United States
Environmental Protection
Agency

Office of
Ground-Water Protection (WH-550G)
Washington DC 20460

January 1987

EPA

Workshop on Guidance for the Wellhead Protection and Sole Source Aquifer Demonstration Programs:

Hydrogeologic Criteria

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

January 7, 1987

OFFICE OF
WATER

Dear Participants:

Welcome, and thank you for participating in this workshop to develop guidance for implementing the Safe Drinking Water Act Amendments of 1986. Enactment of these amendments instituted two new programs to protect the ground-water resource: the Wellhead Protection Program (WHP) and the Sole Source Aquifer Demonstration Program (SSA). The Office of Ground-Water Protection at EPA Headquarters, together with EPA regional offices, is responsible for implementing and administering the programs.

Among its implementation responsibilities, EPA must, by June 1987, develop and issue to the States technical guidance which they may use in determining the boundaries of a wellhead protection area and guidance and rule requirements for the receipt of Federal grant support under both the WHP and SSA programs.

This workshop is intended to obtain a wide range of opinion which will assist EPA in developing this guidance. You and the other participants of this workshop were selected to represent the groups involved in, or otherwise affected by, ground-water protection efforts. Among those represented are state and local governments, environmental groups, business and industry, other federal agencies, and academic experts.

The goal of this workshop is to provide a forum for these individuals and organizations to express their opinions and viewpoints. I can assure you that the input you provide to EPA as a participant of this workshop is vital to the implementation of these programs. EPA will use and build upon your ideas and comments as it develops guidance.

Again, welcome, Best wishes for a productive and interesting workshop.

Very truly yours,

Larry Jensen

Larry Jensen
Assistant Administrator
for Water

WORKSHOP BOOK

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WORKSHOP ON HYDROGEOLOGIC CRITERIA AND GUIDELINES

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9:00-9:45	Background on SDWA Amendments and EPA Implementation Efforts
9:45-10:30	An Overview of Methods and Criteria Used in the U.S. for WHPA Delineation
10:30-10:45	BREAK
10:45-11:30	Presentation on Western European WHPA Experiences
	FIRST ISSUE
11:30-11:45	Prepare Work Groups for First Issue
11:45-1:00	LUNCH
1:00-2:30	Work Groups Separate to Discuss First Issue (Criteria)
2:30-4:00	Work Groups Convene to Make Individual Presentation on First Issue (Criteria)
	SECOND ISSUE
4:00-4:15	Prepare Work Groups for Second Issue
4:15-5:30	Work Groups separate to Discuss Second Issue (Methods)

DATE

Friday, January 23

8:30-8:45	Welcome
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10:00-10:15	BREAK
	THIRD ISSUE
10:15-10:45	Introduce Groups to Third Issue
10:45-12:15	Work Groups Separate to Discuss Third Issue (Cross-Cutting)
12:15-1:15	LUNCH
1:15-2:45	Presentation by Work Groups on Third Issue (Cross-Cutting)
2:45-3:15	Workshop Wrap-Up; General Discussion

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I.

INTRODUCTION TO THE WORKSHOP

CHAPTER I

I. INTRODUCTION TO THE WORKSHOP

Ground-water protection has received increasing emphasis over the past decade as an important environmental responsibility for the states and the federal government. Some states and regions have been active in ground-water protection for years. In all areas of the country, however, the decade has brought a heightened awareness of the vulnerability of ground-water to threats from a myriad of sources.

In 1984, the U.S. Environmental Protection Agency (EPA) took two significant steps to improve and coordinate programs at the federal level that affect ground water and to assist the states in their efforts. First, EPA established the Office of Ground-Water Protection (OGWP) as the focus of ground-water policy coordination and planning for the Agency. OGWP is responsible for working with the states to develop and implement ground-water protection strategies, for coordinating EPA ground-water policies and guidelines, enhancing ground-water data management systems and capabilities, and initiating and conducting special studies of ground-water contamination, among other tasks.

