This indicates a loss of higher successional plants in the plant community, which can result in loss of wildlife habitat, increased water runoff with increased soil erosion, increased soil loss from wind erosion, loss of species diversity, and decreased productivity.

Rangeland condition data for 1982 and 1992 show a 9 percent increase of rangeland with a worsening (negative) condition and only a 2 percent increase of rangeland with an improving (positive) condition (Grazing Figures VIII B-1 and VIII B-2). Thus, some rangeland plant communities are slowly losing quality or moving toward nonsustainability.

Conclusions

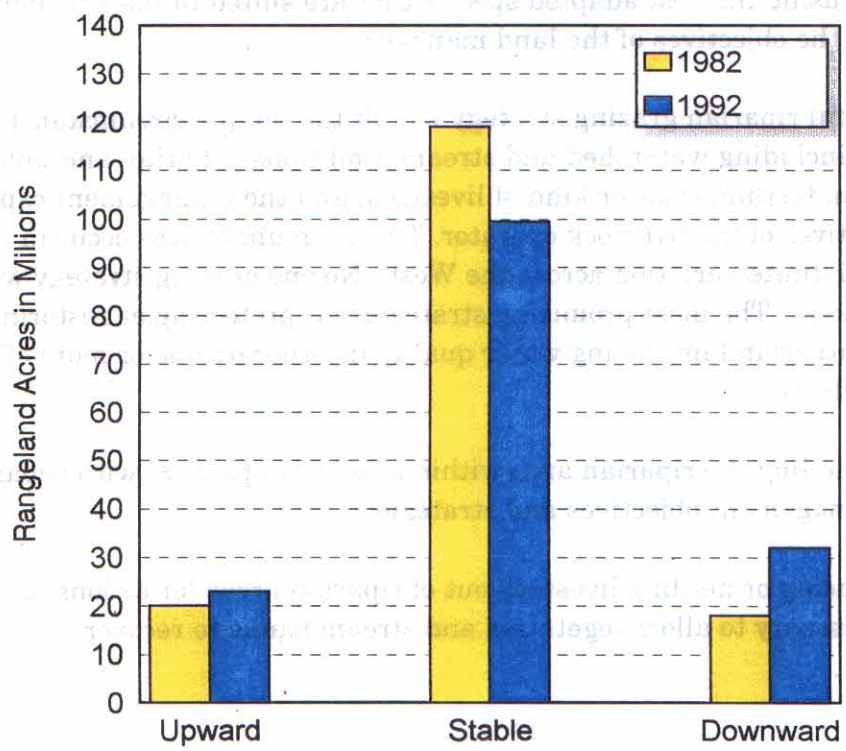
Proper grazing practices can have minimal adverse water quality impacts. A study in northeastern Oregon, following a calibration period without grazing, found no differences in bulk density, infiltration or runoff between properly grazed and ungrazed mountain streamside meadows. (Knight 1977) Several severely deteriorated riparian areas that were once heavily

Figure VIII B-1



Range Condition Classes by acres in the Northern Plains (USDA/NRCS, 1994)

Figure VIII B-2



Acres of apparent trend on rangeland in the Northern Plains (USDA/NRCS, 1994) overgrazed have been rehabilitated with careful management and are currently grazed under a specific grazing strategy (GAO, 1988). On these riparian areas stream banks have been stabilized, stream channels narrowed and deepened, and streams have become perennial again, all of which has been achieved with proper livestock management.

Managing grazing lands requires grazing with the proper kind of livestock, balancing the number of animals with the forage resources, grazing at the correct time of the year, and obtaining proper distribution of livestock. As with riparian areas, there is no simple "cookbook" solution to improve upland condition. Goals need to be clearly defined and based on the vegetation potential of the site. Grazing management must be designed to benefit the plant species desired. Vegetative response to grazing strategies on uplands is not as quick or as dramatic as the response in riparian areas. Monitoring and evaluation are essential to measure progress toward meeting management objectives and fine tuning grazing strategies.

Recommendations

The management of native grazing lands should focus on reestablishing and managing native plant species. Introduced plant species should be used only where they can facilitate this management. Pasture lands should be managed using the best adapted species that are suited to the site and that will meet the objectives of the land managers.

A successful riparian grazing strategy will fit the unique circumstances of each site including watershed and stream conditions, riparian and upland vegetation, terrain, class or kind of livestock, and the management capability and objectives of the livestock operator. These circumstances occur in virtually infinite variation across the West. No one grazing strategy will fit all situations. The most promising strategies for protecting or restoring riparian areas and improving water quality incorporate one or more of the following features:

- Including the riparian area within a separate pasture with separate management objectives and strategies.
- Fencing or herding livestock out of riparian areas for as long as necessary to allow vegetation and stream banks to recover.

- Controlling the timing of grazing to: (a) keep livestock off stream banks when they are most vulnerable to damage, and (b) coincide with the physiological needs of target plant species.

- Adding more rest to the grazing cycle to increase plant vigor, allow stream banks to heal, or encourage more desirable plant species composition.

- Limiting grazing to a level which will maintain desired plant species composition and vigor.

- Changing from cattle to sheep to obtain better animal distribution through herding.

- Permanently excluding livestock from riparian areas at high risk and with poor recovery potential when there is no practical way to protect them while grazing adjacent uplands.

Significant acres of grazing lands are owned and managed as units of less than 20 acres, often as "ranchettes" and rural subdivisions. Taken as a group, these lands share major resource problems and are responsible for serious off-site erosion and deposition, and water quality and quantity problems (NRCS West, 1996). Much of the land is managed by limited resource farmers, including significant numbers of minority groups. A strategy should be developed and implemented that will identify and provide effective technical assistance to these land users.

Mixed ownership and multiple agency involvement causes some confusion and misunderstanding in dealing with grazing land resources. Terminology is not always the same, best management practices (BMPs) are not mutually accepted or defined, and means of classifying range and riparian areas are not standardized. It is recommended that agencies strive to be uniform in the use of terms, resource classification, and BMP evaluation and acceptance.

Confined Animal Feeding Operations

Livestock and poultry production can contribute to excess nutrients (nitrogen and phosphorus), organic matter, salts and pathogens in surface water and in underground aquifers. Potential sources of pollution include confinement buildings, unpaved feedlots, runoff holding ponds, manure treatment and storage lagoons, manure stockpiles and fields on which manure and wastewater are applied.

Water quality problems are often the main concern with livestock operations (primarily surface water). The EPA's 1994 National Water Quality Inventory (305 (b) Report) states that agriculture (including feedlots and animal holding areas) is a primary pollution source of rivers and streams affecting 60 percent of impaired river miles.

Dairy Operations

It is estimated that dairy cattle produce 85 pounds of manure (feces and urine) per day, per 1,000 pounds of live weight. In one year, a 500 cow herd of 1,000 pound cows can produce about 7,750 tons of manure containing 850 tons of solids with 34 tons of nitrogen, 6 tons of phosphorus and 35 tons of potassium (USDA-SCS, 1975). In addition to the manure wastes, the washing of tanks, pipelines, equipment, cows, parlor and milk house floors can produce 735 to 2,600 gallons per day of additional liquids (Ohlensehlen, 1986).

The manure produced by dairy operations contains about 43 percent more liquid with about the same amount of solids per 1,000 pounds live weight as do feedlots. This, coupled with the liquids from the washing operations, means that dairies require more storage, handling, and lot management than do feedlots.

Feedlots

Feedlot cattle produce an estimated 62 pounds of manure per day per 1,000 pounds of live weight. A 500 head lot can produce about 6,900 tons of manure per year with 810 tons of solids, 39 tons of nitrogen, 8 tons of phosphorus and 21 tons of potassium (USDA-SCS, 1995).

Riparian areas and wetlands are directly impacted when they are located within the confined feeding operation. Impacts result from manure being directly deposited in surface water, carried into surface water in runoff or washed from the lot into surface water. Riparian and wetland vegetation located within the confinement area is often over-used and the stream banks are trampled and broken down (Harkness, 1993).

Sediments from confined feeding operations are generally high in organic material. Surface water is impacted by the nutrients and pathogens carried with the sediment when lot runoff control and storage are not adequate. Pathogens can potentially become pollutants when the manure in the lot is maintained in a high-moisture manner.

Pathogens and highly mobile nutrients and pesticides may impact ground water when they percolate downward through the soil. This can occur when surface drainage is not adequate and a restrictive layer, which slows water movement downward, is not maintained near the soil surface. Lots on coarse, sandy textured soils are more susceptible to downward movement of water than those on heavier, clay type soils. The downward loss of nutrients, pesticides and pathogens in storage structures occurs when the structure is not adequately sealed. Contaminants from animal wastes applied to agricultural land may reach ground water when wastes are applied in amounts that exceed the crops' ability to utilize them or when carried below the crop root zone by excessive application of irrigation water.

Regulation of Confined Animal Feeding Operations

Nationwide, there are 650,000 farms with livestock and 450,000 confined facilities. Tracking of these confined animal feeding operations falls on the shoulders of the National Pollutant Discharge Elimination System program. There are a total of 1876 records of state issued NPDES permits which are tracked through the Permit Compliance System (PCS) covering 34 states. Eighty-three percent of those permits are from five western states which include New Mexico, Texas, Oklahoma, Kansas and Nebraska. Texas has 805 permits alone. Half of the permits are current, although the other half have expired or their status is unknown. Some permits expired more than 10 years ago. In the 1994 and 1995 calendar years, 100 permits were issued.. Compliance actions resulted in 557 of the permitted facilities being put on a compliance schedule. Five hundred and twenty-six of these actions are in Oklahoma, Texas and Nebraska. Most systems have achieved compliance, although some have not which has resulted in enforcement actions against 191 facilities. In Texas and Oklahoma 150 actions were taken.

A NPDES permit is issued for a maximum of 5 years. NPDES regulations require permitted facilities to be inspected annually, but only 86 facilities were inspected between 1991 and 1995. This represents less than 5 percent of the total permitted facilities and means that less than 1 percent of the permitted facilities are being inspected each year. Even with limited inspection, PCS identified 12 facilities that meet the significant non-compliance definition. Seven of the significant noncompliance facilities are located in Nebraska.

Conclusions

To date, water quality impacts from confined feeding operations have been addressed primarily by the general NPDES permit issued by the EPA for these operations. This permitting program, however, has not been a panacea. Some limitations of the permit program include the animal unit size limitation of the operations that it covers, the time that animals are concentrated, and the lack of coverage of manure waste application to agricultural lands and possible impacts to ground-water resources.

Many confined operations have not received a general NPDES permit number and are not covered by the permit program for several reasons. The non-permitted confined feeding operations may not meet the requirements related to size (animal units) and discharge, therefore they are not covered by it. Managers may fail to file an intent to discharge because they do not clearly understand permit requirements, do not know the capacity of their waste systems, or choose to take a wait-and-see attitude.

Regulation of CAFOs has been handled on a case-by-case basis when a complaint is received or when inspections reveal non-compliance. The capability of state and federal agencies to perform compliance checks and respond to complaints is limited by the number of inspectors available. The result is seemingly fragmented implementation.

Recommendations

A targeted information and education program is needed to inform the agricultural community of water quality programs and available assistance. Many confined feeding operations managers are aware of potential water quality impacts and strive to maintain a level of management that minimizes potential impacts. There are, however, other managers who are unaware that certain activities may be contributing to water pollution and of the existence of alternatives available to effectively manage animal wastes.

The general NPDES permit program is not applied uniformly from state-to-state. Some operations will be classified such that a permit is not required, while, in another state, the same operation would require a permit. The confusion and misunderstanding that have resulted from the application of the NPDES program have limited its effectiveness in addressing water quality impacts from confined feeding operations.

Although a significant polluter is addressed by existing programs regardless of operation size, the NPDES permit program for CAFO's is apparently oriented toward the size of the operation, not its potential to impact water quality. Therefore, the program does not clearly cover all confined feeding operations that may affect water quality. It is recommended that water quality programs focus on confined feeding operations which are impairing water quality such that it cannot support the designated beneficial uses regardless of size and feeding period.

A complete inventory of all confined feeding operations is needed. The inventory needs to identify the size and location of each operation. It should also include a preliminary evaluation of pollution potential, based on siting criteria.

There is a need to provide cost-share assistance so systems can be installed without creating a financial hardship for confined feeding operations managers. Upgrading a system or changing management is often very costly. The 1996 Farm Bill EQIP program addresses this need and has earmarked $100 million per year for assistance to livestock operations. This program, once fully implemented, could have a substantial positive effect on reducing NPS pollution from livestock operations.

Colorado River Salinity

Salinity is a concern in a number of rivers, especially in the Southwest. No where, however, is the issue of greater national and international concern than in the Colorado River Basin. From the river's origin high in the Colorado Rockies, the river flows southwesterly through a vast arid and semi-arid portion of the continent, ultimately discharging (though rarely) into the Gulf of California in Mexico. The Colorado River is clearly the lifeline of the Southwest, with its waters serving major municipalities both within the basin as well as external to the basin and is also the major source of irrigation water. The Colorado is also a river of national environmental interest because of the high concentration of National Parks and Monuments in the basin and the significance of endangered fish endemic to the basin.

In the Colorado River system, salinity concentration tends to increase as one moves down the basin ranging from less than 100 mg/l in the headwaters to 700 to 800 mg/l in the lower basin. The increase in salinity is a result of both natural processes and human activity. The increase in concentration stems from salt-loading processes (such as irrigation return flows and discharges from saline springs) and salt-concentrating processes (such as reservoir evaporation and out-of-basin exports of higher quality dilution flows) (USGS 1984. p. 74).

Efforts to Address Salinity in the Colorado River Basin

By the 1960s, salinity increases in the lower reaches of the Colorado River were of sufficient concern that the seven Colorado River basin states (Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming) began discussions with federal agencies on how to address the problem. (Colorado River Basin Salinity Control Forum, 1996). The Clean Water Act of 1972 mandated efforts to establish and maintain water quality standards in the United States. Also during this period, Mexico and the U.S. entered into discussions over the increasing salinity of Colorado River water being delivered to Mexico (Ibid).

In 1974, the seven basin states formally organized as the Colorado River Basin Salinity Control Forum with representatives from each state appointed by the Governor. The goal was to foster interstate cooperation and to address salinity control in a basin-wide context. This approach was endorsed by EPA with the adoption of a Colorado River system salinity control policy and standards procedure. (40 CFR, Part 120)). In essence, policy called for maintaining salinity concentrations in the lower mainstream at or below the average values in 1972, and implementing a salinity control plan in the basin. The regulation stated impart:

The salinity control problem shall be treated as a basin-wide problem that needs to be solved in order to maintain lower mainstream salinity at or below 1972 levels while basin states continue to develop their compact apportioned waters. (40 CFR, Part 120.5 (C)(I)(ii) 1974).

In 1974, Congress also enacted the Colorado River Basin Salinity Control Act (P.L. 93-320) with Title I committing the United States to be responsible for meeting salinity commitments to Mexico. Title II established a salinity control program with primary federal responsibility given to the Department of the Interior (primarily the Bureau of Reclamation) and the Department of Agriculture. This basic legislation has been amended on several occasions directing the federal agencies to focus on the most cost effective units, defining a role for BLM, and establishing a voluntary on-farm program. (See Colorado River Basin Salinity Control Forum, 1996, for more details).

Currently, the United States Department of Agriculture, the Environmental Protection Agency, the Fish and Wildlife Service, the Geological Survey, the Bureau of Land Management and the Bureau of Reclamation are all involved in Colorado River salinity control activities.[1] Under the salinity control implementation plan, various activities such as reducing salinity from saline springs, lining of irrigation canals and improvements in on-farm irrigation practices have reduced the salt load to the system.

Despite this progress, water users in the lower basin suffer economic impacts from continued use of water at elevated salinity levels. The Forum estimates that, "at current salinity levels, these damages are estimated to be in excess of $750 million per year." (Colorado River Basin Salinity Control Forum, 1996. p. 2-6).

Several aspects of the Colorado River salinity control make it of particular interest to broader aspects of water quality in the West. First, both the salinity problem and salinity control efforts exemplify the delicate interrelations between water quantity and water quality. Secondly, the basin-wide approach, the institutional arrangements and the state and federal partnerships appear to be unique for dealing with a water quality issue. While there have been, and continue to be significant challenges to addressing salinity issues in the basin, the current approaches warrant further analyses and considerations as a potential model for dealing with water quality issues in a basin-wide context.

[1] For details on federal accomplishments, see USDA, et al 1996.

Mining

Introduction

The January 27, 1997 Denver Post included a feature story on mining, "Colorado's oldest industry is embroiled in reform battles with environmentalists while record production levels continue to pump the economy." The headline illustrates the policy debate taking place today over environmental regulation of the mining industry. The battles mentioned in the Post article are not limited to Colorado; they are taking place throughout the West.

Extent of Historical Mining on Western Lands

While the mining industry remains robust today, it has left a legacy of real and potential environmental problems from over a century of historic mining. Using the U.S. Bureau of Mines' Minerals Availability System (MAS) database, the U.S. Geological Survey has created a snapshot of the number of historic mines in the United States. The report, entitled "National Overview of Abandoned Mine Land Sites Utilizing the Minerals Availability System (MAS) and Geographic Information Systems (GIS) Technology" 1996 by David Ferderer, filters the mine site database using several categories (USGS, Ferderer, 1996). For example, over one-half of the 202,000 mine sites in the contiguous U.S. are hardrock mining sites. The hardrock mining subset excludes energy and industrial commodity mines such as coal, sand and gravel, oil and gas, and clay.. A total of 48,000 hardrock mining sites are past-producers: a category of sites sometimes referred to as abandoned or inactive mine sites. Of the 48,000 abandoned hardrock mining sites, 28,000 are on federal land.[2] (See Table 1)

The USGS has also compiled the mine inventory information by states and watersheds. For example, Colorado leads the way with 7302 abandoned

[2] This is based on 1:2,000,000 scale resolution data.

Table VIII D-1.—Summary of hardrock commodity minerals availability system sites, April, 1995. (USGS, Ferderer, 1996). Numbers are rounded to the nearest thousand.

Sites by category	# of sites
Total sites	202,000
Hardrock sites	106,000
Total past-producer sites	48,000
Past-producer sites on Federal land	28,000
Past-producer sites on private property	20,000
Past-producer sites on DOI administered Federal land	15,000
Past-producer sites on non-DOI administered Federal land	13,000

hardrock sites, followed by California with 5824 (See Table 2).[3] The Spring watershed in the states of Kansas, Missouri, and Oklahoma has 2996 abandoned hardrock sites. The next most impacted watershed in terms of number of mine sites is the Clear Creek watershed in Colorado with 1343 sites (See Table 3). The information contained in these tables is depicted graphically in a map which has been appended to this report in Appendix D.

The USGS information tabulating the number of mine sites by states, on federal land, or in particular watersheds, is one way to gauge the extent of mining on western lands. However, the census of sites per watershed or per state is not necessarily an indicator of pollution levels. For example, the Summitville mine in Colorado is located in a "low-density" watershed yet, the water quality is known to be poor. In other words, the mine site database discussed above does not contain information confirming whether or not the mines are impacting western waters. Unfortunately, there is little compiled information on this subject. The limited information that is available will be discussed later in this section after a brief overview of how mining can potentially impact surface and ground-water quality.

A Mining Primer

The first step in understanding water quality impacts from mining begins with understanding the mining process. A mining operation is prospecting, or looking for an ore body. Once a valuable ore deposit has been located, the

[3]. These numbers are approximate, based upon the resolution of the data.

Table VIII D-2.—Past-producer hardrock commodity sites by western state (USGS, Ferderer, 1996). Numbers are approximate based upon 1:200,000 scale resolution

State	Federal	Non-Federal	Total
Arizona	2,941	562	3,503
California	4,657	1,167	5,824
Colorado	6,310	992	7,302
Idaho	1,519	119	1,638
Kansas	0	56	56
Missouri	408	5,240	5,648
Montana	1,644	336	1,980
Nebraska	0	4	4
Nevada	3,644	74	3,718
New Mexico	817	467	1,284
North Dakota	2	15	17
Oklahoma	2	271	273
Oregon	1,257	107	1,364
South Dakota	467	172	648
Texas	5	371	376
Utah	1,939	205	2,144
Washington	476	234	710
Wyoming	632	287	919

ore is extracted. Extraction is the process of reaching or uncovering an ore body which can be accomplished by either underground or surface mining methods. The process of extraction can create a substantial amount of waste rock or overburden material. Once the ore is recovered from the mine, it is milled. Usually the first step in a milling operation is to crush and grind the ore. The valuable mineral or metal can then be recovered from the crushed ore through a variety of different processes collectively called beneficiation. Beneficiation processes include gravity concentration, magnetic separation, solvent extraction, leaching, and amalgamation. Sometimes the marketable product of the beneficiation process, the concentrate, is further processed by procedures such as roasting or smelting. Most beneficiation processes produce tailings as a waste by-product.

Heap or dump leaching are means of beneficiation used primarily to recover precious metals from lower-grade ores or from tailings that may have residual quantities of the metals. In this case, the material to be treated is placed on a liner or liner system or directly onto the ground and either a cyanide or acidic solution is allowed to percolate through the ore or tailings.

Table VIII D-3.—Watersheds containing more than 300 past-producer hardrock mineral availability systems sites - not limited to western states (USGS, Federer, 1996)

Watershed names and locations	# of sites
Spring; KS, MO, OK	2,996
Clear Creek; CO	1,343
Upper Dolores; CO, UT	875
Arkansas Headwaters; CO	724
Nolichucky; NC, TN	686
St. Vrain; CO	676
Upper Arkansas, CO	578
San Miguel; CO	519
Upper Yuba; CA	424
Meramec; MO	393
Big; MO	380
Upper Santa Cruz; AZ	370
Pecatonica; IL, WI	367
Lower Dolores; CO, UT	350
Upper Missouri; MT	329
Animas; CO, NM	327
Trinity; CA	311
St. Louis; MN, WI	308

These techniques are so successful at removing precious metals from low-grade ore, that there has been a resurgence in the mining industry using heap leaching processes.

Placer mining is the removal of valuable metals from deposits of sand, stream gravel, or other material usually in and around stream beds. The valuable materials, along with the alluvium, is removed from the stream bed by a simple suction dredge, a tool commonly used by recreational placer miners, or by more substantial equipment like bulldozers. In most placer mining operations a sluice box or rocker is used to concentrate the valuable metals.

Mining Impacts on the Environment

If not properly managed, each of the processes described above - extraction, beneficiation, heap leaching, and placer mining - has the potential to cause substantial environmental damage. There are several means by which these impacts can occur.

As mentioned previously, the process of extraction creates a large amount of waste rock or overburden material. The mining industry is different from other industries in that the majority of the material handled during the production process is waste material, not marketable product. The total waste produced by the mining industry ranges from 10 percent of the total material removed from the earth (potash) to 99.9 percent (gold). In 1992, there were approximately 540,661,000 metric tons of waste generated from gold production and 731,065,000 from copper production (U.S. Bureau of Mines, 1992a).

The most common water pollutant resulting from mining operations is sediment. Nitrate, occasionally with ammonia, is frequently found at mines where blasting was used to reach the ore body and where the blasting occurred in the last 20 years. If uranium was the mineral being mined, radionuclides may be present in the waste rock. Additionally, waste rock is often a source of metals to either surface water or ground water. In some instances, depending upon the mineralogy of the area being mined, the waste rock can generate acids, further compounding the metal pollution problem.

Tailings from the beneficiation process can contain a number of environmental contaminants and are frequently more liquid than solid, which increases the difficulty of waste handling. The tailings material is generally disposed in ponds on the mine site. If the tailings pond is not sited in a safe location or is not adequately constructed, the tailings have the potential of contacting ground or surface waters. The same is true of heap leaching operations if the leach containment facilities are not properly sited, constructed, or maintained.