Also in 1984, after several years of development, EPA adopted a formal "Ground-Water Protection Strategy" which set forth goals and objectives for the Agency and described the Agency's management approach to this field. The strategy recognized the need to enhance protection of ground-water quality through improved programs at the Federal and State levels, and acknowledges the States' principal role in resource protection in contrast to EPA's statutory authorities related to specific sources of contamination and contaminants. It called for: (a) an EPA policy of differential protection based on use, value and vulnerability of the resource; (b) greater policy consistency and coordination among ground-water related programs; (c) greater attention to sources of contamination of national concern; and (d) support to states in ground-water strategy development and implementation.

Nearly every State has underway or is completing a state ground-water protection strategy, in part with the support of EPA grants (CWA/106). About half of the States have or are establishing their own ground-water classification systems or other approaches to providing protection.

Last summer, the President signed the Safe Drinking Water Act Amendments of 1986 (SDWAA) into law. The Amendments include two new ground-water provisions: the Wellhead Protection (WHP) Program and the Sole Source Aquifer (SSA) Demonstration Program. Both are designed to support development of state and local efforts to protect ground-water resources. Included, as

Appendix I, is a copy of the statutory language creating these new programs. In addition, that portion of the Congressional conference report which describes the programs is included as Appendix II.

A new Section 1427 of the Act establishes a demonstration program to protect critical aquifer protection areas (CAPA) within designated sole source aquifers. The goal of the demonstration programs, which can be developed by any state or local political subdivision that identifies a CAPA within its jurisdiction, is to demonstrate innovative technologies and control mechanisms that can be used to ensure the maintenance of ground-water quality for the protection of human health, environment, and ground water.

The second new program, Section 1428 of the Act, is designed to protect the wellhead areas of all public water systems from contaminants that may have adverse human health effects. Wellhead protection areas are defined as any surface or subsurface areas adjacent to public water supply wellheads through which containments may move and reach the wellfield.

These two programs represent major new responsibilities for OGWP. In its continuing efforts to assist States in developing a comprehensive strategic approach to ground-water protection, EPA will, to the extent possible, support state efforts to incorporate these new ground-water programs into their approaches.

Both programs are similar in some respects--they are voluntary programs for which some federal support may be available, and both are designed to help keep ground water free from contamination and to protect human health. However, differences exist in both the goals and expected implementation of each program. Each program is discussed in more detail in Chapter 2.

<u>The Workshop</u>

Since passage of the Amendments last June, OGWP has been actively working with a number of experts both within and outside of EPA to help implement the new law. In soliciting this assistance, EPA recognizes and endorses the primary role of the states in ground-water protection. Four technical committees have been established to assist OGWP in this effort: a SSA designation committee; a hydrological criteria committee; a management protection plan committee; and a grant guidelines committee.

As noted above, ground-water protection is primarily a state prerogative. Accordingly, EPA intends to ensure that the guidances developed will provide states and localities maximum flexibility in developing the programs while ensuring that the goals and objectives of the law are met.

As part of its information gathering process, OGWP is conducting two workshops during January 1987. The goal of the workshops is to assist OGWP in developing guidances, which EPA intends to publish for the WHP program by June 1987. The guidances will be used by states and municipalities to develop their programs and to apply for federal grants.

The primary focus of the workshops is directed at the WHP program, rather than the SSA program. Clearly the two are related and much of the information gathered at the workshops will be applicable to the development of guidelines and material for each. Still, EPA is interested in focusing the attention of these workshops on the wellhead protection program.

The first workshop will focus on the guidance that should be provided to the states in their efforts to delineate wellhead protection areas around various wellfields. As described in Subsection 1428(e) of the statute, EPA may consider several factors such as the radius of influence around a wellfield, the depth of drawdown of the water table by the wellfield at any given point, the time and rate of travel as well as the distance from the wellfield of potential contaminants, or other factors affecting the likelihood of contaminants reaching the well and wellfield.

The second workshop will focus on those elements of the state program that are enumerated in the statute to ensure the contamination of public water supply wells is avoided. The workshop is designed to help EPA decide, as required by the statute, how to judge whether a state program adequately meets the goals of the law. The workshop will deal with four areas: the definition of an "adequate state program" as defined in the statute; identification and assessment of potential contaminants and their sources; the management and control of such contaminants; and the need to coordinate the roles of state and local agencies in the design and implementation of the program.

Overview

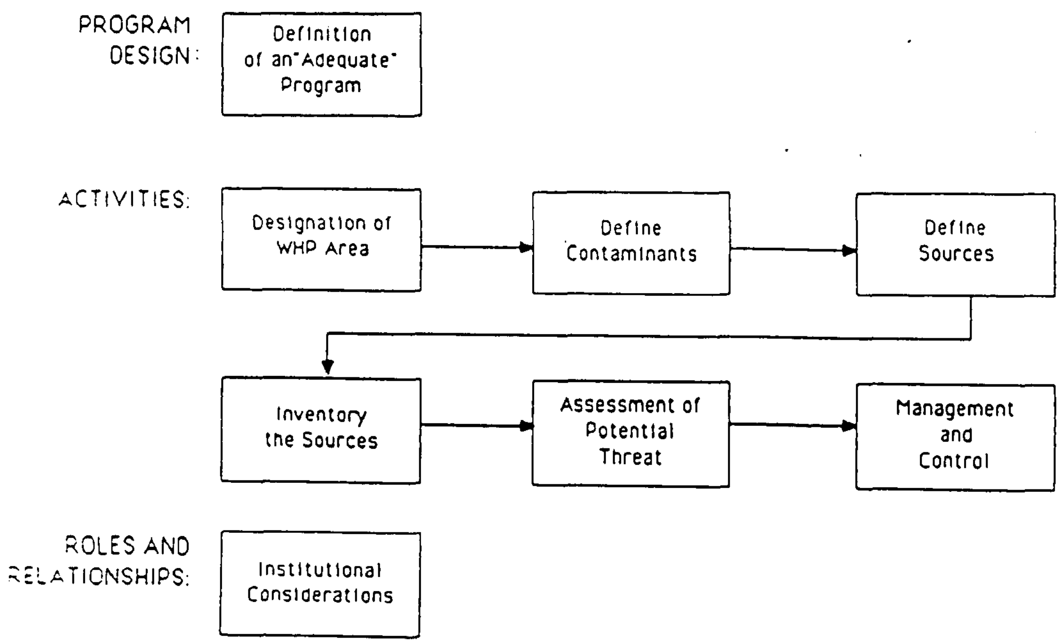
In developing an "adequate" state program that will be eligible for receipt of federal funds, states will have to go through a number of steps as shown diagramatically in Figure I-1. Key elements of these stages will be discussed and evaluated in the two workshops.

Both workshops will consider the overall question of what makes an adequate program and the relative roles and responsibilities of state and local governments in developing and implementing a plan.

The first workshop will also deal with the technical questions concerning the designation of the wellhead protection area (WHPA) around public water supply wells. The second workshop will address more programmatic concerns including the definition of contaminants and their sources, an inventory of the sources, an assessment of the potential threat posed by the sources, and any necessary controls or other management approaches that have to be imposed to ensure protection of the WHPA.

FIGURE I - 1

Major Stages in Developing and Implementing a State WHP Program



Workbook Outline

Chapter 2 provides background information on the two programs and a review of current state activities in wellhead protection. The remaining chapters address the major issues for discussion. Each issue is summarized and several options are presented along with some advantages and disadvantages of each.

Workshop Structure

The workshop will contain four key elements, as follows:

1. Full-Group Discussion--Review of the Working Papers

Full-group, or plenary, discussions will take place in the main meeting room at several points during the workshop. The purpose of these discussions will be to identify and discuss the principal issues presented in this workbook as well as other issues raised by the workshop participants in preparation for more detailed discussions that occur among individual teams.

2. Team Discussions

At several points during the workshop, the participants will break into smaller teams. Each team will be expected to independently evaluate options and develop a preliminary position on the topic assigned. In so doing participants will be asked to discuss and review a number of options that EPA could use in developing its guidance. Moreover, participants will be encouraged to develop new options on their own.