The most serious long-term environmental problems come from mines located in sulfitic, i.e, pyritic, mineralogy. At these mines, both waste rock and tailings have the potential to be especially harmful to the environment. When the sulfitic material is exposed to air and water, sulfuric acid is formed. The sulfuric acid dissolves the metals from the surrounding material, transporting them into the ground or surface water. An especially troublesome problem is when the acid generation process occurs inside underground mines, contaminating surrounding ground water, which is then released to the surface via mine tunnels, adits, or springs. In most cases, the problem of acid mine water is essentially perpetual since there is no easy means of stopping the acid generation process inside the mountain. Cleaning up these contaminants is particularly difficult and expensive.

Placer mining operations can damage the stream environment in a variety of ways such as altering the stream hydrology, increasing the turbidity and sediment load within the water, and destroying the riparian zone next to the stream itself.

Limited Information on Water Quality Impacts of Mining in the West

While there is a significant amount of data available on a site- or watershed-specific basis about the impacts of mining, there is little compiled information on western waters as a whole. In 1996, a group of BLM, EPA, and USGS employees assembled information on mining impacted watershed using state Clean Water Act Section 305(b) reports. This endeavor was undertaken to provide information to not only the Western Water Policy Review Advisory Commission, but the Western Governors Association, an organization also interested in the extent of mining impacted watersheds in the west. The results of the group's work--GIS maps indicating in red those western state stream reaches that have been affected by mining and/or metals--are appended (Appendix D) to this report. The maps are currently in draft form and are being reviewed by state and federal agencies. Revised maps are to be produced in early 1998.

Regulation of the Mining Industry

A number of institutional, statutory, and regulatory programs and requirements respond effectively to active and inactive mining-related problems. Most states have programs that deal with existing and proposed mines and some states have programs to address abandoned mines. Although a rigorous analysis of how well state programs function has not been done, the effectiveness of these programs vary from state-to-state. The state programs tend to be either reclamation-based or water quality-based and this dichotomy potentially leads to jurisdictional overlaps among or gaps between state agencies. Financial assurance and closure requirements, two very important aspects of any mining regulation program, also vary from state-to-state.

On the federal level, there are a number of statutes and associated regulatory programs that are or could be used to regulate mining activities. Most notable of these is the Clean Water Act administered by EPA and delegated states. Under the Clean Water Act, active mines and a few inactive mines with discharges to surface waters are regulated under the Act's National Pollutant Discharge Elimination System. Other federal statutes, such as BLM's Federal Land Policy Management Act and the Forest Service's National Forest Management Act, provide a limited amount of authority to the federal government to regulate active mining. However, the federal statutory program is not comprehensive and leaves gaps in regulation.

Given the regulatory deficiencies of federal statutes to address water quality and environmental impacts from mining operations, some are calling for a comprehensive federal program to regulate hardrock active mines. Many in the mining community do not believe there is a need for a comprehensive program. Absent a comprehensive program, federal agencies with responsibilities related to mining activities need to better coordinate efforts and areas of conflicting or overlapping authorities require resolution. EPA has conducted an analysis of these issues in the draft "National Mining Framework" which provides a more in-depth understanding of the statutes and regulations governing mining and the areas where changes are needed or improvements could be made (EPA, April 1996). The draft National Framework is EPA's attempt to coordinate its own activities more efficiently.

The means by which states and the federal government address the environmental impacts of inactive or abandoned mines is another area where there could be improvement. As mentioned previously, some states do have programs to address these situations, but, as with regulation of active mines, there is no comprehensive federal program to address inactive or abandoned mines. Without a comprehensive program, states and the federal government are forced to use a patchwork set of authorities and funding mechanisms to address the problems of inactive or abandoned hardrock mines.

For example, the U.S. Department of Energy is addressing 24 uranium mill tailings sites under the Uranium Mill Tailings Radiation Control Act. Surface reclamation has been completed at 18 of the 24 sites. Funds authorized under Section 319 of the Clean Water Act have been used by states to address the environmental impacts of many inactive or abandoned mines. Some states have enacted voluntary cleanup programs under which abandoned mining sites could be addressed. However, concerns about the potential for liability under Superfund or the Clean Water Act sometimes act as a deterrent to voluntary cleanup of a mine site under these programs.

The amount of money needed to clean up abandoned and inactive mines on western lands is much greater than the amount available through the Clean Water Act 319 or state voluntary cleanup programs. For this reason, EPA and states have used and continue to use Superfund authorities to address mining sites. For the western states, there are over thirty mining sites on the Superfund National Priorities List which are either being cleaned up or have been cleaned up under Superfund. Additionally, many more mining sites have been addressed using the emergency response authorities of Superfund.

Summary

Environmental regulation of the hardrock mining industry is a hotly debated topic. There is currently no comprehensive federal program to regulate the hardrock mining industry and the need for such a program is one of the subjects being debated. Historic mining has left a profound impact on western waters. There are limited financial means to address historic mining problems. As a result, many mining sites and mine-impacted watersheds have become Superfund sites.

Water Quantity and Quality/Hydromodification and Instream Flow

Hydromodification

Hydromodification is a term used to describe a variety of activities which alter the flow of water. Examples include channelization, dewatering, damming and dredging (EPA, 1995. p.ES-11). Hydromodification can degrade water quality. In fact, based on the 1994 305(b) reports submitted by states and tribes, EPA concluded that hydrologic and habitat modification was the third leading cause of water quality impairment to rivers (EPA, 1995. p. ES-12). Agriculture and municipal sewage treatment plants ranked first and second, respectively. The extensive development of the West's water resources has made western aquatic systems especially vulnerable to hydromodification.

Nationwide, over 68,000 medium and large dams exist for hydropower, water supply and other purposes. The federal government is a major contributor to this development: approximately 700 water projects were developed by the Army Corps of Engineers, storing about one-third of the total water stored.

The Bureau of Reclamation has developed an additional 600 dams and 53,000 miles of canals in the 17 western states. Water quality impacts of dams include alterations in temperature, sediment load, BOD, total dissolved solids, and flow variations, both volume and timing (season, daily and annual). A recent USGS report provides numerous examples of the impacts of dams on the downstream environment[4] (USGS 1996).

Water Quantity and Water Quality

The legal and institution separation of the management of water quantity (flow) from that of water quality presents a challenge for effectively addressing water quality problems arising from hydromodification. As noted by one author, "Unfortunately most western states have traditionally divided the administrative protection of public health (water quality) from that of water allocation (water quantity). This has led to an unrealistic separation of two natural attributes that are integral to one another." (Wolfe, 1996, p. 67).

An extensive study of the relationships between water use and water quality in the West was conducted by Getches, MacDonnel and Rue (1991). One of their summary observations was that "most uncontrolled water quality degradation today relates to water uses authorized by state water allocation systems." (Getches et al, 1991. p. 6). In recognition of the primary role western states play in water allocation and water use, (Getches et al, 1991. p. 132-134) made the following recommendations for state approaches to address water allocation/water quality issues:

- The activities of water allocation and water quality agencies should be formally coordinated
- Water quality considerations should be integrated into water allocation systems
- Instream flow laws and programs should be expanded to include water quality objectives
- The use of special management areas should be expanded to address critical water quality problems

[4] Dams and Rivers--Primer on the Downstream Effects of Dams, USGS 1996.

- Nonpoint sources need to be effectively regulated
- Water quality should be a major part of all relevant planning processes
- Increased funding and political support are vital to the success of a water quality program

Instream Flow

Maintenance of appropriate instream flows is receiving increased attention throughout the West and has both water quantity and water quality implications. Initial attempts to identify necessary instream flows focused on "minimum flows" for survival of sport fish. However, as a better understanding of stream ecology developed, as well as other instream flow needs (such as recreation, water quality , and stream channel morphology) quantified, there has been a trend toward trying to "mimic" the natural hydrograph within the constrains of existing water allocation systems. The majority of western states have created either a legal or institutional mechanism for protecting instream flows.

The interrelationship between water quantity (flow) and water quality was central to a 1994 United States Supreme Court opinion upholding state authority to mandate minimum stream flow through Section 401 certification.[5] The majority opinion, written by Justice O'Connor, noted: "*In many cases, water quantity is closely related to water quality, a sufficient* lowering of water quantity in a body of water could destroy all of its designated uses, be it for drinking water, recreation, navigation or, as here, as a fishery." (Ibid.)

Summary

As demands for water in the West continue to increase, there can be little doubt that hydromodification and the relationships between water quantity and water quality will prove difficult challenges. It appears, however, that states, rather than the federal agencies, will have the primary

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[5] *P.U.D. No. 1 of Jefferson County. and City of Tawmn v. Washington Dept. of Ecology* 114 S.Ct. 1900 (1994)

responsibilities for addressing these challenges. However, since the federal government has been a major participant in the development of water in the West, it should also play a significant role in addressing some of the major environmental problems which have been created by this development.

Pesticides

Pesticide usage in the U.S. has been relatively stable at about 1.1 billion pounds of active ingredient during recent years.[6] The agricultural share of pesticide usage appears to have stabilized and in 1991 accounted for 76 percent of the total or about 817 million pounds. Growth in the use of pesticides has been slowed by lower application rates due to the introduction of more potent pesticides, more efficient use of pesticides, and lower farm commodity prices. U.S. pesticide user purchases account for 24 percent of the total volume of the world market. (Aspelin, Arnold, et al, 1992)

In general, pesticide use in the seventeen western states is lower than in the other states. There are exceptions to this generalization in localized areas of high intensity, usually irrigated, agricultural production. Pesticide use is highly correlated with production of high value agricultural crops. A large percentage of the land area between the Rocky Mountains and the Sierras is federally owned and used for grazing rather than crop production. Forestry in the West uses pesticides but on an infrequent basis. Pesticide use on federal lands is predominantly for the control of noxious weeds. Noxious weeds are nonnative introduced species that spread rapidly, out-compete native vegetation, destroy wildlife habitat and livestock grazing values, and are difficult to remove or control. Even with the relatively low use of pesticides, contamination of ground water and surface water by pesticides contributes to water quality problems occurring in every state.

Monitoring for pesticides in water has been limited, especially in ground water. Not until the late 1970's was it realized that pesticides could reach ground water. Monitoring of surface water for pesticides was limited to those pesticides for which water quality standards had been developed or where there was a special need because of incidents such as fish kills which had occurred. Monitoring is complicated by the fact that laboratory analysis

[6] This figure does not include wood preservatives, disinfectants, and sulfur.

is highly specialized and, until 1988, no broad spectrum screens existed to identify large groups of pesticides. There is still limited data on the presence and causes of pesticide contaminants in water.

Water running off or percolating down to ground water from cropland treated with pesticides has a high potential to be contaminated. Irrigated crop production is concentrated in the 17 western states, which account for 70 percent of the total acres irrigated nationally and 83 percent of total applied water. In the 17 western states, flood irrigation is much more prevalent than in the eastern U.S (USDA, August 1996).

DDT in the Yakima River Basin

The U.S. Geological Survey (USGS) began the National Water Quality Assessment study of the Yakima River Basin in 1986. The purpose of the study was to evaluate the degradation of water quality resulting from non-point sources of pollution such as agricultural runoff. From 1986 to 1991, hydrologists collected samples of soil, water, sediment, and fish for analyses of pesticides and other water quality constituents at about 400 sites. Analyses were done for more than 90 different pesticides in water and sediment samples, and about 65 pesticides were detected. Many of these pesticides were detected in the lower Yakima River, which is downstream from intense agricultural activities.

The USGS report focused on the presence of DDT and its degradation compounds. The report found that even though two decades had passed since the production and use of DDT had been banned, DDT is still widely dispersed in the environment at levels that exceed a chronic toxicity criterion. Concentrations remain elevated in agricultural soils, stream water, suspended and stream-bed sediment, and fish and other aquatic life in the Yakima River Basin. The continued presence of DDT underscores the difficulty facing regulators in their efforts to improve water quality. It also underscores the importance of preventive measures to protect existing water quality. (Rinella, Joseph, 1993)

Pesticides in the Red River

In 1993-1994, the U.S. Geological Survey did a similar study in the Red River of the North in North Dakota and Minnesota. The USGS estimated that 0.5 percent of the approximately 253.000 pounds of atrazine (a persistent herbicide) applied in the watershed left the watershed as contamination of surface water flow in the river. They found this to be true of other agricultural pesticides as well. They found detections of atrazine, cyanazine, metolachlor, and triallate in at least 50 percent of all samples. Concentrations of pesticides varied seasonally but seemed to be highest in the first major runoff event following application. All detections were in the parts per billion range (Tomes, L.H.; 1995).

Pesticides in Fish

Between 1986 and 1989, EPA conducted a national study of chemical residues in fish, collecting samples at 388 sites around the country. The pesticide DDT or its breakdown products were found at 98.6 percent of the sampled sites. There was no significant difference between the levels found in the 17 western states and those found elsewhere. This same study found other chlorinated pesticides at more than 50 percent of sites sampled but did note a regional difference in levels found, with lower levels found in the 17 western states. The highest levels were found in more industrialized areas or areas where the pesticides were manufactured. Of all of the sites sampled, only one site in the 17 western states was determined to have fish contamination levels that warranted an advisory or ban on fish consumption and the pesticide involved was determined to have originated from a point source at a manufacturing plant. In contrast, 40 sites from the eastern U.S. warranted advisories (EPA, September 1992).

States, tribes, and other jurisdictions are not required to report on how many fish kills occur, or what might have caused them. Of the 17 western states, only 10 reported fish kill data for the National Water Quality Inventory 1994 Report to Congress. Seven of these states reported fish kills attributable to pesticides. Kansas reported the most with 21 of 42 fish kills attributed to pesticides. Nine states reported miles of river with water quality impaired by pesticides. The miles impaired per miles surveyed as reported are as follows:

- California
  2,466 out of 11,775,

- Kansas
  4939 out of 16,839

- Nebraska
  584 out of 8,540

- New Mexico
  8 out of 779

- Oklahoma
  2885 out of 7,045

- Oregon
  52 out of 29,109

- Texas
  124 out of 14,359,

- Washington
  388 out of 7,434

- Wyoming
  273 out of 6,091 (EPA Report to Congress, 1995)

Pesticides in Drinking Water Wells

Between 1985 and 1990, EPA conducted a statistically designed, national survey of pesticides in drinking water wells. The survey was designed to accomplish three things: 1) estimate the frequency of pesticide contamination, 2) provide an indication of the level of contamination, and 3) determine the correlation between pesticide use near the well and the presence of contamination. The findings were valid for a national level assessment and cannot be applied to specific states, counties, or sites. The study found that about 10 percent of community wells and 4 percent of rural wells were contaminated at low levels. There was no correlation between well contamination and pesticide use within a half mile of the well, but there was a strong correlation between contamination and the level of agronomic activity within the county. (EPA, January 1992)

Pesticides in Ground Water

To better characterize the degree of pesticide contamination in ground water, EPA compiled a database in 1992 of all of the available monitoring studies conducted by federal, state, and local governments, the pesticide industry and private institutions. The database showed that monitoring programs vary widely in sampling intensity and design from state-to-state. It also showed that the states that sampled the greatest number of wells were often those that found the greatest number of contaminated wells. Of the 17 western states, three had no monitoring data (NM, UT, NV), four had less than 50 wells sampled, and only three had more than 500 wells sampled. Only two of the 14 states for which monitoring data was found showed no contamination. In more than 80 percent of the samples, the contamination was believed to have resulted from normal field use of pesticides. Table VIII F-1 summarizes the monitoring data from these states. Great care should be used in evaluating this data since the database provides no information on the reasons why the wells were sampled or the possible cause of the contamination. The data does indicate the need for additional monitoring to identify the causes of contamination and to characterize those practices that have the greatest potential to minimize contamination (Jacoby, Henry et al, September 1992).

Regulation of Pesticides

All states have laws that control the use of pesticides. These laws are all based on the Federal Insecticide, Fungicide, and Rodenticide Act as amended (7 U.S.C.Sec. 121 et. seq.) and rely on the federal pre-market registration of pesticides. Registration is based on the premise that, if adequate use restrictions can be developed for a particular pesticide, it will not cause "unreasonable adverse effects on the environment"when used as directed. Before EPA can remove a pesticide from the market, the Administrator must determine that there are no additional use restrictions that would allow the continued use of the pesticide. However, the Administrator must also determine that the risks associated with use of the pesticide outweigh its benefits. The restrictions become part of the product label which provides the basis for enforcement.

Table VIII F-1.—National Well Sampling Data by State

State	Number of samples	Number with pesticide contamination
Arizona	40	1
California	10,320	2,046
Colorado	4	4
Idaho	15	0.00
Kansas	214	36
Montana	134	25
Nebraska	2,280	343
Nevada	0.00	0.00
New Mexico	0.00	0.00
North Dakota	515	30
Oklahoma	65	0.00
Oregon	165	114
South Dakota	99	64
Texas	511	134
Utah	0.00	0.00
Washington	182	59
Wyoming	105	41

EPA and the states have implemented numerous programs or requirements to reduce the risks of environmental contamination, especially as it relates to water quality. Some especially high-risk pesticides require the user to be specially trained and/or tested before purchasing the product. The training and testing require knowledge of environmental hazards. It is illegal to dispose of pesticides or clean pesticide application equipment near lakes, streams or ponds. Many pesticide labels require a buffer zone between the site of application and surface waters. Labels prohibit application of pesticides in areas where soils are porous and aquifers are shallow. Before pesticides can be applied through irrigation systems, the user is required to install anti-back siphon valves and other devices to prevent contamination of the water supply. Even with these restrictions, pesticides are still contaminating surface and ground water as shown in the discussion above.

A ground-water protection program still under development will require every state or tribe to develop special pesticide management plans to protect ground water as a condition for allowing a particular pesticide to be used within that state or reservation. (61 FR 33260) These plans will provide a range of best management practices and geographic restrictions to tailor the pesticide use to unique local conditions. This new program will require a much higher degree of monitoring, based on chemical analysis of water samples, than is presently occurring in any of the western states.

Summary

Pesticides are more widely used and introduced into the environment in larger quantities than many other pollutants. The acute and chronic health or environmental effects from pesticides can be extremely severe. Once contamination occurs (especially in ground water), there is limited or no technology available to clean up the water body. Environmental monitoring to determine the current extent of the effects, or even the presence of the pesticides themselves, is very limited. Yet, it is obvious that pesticide contamination of water is occurring with some regularity. The limited data available indicates a direct connection between the level of pesticide use and the presence of pesticides in ground and surface water. All of these factors indicate that a strong regulatory and educational program to prevent contamination is far preferable to trying to respond to incidents of contamination after-the-fact. This is especially true considering the ubiquitous use of pesticides and the extended environmental half-life of some pesticides.

Forestry

Background

This section summarizes the nonpoint source (NPS) pollution problems associated with timber practices in the western United States. The main timber activities related to NPS pollution are forest harvest, road building, forest fertilization and application of herbicides and pesticides. All the above activities negatively impact water quality by making undesirable changes in stream temperature, concentration of dissolved oxygen, Nitrate-N, and sediment. The following information is based upon experiments in more than 40 experimental forest areas in the United States and Canada (Binkley and Brown, 1993).

Temperature

Temperature affects both chemical and biological characteristics of streams. For example, the solubility of oxygen decreases rapidly as temperature increases. A change from 10 to 15 °C reduces oxygen solubility by almost 20percent and removal of tree canopies from over streams commonly raises stream temperatures by 3 to 7 °C. Most aquatic organisms have optimal temperature ranges. Forest practices that change temperatures more than about 2 °C from natural temperatures may be enough to alter development and success of fish populations in areas where cool water temperature limit productivity and fish growth. Removal of forest canopies over streams often increases fish population and biomass, either from direct temperature effects or from increased production in the food chain. It has been found that total fish biomass increased by about 50 percent when forest canopies were removed by logging in nine streams in Oregon and Washington. Many of the early studies on the effects of forest harvesting on temperature did not leave strips of trees along streams to buffer temperatures, and such treatments typically allowed the maximum summer temperatures to increase by 2 to 6 °C (Binkley and Brown, 1993). These impacts may result in a change in species composition and a decrease in the ability of the cool water fish to compete with the fish more suited to a warmer habitat which are often less desirable fish species.

Dissolved Oxygen

The concentration of oxygen dissolved in streamwater is critical for fish and other components of aquatic ecosystems. Streams typically contain about 5 to 10 mg/L of oxygen, with lower concentrations occurring in streams with high levels of organic matter and high temperature. Streams containing spawning salmonid fish should not drop below a single-day mean of 8 mg/L of O_2, or below 9.5 mg/L for a seven-day mean concentration, or 5 to 6.5 mg/L may be sufficient for adults. Only a few studies have examined changes in oxygen concentrations following forest harvesting. However, the forests studied in the West exhibited depressed oxygen levels in the streams due to logging debris. The values of oxygen obtained were 3 mg/L in a California example and 5 mg/L in an Oregor ample (Binkley and Brown, 1993).

Oxygen is not only found in the streamwater but in the streambed. Fine organic debris following forest harvesting can lower dissolved oxygen concentrations in streambed gravels through addition of fine sediments that impede downward diffusion of oxygen. This oxygen deficit can reduce success of fish reproduction (Binkley and Brown, 1993).

Nutrients

Phosphate is a chemical of concern as it relates to forestry practices. Phosphate concentrations in streams commonly limit the productivity of aquatic plants, and increases in phosphate concentrations can lead to increased primary productivity and altered foodwebs in streams. However, forest practices do not appear to degrade water quality with regard to phosphate concentrations (Binkley and Brown, 1993).

Although there is no generally accepted threshold of nitrate toxicity for aquatic ecosystems, the eggs of some salmon species have shown sensitivity to levels of 10 mg-N/L. The drinking water standard is 10 mg/L and is probably sufficient for protection of aquatic ecosystems in areas where a standard has been established. However, most streams are not designated for human consumption and have not drinking water standard. Thus, these streams will not be protected against nitrate toxicity. A variety of forest practices (such as harvesting and fertilization) often increase nitrate concentrations in streams. Nevertheless average concentrations are usually well within drinking water standards (Binkley and Brown, 1993).

As noted earlier, the composition and productivity (such as algae blooms) of stream ecosystems often change after forest harvesting. The most commc responses to these changes are decreased diversity of species, increased productivity, increased fish populations and biomass (i.e., microorganisms, algae and other living matter) (Binkley and Brown, 1993). The changes result in a decline in the overall health of the stream systems.

Sediment

Increases in suspended sediment concentrations may degrade water quality for a variety of uses. High suspended sediment concentrations (or high turbidity) degrade the quality of drinking water. Increased sediment concentrations may be associated with sedimentation of gravel streambeds, lowering permeability of the gravel beds, and degrading habitat quality for spawning fish. Timber roads and logging practices are primary contributors to sedimentation.

The causes of high sediment concentrations include the intermittent nature of small streams, the effect of forest removal on streamflow (increased volume and period of flow), and an apparent failure to retain a vegetated buffer strip next to streams (Binkley and Brown, 1993).

Recommendations

Most of the above mentioned problems can be mitigated by following modified forest management practices. Best Management Practices (BMPs) have been suggested for managing forest harvests. However, it is not clear how effective those BMPs are and how regularly they are implemented. The Association of Forest Service Employees for Environmental Ethics (ASFEEE) has developed an ecosystem management plan for the Interior Columbia River Basin. To serve as general recommendations for other areas, the plan's goals are presented below.

ASFEEE plan goals are:

- Protect, restore, and maintain the natural composition, structure, function, and processes of all aquatic, riparian, and terrestrial ecosystems, with a focus on protecting relatively intact systems
- Increase the opportunity for fire to play its natural role
- Restore soil productivity
- Restore and maintain biological productivity
- End damage to fish habitat and begin water shed restoration

- Manage the public lands in a way that is sensitive to the needs of local communities and that assures economic stability over the long term

- Educate the public about ecosystem processes and functions and the need for change in land management practices

For further details on this plan, please see the Internet address for ASFEEE in the reference to this section of the report.