3. Brief Team Progress Reports

At the conclusion of each of these team working sessions, each team will present to the full working group approximately a five-minute report of its discussion and conclusions. The purpose of these reports will be to provide an indication to the full group of each team's direction and, to the extent achieved, any recommendations to the EPA.

4. Final Discussion

After the team presentations, the participants will discuss the issues raised and the team recommendations made. The workshop will not attempt to reach a consensus on individual issues. Its focus will be on obtaining a full discussion of issues and options for EPA's subsequent use in developing the guidance.

II

II.

BACKGROUND INFORMATION ON THE WELLHEAD PROTECTION PROGRAM AND THE SOLE SOURCE AQUIFER DEMONSTRATION PROGRAM

CHAPTER II

I. BACKGROUND INFORMATION ON THE WELLHEAD PROTECTION PROGRAM AND THE SOLE SOURCE AQUIFER DEMONSTRATION PROGRAM

On June 19, 1986, President Reagan signed into law the Safe Drinking Water Act Amendments (SDWAA) of 1986. Included in this legislation were two programs that call for a new role for the federal government in ground-water protection.

While ground-water protection is traditionally the responsibility of state and local governments, in recent years the Congress has shown increased interest in helping to address the problem from the national level. Both new programs are designed to strengthen state and local efforts to address present ground-water problems and to help eliminate future ones.

During consideration of these, and other, amendments to the Safe Drinking Water Act, the Administration expressed concerns about the potential Federal intrusion into highly localized decisions such as those involving land use policy. The final committee conference report (See Appendix II) addressed some of these concerns and spelled out the Congress' view on the range and scope of the new programs. The report states, inter alia, that:

- A state's existing authority to manage, regulate, protect or identify ground-water resources not be limited, e.g., a State may identify significant recharge areas not contiguous to a well(s) in defining WHPAs.

- The program be structured to afford States maximum flexibility in formulating a protection strategy, e.g., not required to adopt a regulatory program.

- States can be expected to take a wide variety of approaches to wellhead protection and each could develop a different approach for the whole state and within different protection areas.

- EPA should use its disapproval power judiciously. The only penalty for State failure to submit a plan is not receiving grants.

As part of its efforts to implement the new law, EPA intends to produce four documents by June, 1987.

- A technical guidance, as required by the statute, for states to use in determining the extent of an appropriate wellhead protection area

- A grants guidance for states to use in developing state wellhead protection programs and in applying for grants under the Act

- A rule required by statute that will establish criteria for identifying critical aquifer protection areas (CAPA's) eligible for funding consideration under the sole source aquifer demonstration program, and

- A guidance that states and localities can use to develop sole source aquifer demonstration programs and to apply for a grant under provisions of the law

STATE PROGRAMS TO ESTABLISH WELLHEAD PROTECTION AREAS (WHPAs)

Under Section 1428 of the new Amendments, States shall develop programs to protect the wellhead areas of all public water systems within their jurisdiction from contaminants that may have any adverse effects on the health of humans.

WHP Grant Guidance

In order to obtain a WHP grant, a state must submit a program to EPA that is "adequate" to protect the WHP's from contamination. The Act specifies that the following elements be incorporated into state programs.

- Duties of State and local agencies and public water supply systems in implementing the program

- Delineation of wellhead protection areas for each public well

- Identification of all potential anthropogenic sources within the protection area

- A program that contains, as appropriate: technical assistance; financial assistance; implementation of control measures; education; training; and demonstration projects to protect the wellhead areas from contaminants

- Contingency plans for alternative water supplies in case of contamination

- Siting considerations for all new wells

- Procedures for public participation

This program must be submitted to the Administrator of EPA within three years after enactment. The State is expected to implement this program within two years after it has been approved by the Administrator. The only impact on a State for failing to participate in the Wellhead Protection Program, however, is the loss of related funds.

The statute is structured to allow States maximum flexibility in formulating their programs. The Administrator will disapprove a program only if it is not adequate to protect public water wells from contamination. Any disapproval must be made within nine months of submittal and should a program be disapproved the State must modify the program and resubmit its plan within six months.

The Administrator shall make 50-90 percent matching grants to the State for costs for the development and implementation of the state program. The Congress has authorized $20 million for each of FY 1987 and 1988 and $35 million for each FY 1989 through 1991 for these purposes.

Each State which receives funds under this section must submit a biennial State report describing its progress in implementing the program and any amendments to the program resulting from new wells. The Act further specifies that all Federal programs are subject to and will comply with the provisions of a state program. However, the President may exempt any potential sources of pollution from the law if he determines that the exemption serves the paramont interest of the United States.

WHP Technical Guidance

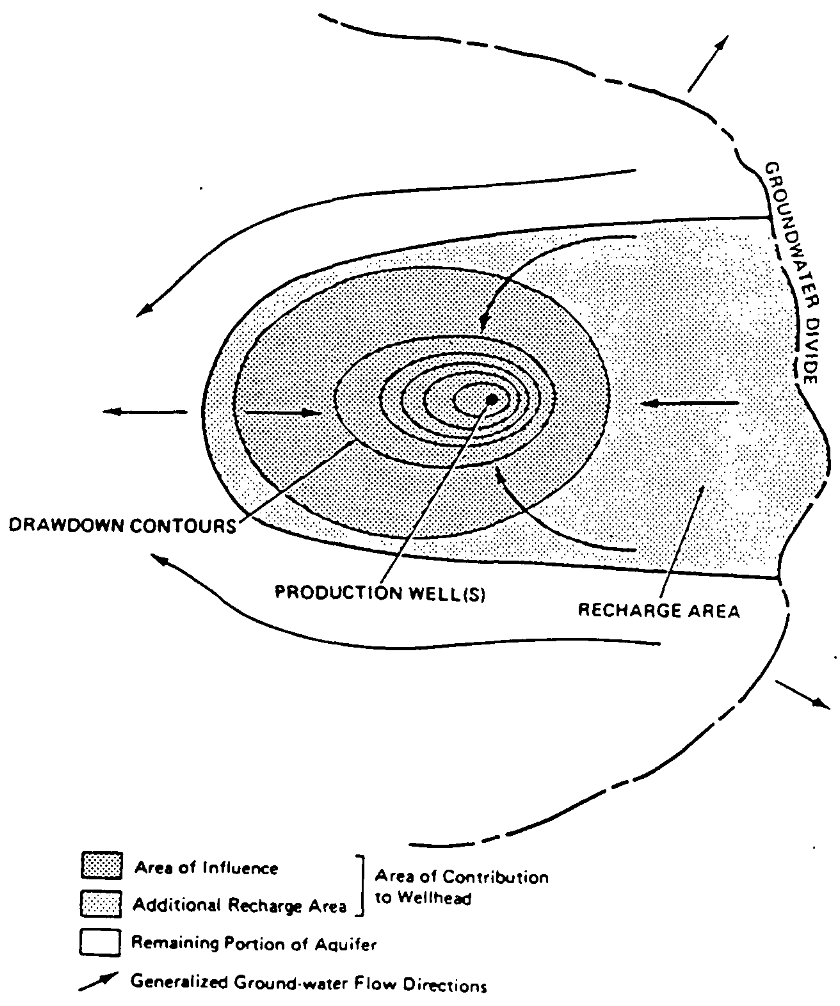
One of the requirements of an adequate state program is that it contains a determination of wellhead protection areas for each public water supply. The term "wellhead protection area" is defined in the SDWA as "the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." The precise delineation of the area is not specified in the law, but is left to be determined by the individual State.

EPA is required to issue technical guidance by June 1987 which States may use in determining the extent of the WHP area. According to the statute, the guidance may consider factors such as radius of influence around a well or wellfield, the depth of drawdown of the water table by such well or wellfield at any given point, the time and rate of travel of various contaminants in various hydrologic conditions, and distance from the well or wellfield.