Municipal Discharges

While much of the discussion of water quality in the West has, rightfully, focused on nonpoint sources (NPS) such as irrigated agriculture, grazing and timber harvesting, the significance of municipal discharges should not be overlooked. Contrary to the general perceptions, the West includes some of the most urbanized areas of the country, and is becoming more so. Therefore, the water quality issues associated with municipal discharges may become even more significant in the future.

In 1995, the EPA concluded that, nationally, "despite the improvements, municipal sewage treatment plants remain the second most common source of pollution in rivers because population growth increases the burden on our municipal facilities", (EPA. December 1995. The Quality of Our Nation's Water: 1994. page 15). The typical pollutants associated with municipal point source discharges are nutrients, oxygen-depleting substances and suspended solids.

With the rapidly changing population dynamics in the West, the issue has been raised as to whether municipal wastewater treatment facilities are keeping up with population growth. There is no regional or national database that can readily address this issue. However, EPA and many states have summarized a list of needs in municipal wastewater treatment facilities to meet increases in population[7]. The survey is an appropriate gauge of "needs" to address the population changes. This information is summarized in Table VIII-H-1.

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[7] *Needs Survey Report on the Assessment of Needs for Publicly Owned Wastewater Treatment Facilities, Correction of Combined Sewer Overflows, and Management of Storm Water and Nonpoint Source Pollution in the United States* (EPA 1992).

TABLE VIII - H-1

NEEDS FOR PUBLICITY OWNED WASTEWATER TREATMENT FACILITIES AND OTHER ELIBILITIES[1]
(January 1992 Dollars in Billions)

NEEDS CATEGORY

TITLE II ELIGIBILITIES

I	Secondary Treatment	IVA	New Collector Sewers
II	Advanced Treatment	IVB	New Interceptor Sewers
IIIA	Infiltration/Inflow Correction	V	Combined Sewer Overflows
IIIB	Replacement/Rehabilitation	VI	Storm Water (institutional source controls only

CATEGORY OF NEED

STATE	I	II	IIIA	IIIB	IVA	IVB	V	VI	NPS	TOTAL
Alaska	70	0	5	0	21	106	0	0	0	202
Arizona	701	69	2	1	182	301	0	0	0	1256
California	5388	144	128	706	684	784	556	6	0	8396
Colorado	129	197	0*	1	25	25	0*	0	172	549
Hawaii	132	4	0	0	69	66	0	0	0	271
Idaho	69	52	0*	2	71	59	0	0	0	253
Kansas	84	64	38	50	50	316	16	0	0	618
Montana	20	0	0	1	30	14	0	0	0	65
Nebraska	97	1	1	31	2	39	61	12	0*	246
Nevada	78	39	2	3	23	20	0	0	0*	165
New Mexico	43	0*	1	17	33	29	0	0	0	123
North Dakota	15	0	0	23	0	0*	0	0	0	38
Oklahoma	176	106	14	13	32	122	0	0	0	463
Oregon	429	368	13	140	292	110	108	0*	0	1460
South Dakota	37	0	1	29	13	23	1	5	0	109
Texas	1804	634	195	89	472	1459	0	0	0	4653
Utah	114	0	0	0	85	31	0	0	0	230
Washington	966	25	141	86	512	664	610	0	16	3025
Wyoming	5	0	1	1	12	1	0	0	269	1398

[1] EPA September 1993. 1992 Needs Survey. Report to Congress (EPA 832-R-93-002)

The "*Needs Survey*" is a joint effort by the states and EPA to summarize the capital construction costs to meet municipal wastewater pollution control needs. While individual states approach the needs survey differently, EPA maintained specific criteria to include only those needs for which a water quality or public health problem could be documented.

General Urban Growth

Background

Urban runoff carries pollutants from many sources and activities. Oil and gasoline from automobiles, salt on roads, atmospheric deposition, processing and salvage facilities, chemical spills, pet wastes, industrial plants, construction site erosion, and the disposal of chemicals used in homes and offices are all part of urban runoff. Not surprisingly, pollutant levels in urban water bodies are generally much greater than in forested watersheds (Terrene Institute, 1994).

The correlation between worsening runoff water quality and increasing urbanization results from a number of factors:

- Trees and other vegetation that once intercepted rainfall are gone.
- Natural dips or depressions that had formed temporary ponds for rainwater storage are lost by grading and filling for development.
- Thick, absorbent layers of natural vegetation and soils are replaced by paved (impervious) surfaces such as roads and roofs.
- Eroded paths such as stream banks become channels, increasing the amount of sediment carried by runoff (Terrene Institute, 1994).

As asphalt and concrete replace vegetation, runoff increases and reaches water bodies faster and with greater force. When the land loses its capacity to absorb and store rainwater, the ground-water table drops and stream flows decrease during dry weather (Terrene Institute, 1994). Below is a table that summarizes the common urban runoff pollutants and their impacts on water quality.

Table VIII-I-1.—Summary of urban runoff pollutants[1]

Category	Parameters	Possible sources	Effects
Sediments	Organic and inorganic Total suspended solids	Construction sites Urban/agricultural runoff	Turbidity Habitat alteration
Nutrients	Nitrate Nitrite	Urban/agricultural runoff Landfulls, septic fields	Surface waters Algal blooms
Pathogens	Total coliforms Fecal coliforms	Urban/agricultural runoff Septic systems	Ear/intestinal infections Shellfish bed closure
Organic enrichment	Biochemical oxygen demand (BOD)	Urban/agricultural runoff Combined sewer outflows	Dissolved oxygen depletion Odors
Toxic pollutants	Toxic trace metals Toxic organics	Urban/agricultural runoff Pesticides/herbicides	Bioaccumulation in food chain organisms and potential toxicity to humans
Salts	Sodium chloride	Urban runoff Snowmelt	Vehicular corrosion Contamination of drinking water

[1] EPA document: EPA/625/R-93/004.

Summary

As part of the continuing growth and development of the West, natural land surfaces are being replaced with new surfaces such as buildings, streets, parking lots, driveways, and sidewalks. These new surfaces are impervious to rain. Keeping the water on the surface instead of letting it infiltrate into the ground depletes ground-water supplies. When the additional runoff is redirected into local streams, it creates flooding, erosion, pollution problems, and degrades fish and wildlife habitat (City of Olympia Report, 1994).

Recommendations

These following recommendations first address the problem of increased runoff due to impervious surfaces resulting from growth. These recommendations are found in a draft report written for the City of Olympia, Washington: "Impervious Surface Reduction Study".

Policy and Management.—

- Integrate impervious surface reduction into policies and regulations.
- Establish growth management policies that encourage infill of urban areas and reduce urban sprawl.
- Provide a public transit system and alternative modes of transportation that reduce the need for streets and parking.

Urban Design.—

- Develop standards for narrower residential streets with reduced, but adequate, parking opportunities.
- Use pavers and other pervious surfaces for low use areas such as overflow parking and emergency access roads.
- Narrow alley widths, use alternative surfaces for alleys, and/or design alleys to drain to vegetated strips or central drains.
- Encourage cooperative parking such as joint, shared, and coordinated parking.
- Encourage underground or under-the-building parking and the construction of multi-storied parking structures.
- Develop flexible parking regulations related to parking region-wide that limit the amount of impervious surface, while still providing for true parking needs.
- Construct narrower sidewalks or sidewalks on only one side of the street, and/or slope-sidewalks to vegetated strips or gravel catchments.

Residential and Commercial Area Design.—

- Limit soil compaction on newly developed residential and commercial sites, especially those sites with sensitive features. Reduce soil compaction and restore infiltration capacity on already cleared sites whenever practical.

- Limit land clearing on newly developed residential and commercial sites, especially those with sensitive features.

- Encourage measures such as homeowner association covenants and/or add plat map conditions that protect existing vegetation and undisturbed areas.

- Encourage cluster development that minimizes impervious surfaces.

- Encourage the building and use of taller structures to reduce the size of building footprints.

Education and Outreach.—

- Develop and disseminate written materials that communicate the above recommendations.

- Develop and provide training and technical assistance to the region's development and business community.

Monitoring.—

- Design a monitoring program to determine the status of water quality in surface and ground-water bodies within the affected watersheds.

- Monitor the increase in impervious surfaces as development takes place.

It is extremely important the information be gathered to quantify the effects of urban runoff and growth on pertinent water resources. Degraded water bodies cannot produce either the goods or the services that are vital to society (Karr, 1996).

Total Maximum Daily Loads

Water Quality-Based Decisions: The TMDL Process

Efforts to solve water quality problems in the West have remained technically and politically complex. One comprehensive approach for attaining water quality standards for particular bodies of water is identified in the Clean Water Act as total maximum daily loads (TMDLs). The EPA has described the TMDL process as a crucial means to make the transition from a clean water program based primarily on technology-based controls to water-quality based controls implemented on a watershed basis. The TMDL program brings vigor, accountability, and statutory authority to the process. It is particularly important in cases where nonpoint sources, for which effective management programs are lacking, are the primary cause of the inability to meet water quality standards. The TMDL process has also received much attention in recent litigation against EPA to the degree that future water quality programs at the state and federal levels may be significantly influenced by resulting court decisions.

The following describes the TMDL program and identifies some of the contemporary issues related to its implementation in state water quality programs.

The Clean Water Act Requirements Regarding TMDLs

There are two fundamental requirements in the Act associated with TMDLs as found in Section 303(d). First, all states are to identify water bodies where water quality standards will not be attained or maintained after the application of the baseline treatment requirements imposed on point source discharges. These baseline requirements are mandated under Section 301(b) of the Clean Water Act and are known as technology-based requirements rather than water-quality based requirements. They apply to municipal and industrial point source discharges into surface waters and are applicable to point sources across the Nation, through the NPDES permit, regardless of the water body they discharge to. When technology-based requirements are not sufficient to protect certain bodies of water, then water-quality based limits must be identified. In order to meet the water quality standard, TMDLs are then established for that body of water. Although TMDLs apply to point and nonpoint sources, alike, the Clean Water Act has not identified any technology-based regulatory requirements for nonpoint sources.

The waters identified by the state as needing additional controls beyond baseline requirements are called "water quality-limited" water bodies. Each State is required to submit a list of water quality-limited waters to EPA for which TMDLs have yet to be developed. This list is known as a state's 303(d) water body list. The Act requires EPA to intervene and develop the 303(d) list if a state fails to do so.

The second requirement in the Act associated with TMDLs is for states to develop TMDLs for all of their water bodies. The primary emphasis, however, is with the waters on the state's 303(d) water body list. The Act requires that EPA develop TMDLs for the waters on the 303(d) list if EPA disapproves of the TMDLs. Although there is a statutory requirement for states to develop informational TMDLs for all other waters not on the 303(d) list, there is no requirement for EPA to review or develop TMDLs for these waters if the state fails to do so. When establishing a TMDL, a state is required by the Act to consider seasonality in the decisions as well as incorporate a margin of safety in the TMDL decisions.

The Act addresses tribal TMDL authority by calling for EPA to first develop regulations describing what steps are to be taken to delegate TMDL authorities to tribes. EPA has not done this to date, so the commonly accepted interpretation is that EPA retains the responsibility and authority to establish TMDLs and develop 303(d) lists for waters in tribal lands.

How TMDLs Are Defined

TMDLs can simply be defined as the level of pollutant control needed for point and nonpoint sources, alike, to assure water quality standards are met for a particular body of water. They are developed and calculated in the context of the given water quality standards established by the state or tribe and lead to water quality controls. Figure VIII-I-1 provides a graphical description of how TMDLs fit into the water quality-based process. The EPA has the responsibility to either approve or promulgate water quality standards the same way it has the responsibility to either approve or promulgate TMDLs. It should also be noted that TMDLs are pollutant-specific, so a water body can have many TMDLs developed for it.

EPA regulations of the TMDL program provide for a broad definition of TMDLs (see 40 CFR Part 130). The TMDL rule states that TMDLs can be articulated in such ways as mass-per-time, toxicity units, or any other

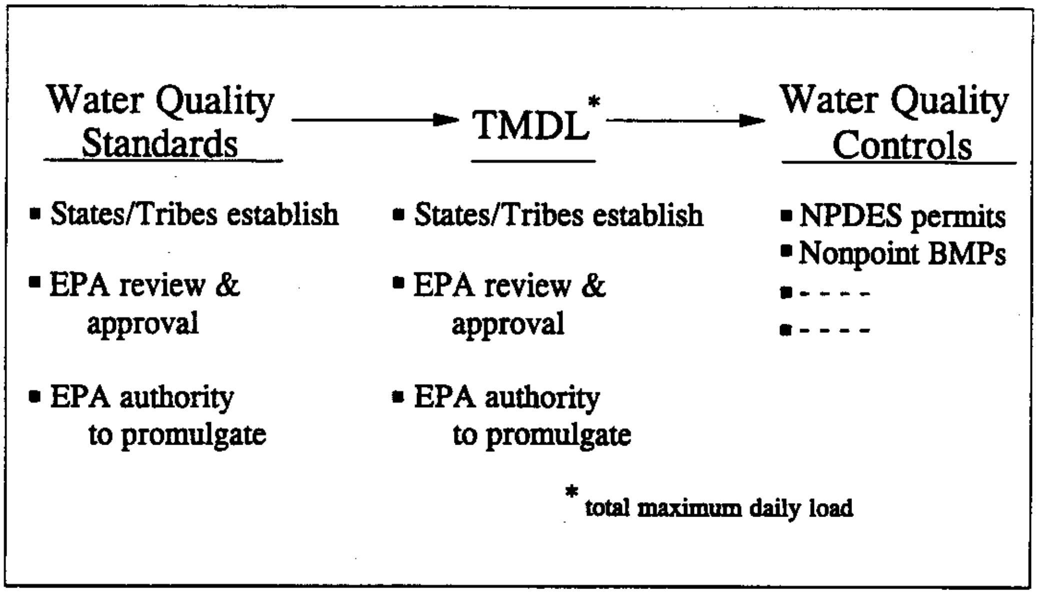

Figure VIII-I-1.—How TMDLs fit into the water quality-based process.

appropriate measure. This allows the tailoring of the TMDL to the particular water quality problem. For example, in a TMDL that addresses the pollutant loadings from a municipal wastewater treatment facility, it is usually most appropriate to identify the TMDL to use a pounds-per-day measure. For some pollutants associated with nonpoint sources, such as sediment which cause siltation in a stream, the most appropriate method may be either a pounds-per-year limit, an estimate of percent reduction of sediment in a watershed, or it may be a reduction in the miles of erosive or unstable streambanks within the watershed. TMDLs are particularly relevant to the water quality issue because they are quantitative in some manner, and will be of some utility in directing efforts to clean up the water.

The terminology "total maximum daily load" is most likely too narrow to describe all the actions that would qualify as a TMDL. Not all TMDLs will be a pollutant load. TMDLs that address radionuclides, bacterial contamination, or thermal pollution.are not associated with pounds of pollution. Likewise, some water quality targets are presented as "minimum" loads, such as those for dissolved oxygen. Furthermore, some loads, such as those for lakes and reservoirs, may be best described as annual, rather than daily, loads.

The geographic scale addressed by any given TMDL will vary depending upon the particular water quality issue. Some problems are spatially focused and require TMDLs on a site-specific scale. Such are the TMDLs that are associated with pollutants that do not persist in the environment, such as chlorine or ammonia from a municipal treatment facility. Pollutants that are persistent (such as dioxin) or may show their effect in a cumulative manner (such as sediment coming from erosive lands in a watershed) should be addressed by TMDLs that are developed on a watershed scale.

Guidance from EPA also addresses the need to develop TMDLs for waters that are threatened, but not yet impaired.[8] In this way, a state and tribe's antidegradation standard is implemented.

Litigation Over the TMDL Program

Recent years have seen an tremendous increase in the number of lawsuits related to TMDLs. The TMDL programs in 27 states are currently subject to litigation or pre-litigation activities. Plaintiffs have been quite successful in obtaining favorable decisions in court or in obtaining settlements that address a particular state's water quality program. It should be noted that EPA is usually the defendant in TMDL lawsuits because it is held that the Act imposes a mandatory duty on the part of EPA to perform where a state fails to do so.

The Clean Water Act makes it clear that, like water quality standards, TMDLs need to be developed to assure translation of those standards into the appropriate point and nonpoint source controls. Courts have agreed with plaintiffs that some states have not done a thorough job of either identifying water quality-limited water bodies on a 303(d) list or developing TMDLs for their problem waters. EPA can and has been legally compelled to develop the 303(d) list for states as well as be put on a schedule for developing TMDLs for all the 303(d)-listed waters. In a case related to Georgia's TMDL program, the court has included a directive to EPA that it develop TMDLs for waters on the state's 303(d) list within 5 years.

In *Alaska Center for the Environment v. Browner* (20 F.3d 961, 9th Cir. 1994) citizens sued EPA for its failure to establish total maximum daily loads

[8] For EPA's general guidance on TMDLs, see *Guidance for Water Quality-based Decisions: The TMDL Process*, EPA 440/4-91-001; April 1991. See also memorandum of Robert Perciasepe, EPA Assistant Administrator for Water, August 8, 1997.

for Alaskan waters to achieve desired standards of water quality. The court found that the citizens had standing and issued an injunction requiring EPA to comply with the law.

In a 1989 report from the US Government Accounting Office the implementation of the TMDL program on the part of states and EPA was critically reviewed with certain recommendation made to the agency on how to improve its performance.[9] It was noted that the TMDL requirements had been in the Act since 1972. EPA, in part, explained that a "functional equivalent" program had been actually implemented through the years, but improvements were needed both expanding the program into nonpoint source control as well as assuring that there is an explicit administrative record of review and approval for all TMDLs In a litigation occurring in the 1970s, plaintiffs were willing to accept the concept of a "functional equivalent" TMDL program. In recent years, both plaintiffs and courts have not been so willing to accept such an approach.

In response to the 1989 GAO report, EPA embarked on a effort to improve the TMDL efforts of the states. This need to improve TMDL programs compliments the recent emphasis on watershed-based planning since TMDLs take into consideration the combined effect of all pollutant sources over an appropriate geographic scale.

The concern of plaintiffs, who tend to be environmental groups, relates to the perceived limited success of state environmental programs to address water quality problems. In the West, environmental groups have been particularly interested in water quality issues on federally-managed lands. It is estimated that every state in the West has a number of water bodies on their 303(d) list proportional to the area of land being managed by the federal government. Generally, the water quality problems at issue are nonpoint source in nature, resulting from forestry, mining, grazing, and oil/gas activities.

As of this writing, EPA has either been sued or have received a notice of intent to sue over the TMDL programs in the following states:

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[9]. *Water Pollution: More EPA Action Needed to Improve the Quality of Heavily Polluted Waters*"; GAO/RCED-89-38; January 1989.

Alabama	Montana
Alaska	New York
Arizona	New Mexico
California	New Jersey
Delaware	North Carolina
Florida	Oregon
Georgia	Pennsylvania
Idaho	Washington
Kansas	West Virginia
Louisiana	Wyoming
Mississippi	

Current Efforts by EPA to Address Programmatic and Legal Needs in the TMDL Program

The EPA has recognized that the TMDL program needs to be overhauled to some degree to make it more relevant to contemporary water quality issues. EPA recognizes TMDLs as a tool which can be used in water quality planning efforts to lead to appropriate controls. Integrating this tool into the current state, tribal, federal, and local efforts where it is currently not being used would be the most appropriate approach.

How to best accomplish this is the subject of the following efforts being sponsored by EPA.

Federal Advisory Committee

EPA has convened a committee in accordance with the Federal Advisory Committee Act (FACA) to obtain advise on ways to improve the TMDL program. The Committee will share and discuss information on the status of the TMDL program and analyze the key issues related to its full implementation. The Committee will prepare a report to EPA containing its advice and recommendations. The Committee will conduct several meetings over the year through January of 1998. These meetings will be open to the public and the proceedings generally available.

Policies for Establishing and Implementing TMDL

The EPA has developed a written policy explaining how states should schedule, set priorities, and direct management tools for the TMDL program. The policy explains how EPA will seek to build partnerships with states, tribes, federal agencies, and key stakeholder groups to support an effective TMDL program.

The policy specifies that:

- Each state should establish an appropriate schedule for the establishment of TMDLs for all waters on the most recent section 303(d) list, reflecting the state's own priority ranking of the listed waters. These state schedules should be expeditious and normally extend from 8 to 13 years in length.

- A TMDL improves water quality when the pollutant allocations are implemented, not when a TMDL is established. Section 303(d) does not establish any new implementation authorities. . .For all section 303(d)-listed waters impaired solely or primarily by nonpoint sources, each EPA region should work in partnership with each state to achieve TMDL load allocations for nonpoint sources. All available federal, state, and local programs and authorities should be used, including nonregulatory, regulatory, or incentive-based programs authorized by federal, state, or local law.

- For waters impaired solely or primarily by nonpoint sources, each state must have an implementation plan that should, at a minimum, include:

  - Reasonable assurances that the nonpoint source load allocations established in TMDLs (for waters impaired solely or primarily by nonpoint sources) will in fact be achieved. These assurances may be nonregulatory, regulatory, or incentive-based, consistent with applicable laws and programs.

- A public participation process.

- Appropriate recognition of other relevant watershed management processes, such as local source water protection programs, urban storm water management programs, state section 319 management programs, or state section 303(e) continuing planning processes.

Information on the FACA Committee and the strategy as well as information on other TMDL issues and efforts can be found on the Internet address http://www.epa.gov/owowwtr1/tmdl/index.html which is subpart of EPA's home page.

Water Quality Monitoring

This section briefly summarizes the types of monitoring currently being conducted for surface and ground water, and the problems that have been identified by the Intergovernmental Task Force on Monitoring (ITFM) with the current status of monitoring. The ITFM is a federal interagency group working on improving water quality monitoring in the U.S.. The conclusions and recommendations of the ITFM are discussed later in this section. The authors of this report support the recommendations of the ITFM.

One critical conclusion stated by the ITFM is that current monitoring programs for surface water and ground water are insufficient to answer the basic questions, "Are programs to prevent or remediate problems working effectively?" and "Are water quality goals and standards being met?"

Surface Water Monitoring

A large number of federal agencies are involved in monitoring water quality in the West. Listed below are the primary agencies and programs. The list is taken from "Environmental Monitoring Activities of Federal Agencies" tabulated by the ITFM (ITFM, 1993). It is beyond the scope of this document to summarize all the ambient and compliance surface water monitoring that is occurring in the 19 western states. There are numerous studies being conducted by the federal, state, tribal and local governments. The monitoring has not been well coordinated between groups. However, with

Major water monitoring activities of federal agencies

Agency	Program or activity
USDA	Water quality research, non-point source studies
USEPA	Clean Water Act (319 program, 305b, Clean Lakes) Biological Monitoring and Assessment Program (BMAP) National Pollutant Discharge Elimination System Permits Safe Drinking Water Act Environmental Monitoring and Assessment Program (EMAP)
DOI/USFWS	National Wetlands Inventory Biomonitoring of Environmental Status and Trends (BEST)
DOI/USGS	Federal/State Cooperative Program Water Resources Division/National Hydrologic Benchmark Network National Stream Quality Accounting Network (NASQAN) National Water Quality Assessment Program (NAWQA) National Water Summary Program Toxic Substances Hydrology Program

the creation of the Intergovernmental Task Force on Monitoring (ITFM) and the National Environmental Monitoring Initiative coordination on monitoring is improving.

Some of the other agencies with monitoring programs include National Park Service, National Oceanic and Atmospheric Administration, Department of Defense/Corp of Engineers, Bureau of Indian Affairs, Bureau of Land Management, Office of Surface Mining, Bureau of Reclamation, U.S. Forest Service, and the Department of Energy. In addition, biological assessments being conducted by states for streams and rivers are summarized by state in U.S. EPA (1996) (Report number EPA230-R-96-007).

A large number of databases store the data collected in these programs, such as STORET and WATSTORE.. One of the goals of the ITFM is to create standard data elements for all water databases so that data can be exchanged easily between agencies.

Ground-Water Monitoring

Ground-water monitoring in the western states is conducted by a variety of federal, state and tribal programs Most of the monitoring is supported by the U.S. Geological Survey (USGS), U.S. Environmental Protection Agency

(USEPA), Department of Agriculture (DOA), state water quality agencies, tribes, and counties or other special districts. Ambient water quality monitoring for each western state is described in Table VIII-K.[10]

Most ambient monitoring (meaning monitoring at locations where there is no known anthropogenic contamination of ground water) is being conducted as a result of the USGS National Water Quality Assessment (NAWQA) Program studies, Safe Drinking Water Act (SDWA) monitoring requirements, or pesticide studies conducted by the Department of Agriculture (DOA) or a state or special district (see Table VIII-K).

Some interesting results from the survey include the following:

- There is very little ambient ground-water monitoring being conducted in the western states.

- Only North Dakota and South Dakota require bacteriological testing of new domestic wells (although most banks require testing when property is transferred).

- Very few states are even attempting to create a comprehensive database to include ambient ground-water monitoring data (the states that are include Colorado, Kansas, and Nebraska).

- In most states there are networks of USGS wells being used to monitor water levels, and some of these could be used to monitor water quality as well.

The State of South Dakota appears to have the best ambient ground-water monitoring program in the western states. The network consists of four-inch wells at approximately 102 sites covering 27 different shallow aquifers. The aquifers were deemed high priority on the basis of 1) surface and ground-water connection, 2) depth to ground water, 3) volume of water withdrawn and 4)population served. The program is unique because all the wells in the network have been or will be installed by the South Dakota Geological Survey and will thus be of known quality and uniform construction, with dedicated pumps. At almost all sites, there will be a well screened just below the water table and another well screened deeper.

[10] Table VIII-K is taken from "Ambient Groundwater Monitoring", prepared by Stephen Gould, EPA Region 2, November 1996 (U.S.EPA, 1996). The report is based on telephone interviews with various departments of each state government.

TABLE VIII - K, SUMMARY OF WESTERN STATES' AMBIENT GROUND WATER MONITORING

Source: U.S. EPA, REGION II, STEPHEN GOULD (U.S. EPA, 1996)

NAWQA = National Water Quality Assessment Program; run by the U.S. Geological Survey
CWS = Community Water Supply Wells
NC-NT = Non-Community, Non-Transient Wells
NC-T = Non-Community, Transient Wells

STATE	AMBIENT MONITORING	U.S. GEOLOGICAL SURVEY OR STATE GEOLOGICAL SURVEY	DOMESTIC	SAFE DRINKING WATER ACT	PESTICIDES
Alaska	No program.	NAWQA study Cook Inlet 54-well water level monitoring network.	700 new wells per year recorded. No water quality testing required.	1,451 CWS and NC - NT systems 1,371 NC-T systems	No ambient pesticide network.
Arizona	200-well network, sampled every 2-3 years, analyses vary.	NAWQA study, 37 wells.	103,000 active registered wells. No testing required by state.	2,133 CWS 487 NC-NT, 1,036 NC-T wells in state	80-90 wells analyzed for 120 pesticides.
California	No fixed, state-wide network.	NAWQA program had 150 wells sampled for various compounds. State has 1,200 wells for water level monitoring, 250 of these wells are sampled for water quality.	Permit required by county. Some counties require water quality testing, state does not.	17,264 active PWS wells.	No state-wide network but pesticide data collected from PWS wells and pesticide monitoring studies.
Colorado	No ambient ground-water monitoring program.	NAWQA program has sampled approximately 90 wells since 1991. State Engineer's office measures water levels in 800 wells.	210,000 permitted wells (155,000 are domestic). No state requirement for testing, counties may require.	1,989 CWS, 227 NC-NT, and 1,219 NC-T wells.	Dept. of Agriculture (DOA) is monitoring 150 wells/year (mostly domestic) for 46 pesticides.
Hawaii	No ambient ground-water monitoring program.	NAWQA studies to start in 1997.	3,500 wells registered. No state requirement for testing.	457 ground-water sources, 100 analytes tested for.	No pesticide monitoring currently.

STATE	AMBIENT MONITORING	U.S. GEOLOGICAL SURVEY OR STATE GEOLOGICAL SURVEY	DOMESTIC	SAFE DRINKING WATER ACT	PESTICIDES
Idaho	1,500 wells of all types are sampled for SDWA analytes and pesticides, 400 wells sampled/ year, subset of 100 wells sampled every year.	NAWQA provided pesticide sampling at 82 wells.	5,000-6,000 new well permits per year. 80,000 records dating to 1950's. No state requirement for testing.	2,000 CWS and NC-NT wells.	Dept. of Agriculture (DOA) just completed sampling 52 wells, analyzing for nitrate and 80 pesticides.
Kansas	250-well network (PWS, irrigation, domestic) covering entire state. Sampled every 2 years for inorganics, metals, 31 pesticides. VOCs and radionuclides sampled less frequently.	NAWQA study to start near Wichita in FY'98.	7,000-8,000 new well reports per year. No testing required by state.	2,013 CWS, 159 NC-NT, and 139 NC-T systems.	DOA monitors ground-water near chemigation systems.
Montana	State has network of about 700 wells, 10% sampled per year. Monitoring for major ions, trace metals, some radon, no pesticides or VOCs. Local water quality districts also monitor.	No USGS ground-water work currently.	150,000 well reports. No state testing.	1,120 CWS, 478 NC-NT, and 1,077 NC-T wells.	DOA has network of 19 wells, sampled twice per year for nitrate and 56 pesticides.
Nebraska	No state-wide ambient grand water monitoring network, but some Natural Resource Districts have their own programs (some sample 300-400 wells per year for nitrate).	NAWQA monitored 11 wells in Platte Valley. High Plains Regional Aquifer Assessment done 18 years ago. USGS has conducted water quality assessments at hundreds of irrigation wells, monitoring nitrate, trace elements, major ions, radon and locally-used herbicides.	Approximately 5,000 new well reports per year, with 90,000 records on file. No state requirement for testing.	1,500 CWS, 250 NC-NT, and 600 NC-T wells	No dedicated system, but monitoring data from other sources used (USGS, etc.).

STATE	AMBIENT MONITORING	U.S. GEOLOGICAL SURVEY OR STATE GEOLOGICAL SURVEY	DOMESTIC	SAFE DRINKING WATER ACT	PESTICIDES
Nevada	No ambient ground-water monitoring network.	NAWQA studies conducted near Reno and Carson Valley (90 shallow wells sampled). 50 deep wells installed also.	22,000 recorded wells. No state testing, but several counties require it.	690 CWS and NC-NT systems with approximately 1,200 wells.	DOA is sampling 10 agricultural areas. Each area has 25 wells and is monitored every 10 years, twice per year. Analytes are 40 pesticides.
New Mexico	No ambient program, but data from CWS wells are used.	NAWQA studies have included installation of approximately 120 wells, sampled for the full suite of NAWQA parameters.	Estimated 100,000 domestic wells in state. No testing required.	1,228 CWS 180 NC-NT, and 555 NC-T wells, springs and infiltration galleries.	No pesticide monitoring currently in place.
North Dakota	Ambient monitoring network of 1,000 wells. Various state agencies sample about 200 wells per year. Analytes are nitrate, major ions and selected pesticides.	NAWQA program includes 74 wells monitored for NAWQA analytes.	Approximately 20,000 well records on file. 1,000 new wells per year. A bacteriological test is required but not strictly enforced by the state.	Approximately 600 CWS, 50 NC-NT and 300 NC-T wells.	DOA uses ambient network, provides input on which pesticides to test for.
Oklahoma	No current ambient ground-water monitoring network.	NAWQA studies have been conducted in past and future studies are planned.	Approximately 12,000 well records per year are received with a total of 50,000. No testing required.	Approximately 4,000 PWS wells.	No statewide network for pesticide monitoring.
Oregon	In past 15 years state has monitored approximately 60 areas (each w/ 20-40 wells). Analytes include major ions, metals, VOCs and approximately 20 pesticides.	NAWQA study using 80 wells, monitored for full list of NAWQA parameters.	Approximately 300,000 well records with approximately 9,000 new wells per year. State requires nitrate and coliform testing upon property transfer.	775 CWS, 340 NC-NT and 1,337 NC-T systems.	Between 1987-1990, approximately 350 wells sampled for pesticides. Monitoring is ongoing at 40 stations for selected pesticides.

STATE	AMBIENT MONITORING	U.S. GEOLOGICAL SURVEY OR STATE GEOLOGICAL SURVEY	DOMESTIC	SAFE DRINKING WATER ACT	PESTICIDES
South Dakota	State is installing a network of wells at 102 sites (2 wells per site). Monitoring is taking place at 100 wells for radionuclides, trace metals, and cyanide. Some VOC and pesticides analyses will be conducted	NAWQA studies will start in the year 2000.	Approximately 800 records for new wells in 1996. New wells must be sampled for bacteria, nitrate, sulfate, sodium and conductivity.	No data.	The DOA uses the ambient monitoring network, providing input on which pesticides to monitor.
Texas	State has approximately 4,000 wells (CWS, domestic, irrigation). Wells are sampled on a 5-6 year rotating basis (approximately 700 wells/year). Samples tested for major ions, trace metals, radionuclides. VOCs and pesticides are rarely analyzed.	NAWQA studies currently using 60 wells.	30,000 well reports per year are submitted. No state requirement for testing.	12,000-15,000 PWS in state.	No state network, but some pesticides monitored in ambient monitoring. Many localized pesticide monitoring studies.
Utah	No state-wide network.	NAWQA study in Great Salt Lake Basin.	Approximately 45,000 domestic wells in state, with approximately 600 new wells/year. No state required testing.	1,159 CWS, 83 NC-NT and 467 NC-T ground-water sources.	Sampling is planned based on soil types, hydro-geologic information and location of agricultural areas.

STATE	AMBIENT MONITORING	U.S. GEOLOGICAL SURVEY OR STATE GEOLOGICAL SURVEY	DOMESTIC	SAFE DRINKING WATER ACT	PESTICIDES
Washing-ton	No state-wide network.	NAWQA program in Columbia Basin sampled approximately 180 shallow wells, testing for major ions, nutrients, VOCs and 95 pesticides.	Approximately 1,000,000 domestic wells in state. No state testing, but counties require coliform test on new wells.	No information on number of wells.	Since 1988, state has tested water at 243 sites for approximately 100 pesticides and metabolites. In 1994, state tested 1,326 PWS wells for suite of pesticides.
Wyoming	No state-wide network.	NAWQA study on Yellowstone River Basin begins FY'97. State has 50-100 water level monitoring wells, some of which are used by USGS for water quality monitoring.	Approximately 200,000 well records, 2/3 are domestic. No state testing required.	No information on number of wells.	State has ranked all 23 counties by vulnerability to pesticides. DOA has begun a study in high-priority Goshen County (29 wells, monitoring for 54 pesticides).

Monitoring is currently proceeding at 100 wells that have been installed. Analytes are radionuclides, trace metals, cyanide, VOCs at some wells and pesticides.

Compliance Monitoring

There is an extensive amount of monitoring data for contaminated ground water, primarily from Superfund, RCRA, Underground Storage Tank, DOE, and DOD sites. However, the data from these studies are not placed on a common database and often the data are not even electronically available. Monitoring may continue for several years and then be terminated when the goals of the study are met. This makes it almost impossible to obtain the data from these sites to prepare a comprehensive database for a state. There has historically been very little cooperation between agencies for sharing data. However, this is changing with the creation of the International Task Force on Monitoring Water Quality (ITFM), discussed in a following section.

Summary

The minimal amount of ambient ground-water monitoring and the failure to have the existing ambient and compliance data on a common database for access by other parties makes it virtually impossible to evaluate the success or failure of ground-water protection programs. This is one reason the Intergovernmental Task Force on Monitoring Water Quality (ITFM) was created, as described in a subsequent section.

Drinking Water Monitoring

The monitoring requirements of the Safe Drinking Water Act mandate that public water systems monitor the quality of their water after treatment. Therefore, any review of data from drinking water systems provides an indication of the quality of water treatment more than the quality of naturally occurring waters.

Additionally, even though there are standards for over 80 drinking water contaminants, plus monitoring requirements for dozens more, the Act allows states to grant "monitoring waivers" to water systems. These waivers, based on either "use" of a contaminant or "vulnerability" of the water system's source, allow water systems to forego monitoring, thereby potentially saving hundreds to thousands of dollars in analytical costs. Variations in the stringency of monitoring waiver programs from state-to-state have led to differences in the amount of monitoring that has actually been required of, and performed by, public water systems.

Historically, states have only been required to report to EPA specific data that shows a violation of drinking water standards. This data is maintained in the Safe Drinking Water Information System (SDWIS), EPA's national drinking water database. The 1996 Amendments to the Act require EPA to develop a new "national drinking water contaminant occurrence database." This database will contain information on both regulated and unregulated contaminants found at a "quantifiable level," not just those in violation of EPA standards. This information will help EPA which new contaminants should have standards developed. It will also provide a more complete picture of drinking water quality in the West, as well as the rest of the Nation.

Intergovernmental Task Force on Monitoring Water Quality

It became widely apparent in the late 1980's that water quality protection and management goals could not be achieved without considering both point and nonpoint sources of pollution, as well as habitat degradation. The need to shape an overall monitoring strategy became clear.

In 1992, the ITFM convened to prepare a strategy for improving water quality monitoring nationwide. The ITFM is a federal/state partnership of 10 federal agencies, 9 state and interstate agencies, and 1 American Indian Tribe. The EPA and USGS chair the ITFM. The mission of the ITFM is to develop and aid implementation of a national strategic plan to achieve effective collection, interpretation, and presentation of water quality data and to improve the availability of existing information for decision making at all levels of government and the private sector. A permanent successor to the ITFM, the National Monitoring Council, will provide guidelines and support for institutional collaboration, comparable field and laboratory methods, quality assurance/quality control, environmental indicators, data management and sharing, ancillary data, interpretation and techniques, and training.

Until the ITFM effort, coordination among the various new programs was uneven. Today, it is widely agreed that existing data programs cannot be added together to provide all the information needed to answer the more recent and complex questions about national or regional water quality.

Improved monitoring is needed to assess the quality of essentially all the Nation's water resources in a targeted way that will provide quantitative answers to the following questions:

- What is the condition of the Nation's surface, ground, estuarine, and coastal waters?

- Where, how and why are water-quality conditions changing over time?

- Where are the problems related to water-quality? What is causing the problems?

- Are programs to prevent or remediate problems working effectively?

- Are water-quality goals and standards being met?

Historically, these questions have been difficult or impossible to answer, especially at the regional and the national scales. Yet, answering such questions is a key issue because total expenditures in the public and private sectors on water pollution control are tens of billions of dollars every year.

The ITFM has been working since 1992 to determine the kinds of problems affecting current water quality monitoring being conducted in the U.S. In response to these problems, the ITFM has assembled a number of recommendations. Some of these recommendations are listed below. This list represents approximately one-half of the strategy and recommendations presented in the ITFM "Strategy for Improving Water-Quality Monitoring in the United States" (ITFM, 1995). The following recommendations are those considered to be of most interest to the Western Water Policy Review Advisory Commission. In the authors' opinion, the ITFM did an excellent job of gaining consensus on the monitoring issues and proposing methods to remedy some of the problems.

ITFM Strategy and Recommendations

Goal-Oriented Monitoring and Indicators

- Participating organizations should choose water-quality indicators jointly by using criteria identified by the ITFM to measure progress toward goals.

Gather and Evaluate Existing Information

- Characterize current water-quality conditions by using available information. If possible, map the conditions by using geographical information systems and include the actual locations of and reasons for impaired waters.

- After evaluating existing information, identify monitoring gaps and rank them by priority. Gaps that are lower priority and could not be monitored within available resources need to be clearly acknowledged.

Flexible and Comprehensive Monitoring

- Use a flexible monitoring design, including public and private groups, to assess ambient waters nationwide comprehensively by using a watershed-based rotational schedule of 5 to 10 years.

- Tailor monitoring designs based on the conditions of and uses and goals for the waters.

Institutional Collaboration

- Link federal ambient water-quality-assessment programs by:

  - Meeting at least annually to share information that results from federally-funded assessment efforts and to coordinate future plans,

  - Identifying opportunities to collaborate and share resources, and

  - Considering an Executive Order to implement federal aspects of the strategy.

Information Automation, Accessibility and Utility

- Automate data and information of general interest and usefulness.
- Develop additional tools to facilitate information searches and retrieval across databases. One such tool is a set of minimum data elements for sharing existing data.

Research and Development

- Identify needs for new or improved monitoring techniques to support current and emerging water management and environmental protection requirements. The ITFM's strategy is to work closely with the National Science Foundation, the National Council on Science and Technology, and similar groups to ensure that water quality monitoring research needs are considered in ranking national science priorities.

Training

- Promote training incorporating all organizations to:
  - Transfer technology
  - Inform others about needed changes in monitoring planning and procedures.
  - Achieve the quality assurance and quality control necessary to assure scientifically sound information for decision-makers.
  - Facilitate comparability of methods.

Implementation

- Continue the concept of intergovernmental collaboration for the development and use of monitoring guidance and for technology transfer.
- Establish a National Water Quality Monitoring Council representing all levels of government and the private sector to guide the overall implementation of the strategy. Such a council is needed to:

- Ensure that technical support and program coordination is maintained among participating organizations,
- Evaluate periodically the effectiveness of monitoring efforts nationwide and account for regional differences, such as between arid and water-rich states,
- Revise the strategy as needed to ensure that monitoring continues to meet changing needs, and
- Develop additional technical information and guidelines to support ground-water, coastal water, and wetland monitoring.

Funding

- Provide some federal resources to help support pilot studies in selected areas.

Additional Recommendations

- Allocate monitoring resources on the basis of water-quality goals, conditions and uses.
- Integrate surface- and ground-water monitoring.
- Link compliance and ambient monitoring.
- Include ecological, biological and toxicological information.
- Make data more accessible and of known quality.

Implementation of the nationwide strategy for water quality monitoring by all levels of government and the private sector will make information available in a timely manner to support management decisions and to measure progress towards meeting water quality goals. Additional specific technical recommendations are provided in the ITFM reports.

National Environmental Monitoring Initiative

The National Science and Technology Council's (NSTC's) Committee on Environmental and Natural Resources (CENR) established an interagency working group in July, 1995 and charged it to "recommend a framework for an integrated monitoring and research network that allows evaluations of the Nation's environmental resources". The NSTC is a cabinet-level council established by President Clinton in November 1993. It is the principal means for coordinating science and technology across the federal government.

All federal agencies that have major environmental monitoring and related research networks will be involved in this cooperative venture coordinated through CENR. The CENR is working closely with the Interagency Task Force on Monitoring of Water Quality (ITFM).

IX. Innovations in Water Quality Management

Chapter Summary

As identified in previous chapters, current management strategies for maintaining water quality have not always proven fully successful. A number of new approaches have been identified that may address certain deficiencies in water quality management techniques. This chapter will discuss the following approaches:

- Watershed approach which addresses the highest priority problems within hydrologically-defined, geographic areas.

- Ecological restoration which restores streams, rivers, lakes and wetlands to reestablish ecological, recreational, aesthetic and water quality values of impacted aquatic systems.

- Trading which allows those parties responsible for impairing water quality to form agreements allocating responsibility for certain clean-up activities This approach affords more flexibility.

- Ground-water management programs such as the wellhead protection program, the sole source aquifer program, and efforts to characterize interactions between ground water and surface water, all contribute to increased understanding and protection of groundwater resources.

Watershed Approach

Introduction

> *Water resources professionals continue to emphasize the futility of trying to solve complex, interrelated water problems through individual decisions on thousands of discrete but connected activities, (Adler, 1995, p. 977).*

Over the past 20 years, substantial reductions have been achieved in the discharge of pollutants into the Nation's lakes, rivers, wetlands, estuaries, coastal waters, and ground water. These successes have been achieved primarily by controlling point sources of pollution and, in the case of ground water, preventing contamination from hazardous waste sites and leaking underground storage tanks. However, as the introductory quote emphasizes, many challenges remain. The watershed protection approach is a tool which could help government organizations and citizens address these remaining challenges.

One way to view the watershed protection approach is the marrying of public and private sector efforts to address the highest priority problems within hydrologically-defined, geographic areas. The aim of the watershed approach is to prevent pollution and to achieve and sustain environmental improvements, while at the same time meeting other goals important to the watershed community such as economic sustainability or participation in governmental decision-making. The watershed protection approach is not a retreat, as some fear, from the basic goal of the Clean Water Act which is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Instead, the watershed protection approach can serve as a coordinating framework for achieving these goals.

The concepts behind the watershed protection approach are not new. They have been applied to a limited extent by government organizations at all levels in the past. For example, Section 208 of the 1972 Clean Water Act called for the development of area-wide waste treatment systems and the appointment of regional planning boards to manage these systems. Now, over two decades later, EPA and other federal, state and local agencies have begun to reorient existing water pollution control programs towards operating in a more comprehensive and coordinated manner.

The watershed protection approach is not a new centralized government program that competes with or replaces existing programs. To some, this may be a failure on the part of the watershed protection approach. Adler reports that:

> *...as of 1973, the last time a comprehensive inventory was taken, the U.S. Water Resources Council identified twenty-two major federal or interstate agencies, commissions, or other entities, and twenty-six subentities within them, involved in implementing various federal water resource program under hundreds of separate federal laws and programs, not including the additional layers of state and local laws and regulations (Adler, 1995, p. 993).*

Reasons to Use the Watershed Protection Approach

In 1996, the University of Colorado Natural Resources Law Center completed a study of watershed-based solutions to natural resources problems (University of Colorado, 1996). The Center concluded that existing institutions for water decision-making are deficient. One reason is that transboundary issues are not easily addressed by competing sovereign units. Other reasons are that surface and ground water are regulated differently and water quality and water quantity issues are addressed separately and by separate organizations. The Center believes that the watershed protection approach is a possible solution to these institutional problems.

The Center lists three compelling reasons along with examples of why the watershed approach should be used to manage natural resources. These are:

- To address problems that extend beyond existing jurisdictional boundaries,
- To coordinate the efforts of resource managers, and
- To produce more effective solutions by considering the entire watershed and all the interested parties.

Adler also mentions the disconnect and the resulting conflict between the control of water quantity, which is largely left to states, and the federal regulation of water quality as a reason for pursuing the watershed protection approach (Adler, 1995, p. 992). Another area of conflict is between land use decisions, which are most frequently made at the local and state level, and the federal regulation of water quality (Adler, 1995, p. 992). And finally, Adler offers what he believes is a more profound reason to pursue the watershed protection approach and that is that "people are more willing to take actions and to make sacrifices to protect and restore a special place - like the Great Lakes, Chesapeake Bay, or the Columbia River - than to promote some abstract idea of environmental quality (Adler, 1995, p. 1000)." Adler goes on to quote a U.S. Senate staffer, "people love their streams, lakes and bays. They don't necessarily love permits, regulations, or even the Clean Water Act (Adler, 1995, p. 1000)."

EPA adds its voice to the debate by noting that while watershed approaches vary in terms of specific objectives and priorities, elements, timing, size, and resources and while some are initiated by governmental agencies, and others by citizens, most watershed approaches have some basic principles in common. These principles include partnerships, geographic focus, and sound decision-making based on strong science and data (EPA, June 1996).

Partnerships are important to the watershed protection approach so that people who depend upon the natural resources within the watershed are well-informed and participate in planning and implementing watershed activities. Keeping those most affected by the decisions of regulatory and land-management agencies involved in shaping those decisions ensures that environmental objectives are well-integrated with economic stability and other social and cultural goals of the community.

A geographic focus is a critical aspect of the watershed protection approach because ground and surface waters do not respect political boundaries. Federal water laws tend to focus on particular sources, pollutants, or water uses rather than creating an integrated environmental management approach. Consequently, significant gaps exist in efforts to protect watersheds and aquifers from the cumulative impacts of a multitude of activities and pollutant sources.