The terminology used to describe wellhead protection areas is exhibited in Figure II-1 on the following page. In general, a wellhead protection area represents a portion of an aquifer which includes all or part of the area of influence around a pumping well and sometimes portions of upgradient recharge areas or portions of the surrounding aquifer as well. The "area of influence" is the area surrounding a pumping or recharging well within which the potentiometric surface has been changed. The "recharge area" is that permeable layer through which precipitation and surface water may percolate to the aquifer and eventually reach the well. It is important to remember that the Amendments allow considerable flexibility to the States in defining which portion of this theoretical model would apply in specific cases.

Some governments have defined wellhead protection areas to be only hundreds or a few thousand feet from the well. Other governments have defined them to be a mile or several miles from the well. Wellhead protection areas are fairly common in Western European countries such as Germany, Switzerland, and the Netherlands and are being used in parts of the United States such as Dade County, Florida and Cape Cod, Massachusetts.

FIGURE II - 1



TERMINOLOGY FOR WELLHEAD PROTECTION AREA DELINEATION

SOLE SOURCE AQUIFER (SSA) DEMONSTRATION PROGRAM

This new Section, 1427 of the Act, builds upon the existing Sole Source Aquifer program, Sec. 1427(e) of the SDWA. It is a demonstration program establishing critical aquifer protection areas (CAPA) within designated sole source aquifers to ensure the maintenance of ground-water quality for the protection of human health, environment and ground-water. The purpose of any demonstration is to assess the impact of programs on ground-water quality and to identify protection measures that are found to be effective in protecting ground-water resources. EPA must develop by June 1987 a rule including hydrogeological, social, and economic criteria that will be used to identify critical aquifer protection areas. Finally, using information obtained by the states on their programs, EPA must provide to Congress by September 30, 1990, a report assessing the accomplishments of the demonstration program.

Any State or local government, municipality or other political subdivision which identifies a CAPA over which it has jurisdiction may apply to the EPA Administrator to have that area selected for the demonstration program. The Governor must be a co-applicant. An area can be defined as a CAPA if it is a designated sole source aquifer or is part of a sole source aquifer for which an application and designation has been received and approved within twenty-four months of enactment and meets CAPA criteria. Designated SSAs with an approved area-wide ground-water quality plan under section 208 of the Clean Water Act as of the date of enactment are defined as CAPAs under the statute.

An applicant for a demonstration program approval must prepare or complete several activities including the development of a comprehensive management plan for the proposed critical aquifer protection area (CAPA). This plan must contain the following:

- A map detailing the boundary of the critical aquifer protection area
- Existing and potential point and non-point sources of ground-water contamination
- An assessment of the relationship between activities on the land surface and ground-water quality
- Proposed actions and management practices to prevent adverse ground-water quality impacts
- Identification of the authority adequate to implement the plan, estimates of costs, and sources of matching funds

An applicant can include optional components in the management plan including an assessment of the quality of existing ground-water recharged through the area and a comprehensive statement of land use management. If an applicant has an approved ground-water quality management plan at the time of enactment under Section 208 of the CWA this can be submitted in place of the comprehensive management plans. During the development of the plan the applicant is required to hold public hearings and consult with all affected governmental entities.

The Administrator must approve any application received within 120 days based on a determination that the application meets the definition of a critical aquifer protection area and meets the objectives of the sections. Should the application be rejected it may be modified and resubmitted.

If the demonstration program application is approved the Administrator may enter into a cooperative agreement with the applicant to establish a demonstration program. The applicant may receive 50 percent matching grants for both the development and implementation of the program. However, the total amount of the grant cannot exceed $4 million per year per aquifer. The program has been authorized $10 million for FY 1987, $15 million for FY 1988, and $17.5 million for each of the three fiscal years 1989 through 1991.

The State must prepare a report assessing the impact the program on ground-water quality and identify those measures found to be effective in protecting ground water. A report is due from the State to EPA by December 31, 1989. EPA must submit a combined report to the Congress by September 30, 1990.

CURRENT STATE ACTIVITIES IN WELLHEAD PROTECTION

Within the past five years most states have initiated ground water protection programs. The structure and scope of these programs is variable and reflects differing demographic, political and hydrogeological conditions.