Making decisions based on strong science and sound data is the third guiding principle of the watershed protection approach. Assessing and characterizing natural resources and knowing the communities that depend upon them is an essential part of this approach. Problems should be identified, then prioritized based on the condition and vulnerability of watershed resources, the needs of the aquatic ecosystem, and the concerns of the people within the community. Finally, realizing solutions to problems in the watershed and monitoring the effectiveness of those solutions is important to the watershed protection approach.

Federal Approaches to Watershed Protection

Environmental Protection Agency.—EPA announced its support of the watershed protection approach in 1991 (EPA, December 1991). In order to implement this approach, EPA began to change its budgeting process to provide the flexibility needed to redirect resources toward identifying and focusing on the watersheds of greatest concern. Several watershed efforts are being directly supported by EPA funding.

EPA is also undertaking several programmatic changes in order to promote the watershed protection approach. These changes include reducing water quality reporting requirements, using funds authorized under the Safe Drinking Water Act for source water protection, simplifying wetlands permitting, providing technical assistance to states and local organizations, and facilitating the development of wetlands mitigation banks and effluent trading (EPA, February 1996).

U.S. Forest Service.—On June 4, 1992, the U.S. Forest Service announced that ecosystem management would become the new framework for the use and care of the national forests and grasslands under its jurisdiction (USDA, April 1994). The Forest Service has developed recommendations and identified research needs to assist the agency in the implementation of ecosystem management. These recommendations include, but are not limited to, reviewing administrative and budgeting structures and staffing, integrating ecosystem management into the land management planning process and forest plan revisions. Developing effective methods for helping all agencies, the public, and other clients become aware of ecosystem management principles and of the limitations of ecosystems to preserve and/or produce commodities would support this approach. (Kaufmann, et. al., USFS, May 1994, p. 12).

Some of the research needs identified by the Forest Service include:

- Developing ecological risk assessment models and databases for assessing the likely ecological consequences of various management options

- Developing and evaluating appropriate ecological process models for forest succession and for natural disturbances that examine the likely consequences of human disturbance on future conditions

- Formulating regional conservation strategies (Kaufmann, et al, USFS, May 1994, p.13)

Bureau of Land Management.—The Bureau of Land Management (BLM) is undertaking several watershed and water resource programs. One program is a comprehensive watershed analysis which is a joint BLM and Forest Service effort to develop common, interdisciplinary watershed resource characterization procedures, especially to support management planning and decisionmaking. A component of this effort is to develop minimum national standards for hydrologic analyses. BLM is implementing the Riparian-Wetland Initiative which is a combined effort of BLM, the Forest Service, and the National Resources Conservation Service (NRCS). The Riparian -Wetland Initiative has four goals:

- Restore and maintain riparian-wetland areas
- Protect riparian-wetland areas and associated uplands through proper management
- Ensure an aggressive riparian-wetland information outreach program
- Improve partnerships and cooperative restoration and management processes in implementing the Riparian-Wetland Initiative

Other BLM watershed efforts include the Abandoned Mine Lands/Watershed Cleanup program which is an interagency, risk-based, watershed approach to restore damaged lands and mitigate polluted drainage from abandoned mines on public lands. The goal of this program is to use watershed characterization and pollution source ranking to achieve the greatest water quality improvement with the limited resources available. Visualization of rangeland health is a project to educate and train resource specialists to quickly assess the health of upland watersheds. And finally, BLM has developed the Interagency Watershed Training Cooperative which brings together scientific, technical, and physical assets to develop and implement watershed analysis training.

Natural Resources Conservation Service.—The Natural Resources Conservation Service (NRCS) is leading an effort with U.S. Department of Agriculture (USDA), Department of Interior (DOI), Department of Defense (DOD), Housing and Urban Development (HUD), and EPA to publish guidelines for designing stream corridor restoration projects in rural and urban settings (Personal Communication, November, 1996). The NRCS provides resource planning and implementation assistance to individuals, groups, and governmental organizations. This planning is ecosystem-based, focusing on natural systems and processes (SCS, September 1993, p. 1). The NRCS's Small Watershed Program is intended to provide technical and financial assistance to state agencies and local governments to protect and develop land and water resources in small watersheds that do not exceed 250,000 acres.

A catalog of federal watershed protection programs published by EPA summarizes these and several other federal programs that deal with some aspect of the watershed protection approach. (EPA, March 1993).

State and Local Approaches to Watershed Protection

Several western states including Washington, Oregon, Idaho, Utah, Colorado, and Nebraska have begun to either promote the concepts of the watershed protection approach or to orient their traditional water programs toward a watershed protection framework. Nebraska's watershed program is among those highlighted in a report issued by EPA entitled, "Watershed Protection: A Statewide Approach" (EPA, August 1995).

Local municipalities, districts and private organizations are also recognizing the value of watershed protection. Many of these local programs are described in another EPA report, "The Watershed Protection Approach: 1993/94 Activity Report," (EPA, November 1994). The University of Colorado Natural Resources Law Center has compiled descriptions of watershed approaches being implemented in nearly 80 watersheds in the states of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming (University of Colorado, 1996). The reader is referred to reports by the EPA and the Center for more information.

Summary

Public and private organizations are joining forces and creating partnerships to focus on watershed problems; community-by-community and watershed-by-watershed. This change in approach has resulted in part from the realization by government officials, private entities, and citizens that there are gaps in the existing myriad of water control statutes, regulations, and programs and the nearly overwhelming array of organizations charged with implementing these programs. The watershed protection approach has the potential to result in significant restoration, maintenance and protection of western water resources.

Ecological Restoration

An interesting development that merits additional consideration is the growing support for restoration of impacted aquatic ecosystems. From the highly-publicized flow releases at Glen Canyon to help restore the riverine ecosystem in the Grand Canyon to very local citizen activities to cleanup and restore local streams and wetlands, there appears to be a broad recognition of the desirability of restoring streams, rivers, lakes and wetlands that have been adversely impacted by various activities.

The interest in restoration appears to be driven by a desire to reestablish a variety of ecological, recreational, aesthetic and water quality values to impacted aquatic systems.

In 1992, the National Research Council prepared a report which provides an excellent overview of the opportunities to restore lakes, rivers and streams, and wetlands and provided descriptions of restoration case studies. (Restoration of Aquatic Ecosystems, 1992) The report also recommends that a national strategy be developed to restore aquatic ecosystems:

> *"The committee recommends that a national aquatic ecosystem restoration strategy be developed for the United States. This comprehensive program should set specific national restoration goals for wetlands, rivers, streams, and lakes, and it should provide a national assessment process to monitor achievement of those goals. The following recommendations are proposed as building blocks for the program and its guiding strategy. Details of the program design should be developed by federal and state agencies in collaboration with non-governmental experts. A national strategy would include four elements:*
>
> 1. *National restoration goals and assessment strategies for each ecoregion (regions that have broad similarities of soil, relief, and dominant vegetation).*
>
> 2. *Principles for priority setting and decision making.*
>
> 3. *Policy and program redesign for federal and state agencies to emphasize restoration.*

4. Innovation in financing and use of land and water markets." (National Research Council, 1992. p. 3).

Ecological Restoration as a Means to Attain Water Quality Objectives

In addition to achieving ecological objectives, restoration can also be a tool for attaining specific water quality goals. A 1995 report by EPA discussed relationships between restoration practices and water quality parameters. Perhaps this relationship can best be described by summarizing one of the case studies discussed in the EPA report ((Ecological Restoration: A Tool to Manage Stream Quality EPA, 1995. p G-14 to G-18).

The City of Boulder, Colorado, needed to renew the wastewater treatment plant's discharge permit for discharges to Boulder Creek. Studies of Boulder Creek indicated that the river segment below the wastewater treatment plant was not fully supporting its aquatic life uses and that un-ionized ammonia seemed to be a critical water quality factor. Additional studies also indicated that the Creek had been physically degraded by a variety of activities including channelization and destruction of the riparian zone. The analysis suggested that this degradation of the riparian zone caused higher water temperatures and increased pH, conditions that favor conversion of ammonia to its toxic un-ionized form. These conclusions led to the development of the Boulder Creek Enhancement Project which is intended to alleviate the un-ionized ammonia problem and restore full use of the river as a warm water fishery. The first step of the project was to improve the quality of the effluent at the wastewater treatment plant. The second and third steps were to improve the riparian zone along the river and to restore instream habitats. Riparian vegetation was planted, streambanks stabilized and a thalweg excavated. Monitoring is taking place to determine the effectiveness of these restoration techniques to meet the specific water quality objectives.

Ecological restoration can also be an important part of a "watershed approach". For example, on a broader, river basin scale, an interagency review of the 1993 Midwest flooding (Interagency Floodplain Management Review Committee, 1994) observed that drainage of wetlands and constrictions of the flood plains had aggravated the flood damage. The report also concluded that in some situations, it would be more cost effective to restore wetlands and a functioning flood plain than to rebuild more traditional engineering control structures. (Foote-Smith, 1996) has also discussed the importance of wetland restoration in a watershed context and described a sequential process being used by the State of Massachusetts. A key step is the identification of watershed "deficits" which can include water quality.

The growing interest in ecological restoration for various values including water quality provides a potential theme which should be furthered explored in terms of the role of federal water agencies in the West.

Trading

In general, the term "trading" describes any agreement between parties contributing to water quality problems in a water body where the agreement alters the allocation of the pollutant reduction responsibilities among the sources. These agreements may include third parties, such as state or local agencies or brokerage entities. Trading allows parties to identify more flexible and cost-effective means to resolve particular water quality problems.

On January 18, 1996, the EPA issued a policy statement concerning trading in watersheds. The policy reads in part:

> *"EPA will actively support and promote effluent trading within watersheds to achieve water quality objectives, including water quality standards, to the extent authorized by the Clean Water Act and implementing regulations. EPA will work cooperatively with key stakeholders to find sensible, innovative ways to meet water quality standards quicker and at less overall cost than with the traditional approaches alone. EPA will assure that effluent trades are implemented responsibly so that environmental progress is enhanced, not hindered." (EPA, January 18, 1996).*

EPA's trading policy was developed in response to President Clinton's "Reinventing Environmental Regulation" pronouncement in March, 1995. The means by which EPA's trading policy is to be implemented are discussed in the "Draft Framework for Watershed-Based Trading" (EPA, May 1996). The Draft Framework is a living document and EPA is currently reviewing the comments received on the document during a public comment period which ended in September, 1996.

One definite theme of the comments received on the Draft Framework is that the Nation's waters must continue to be protected. EPA agrees with this conclusion. Trading is not a retreat from the goals set forth in the Clean Water Act. The preservation of designated uses of a water body, such as fishing and swimming, remains paramount. EPA is committed to using trading to achieve overall pollutant reductions in watersheds. Trading supplements the current regulatory approach and can be a commonsense solution to water quality problems in many watersheds.

Trading provides a range of economic, social, and environmental benefits. Economic benefits are derived by allowing dischargers to take advantage of economies of scale and treatment efficiencies that vary from source to source. Trading fosters the development of holistic solutions for watersheds whose water quality is impaired by multiple sources. Social benefits accrue when the regulated community works with regulatory agencies and the public to develop these holistic solutions. And, finally, the watershed and its environment benefit when a trading program reduces the cumulative pollutant loading to the watershed and when, because of the trading program, dischargers go beyond minimum pollution reduction requirements, consider pollution prevention, or use effective and innovative technologies.

Trading can take many forms. A discharger might find it cost-effective to allocate pollutant discharges among various outfalls and, at the same time, reduce the overall amount of pollutants discharged. This is called intra-plant trading. Trading can be between point sources and nonpoint sources. There are also pretreatment trading opportunities for discharges to publicly-owned treatment works. Trades can involve either direct exchanges between parties or market-driven approaches where pollutant reduction credits are bought, sold, or banked.

Trading programs are being tested in several western watersheds. Examples include phosphorous trading in Cherry Creek, Colorado and also Dillon Reservoir in Colorado. A point/nonpoint source trading program to deal with biological oxygen demand (BOD) is being considered in the Chehalis river basin in Washington. Ammonia trading is being explored in Boulder Creek, Colorado, and a multiple resource, market incentive trading program entitled, "Cleaning-up Orphan Sites for Credit," is being developed for Clear Creek, Colorado. The Draft Framework provides more details about these case studies and others.

In summary, water quality trading has the potential to provide many economic, social, and environmental benefits. Trading programs should be designed to provide flexibility along with accountability consistent with the goals of the Clean Water Act. EPA wishes to provide incentives to trade within the statutory and regulatory responsibilities of federal, state, and local governments.

Ground-Water Protection

Since the 1960s, when synthetic chemicals were discovered in ground-water sources of drinking water in several states, there has been an increasing awareness of the need to prevent ground-water contamination. Contaminated ground water can pose significant risks to human health, the economy and sensitive ecosystems. Also, it has been shown time and time again that cleaning up contaminated ground water can be tremendously expensive and is not always possible. Recognizing the importance of a proactive, preventative approach to ground-water management, the U.S. EPA issued its "Groundwater Protection Strategy" in 1984. This strategy led to the development of a number of EPA initiatives and activities, as well as federal legislation, which focused on the development and implementation of state and local ground-water protection programs.

New Techniques to Characterize Ground-Water Resources

To support the implementation of ground-water protection activities, new techniques are being developed to better characterize aquifers and ground-water resources. These include assessment of ground-water sensitivity and vulnerability, delineation of zones of contribution for a well or wellfield, the use of ground-water tracing techniques to characterize ground-water flow paths and techniques for characterizing the hyphoreic zone and ground-water/ surface water interaction.

Since 1986 a number of ground-water protection programs have been authorized by federal legislation. States are subject to the provisions of these programs and have been developing programs that meet the requirements of the federal legislation. For many of these programs, actual implementation will be the responsibility of local governments. With funding and technical assistance provided by EPA, the USGS and other federal agencies, states and local governments are beginning to better characterize their ground-water resources and integrate ground-water protection measures into existing programs.

However, implementation of these programs has been significantly hindered by lack of financial and technical resources. To date, no valid national assessment has been conducted to gauge the effectiveness of these various programs. The EPA Office of Ground Water and Drinking Water is currently developing methods for doing such an assessment. Some of the more important of the proactive, preventative programs are described below.

Wellhead Protection Program

The 1986 amendments to the Safe Drinking Water Act (SDWA) established the Wellhead Protection (WHP) Program. The aim of this program is to

- Delineate that portion of an aquifer that provides water to a public water supply well or wellfield
- Identify and characterize potential sources of ground-water contamination within the wellhead protection area
- Develop and implement a management plan for the protection area

Under Section 1428 of the SDWA, each state must prepare a WHP Plan and submit it to EPA for approval. As of January 1996, 39 states had approved WHP programs. Though the law requires states to develop WHP Programs, the intent is for local governments to develop and implement the management plans for the WHP areas. As of May 1996, 18,000 communities had delineated their WHP areas, but only 4,000 communities were actually implementing management plans.

Sole Source Aquifer Program

The Sole Source Aquifer (SSA) Program was established under Section 1424(e) of the SDWA of 1974. The program allows individuals and organizations to petition the EPA to designate aquifers or portions of aquifers as the "sole or principal source" of drinking water for an area. If an area has an aquifer designated as sole source, then all federally financed projects planned for the area are subject to review by EPA to determine their potential for contaminating the aquifer.

The 1986 amendments to the SDWA added Section 1427 to establish procedures for development, implementation and assessment of demonstration programs designed to protect critical aquifer areas located within sole source aquifers. As of 1995, 65 SSAs had been designated, primarily in the northeast and the northwest parts of the country. The designated aquifers provide drinking water to more than 30 million people. It is important to note that only federally "financially-assisted" projects are subject to review. These projects represent a small percentage of the activities that have the potential to impact ground-water resources.

State Ground-Water Classification

A few western states have the legislative authority to classify ground waters for a particular use. Entire aquifers or portions of aquifers may be classified. Once the classification process is complete, ground-water quality standards for the designated use apply to ground water in the aquifer--as compared to ground water at the point of distribution. This provides a mechanism to prevent degradation of ground-water quality. However, enforcement of applicable standards occurs only when a complaint is lodged by an affected water user and there is clear data to determine who is responsible for contaminating the ground water. These classification systems are relatively new, and it is too early to measure results.

As mentioned above, new characterization techniques are being developed for aquifers and ground-water resources. Two of the most innovative are described below:

Aquifer Sensitivity and Vulnerability Assessments.—Aquifer sensitivity is defined as "the relative ease with which a contaminant applied at or near the land surface can migrate to the aquifer of interest". Aquifer sensitivity is a function of the intrinsic characteristics of the aquifer and the overlying unsaturated zone. Sensitivity is not a function of land use practices or contaminant characteristics.

Ground-water vulnerability is defined as "the relative ease with which a contaminant applied at or near the land surface can migrate to the aquifer of interest under a given set of land use practices, contaminant characteristics and sensitivity conditions".

Methods for conducting sensitivity and vulnerability assessments have been steadily developing over the past 15 years. There are numerous methods in use and the scale, validity and use of the assessments vary significantly. However, the ability to identify and characterize aquifers and ground waters which are highly susceptible to contamination is very useful for implementing ground-water protection programs. Many such assessments have been completed in the western states. Most have been done at a regional scale (county area or larger). There is still significant uncertainty as to the true predictive nature of these assessments. However, they are increasingly being used in the implementation of programs like State Pesticide Management Plans, Underground Injection Control Program and possibly the forthcoming Groundwater Disinfection Rule. There remains an important need to field test these assessments.

Characterization of Ground Water/Surface Water Interaction.—During recent years, there has been significant research attention focused on the hyphoreic zone, which is the subsurface zone beneath a stream or lake where ground-water and surface water are in constant interaction. The chemical, biological and hydrological process that occur in this zone are very important for maintaining suitable water quality and ecological conditions in overlying surface waters. The U.S. EPA has sponsored two international conferences on ground-water ecology in recent years. Significant research has been presented in these meetings and the Agency continues to fund some research in this area. There is clearly a growing understanding of the significant degree of ground-water/surface water interaction in most hydrogeologic settings. Ground-water supplies most of the water in the Nation's streams and rivers for most of the year. Ground water is also a critical source of water supply and water quality to such features as fens, wetlands and lakes. As understanding of ground-water/surface water interactions increase, ground-water management will improve.

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APPENDIX A

STATE NONPOINT SOURCE PROGRAMS

State Nonpoint Source Programs

The following summary of each state's Nonpoint Source program (NPS) and corresponding dollars provided to them through section 319(h) of the Clean Water Act was compiled using available data from EPA's Executive Summary of the National Water Quality Inventory; 1994 Report to Congress, and EPA's Grants Information and Control System database.

Alaska

From 1990 through 1996 Alaska received $3,833,630 in NPS funds through the 319(h) grant program and has implemented 111 projects covering areas such as agriculture (27%); silviculture (24%); Resource Extraction (6%); urban runoff (18%); and other (12%). These projects address the major concerns identified in the state's NPS Assessment Report and have made positive strides toward reducing NPS pollution.

Arizona

Arizona's NPS Control Program integrates regulatory controls with nonregulatory education and demonstration projects. Regulatory programs include the Aquifer Protection Permit Program, the Pesticide Contamination Program, and best management require-ments for controlling nitrogen and concentrated animal feeding operations. The state is also developing BMP's for timber activities, grazing activities, urban runoff, and sand and gravel operations. Arizona's point source control program encompasses planning, facility construction loans, permits, pretreatment, inspections, permit compliance, and enforcement.

From 1990 through 1996, Arizona received $6,407,980 in NPS funds from the 319(h) grant program and has implemented 69 projects covering major areas such as agriculture (42%); multiple categories (16%); and other (33%). These projects have addressed the major concerns identified in the NPS Assessment Document.

California

To aid California in its NPS activities, the 319(h) grant program provided $23,241,569 in NPS funds from 1990 through 1996. Utilizing these dollars, California has implemented 151 projects covering major areas such as agriculture (42%); silviculture (3%); multiple categories (15%); urban runoff (13%); and other (25%). These projects address the major concerns identified in the state's NPS Assessment Report.

Colorado

Colorado's NPS Program supports a wide range of projects. Ten projects were funded to identify appropriate treatment options for waters polluted by abandoned mines. Several projects identified and funded implementation of good management practices for riparian areas. Under another project, Colorado developed agreements with the

U.S. Bureau of Land Management and the U.S. Forest Service to ensure that these agencies implement effective BMP's to control nonpoint runoff from grazing, timber harvesting, and road construction activities on federal lands. To date, Colorado has received $8,189,164 in NPS funds through the 319(h) grant program, and has implemented 88 projects covering major areas such as agriculture (26%); urban runoff (13%); Resource Extraction (26%) multiple categories (22%); and other (9%). .

Hawaii

County governments are required to set erosion control standards for various types of soil and land uses. These standards include criteria, techniques, and methods for controlling sediment erosion from land-disturbing activities, The state would like to enact ordinances that require the rating of pesticides on their potential to migrate through soil into ground-water. The state would regulate the use of pesticides that pose a threat to groundwater. Until more stringent ordinances can be enacted, the state recommends using alternatives to pesticides, such as natural predators and other biological controls. The state also encourages the use of low-toxicity, degradable chemicals for home gardens, landscaping, and golf courses.

Through the 319(h) grant program, Hawaii received $817,538 in NPS funds from 1990 through 1996, and has implemented 11 projects covering major areas such as agriculture (55%);multiple categories (27%); and other (18%). These projects have addressed the major concerns identified in the state's NPS Assessment Report.

Idaho

Idaho is restructuring its Surface Water Quality Management Program around the watershed protection approach. As a first step, Idaho is redesignating it waterbodies and expanding its assessment database to include smaller streams that previously were not assessed. The state postponed its water quality assessment until all surface waters are designated and classified under a consistent system.

Idaho's Department of Environmental Quality identified several waterbodies with significant problems. Heavy metals and nutrients impact the Coeur d'Alene River drainage, while nutrients and sediments impact Henry's Fork. The Middle Snake River exhibits severe eutrophication from nutrient enrichment. Mercury contaminates fish tissue. Brownlee Reservoir does not support agricultural uses due to overenrichment with nutrients.

To aid Idaho in its NPS program, $4,498,378 was received in the 319(h) grant program from 1990 through 1996 initiating 70 projects addressing the areas of agriculture (47%); silviculture (11%); Resource Extraction (11%); urban runoff (9%); and other (11%). These projects have addressed the major concerns identified in the state's NPS Assessment Report.

Kansas

The major elements of the Kansas NPS Pollution Control program include interagency coordination, information and education, technical assistance, enforcement, and water quality certification.

From the years 1990 through 1996, Kansas received $5,247,512 in NPS funds through the 319(h) grant program and has implemented 52 projects covering major areas such as agriculture (48%); multiple categories (29) and other (21%). These projects have addressed the major concerns identified in the states' NPS Assessment Report.

Montana

Montana is actively pursuing interagency/interdisciplinary watershed planning and management. Currently, five large watershed projects are under way in Montana: the Flathead Lake Watershed Management Plan, the Blackfoot River Management Project, the Grassroots Planning Process for the Upper Clark Fork Basin, the Tri-state Clark Fork Bend Oreille Watershed Management Plan, and the Kootenai River Basin Program. Each program advocates collaboration by all interested parties to devise comprehensive management options that simultaneously address all major factors threatening or degrading water quality.

In addition, from 1990 through 1996 Montana received $6,475,752 in NPS funds through the 319(h) program, and has implemented 80 projects covering major areas such as agriculture (63%); silviculture (8%); multiple categories (11%); and other (25%). These projects incorporate the major concerns identified in the state's NPS Assessment Report.

Nebraska

Until recently, Nebraska's NPS Management Program concentrated on protecting groundwater resources. Surface water protection consisted of two federally-funded demonstration projects on Long Pine Creek and Maple Creek. Now, Nebraska is evaluating the role of NPS pollution statewide. Nebraska has received $8,379,325 in NPS funds through the 319(h) grant program and has implemented 67 projects from 1990 through 1996, covering major areas such as agriculture (42%); multiple categories (48%); and other (10%).

Nebraska recently revised wetlands water quality standards to protect beneficial uses of aquatic life, aesthetics, wildlife, and agricultural water supply. The state also protects wetlands with the water quality certification program, permit requirements for underground injection activities, mineral exploration activities and mineral exploration, and water quality monitoring.

Nevada

Agricultural practices (irrigation, grazing, and flow regulation) have the greatest impact on Nevada's water resources. Agricultural sources generate large sediment and nutrient loads. Urban drainage systems contribute nutrients, heavy metals, and organic substances that deplete oxygen. Flow reductions also have a great impact on streams, limiting dilution of salts, minerals, and pollutants.

Nevada's NPS Management Plan aims to reduce NPS pollution with interagency coordination, education programs, and incentives that encourage voluntary installation of BMPs. During 1992-1994, the state supported NPS assessment activities in each of the six major river basins. The state also completed a Wellhead Protection Plan for the state and began developing a state Ground Water Protection Policy.

The 319(h) grant program provided Nevada with $3,244,658 in NPS funds from 1990 through 1996 which has implemented 94 projects covering major areas such as agriculture (34%); multiple categories (45%); and urban runoff (7%). These projects have addressed the major concerns identified in the state's NPS Assessment Report.

New Mexico

New Mexico's NPS Management Program contains a series of implementation milestones that were designed to establish goals while providing a method to measure progress and success of the program. Implementation consists of coordinating efforts among NPS management agencies, promoting and implementing best management practices, coordinating watershed projects, inspections and enforcement activities, consistency reviews, and education and outreach activities.

To date, New Mexico has implemented 52 projects covering major areas such as agriculture (33%); Resource Extraction (15%); hydrologic modification (10%); multiple categories (17%) and other (10%). These projects have addressed the major concerns identified in the states' NPS Assessment Report and have totaled $4,102,945 in NPS funds from the 319(h) grant program.

North Dakota

North Dakota's NPS Management Program has provided financial support to 26 projects over the past 4 years. Although the size, type and target audience of these projects vary, the projects share the same basic goals: (1) increase public awareness of nonpoint source pollution, (2) reduce or prevent the delivery of NPS pollutants to waters of the state, and (3) disseminate information on effective solutions to NPS pollution. Major areas such as agriculture (66%); multiple categories (18%); and other (9%) have all been addressed in the NPS program, which has received $5,471,739 through the 319(h) grant program. These projects have addressed the major concerns identified in the state's NPS Assessment Document.

Oklahoma

Oklahoma's NPS control program is a cooperative effort among state, federal, and local agencies that sponsors demonstration projects. The demonstration projects feature implementation of agricultural best management practices (BMPs), water monitoring before and after BMP implementation, technical assistance, education, and development of comprehensive watershed management plans.

From 1990 through 1996, Oklahoma received $7,621,179 in NPS funds through ;the 319(h) grant program, and has implemented 76 projects covering major areas such as agriculture (24%); multiple categories (8%); and other (51%). These projects have addressed the major concerns identified in the state's NPS Assessment Report.

Oregon

Oregon recently initiated a Watershed Health Program to encourage public/private partnerships for managing water quality and ecosystem enhancement. Under the Watershed Health Program, field-based technical teams work closely with watershed councils composed of local residents and stakeholders to set priorities and fund projects. The Department of Environmental Quality and other state agencies targeted the Grand Ronde Basin and the combined South Coast and Rogue Basins to begin implementing the Watershed Health Program with $10 million in state funds for 1994 and 1995. These basins were selected because of existing total maximum daily load programs. In addition to state funds, Oregon has received $4,890,119 in NPS funds through the 319(h) program covering major areas such as agriculture (53%); silviculture (12%); construction (7%); urban runoff (12%); multiple categories (11%); and other (10%). These 102 projects have addressed the major concerns identified in the state's NPS Assessment Report.

South Dakota

South Dakota relies primarily on voluntary implementation of BMPs to control pollution from nonpoint sources, such as agricultural activities, forestry operations and mining. South Dakota has one on the most effective NPS programs in the Nation. The state has utilized Section 319 as the focal point for the large number of existing NPS control programs. To date, South Dakota has received $8,140,846 in 319(h) funds to carry out the NPS program which covers major areas such as agriculture (96%); urban runoff (2%); and hydrologic modification (2%). These 48 projects have addressed the major concerns identified in the state's NPS Assessment Report.

Texas

The Texas Natural Resource Conservation Commission (TNRCC) launched a basin approach to water resource management with the Clean Rivers Program (CRP). The CRP is a first step in the development of a long-term, comprehensive and integrated geographic management approach aimed at improving coordination of natural resource functions in the TNRCC. The basin approach allows for the use of risk-based targeting to prioritize issues and better allocate finite public resources.

From 1990 through 1996 Texas received $21,676,045 in NPS funds through the 319(h) grant program and has implemented 118 projects covering major areas such as agriculture (29%); urban runoff (22%); multiple categories (23%); and other (19%). These projects have addressed the major concerns identified in the NPS Assessment Report and have made positive strides toward reducing NPS pollution.

Utah

The state's NPS Task Force is responsible for coordinating nonpoint source programs in Utah. The task force is a broad based group with representatives from federal. state and local agencies; local governments; agricultural groups; conservation organizations; and wildlife advocates. The task force helped state water quality and agricultural agencies prioritize watersheds in need for NPS pollution controls. As BMPs are implemented, the task force updates and reprioritizes the list.

From 1990 through 1996, Utah received $6,048,396 in NPS funds from the 319(h) grant program and has implemented 84 projects covering major areas such as agriculture (69%); urban runoff (5%); and multiple categories (21%). These projects have addressed the major concerns identified in the state's NPS Assessment Report.

Washington

Washington provides financial incentives to encourage compliance with permit requirements, the principal vehicle for regulating point source discharges. The state also has extensive experience developing, funding, and implementing nonpoint source control plans with best management practices for forest practices, dairy waste, irrigated agriculture, dryland agriculture, and urban stormwater. The state is now focusing attention on watershed planning. Efforts are currently geared toward prioritizing watersheds and developing comprehensive plans for the priority watersheds.

Washington has implemented 142 projects, from 1990 through 1996, and has received $7,459,120 in NPS funds through the 319(h) grant program, covering major areas such as agriculture (52%); silviculture (13%);multiple categories (6%); and other (8%). These projects have addressed the major concerns identified in the state's NPS Assessment Report.

Wyoming

Wyoming's NPS Program is a nonregulatory program that promotes better management practices for all land use activities, including grazing, timber harvesting, and hydrologic modification.

Through the 319(h) grant program, the state has received $4,377,965 in NPS funds and has implemented 51 projects covering the major areas of agriculture (63%); multiple categories (24%); and other (6%). These projects have addressed the major concerns identified in the state's NPS Assessment Report.

APPENDIX B

THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

USGS Water NAWQA Help!

The National Water-Quality Assessment Program

INTRODUCTION

The Nation's water resources are the basis for life and our economic vitality. These resources support a complex web of human activities and fishery and wildlife needs that depend upon clean water. Demands for good-quality water for drinking, recreation, farming, and industry are rising, and as a result, the American public is concerned about the condition and sustainability of our water resources. The American public is asking: Is it safe to swim in and drink water from our rivers or lakes? Can we eat the fish that come from them? Is our ground water polluted? Is water quality degrading with time, and if so, why? Has all the money we've spent to clean up our waters, done any good? The U.S. Geological Survey's **National Water-Quality Assessment (NAWQA) Program** was designed to provide information that will help answer these questions.

NAWQA is designed to assess historical, current, and future water-quality conditions in representative river basins and aquifers nationwide. One of the primary objectives of the program is to describe relations between natural factors, human activities, and water-quality conditions and to define those factors that most affect water quality in different parts of the Nation. The linkage of water quality to environmental processes is of fundamental importance to water-resource managers, planners, and policy makers. It provides a strong and unbiased basis for better decisionmaking by those responsible for making decisions that affect our water resources, including the United States Congress, Federal, State, and local agencies, environmental groups, and industry. Information from the NAWQA Program also will be useful for guiding research, monitoring, and regulatory activities in cost effective ways.

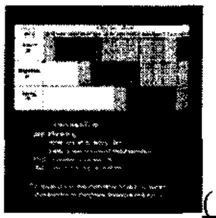
PROGRAM DESIGN

The NAWQA Program's unique design provides consistent and comparable information on water resources in 60 important river basins and aquifers across the Nation. Together, these areas account for 60 to 70 percent of the Nation's water use and population served by public water supplies and cover about one-half of the land area of the Nation. Investigations of these 60 areas, referred to as "study units," are the principal building blocks of the NAWQA Program.

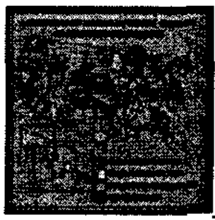
The similar design of each investigation and use of standard methods make comparisons among the study unit's results possible. Regional and national assessments can be made. These regional and national assessments, referred to as "National Synthesis," focus on priority national issues, including non-point source pollution, sedimentation, and acidification. Each issue is unique and manifests itself differently among the Nation's diverse geographic, geologic, hydrologic, and climatic settings. The challenge and goal for NAWQA is, therefore to identify the common environmental characteristics associated with the occurrence of key water-quality constituents and to explain their differences throughout the Nation.

PROGRAM IMPLEMENTATION

In 1991, NAWQA began the transition from a pilot program to a full-scale program with the start of 20 study-unit investigations, along with synthesis activities on a national scale. In October, 1993 an additional 20 study-unit investigations started. When fully implemented in 1997, the program will include hydrologic investigations of 60 study areas that are distributed throughout the Nation.



(15KB GIF). To make the program cost effective and manageable, intensive assessment activities in each of the study units are being conducted on a rotational rather than a continuous basis, with one-third of the study units being studied intensively at any given time For each study unit, 3- to 5-year periods of intensive data collection and analysis will be alternated with 5- to 6-year periods of less intensive study and monitoring.



Locations of the 60 NAWQA study units and their proposed implementation dates (26K GIF)

Coinciding with the study-unit investigations are the national synthesis assessments. The large geographic extent and large variability in environmental factors throughout the Nation, and limited resources make it necessary to focus on a limited set of high priority water-quality issues. Generally, two to four national synthesis topics will be studied at a given time. Two issues of national priority--the occurrence of nutrients and pesticides in rivers and ground water--were selected as the first issues investigated by national synthesis. These topics were ranked among the highest in importance because of widespread environmental and public health concerns and because information necessary for a national assessment of these contaminants was incomplete.

The next topic for national synthesis is the occurrence and distribution of volatile organic compounds (VOCs). Many VOCs are toxic and are a major focus of a number of Federal regulations related to water quality. Major work elements planned for the study of VOCs in 1994 and 1995 are to (1) identify regulated and non-regulated VOCs; (2) determine the amounts of VOCs released to water, land, and air, and (3) evaluate strategies to characterize the use and releases of VOCs to the environment, including ground water.

The first two years of both study-unit investigations and national synthesis studies involve compilation and analysis of existing information. In addition to USGS data, information and methods developed by other Federal agencies, as well as by State and local agencies, universities, and volunteer organizations are reviewed and integrated as appropriate. This preliminary information on water-quality conditions, trends, and functions forms the basis of a three-year period of intensive data collection and analysis to fill identified gaps in subsequent years.

Perennial data collection and sequential assessments in the study units and regional and national synthesis are key attributes of the program, not only to define changes and trends, but also to build an evolving understanding of water quality in each of the study units and across the Nation. This understanding will be achieved through careful analysis and interpretation of long-term data sets on the physical, chemical, and biological characteristics of the water resource. The data sets will be related to carefully compiled information on hydrology and geology and changes in land-use activities and management practices. The long-term commitment of the NAWQA Program to water-quality monitoring at local, regional, and national scales is designed to answer critical questions about the status and trends in the quality of our Nation's water.

EARLY FINDINGS

The NAWQA Program is producing many useful findings about our local, regional, and national water resources.

Highlights of NAWQA Study Unit Findings

- Hudson River Basin
- Delmarva Peninsula
- Western Lake Michigan drainage
- Red River of the North
- Trinity River Basin
- Lower Kansas River Basin
- Rio Grande Valley
- Upper Snake River Basin
- Yakima River Basin
- Nevada Basin and Range

Selected early results from the National Synthesis on Pesticides and Nitrates include the following:

- A review of existing information on pesticides in the atmosphere showed that pesticides have been detected in most samples analyzed throughout the Nation. Pesticides were ubiquitous and were generally detected wherever they were sought. The degree of use and environmental persistence explain the dominant patterns in frequency of detection. The review revealed that no consistent, long-term studies at a national scale have been done.
- A statistical analysis of the occurrence of nitrate in streams at about 150 sites in 10 states in the Midwest, showed there was a relation between the concentration of nitrate and each of the following: the amount of precipitation, rate of streamflow, the acreage of the basin planted in corn, the acreage planted in soybeans, cattle density, and population density. These findings help State and local managers to focus scarce monitoring resources to the most critical areas.
- Estimates of point- and nonpoint-source nitrogen loadings were made for about 90 watersheds throughout the United States. The relative proportions of input to streams vary as a function of climate, hydrology, land use, population, and physiography. A large percentage of point-source loads occur near cities. Nonpoint loading varies widely, and is strongly influenced by precipitation and runoff. However, no single nonpoint-nitrogen source is dominant everywhere. Information derived from NAWQA study units will aid in the development of methods to reduce point- and nonpoint-source nitrogen loading.
- Effects of agricultural activities on ground-water quality was studied in five regions from New York to Nebraska. The quality of water in surficial, unconsolidated aquifers was affected by the geology and soils, land-management practices, fertilizer use, and the amount of irrigation. Concentrations of nitrate were greatest in areas that are heavily irrigated or areas that have well-drained soils or sediments.

Results from the NAWQA Program are being released to the public through a variety of publications as elements of the studies are completed.

COMMUNICATION AND COORDINATION

Communication and coordination between U.S. Geological Survey personnel and other interested scientists and water-management organizations are critical components of the NAWQA program. Early in the program, the National Academy of Sciences reviewed the proposed activities and issued a report supporting the program. Since 1991, the NAWQA Advisory Council, a panel of Federal scientists, has met to ensure use of the best and most current scientific methods and to ensure national relevance of the program's findings. In 1993, representatives from National, State, and regional organizations; Native American groups; professional and technical societies; public interest groups; private industry; and the academic community were invited to join the Council. At the study-unit level, each investigation now underway has a local liaison committee consisting of representatives with water-resources responsibilities or interests from Federal, State, and local agencies, universities, and the private sector. Specific activities of each liaison committee include (1) the exchange of information about water-quality issues of regional and local interest, (2) the identification of sources of data and information, (3) assistance in the design and scope of project products, and (4) the review of project planning documents and reports.

U.S. Geological Survey
Open-File Report 94-70
By P.P. Leahy and T.H. Thompson

For further information on this and related studies, contact:
NAWQA Program
U.S. Geological Survey
413 National Center
Reston, Virginia 20192
email: nawqa_whq@usgs.gov

URL: http://wwwrvares.er.usgs.gov/nawqa/NAWQA.OFR94-70.html
Maintainer: kjhitt@usgs.gov
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Last modified: Mon Jun 9 11:08:19 1997

USGS Water NAWQA *Help!*

National Water-Quality Assessment (NAWQA)
National Synthesis--National Assessments of Water Quality

National Synthesis is the synthesis of results from all study units with information from other programs, agencies, and researchers to produce regional and national assessments for priority water-quality issues.

National synthesis of water-quality data, based on aggregation of consistent information obtained from the study units, is a major component of the National Water-Quality Assessment Program. Differences and similarities in water-quality conditions among study areas will be highlighted as will trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic chemicals, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water, as the information becomes available.

The goals of National synthesis are:

- Assess water quality across the Nation and trends over time
- Relate status and trends in water quality to natural and human factors
- Determine effects water quality might have on aquatic life
- Provide information for water-resources management

The first topics discussed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology.

- Pesticides
- Nutrients
- Volatile Organic Chemicals
- Aquatic Biology

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Maintainer: kjhitt@usgs.gov
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CENTRAL REGION STUDY UNITS

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APPENDIX C

SUMMARY OF STATE GROUND-WATER INFORMATION

ALASKA

Groundwater Use (1986 data)

-70% of the population obtains water from groundwater; suitable for most uses except for high iron and hardness in most areas.

Principal Aquifers

Detailed mapping and use of groundwater only near the widely separated major population centers. The majority of groundwater withdrawn from unconsolidated aquifers.

Unconsolidated Alluvium and Glacial Outwash:

TDS generally less than 400 mg/L, but higher in shallower zones; high iron and hardness are common.

Bedrock Aquifers:

Little used but some development of fractured schist uplands near Fairbanks; highly variable quality, but generally high TDS and hardness. Also naturally high iron, nitrate and arsenic in Fairbanks area.

Groundwater contamination resulting from human activities

Naturally high arsenic in Fairbanks.

Naturally high mineralization and salinity in the Copper River basin due to upwelling from the underlying marine sedimentary rocks.

Potential and localized contamination from septic systems, land disposal of wastes, and leaking USTs. Already reported in Anchorage, with potential in all the population centers.

Disposal of sewage in lagoons and ponds that connect to shallow groundwater has caused contamination in small villages and remote field/construction camps.

Petroleum contamination from spills at remote construction sites.

Saltwater intrusion along coastal areas.

193 waste sites at 45 military installations.

ARIZONA

Groundwater Use (1986 data)

-66% of water used derived from groundwater.
-73% of the groundwater used was for agriculture.

Principal Aquifers

Three distinct water provinces in the state:

Basin and Range lowlands: southern half of the state

Alluvial aquifers: TDS generally less than 1,000 mg/L but range from less than 100 to more than 40,000 mg.L.

Water quality varies with location and depth, depending on the local lithology and mineralogy. Naturally occurring concentrations of fluoride, barium, arsenic and chromium exceed state and federal maximums.

Central Highlands: central east-west strip across state, separates the other two provinces - most usable water is from fractured bedrock or limited valley fill alluvium. Bedrock aquifers: TDS generally less than 1000 mg/L, but data limited.

Plateau Uplands: northern half of the state:

Kaibab Lm.- TDS averages about 500 mg/l, Coconino Sandstone - TDS less than 500 mg/l near southern edge of plateau but increases dramatically north of little Colorado River,

Groundwater contamination resulting from human activities:

Contamination documented in 347 wells per AZ Department of Health Services.

Irrigation:

Increased TDS from recharge by irrigation water containing salts, also cross contamination due to poorly constructed and abandoned irrigation wells. Pesticide contamination in some counties.

Mining:

Localized increased TDS and acidity; increase TDS, metals and sulfate from copper mining. Major degradation of a large portion of a surficial aquifer near Globe as a result of acid disposal associated with copper mining.

Urbanization: mostly Salt Lake County

Contamination is evident in groundwater, which may result from storm drains, dry wells and disposal ponds, several large solvent plumes have been associated with waste disposal at electronics facilities and industrial landfills

Waste Disposal or Storage sites

5 RCRA sites, 5 CERCLA sites, hazardous waste sites at 6 military facilities, petroleum and solvent contamination at numerous underground storage tank locations, a few public supplies have been significantly impacted by leaking USTs

CALIFORNIA

Groundwater Use (1986 data)

-69% of the population rely on groundwater, but not all groundwater is suitable for all uses.

-Groundwater supplies 40% of California's annual applied water needs.

Principal Aquifers

Three principle aquifer types in the state; additional variations in different physiographic provinces,461 alluvial and basin fill "groundwater basins" have been identified by the state; 248 are considered significant sources of groundwater.

Alluvium and older sediments:

> Coastal Basin: median TDS greater than 1000 mg/L; variable types of degradation due to excessive withdrawals and GW recycling: increased nitrate plus nitrite as nitrogen, TDS exceeds 2000 -3000 mg/L along west; up to 24,000 due to saltwater intrusion along coast.
>
> Central Valley: median TDS around 300 mg/L; localized areas of higher TDS, possibly due to upwelling from deeper saline sources to the west. Surface water recharge from the eastern crystalline rocks yields lower TDS water. Localized high Boron concentrations due to mineral springs. Impact on boron sensitive plants.
>
> Southern California: insufficient data - small area

Basin Fill Deposits in Desert:

> Alluvial fan deposits within desert basins and basin and range fault block basins. No surface water available in this region. Groundwater TDS ranges widely with the highest in the shallow playa deposits, ranging to 10s of thousands of mg/L. Median TDS overall is 510 mg/L.

Volcanic Rock Aquifers:

> Water located in fractures, rubble zones and sand/gravel layers between lava flows; not used extensively.

Groundwater contamination resulting from human activities

Agriculture:

> Widespread degradation from irrigation return flow, use of pesticides and fertilizers, improper waste disposal and industrial practices and saltwater intrusion; Selenium contamination in part of the San Joaquin Valley.

Industry:

> Organic chemicals detected in groundwater in urban and industrialized areas.

Waste Disposal or Storage sites

- -71 RCRA sites
- -34 CERCLA sites
- -23 hazardous waste sites at 12 military facilities warranted a CERCLA type response; 34 total facilities with 405 hazardous waste sites are identified.
- -120 state-monitored sites.

<u>Summary</u>: Overpumping for agricultural and population growth is increasing saltwater intrusion. Unplugged abandoned wells can provide a vertical conduit for contaminant migration.

COLORADO

<u>Groundwater Use (1986 data)</u>

- 18% of total water use is groundwater.
- Total groundwater use - 96% for irrigation, 2% for public water supply, 1% for rural domestic supply.
- 11% of 1980 population served by Public Water Supply systems which use groundwater.

<u>Principal Aquifers</u>

There are seven principal aquifers or aquifer systems in Colorado. Four of these are comprised of unconsolidated to semi-consolidated fluvial deposits (South Platte and Arkansas valley-fill deposits, High plains aquifer, San Luis Valley aquifer system) and three are comprised of sedimentary bedrock formations (Denver Basin aquifer system, Piceance Basin aquifer system, Leadville Limestone). Valley fill deposits in the South Platte and Arkansas valleys are the most productive aquifers and account for most of the withdrawals. However, use of the bedrock aquifers in the Denver Basin Aquifer system has increased significantly in the past ten years as a result of tremendous growth in the Denver metropolitan area.

Valley fill deposits in the South Platte valley:

Median TDS concentration exceeds 1000 mg/l; median sulfate concentration exceeds 400mg/l; nitrate exceeds MCL in more than 25% of samples.

Valley fill deposits in the Arkansas valley:

Median TDS concentration = 2900 mg/l in deposits underlying main valley; sulfate commonly exceeds MCL.

High Plains aquifer in eastern Colorado:

Median TDS concentration less than 500 mg/l; fluoride concentration commonly greater than 2.0 mg/l; locally sulfate exceeds MCL.

San Luis Valley aquifer system:

Shallow unconfined aquifer (130 ft. thick) underlain by thick confined aquifer(several thousand ft.thick);

Shallow aquifer - median TDS = 315 mg/l but 10% of samples exceeded 2200 mg/l, median sulfate = 36 mg/l but 10% of samples exceeded 476 mg/l, 25% of samples exceeded MCL for iron;
Confined aquifer - median TDS = 184 mg/l, sulfate and iron consistently below MCL.

Denver Basin aquifer system:
Comprised of four bedrock aquifers with a combined thickness of 3200 feet. Median TDS concentration increases from 200 mg/l in upper most aquifer to 1200 in lower aquifer; sulfate concentration are typically less than MCL except locally along aquifer margins; hydrogen sulfide and methane occur locally in deeper parts of aquifer system.