A handful of states and municipalities have developed wellhead protection programs as part of an overall ground-water protection program. The main focus of these programs is the delineation of wellhead or recharge protection areas within which land use controls are often imposed to protect water supply wells.

Numerous methods have been developed to delineate these protection areas. Six of the most common techniques used in the U.S. and in Western Europe in these delineations are listed in Figure II-2.

FIGURE II-2 WHPA DELINEATION METHODOLOGY CRITERIA, AND USE RELATIONSHIPS

METHOD	CRITERIA RELIED ON	SELECTED LOCATIONS WHERE USED*
1. Arbitrary Fixed Radius - A circle of standardized dimensions having little to no hydrogeologic basis.	Distance	Nebraska Florida Edgartown, MA Duxbury, MA
2. Calculated Fixed Radius - A circle of standardized dimensions determined mathematically with hydrogeologic basis.	Distance Time of Travel	Florida
3. Simplified Variable Shapes - Standardized recharge areas derived from analytical calculations.	Time of Travel Drawdown	England
4. Analytical Flow Model - A mathematical determination of the area in which ground-water contributes to a pumping well.	Drawdown Physical Features	Cape Cod, MA Duxbury, MA Edgartown, MA West Germany Holland
5. Geologic/Geomorphic - An area defined by flow boundaries detected through geologic field study and observation.	Physical Features	Vermont Midstate Reg. Planning Agen., CT Duxbury, MA
6. Numerical Flow/Transport Model A computerized approximation to the solution of differential equations (e.g., ground-water flow and/or solute transport).	Time of Travel Drawdown	Dade Co., FL Broward Co.,FL Palm Beach, FL

* or being considered

The methods range in sophistication from those which can be applied simply by non-technicians (e.g., Fixed Arbitrary Radius) to very complex methods which require a highly trained, technical specialist (e.g., Numerical Flow/Transport Model). Each has inherent strengths and limitations which must be considered in method selection and program implementation. The less sophisticated forms can be easily applied and are relatively simple to administer. They are, however, less likely to reproduce actual conditions. They may therefore provide "inadequate" or "excessive" protection in different settings. More sophisticated methods more closely reproduce actual conditions, however, they are more expensive to implement and more complex to administer. Thus, certain tradeoffs or method combinations may be required when designing WHPA programs in order to adequately define the area to be protected.

A brief review of wellhead protection activities in selected states follows. While not exhaustive, this survey will give workshop participants an indication of what is already being done at the state and local level in wellhead protection.

State of Florida

Florida's state and county governments have some of the most sophisticated ground-water protection program in the nation. The state has also proposed amendments to Chapter 17-3 of the Florida Administrative Code that would establish a wellhead protection program for highly vulnerable aquifers. The program would require protection zones around wellheads in which land use controls would be used to restrict activities that could potentially contaminate the ground-water supply.

The proposed law establishes two protection zones around major public community drinking water supplies (with an average daily withdrawal of at least 100,000 gallons of ground-water). The zones are defined as two concentric areas around the major public water supply well(s) or wellfield(s) of 200 feet and five years ground-water travel time respectively.

Discharges into the ground-water from storm water facilities, underground storage facilities, underground transportation pipes and other sources are subject to varying degrees of control depending on their proximity to the wellhead.

The proposed law, for example, prohibits new discharges and new installations within the 200 foot zone of protection. Within the five year zone of protection, new discharges from several types of facilities are subject to varying levels of control and monitoring requirements. New discharge of industrial waste that contains hazardous constituents is prohibited and new discharge of treated domestic waste effluent is allowed provided a number of conditions are met.