Piceance Basin aquifer system:
Includes two important aquifers - a surficial aquifer comprised of stream valley alluvium and two underlying, hydraulically connected sedimentary formations and a lower sedimentary bedrock aquifer. The two aquifers are separated by a confining unit. Concentrations of TDS, sodium, fluoride, boron and lithium increase with depth. concentrations of nitrate, calcium, magnesium and sulfate decrease with depth. TDS concentrations in lower aquifer range from 660 to 4100 mg/l.

Leadville Limestone aquifer:
This aquifer has not been extensively developed. Flow controlled in large part by deep fractures and solution openings. Many springs discharge from aquifer. TDS concentrations generally less than 500 mg/l in upper 1000 feet of aquifer. Below 1000 feet TDS concentrations increase significantly.

Groundwater contamination resulting from human activities

Agricultural practices:
Use and reuse of water for irrigation has resulted in significant increases of TDS particularly in South Platte and Arkansas valley fill aquifers; nitrate concentrations commonly exceed MCl in these two aquifers and the San Luis Valley aquifer system as a result of fertilizer application.

Waste Disposal:
783 known landfills (1986), few have been investigated, organic compounds detected in groundwater.

Urbanization:
Tremendous growth in Colorado in 1990s, results in increase in septic tanks, USTs, sludge disposal; also resulting in probable mining of groundwater in Denver Basin aquifer system.

Mining:
Hundreds of abandoned mine sites within Colorado (primarily precious metal mines, also uranium and molybdenum), drainage from mine sites produces acidic water and high concentrations of heavy metals, aquatic life impacted in hundreds of miles of streams, locally alluvial aquifers impacted.

HAWAII

Groundwater Use (1986 data)

-95% of the population depends on groundwater.

Principal Aquifers

Eighteen volcanic aquifers have been identified on the 6 largest islands. For all of these aquifers the freshwater extends below sea level, floating as a freshwater lens in equilibrium with the underlying denser saline water. The freshwater lens is maintained by recharge from rainfall and surface water. Reduced recharge or overpumping causes saltwater encroachment. The freshest groundwater occurs in the interior of each island. TDS concentrations are commonly less than 500 mg/L. The aquifers underlying Oahu and Hawaii have lowest TDS and the aquifers underlying Maui have the highest TDS concentrations of the four largest islands.

Groundwater contamination resulting from human activities

All water developed for public supplies (as of 1986) met the required federal and state standards for TDS, chloride and nitrate. However saltwater intrusion is a potential problem.

Several areas have been contaminated by organic compounds. There are no active hazardous waste sites. There are 3 nonhazardous RCRA sites and 6 sites are proposed for NPL listing. There are 32 waste sites at 7 military facilities.

Urbanization:

Excess pumping has caused a lowering of water levels above sea level, and a concurrent loss of freshwater thickness below sea level (Ghyben-Herzgerg principle puts the ratio at 1:40).

Irrigation:

Localized upcoming of saline water due to excess pumping of the basal aquifers; recharge of the upper aquifers by application of brackish irrigation water has raised the chloride and TDS concentrations, minor pesticide and organic contamination, but some wells closed, and remediation underway.

County and Private Landfills for industrial and domestic solid wastes:

Most located in non-recharge areas.

IDAHO

Groundwater Use (1986 data)

- 90% of public water supplies uses groundwater; 79% of rural-domestic and livestock uses groundwater.

- Groundwater for public and rural use is only 3% of total groundwater used in the state.

Principal Aquifers

All the principal aquifers contain both thermal and nonthermal water. Nonthermal waters come from both unconfined and confined zones at all depths. Thermal water is commonly from confined zones more than 400 feet deep. About 21,800 acres are designated as known geothermal resource areas, and nearly 15 million acres are potentially valuable for geothermal exploration.

Thermal water quality differs from nonthermal. Nonthermal waters in all aquifers are similar in concentrations of key constituents. Thermal waters generally have higher pH and fluoride concentrations, and lower hardness and nitrogen.

Valley Fill Aquifers:

Nonthermal - TDS median approx. = 260 mg/L
Thermal - TDS median approx. = 700 mg/L

Basalt Aquifers:

Nonthermal - TDS median approx. = 270 mg/L
Thermal - TDS median approx. = 310 mg/L

Sedimentary and Volcanic Aquifers:

Nonthermal - TDS median approx. = 280 mg/L
Thermal - TDS median approx. = 350 mg/L

Groundwater contamination resulting from human activities

Most contaminant incidents occur in urban areas and are associated with movement, storage or transfer of petroleum or hazardous materials, and land disposal of solid or liquid wastes.

Waste disposal:

6 RCRA sites, 4 CERCLA sites, 12 waste-disposal sites, 39 sites with potential contamination, not regulated under CERCLA or RCRA, 12 hazardous waste sites at 2 Department of Defense facilities, more than 1500 class V injection wells are active in the state (1986)

KANSAS

Groundwater Use (1986 data)

- Principal source of supply for more than 500 PWS systems.
- 60% of population drink groundwater.
- 90 % of irrigation water is groundwater.

Principal Aquifers

There are seven principal aquifers or aquifer systems in Kansas, all with different water quality. About 90 % of the groundwater used in the state is withdrawn from unconsolidated alluvial aquifers, glacial drift aquifers and the High Plains aquifer. Mesozoic and Paleozoic bedrock formations comprise the other four principal aquifers.

Alluvial aquifers:
TDS concentrations typically less than 1000 mg/l, locally inflow of saline water from underlying consolidated rocks results in TDS concentrations in excess of 9000 mg/l.

Glacial drift aquifers:
Occur only in NE part of state, TDS and chloride concentrations typically less than in alluvial aquifers, 10% of samples contained nitrate concentrations in excess of 10 mg/l.

High Plains aquifer:
Underlies west half of state, Median TDS concentration -340 mg/l, locally chloride concentrations exceed 70 mg/l, nitrate concentrations typically less than 10 mg/l.

Great Plains aquifer:
TDS concentrations less than 500 mg/l where aquifer outcrops or is overlain by unconsolidated deposits, TDS increases with depth and distance from outcrop areas.

Chase and Council Grove Aquifer:
TDS and nitrate within acceptable range for drinking water except locally in southern part of aquifer, locally sulfate concentrations exceed MCL.

Douglas aquifer:
TDS concentrations typically less than 500 mg/l, aquifer used only near outcrop area.

Ozark aquifer:
Median TDS concentration - 1000 mg/l, chloride concentrations are very high at depth.

Groundwater contamination resulting from human activities

Agricultural practices:
Irrigation return flows have resulted in increased concentrations of calcium, sodium, sulfate, chloride and TDS in some alluvial aquifers, herbicides and insecticides found in trace amounts locally in alluvial aquifers.

Waste disposal:
Numerous industrial waste disposal sites, wastes present at these sites include arsenic, chromium, lead, petroleum products, VOCs and agricultural chemicals;

more than 104 active landfills, more than 280 closed or abandoned landfills, few data available on groundwater quality at these sites, leakage from brine disposal pits have caused local contamination of alluvial aquifers.

Mining:

Drainage from abandoned lead-zinc and coal mines has caused groundwater contamination alluvial aquifers and possibly the Ozark aquifer, contaminants include iron, manganese, zinc, sulfate and acid.

MONTANA

Groundwater Use (1986 data)

- 54% of population uses groundwater for domestic purposes.
- Groundwater for domestic use is only 0.5% of total surface and groundwater used in state. Groundwater for irrigation, livestock and industry are 1.5% of total water use.

Principal Aquifers:

Two Hydrogeologic Regimes in the state:

Western and southwest central 1/3 is heavily faulted bedrock. Aquifers are the overlying Cenozoic alluvial and glacial deposits; Backgroundwater quality is calcium bicarbonate.

Eastern and north central 2/3 include unfaulted, undeformed Paleozoic through Cenozoic aquifers; Backgroundwater quality is sodium bicarbonate or sodium sulfate.

Cenozoic: unconsolidated

Western alluvial (and glacial): TDS median = 230 mg/L
Eastern alluvial (and glacial): TDS median = 2,000 mg/L
Fort Union Formation: TDS median = 1600 mg/L

Mesozoic Aquifers:

Hell Creek & Fox Hills: TDS median = 910 mg/L
Judith River: TDS median = 2400 mg/L
Eagle SS: TDS median = 2050 mg/L
Kootenai: TDS median = 850 mg/L

Paleozoic - Madison Group (limestone): TDS median = 1600 mg/L

Groundwater contamination resulting from human activities:

Agricultural Practices:

-Dryland farming resulting in saline seeps in eastern Montana.
-No widespread pesticide or fertilizer contamination.

Mining:

-Localized only: high TDS from mine spoils, cadmium or arsenic localized.

Waste Disposal/Spillage:
- -Contamination at 4 of 11 RCRA sites
- -7 CERCLA sites
- -Petroleum from USTs and pipelines

Saline seeps (MDHES, 1982) and petroleum from USTs (MDHES, 1984) considered two biggest contaminant problems in state.

NEBRASKA

Groundwater Use (1986 Data)

- groundwater is the major source of drinking water for approximately 82% of the population. Drinking water accounts for only 4% of use in state.
-Irrigation accounts for 94% of total use.

Principle Aquifers

There are three major aquifer systems in Nebraska, with variable water quality. Approximately 95% of total groundwater withdrawals from the state are from the High Plains system.

Valley and principal paleovalley alluvial aquifers:

Primarily Todd Valley in Saunders County and east-trending paleovalleys in southeastern Nebraska. The median TDS concentration is 390 mg/L.

High Plains aquifer system (includes Quaternary sand and gravel, Ogallala Formation, Arikaree Group, Brule Formation and Niobrara Formation):

This is by far the most important aquifer system in the state and underlies 85% of the state. TDS in this system is generally less than 750 mg/L. An estimated 70 % of the water pumped for irrigation comes from the Quaternary sands and gravels, which have a median TDS concentration of 350 mg/L. The nitrate standard of 10 mg/L was exceeded in 10% of 2,171 samples collected in the Quaternary sands and gravels. In some areas where the water table is shallow and soils are sandy, nitrate concentrations are several times the standard.

The median TDS concentration in the Ogallala Formation is 260 mg/L.

Dakota aquifer system:

The Dakota Sandstone is an important aquifer in eastern Nebraska, where it extends from the land surface to a depth of 1500 feet. It is not used for water supply farther west.
The median TDS concentration is 840 mg/L.

Groundwater contamination resulting from human activities

There are 103 known wells (as of 1986) that yield contaminated water with one or more constituents exceeding drinking water standards.

Agricultural practices:

Cultivated land accounts for more than 40 % of all land use in Nebraska. More than one-third of all cropland is irrigated, and more than 80 % is irrigated with groundwater.

Large increases in the use of fertilizers and pesticides have accompanied irrigation and provide the potential for widespread nitrate and pesticide nonpoint source contamination of shallow groundwater. Areas where nitrate concentrations exceed the standard of 10 mg/L include Merrick, Holt, Kearney and Phelps Counties. However, median nitrate concentrations for all aquifers combined are lower than the standard.

Small concentrations of the pesticide atrazine have ben detected in about one-third of the water samples from agricultural areas analyzed for pesticides by the U.S.G.S. during 1984-85.

Nitrate and pesticide contamination of groundwater from nonpoint sources is expected to increase.

Industry:

Contamination from several other organic compounds has been found in groundwater at industrial sites or at locations where underground storage tanks have leaked.

Waste disposal:

-11 RCRA sites require groundwater monitoring, with groundwater contamination at 6 of the sites.
-5 Superfund sites are listed or proposed.
-137 DOD sites at 2 facilities have the potential for contamination. These include surface impoundments, evaporation ponds, and active or buried landfills.

NEVADA

<u>Groundwater Use (1986 data)</u>

- 50% of population uses groundwater for domestic purposes, but uses only 15% of the total groundwater used.
- Irrigation accounts for 74% of the total groundwater used.

<u>Principal Aquifers</u>

Basin-Fill Aquifers:

Locally present across entire state- TDS varies with location but median TDS is generally less than 500 mg/L. Naturally occurring high TDS, arsenic, sulfate, nitrate and fluoride in the southeast near Las Vegas - originates from volcanic and sedimentary rocks in the area.
Saline and brine groundwaters present in areas of groundwater evapotransporation. High TDS, fluoride, arsenic and boron in geothermal areas; also in selected other locations depending on geology.

Carbonate Rock Aquifers:

Across eastern 1/2 of state: Generally Hard, but TDS does not exceed 1000 mg/L.

Volcanic Rock Aquifers:

In places, arsenic exceeds 50 ug/L, but otherwise water is suitable for most uses.

Groundwater contamination resulting from human activities:

Mining

Metals contamination and increased hardness and TDS from copper mining operations.

Urbanization:

Petroleum contamination from USTs in 7 urban areas as of 1985; other localized septic tank contamination.

Waste disposal, storage and contamination

5 RCRA facilities, including one low-level (nuclear) disposal facility, and an army ammunition plant, a variety of above and below-ground nuclear testing or storage sites, 16 hazardous waste sites at 2 military facilities, unregulated (in 1984) pesticide disposal and industrial waste sites (text does not state what these sites are), explosives and organic chemicals contamination in limited areas

NEW MEXICO

Groundwater Use (1986 data)

- Groundwater supplies one half of total state water demand
- In 1980 1.9 million AF of groundwater withdrawn, 86% used for irrigation, 12% used for municipal domestic supplies

Principal Aquifers

The major aquifers in the state can be grouped into five types: (1) Valley fill deposits along the major rivers - primarily the Rio Grande, Pecos and San Juan rivers, (2) basin fill aquifers in eastern, central, southern and southwestern New Mexico, (3) sandstone aquifers in the San Juan basin in NW New Mexico, (4) limestone artesian aquifers in the Pecos River Basin and Rio San Jose basin, (5) the High Plains Aquifer.

Valley-Fill Aquifers:

TDS increases in downstream direction in alluvial aquifers along Rio Grande and commonly exceeds 500 mg/l in Sierra and Dona Ana counties, water typically hard > 120 mg/l as $CaCO_3$, nitrate concentrations were less than 4 mg/l for 90% of wells sampled, water in alluvial aquifer along Pecos River is much more saline with TDS and sulfate concentrations commonly exceeding 3000 mg/l and 1000 mg/l respectively, alluvial aquifers along the San Juan River typically contain water with TDS concentrations greater than 500 mg/l and sulfate concentrations greater than 250 mg/l.

Basin-Fill Aquifers:

Rio Grande structural basin Up to 6000 feet of sediments, fresh water found to depths of 3500 feet, water occurring along the edges and in the deeper portions has higher TDS and sodium concentrations,

Southwest New Mexico basin fill - basin fill is comprised of coarse-grained sediments deposited in closed basins, TDS less than 500 mg/l in 90% of sampled wells, water typically hard, nitrate concentrations less than 3.2 mg/l in 90% of sampled wells

Estancia and Tularosa basin-fill aquifers - very limited use

High Plains Aquifer:

Occurs in eastern New Mexico along boundary with Texas, mainly Ogallala Fm., TDS and sodium concentrations are low, suitable for all uses

Sandstone aquifers in San Juan basin:

Comprised of Tertiary, Cretaceous and Jurassic sandstones separated by shales and siltstones, TDS concentrations exceeded 500 mg/l in 50% of wells sampled, lower TDS concentrations in recharge areas along the flanks of the basin, hardness varied considerably, sulfate commonly exceeds 250 mg/l, nitrate concentrations were less than 1.0 mg/l in 90% of sampled wells

Limestone aquifers:

These aquifers are segments of the extensive, but discontinuous, San Andres Formation which is a Permian limestone and gypsum, flow systems are complex due to faulting and karst features, water quality varies significantly depending on location within flow system, lower TDS, and sulfate concentrations occur in recharge areas and much higher concentrations occur in discharge areas, TDS concentrations can exceed 3000 mg/l and sulfate can exceed 100 mg/l, water typically very hard

Groundwater contamination resulting from human activities

Petroleum production and refining and leaking underground storage tanks:

103 reported groundwater contamination sites as of 1984, contaminants are primarily oils, gases and fuels and salinity, all major aquifers impacted except deeper sandstone aquifers

Sewage disposal including individual septic tanks:

33 reported groundwater contamination sites as of 1984, contaminants are primarily nitrate, ammonia and bacteria, the valley-fill and the basin-fill aquifers have been impacted

Mining and mineral processing:

7 reported groundwater contamination sites as of 1984, contaminants are dissolved metals, the three major sandstone aquifers have been most impacted by mining activities, overlying valley- aquifer in northern Rio Grande River basin impacted by mine waste, 2 CERCLA sites at uranium mill tailings disposal areas

Waste disposal:

More than 200 active landfills, 15 monitored RCRA sites as of 1986, 48 hazardous waste sites at 5 DOD facilities, one UIC class I well contaminants are primarily synthetic organics (solvents), trace metals and petroleum products, typically impacts surficial aquifers. one CERCLA site at railroad refueling facility

Urbanization including commercial and industrial sites:

25 reported groundwater contamination sites as of 1984, contaminants are primarily natural and synthetic organic compounds, surficial valley-fill, and basin-fill aquifers are most impacted, one CERCLA site in industrial area of Albuquerque

In 1986 the New Mexico Environmental Improvement Division designated 5 areas that have special groundwater contamination concerns:

1. South valley industrial area -Albuquerque
2. Oil production/sewage disposal area - Lea County
3. Grants Mineral Belt uranium mining and milling area
4. Oil and gas refinery and liquid landfill area in San Juan River valley
5.; Dairy farms and agricultural waste disposal area in lower Rio Grande river valley.

NORTH DAKOTA

Groundwater Use (1986 data)

- 60% of total water used for public/private drinking water.
- 50% of agricultural water is groundwater.
- 62% of 1986 population relies on groundwater.

Principal Aquifers

There are four principal aquifers or aquifer systems in North Dakota. Unconsolidated glaciofluvial and glaciolacustrine deposits comprise the principle aquifer east of the Missouri River. Four extensive bedrock aquifers are used primarily for drinking water and livestock watering, particularly west of the Missouri River.

Unconsolidated aquifers:

Water quality differs between surficial and buried glacial aquifers. Concentrations of TDS, sulfate, nitrate, sodium typically less than MCL, locally concentrations do exceed MCL.

Fort Union aquifer system:

Uppermost aquifer system, variable extent and thickness, locally TDS and sodium exceed MCL, naturally occurring selenium occurs in concentrations of 50 to 600 ug/l.

Hell Creek-Fox Hills aquifer system:

Median TDS concentration 1060 mg/l (sodium is primary dissolved solid); 50 % of samples have fluoride concentration greater than 2.0 mg/l; median sulfate concentration less than MCL but 25% of samples exceed MCL.

Dakota aquifer system:

Use restricted primarily to livestock watering in SE part of state, TDS concentrations average more than 7000 mg/l in western part of state.

Groundwater contamination resulting from human activities

Agricultural practices:

There are 40 million acres of agricultural land in ND and non-point source contamination of groundwater by agricultural chemicals is a significant problem. Pesticides are present in groundwater though typically only in trace amounts. Nitrate exceeds MCL locally in surficial unconsolidated aquifers. Arsenic exceeds 50 ug/l over 170 mi2 area in SE part of state.

Waste Disposal:

Approximately 10 hazardous wastes sites. Approximately 100 non-hazardous waste disposal sites. Groundwater contamination has been detected at a number of fly-ash disposal sit

Hydrocarbon contamination:

Leaks and spills of gasoline, fuel oil, diesel fuel and lubricating oil are most common Groundwater contamination sources. A few are major (more than 1 million gallons).

Wastewater impoundments:

Impoundments are most common method for treatment and storage of wastewater. Numerous PWS wells have been contaminated. TDS, chloride and ammonium are typical contaminants.

OKLAHOMA

Groundwater Use (1986 data)

- Groundwater accounts for 46% of total water development 28% of total public water supply
- Groundwater is major source of irrigation water which is largest single use of water and major source of domestic water supply
- 60% of total groundwater withdrawals are from 3 aquifers; High Plains, Rush Springs and Dog Creek-Blaine

Principal aquifers

The USGS has identified 9 major aquifers in Oklahoma. Unconsolidated alluvial and terrace deposits along major streams are considered to be one aquifer system. The semi-consolidated High Plains aquifer occurs in the panhandle of the state. In addition, seven bedrock aquifers are developed for irrigation and drinking water supplies. These are the Rush Springs Aquifer, the Dog Creek-Blaine Aquifer, the Gerber-Wellington Aquifer, the Vamoosa-Ada Aquifer, the Roubidoux Aquifer, the Arbuckle-Simpson Aquifer and the Arbuckle-Timbered Hills Aquifer.

Alluvial and Terrace Aquifers:

Water type ranges from calcium-magnesium carbonate-bicarbonate to calcium-magnesium sulfate, median TDS value is 485 mg/l (20% of samples exceeded 1000 mg/l), median hardness concentration was 340 mg/l, less than 10% of chloride concentrations and less than 20% of sulfate concentrations exceeded 250 mg/l

High Plains Aquifer:

Irrigation is major use, water is calcium-magnesium chloride-sulfate type, median TDS value was 364 mg/l with 10% samples over 1000 mg/l, 95% of samples had hardness concentrations greater than 180 mg/l, 5% of chloride and sulfate concentrations were greater than 250 mg/l,25% of fluoride concentrations exceeded 2 mg/l

Rush Springs Aquifer:

Primary use is irrigation, water is calcium-magnesium chloride-sulfate type,median TDS value was 408 mg/l w/25% of values greater than 1000 mg/l, 70% of hardness concentrations were greater than 180 mg/l, 5% of chloride concentrations & 30% of sulfate concentrations were greater than 250 mg/l,

Dog Creek-Blaine Aquifer

Use is irrigation, water is calcium-magnesium chloride-sulfate type,median TDS value was 3040 mg/l, median hardness concentration was 2000 mg/l, median chloride value was 145 mg/l, median sulfate value was 1750 mg/l,

Garber-Wellington Aquifer:

Primary use is public and domestic drinking water supply, water is calcium-magnesium carbonate-bicarbonate type, median TDS value was 372 mg/l, median hardness concentration was 190 mg/l, median chloride value was 17 mg/l, median sulfate value was 18 mg/l

Vamoosa-Ada Aquifer

Primary use drinking water supply, water is sodium-potassium chloride-sulfate type, median TDS value was 325 mg/l, median hardness concentration was 135 mg/l, median chloride value was 20 mg/l, median sulfate value was 23 mg/l

Roubidoux Aquifer:

Primary use is public drinking water supply, water is sodium-potassium chloride-sulfate type, median TDS value was 280 mg/l, median hardness concentration was 140 mg/l, median chloride value was 50 mg/l, median sulfate value was 15 mg/l

Arbuckle-Simpson Aquifer:

Primary use is drinking water supply, water is calcium-magnesium carbonate-bicarbonate, median TDS value was 369 mg/l, median hardness concentration was 330 mg/l, median chloride value was 21 mg/l, median sulfate value was 18 mg/l, 30% of fluoride values exceeded 2.0 mg/l

Arbuckle-Timbered Hills Aquifer

Aquifer is largely undeveloped, some drinking water use, water is sodium-potassium mixed type, median TDS value was 772 mg/l, median hardness concentration was 21 mg/l, median chloride value was 190 mg/l, median sulfate value was 70 mg/l, median fluoride concentration was 9.1 mg/l

<u>Groundwater contamination resulting from human activities</u>:

Agricultural practices:

Nitrate contamination of groundwater due to agricultural practices is widespread in Oklahoma. Chemigation is a common method of applying fertilizers. As of 1986 there was very little data on pesticide concentrations in groundwater.

Waste Disposal:

As of 1986 there were approximately 106 active municipal landfills in Oklahoma, 50 RCRA sites for storage or disposal of hazardous waste, 4 CERCLA sites and 11 UIC wells. Adequate monitoring systems had not been implemented at these sites as of 1986 so little is known about groundwater contamination associated with these facilities. As of 1985 the DOD had identified 29 hazardous waste sites at 4 facilities in Oklahoma that had the potential for groundwater contamination. Metals contaminated water from abandoned underground lead-zinc mines in Ottawa County. has contaminated portions of the Roudidoux Aquifer.

Oil and Gas Industry:

Nearly 400,000 oil and gas wells have been drilled in Oklahoma. Plugging and abandonment requirements were not in place until the late 1970s. Many of the older unplugged and partially unplugged wells may serve as conduits for brine waters to move from oil and gas producing formations into fresh water aquifers. Poorly constructed and unlined brine disposal pits are also a potentially major source of groundwater contamination. A few studies have related oil and gas industry activities to groundwater contamination, however the effects of this potentially significant problem are still largely undocumented.

OREGON

<u>Groundwater Use (1986 data)</u>

- 40% of state's population uses groundwater for drinking supply.

Principal Aquifers

Three aquifer groups in the state as follows:

Basin fill and alluvial:
Thickness and distribution vary across state: Median TDS = 170 mg/L.

Volcanic and sedimentary:
Present in the southeastern 2/3 of the state. Consists of interbedded units exceeding several thousand feet thick, but only small basin areas are used, so hydrology of entire unit aquifer system unknown.
Median TDS = 160 mg/L.

Columbia River Basalt:
Underlies northcentral and northeast parts of the state; 5 separate formations may exceed 5000 feet thick; 600 feet have been developed for groundwater.
Median TDS = 230 mg/L.

Groundwater contamination resulting from human activities:

As of 1986, groundwater in Oregon was generally unpolluted and suitable for most uses.

Industry contaminants:
Localized only-increased turbidity, oil, organics, nitrates.

Agriculture:
Localized nitrates and pesticides.

Waste disposal:
- 9 RCRA sites
- 6 CERCLA sites
- 24 landfills producing leachate

SOUTH DAKOTA

Groundwater Use (1986 data)

- 77% of 1985 population use groundwater for drinking water.
- More than 1000 community wells, more than 60,000 private wells.

Principal Aquifers

There are six principal aquifers or aquifer systems in South Dakota. Glacial drift and alluvial aquifers underlie most of the state east of the Missouri River. The Big Sioux aquifer, comprised of glaciofluvial sediments, is the most important aquifer in the state. Fourteen sedimentary bedrock formations are used as aquifers. These formations comprise five major aquifer systems. West of the Missouri River these aquifers are the only source of groundwater, except for a few small areas underlain by alluvium along major streams.

Glacial drift and alluvial aquifers:

75% of samples exceeded MCL for TDS (median=670 mg/l), median TDS in buried drift aquifers greater than 1000 mg/l, nitrate concentrations exceeded MCL in 10% of samples, calcium and magnesium are dominant cations.

High Plains aquifer:

Occurs in south central SD, 90% of use is for irrigation, TDS concentrations typically less than 400 mg/l, very little nitrate data from this aquifer, 25% of selenium samples exceed MCL - median concentration is 8 ug/l.

Fort Union, Hell Creek and Fox Hills Aquifers:

Occur primarily in NW part of state, confined over most of aerial extent, water is typically sodium bicarbonate or sodium sulfate, median TDS concentration about 1000 mg/l, 75% of nitrate samples less than 1.5 mg/l, selenium concentrations in 18% of samples exceeded 2.4 mg/l, locally molybdenum concentrations are high.

Niobrara-Codell aquifer:

Comprised of sandstone and chalk, occurs only in eastern SD, water is slightly saline, median TDS concentration is 1670 mg/l (80% of samples exceeded 1100 mg/l), water is predominantly sodium sulfate type, nitrates are typically less than 1.0 mg/l, selenium generally less than detection, fluoride concentrations in more than 90% of samples were less than 1.8 mg/l.

Dakota-Newcastle aquifers:

Underlies most of state, water is slightly to moderately saline. Sodium, chloride and sulfate are dominant ions, primarily used for livestock (rarely for irrigation or drinking water). Two types of water in aquifer; type 2 in SE part of state -median TDS concentration is 2170 mg/l, sodium is dominant cation; type 1 -occurs in rest of state, median TDS is 690 mg/l, calcium and magnesium are dominant cations; selenium and fluoride concentrations are low for both water types.

Inyan Kara, Sundance, Minnelusa and Madison aquifers:

Aquifers are confined over most of extent, development limited mainly to area near Black Hills, elsewhere development limited by great depth, water is sodium sulfate type in western SD and calcium sulfate in eastern SD, TDS concentrations typically exceed MCL and commonly exceed 1000 mg/l, fluoride concentrations commonly exceed MCL of 2 mg/l, radium 226 and gross alpha exceed MCL in parts of Madison and Inyan Kara.

Groundwater contamination resulting from human activities

Agricultural practices:

Improper storage, disposal and leakage of agricultural chemicals have resulted in contamination of numerous water supply wells, nitrate concentrations greater than 10 mg/l are common near feedlots which are numerous throughout the state.

Wastewater disposal:

As of 1983 there were 72,000 individual wastewater-disposal systems serving 185,000 people, an additional 443,000 people are served by 350 centralized wastewater-disposal systems, localized groundwater contamination has occurred.

Hydrocarbon contamination:

Accidental spills and leakage of petroleum products have resulted in contamination of numerous water-supply wells, leakage from brine disposal pits related to oil and gas production has resulted in localized groundwater contamination.

Mining:

Extensive gold mining in the Black Hills has produced large quantities of tailing which have been the source of arsenic and mercury contamination of alluvial groundwater, heavy metal concentrations and acidic water have are also a problem locally.

TEXAS

Groundwater Use (1986 data)

- 60% of freshwater used is groundwater.
- 46% of water used for PWS is groundwater.
- 80% of groundwater use is irrigation, 9% for PWS.

Principal Aquifers

There are seven principal aquifers or aquifer systems in Texas. Two of these are comprised of unconsolidated to weakly consolidated deposits (alluvium and bolson deposits and High Plains aquifer) and five are comprised of consolidated bedrock formations. About 75% of the state is underlain by at least one of these principal aquifers. The High Plains aquifer is the most extensively developed. In addition to the seven principal aquifers, seventeen minor aquifers have been delineated in Texas. Each is important locally and in some areas provide the only source of fresh water.

Alluvium and bolson deposits:

These deposits are found locally in far western and north-central Texas, TDS concentrations vary considerably, the median TDS concentration is 771 mg/l, nearly 45% of the samples had TDS concentrations over 1000 mg/l, 40% of the samples had nitrate concentrations above 10 mg/l.

Gulf coast aquifer system:

Used mainly for public water supplies in densely populated areas, TDS generally between 500 and 1000 mg/l, higher TDS concentrations in southern part of aquifer, 19% of samples had TDS concentrations above 1000 mg/l, about 10% of samples had nitrate concentrations above 10 mg/l, locally concentrations of barium, strontium, and gross alpha are high.

High Plains aquifer:

TDS concentrations ranged from 200 to 9000 mg/l with median concentration of 419 mg/l, in SE part of aquifer saline groundwater is associated with small playa lakes, nitrate concentrations exceeded 10 mg/l in 25% of samples, 20% of samples had fluoride concentrations greater than 4.0 mg/l.

Carrizo-Wilcox aquifer:

This aquifer yields fresh to slightly saline water with TDS concentrations ranging from 100 to 3100 mg/l - 10% of the samples exceeded 1000 mg/l, nitrate and fluoride concentrations are consistently below MCLs, locally high iron concentrations limit the use of the water from this aquifer.

Edwards aquifer:

This is the portion of the Edwards aquifer that occurs in the area of the Balcones fault zone, numerous high flow springs constitute most of aquifer discharge, TDS concentrations range from 200 to 3000 mg/l with a median concentration of 371 mg/l, 15% of samples had nitrate concentrations above 10 mg/l, locally barium and strontium concentrations are very high.

Edwards-Trinity aquifer:

This is the portion of the Edwards aquifer in the area of the Edwards plateau, TDS concentrations range from 200 to 3500 mg/l with a median concentration of 773 mg/l, higher TDS in western part of aquifer, 35% of samples had nitrate concentrations above 10 mg/l.

Trinity Group aquifer:

TDS concentrations ranged from 70 to 3500 mg/l with a median concentration of 619 mg/l, 30% of samples had nitrate concentrations above 10 mg/l.

<u>Groundwater contamination resulting from human activities</u>

Agricultural practices:

Nitrate contamination (concentrations greater than 10 mg/l) is widespread in northwest Texas particularly in the High Plains aquifer and the Edwards-Trinity aquifer - probably due to agricultural practices, arsenic from cotton gin waste has

contaminated a limited part of High Plains aquifer, very little investigation of effects of widespread pesticide use.

Waste disposal / Industrial activity:

Most of these sites are along the Gulf Coast and potentially impact the Gulf Coast aquifer system, these sites include CERCLA sites, RCRA sites, UIC class two wells and IRP (DOD Installation Restoration Program) sites. At least six CERCLA sites have documented contamination of shallow aquifers, as of 1985 there were 168 IRP hazardous waste sites at 19 facilities in Texas, there are about 180 RCRA sites and groundwater contamination has been documented at about 1/2 of them. There are many industrial waste disposal wells which inject chemical-petrochemical industrial effluent, as of 1984 there were about 15,000 saltwater disposal wells, 33,000 secondary-recovery injection wells and 40,000 solution-mining wells. There are thousands of brine disposal pits associated with oil and gas production and prior to 1976 lining was not required.

Urbanization / Groundwater withdrawals:

Increases in groundwater salinity due to municipal and industrial pumpage have occurred in several population centers in the Gulf Coast area, in northern Texas and near El Paso. Migration of saline water towards pumping centers has been documented at numerous locations.

UTAH

Groundwater Use (1986 data)

- 63% of population uses groundwater for domestic purposes.

Principal Aquifers

There are two categories of aquifers in the state.

Unconsolidated Basin-Bill and Valley-Fill Aquifers:

In west and northwest, TDS generally less than 1000 mg/L, lower TDS in recharge zones along mountain ranges, basin fill most common used.

Sandstone and Carbonate Rock:

In southeast and east, TDS in the sandstones are less than 1000 mg/L in the recharge areas, increasing down gradient with depth. Carbonate aquifer is not used.

Groundwater contamination resulting from human activities:

The shallower units are generally the only ones contaminated, due to upward hydraulic gradients and multiple confining zones in the basin fill aquifers.

Urbanization: mostly Salt Lake County

-Dry wells collect stormwater drainage and runoff; increased salt from winter deicing.

-Most direct infiltration is from lawns and gardens and is heavy in fertilizers and other chemicals.

Mining: mostly Salt Lake Valley

-Increased TDS, acidity, radioactivity from selected mining operations.

Irrigation:

-Increased TDS from river water and from saline intrusion; recirculated groundwater used repeatedly for irrigation also increases TDS.

Waste Disposal or Storage sites

-21 RCRA sites

-3 CERCLA sites

-3 under consideration for NPL listing

-108 hazardous waste sites at 5 DOD facilities

WASHINGTON

Groundwater Use (1986 data)

- 49% of state's population used groundwater for domestic purposes in 1980.

Principal Aquifers

Glacial Drift:

Three geographic areas with separate units, all three display very small range of variation in TDS and hardness across several hundred samples.

- Puget Sound drift: TDS median at 100 mg/L and does not exceed 200 mg/L.
- Northeast Washington drift: Median TDS is less than 200 mg/L.
- Columbia Plateau unconsolidated rocks; overlies Columbia River basalt, and includes drift deposits, terrace and valley fill sediments. Median TDS about 230 mg/L.

Terrace and Valley fill:

Three areas in the southwest portion of the state, lowest median TDS of 68 mg/L in one area, other two areas exhibit median TDS below about 160 mg/L.

- Columbia River Basalt: three units underlie southeast quarter of the state-separated based on age and geographic distribution, median TDS less than 320 mg/L for all three units.

Groundwater contamination resulting from human activities:

As of 1986, groundwater in Washington was generally suitable for most uses, with the exception of some naturally high concentrations of iron and manganese in Western Washington.

Urbanization:

-Localized saltwater intrusion in the coastal and island counties;

-Localized septic contamination in areas of rapid growth

Agriculture:

-Nitrate and pesticide contamination is some areas;

-High natural water levels and recharge from irrigation water causes particular contaminant problems from inundated septic systems and exposure to the surface.

Industrial:

-Organic solvent contamination in the Spokane area

-Nitrate and radioactive tritium plumes is the vicinity of the Hanford nuclear site due to past discharges of cooling water and wastewater to the surface. Migration to the Columbia River.

Waste sites in the state include:

- 25 RCRA sites
- 19 CERCLA sites = 9 proposed in 1986
- 132 state priority cleanup sites
- 104 sites at 7 military facilities with potential for contamination.

WYOMING

Groundwater Use (1986 data)

- 65% of population obtain drinking water from wells and springs
- 69% of total groundwater withdrawals used for irrigation and 24% is used for industry

Principal Aquifers

Four principal aquifer systems occur within Wyoming: alluvial valley fill aquifers, the High Plains and equivalent aquifers, sedimentary aquifers in structural basins and the carbonate and sandstone aquifer system. Alluvial valley fill aquifers occur in valleys and terraces of most large streams in Wyoming and are generally less than 50 feet thick. The High Plains aquifer consists of semi-consolidated sands and gravels and occurs in the southeast part of the state. Extensive beds of sandstone, coal and shale comprise shallow aquifers within the 13 structural basins in Wyoming. These are the most widespread and most extensively used aquifers in terms of number of wells, however yields are typically less than 50 gpm. Thick carbonate and sandstone aquifers are exposed in the mountainous areas adjacent to structural basins and become progressively more deeply buried towards the center of the basins. These aquifers are characterized by large secondary permeability and high yields are common. Few wells are completed in this aquifer system because it outcrops in the rugged flanks of the mountains and is deeply buried beneath the adjacent basin floors.

Alluvial valley fill aquifers:

75% of samples had TDS concentrations less than 760 mg/l, median hardness concentration - 280 mg/l, 10% of samples exceeded MCL for nitrate and 10% exceeded MCL for fluoride, selenium concentrations exceed MCL in some irrigated areas

High Plains and equivalent aquifers:

80% of samples had TDS concentrations less than 500 mg/l, median hardness concentration -160 mg/l,10% of samples had exceeded MCL for nitrate, less than 2% of samples exceeded MCL for fluoride or selenium

Sedimentary aquifers in structural basins:

Median TDS concentration - 1100 mg/l, median hardness concentration -160 mg/l, nitrate concentrations exceeded MCL less than 3% of samples, 8% of samples exceeded the MCL for fluoride, 5% of the samples exceeded the MCL for selenium

Carbonate and sandstone aquifer system

Water quality in recharge areas (mountain flanks) quite different than where aquifers are deeply buried, TDS low in outcrop areas and high where buried deeply, median hardness concentration - 260 mg/l, no samples exceeded MCL for nitrate or selenium, 4% of samples exceeded MCL for fluoride

<u>Groundwater contamination resulting from human activities</u>

Waste Disposal:

Contamination documented at 8 RCRA sites and 1 NPL site (as of 1985), 14 hazardous-waste sites at F.E. Warren AFB, 8 Class 1 UIC wells, more than 150 known industrial landfills sites, more than 100 known municipal landfills, several incidents of improper disposal of septic tank waste has been documented

Agriculture:

Increased TDS due to leaching of salt from irrigation water has been documented in alluvial aquifers along Shoshone, Bighorn & Big Sandy Rivers,nitrate contamination common in agricultural areas - particularly in the alluvial aquifer along North Platte River, extensive use of pesticides may be a problem in some areas

Mineral Extraction and processing

Seepage from uranium tailings ponds has resulted in increased TDS, sulfate, chlorides and radionuclides at 10 or more sites, contamination has also resulted from experimental underground coal-gasification burns & leaching of coal spoil & trona tails

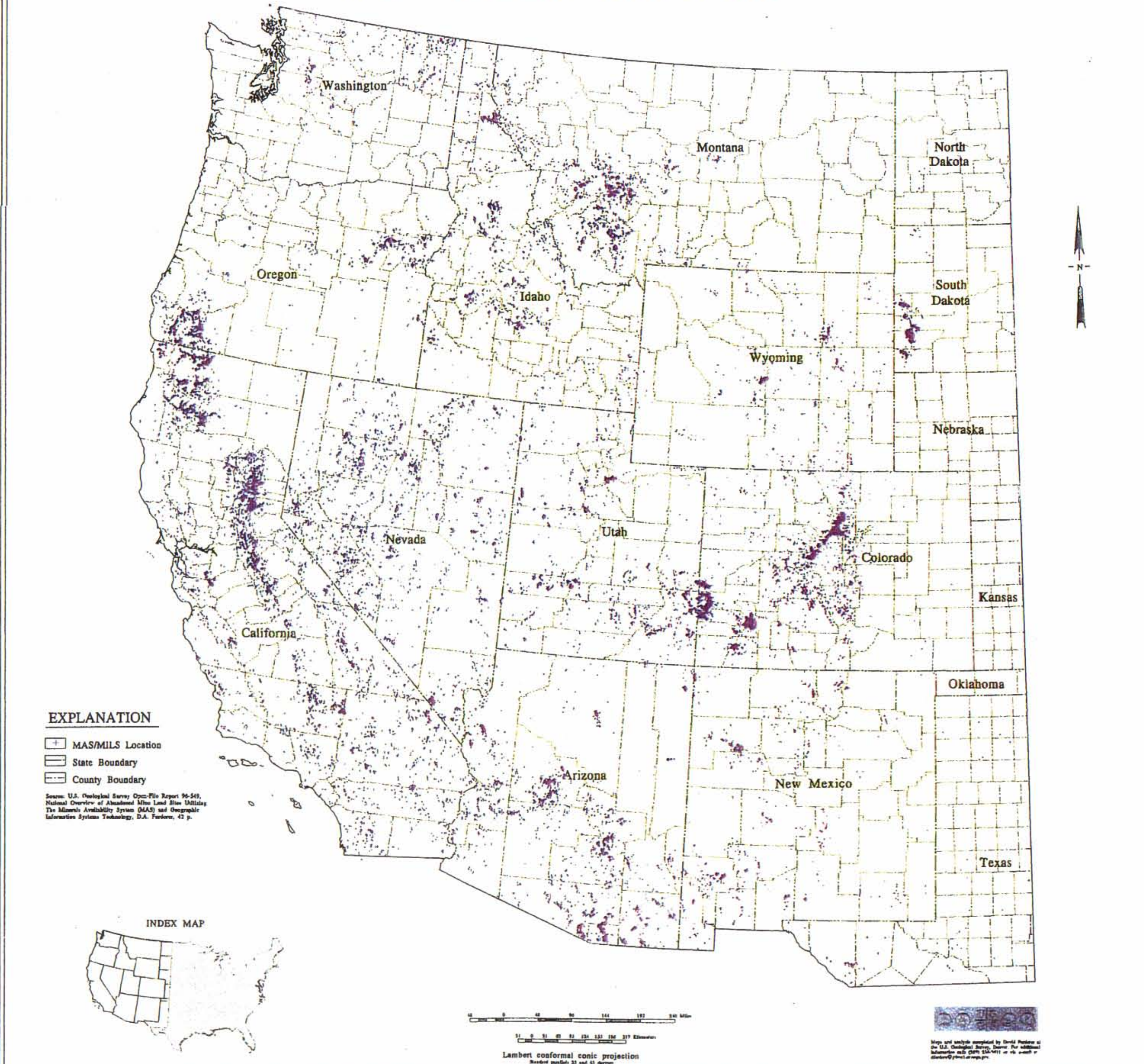
Urbanization

Leaking fuels from USTs and nitrate from septics have been documented at numerous sites

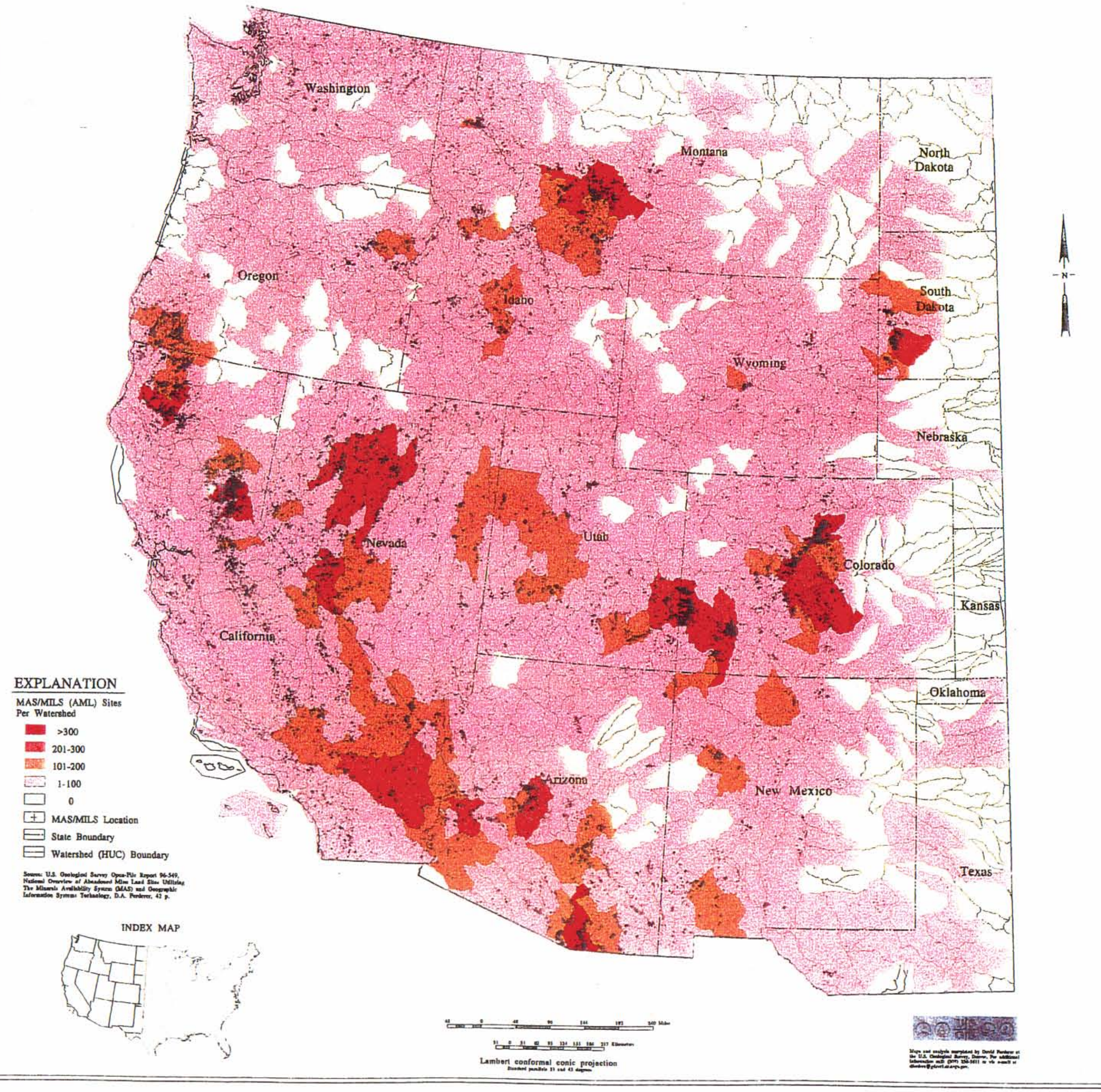
APPENDIX D

PRELIMINARY MAPS OF MINING/WATER QUALITY CONCERNS IN THE WEST

PAST-PRODUCER HARDROCK COMMODITY MAS/MILS LOCATIONS IN THE WESTERN UNITED STATES



WATERSHED PRIORITY ASSESSMENT BASED ON PAST-PRODUCER HARDROCK MAS/MILS LOCATIONS IN THE WESTERN UNITED STATES



PRELIMINARY MAP OF PAST-PRODUCER METAL MINES WITH STREAM REACHES AFFECTED BY METALS AS DESIGNATED BY THE CLEAN WATER ACT 305(b) ASSESSMENTS