Dade County, Florida

Dade County has developed a comprehensive wellhead protection program. The County's program consists of five elements: water management, water and wastewater treatment, land use policy, environmental regulation and enforcement, and public awareness and involvement. The program consists of an array of prohibitions, restrictions, permit requirements, land use tools and management controls designed to protect all of Dade County's public water supply wells from contamination by the approximately 900 substances the county has identified as hazardous. Features of the county's program include:

- Delineation of recharge areas around wellfields, using computer modeling
- An array of restrictions applied within designated wellfield protection zones. Examples include
  - No new activities involving hazardous materials
  - Annual permitting and inspection of all non-residential uses
  - Density restrictions within protection zones
  - Expedited sewering of unsewered protection areas
  - Expedited clean-up of known areas of contamination
- Information programs to educate the public concerning the importance and methods of protecting drinking water
- Treatment programs to adequately purify drinking water (including air stripping of volatile organics) and for safe disposal of wastewater and other wastes. Clean-ups of known sources of contamination are included
- A water management program, including canal construction, to protect wellfield recharge areas from existing contamination, and a monitoring program to verify the results
- A regulatory program including extensive permitting and inspection of all non-residential activities in wellfield areas plus extensive design criteria for development
- A land use control program prohibiting or limiting certain land uses in proximity to wellfields as a function of hydraulic travel time.

Furthermore, Dade County maintains a computerized inventory of contaminant sources and issues approximately 10,000 operating permits per year to recognized, non-residential, users within the delineated wellfield protection zones.

Massachusetts

Massachusetts implements its wellhead protection program through the Aquifer Land Aquisition Program (ALA). The goals of the program are to help local officials define the primary water recharge areas around public water supply wells, to work with local officials to properly address land uses within the recharge areas of these wells, and to reimburse eligible applicants for land aquired in the recharge area for water supply protection purposes. The program encourages a mix of strategic land aquisition and effective land use controls to achieve water well protection.

As part of the program the Massachusetts Department of Environmental Quality Engineering (DEQE) has defined 3 zones of contribution that compose the total recharge areas to a public well. Theoretically these 3 zones constitute the geographic area in which land uses may impact the drinking water supply well.

- Zone 1, the 400' radius or other designated area surrounding a water supply well, must be in compliance with DEQE Drinking Water Regulation (310 CMR 22.00)

- Zone II is that area of an aquifer which contributes water to a well under the most severe recharge and pumping conditions that can be realistically anticipated. It is bounded by the ground-water divides which result from pumping the well and by the edge of the aquifer with less permeable materials such as till and bedrock. At some locations, streams and lakes may form recharge boundaries.

- Zone III is that land area beyond the area of Zone II from which surface water and ground water drain into Zone II. The surface drainage area as determined by topography is commonly coincident with the ground-water drainage area and will be used to delineate Zone III. In some locations, where surface and ground-water drainage are not coincident, Zone III shall consist of both the surface drainage and the ground-water drainage areas.

The delineation and management of these 3 zones forms the basis of a competitive ALA grant program through which local governments compete to obtain funds from the state to purchase land for water well protection purposes.

The Commonwealth has restricted the reimbursement for land purchases to Zone II. The rationale for this decision was that Zone II areas consist of relatively permeable surficial deposits and represent the area of the municipality in which land uses have the greatest potential for adversely impacting the local water well(s). Zone I was eliminated from the reimbursement scheme because under Massachusetts law the water supplier is already required to control land use within the 400 foot radius surrounding the well.

The program requires applicants to supply four major categories of information: aquifer/water supply information, land use information, resource protection plans, and land aquisition information. Under the first category, Zones I, II and III must be delineated and mapped. Any pump tests or modelling used to delineate zones must be documented.

Some level of land use information must be supplied for all three zones. All major land use activities such as commercial, residential, agricultural, and industrial uses in Zone II must be mapped and public transportation and corridors identified. For areas in Zone III, only those land use activities that pose significant threats to ground water such as hazardous waste sites, surface impoundments, landfills, auto junkyards, underground storage tanks, salt storage sheds, and sand and gravel operations that occur in the zone, need be documented.

A water resource protection strategy that identifies existing and/or proposed land use controls designed to protect the supplies must be included in the package on the suggested land and/or easement purchase. The state uses this information to determine whether there is a sound basis for the locality aquiring the land and whether the town will indeed be able to complete the land aquisition should an award be granted.

All applications are ranked and prioritized based on two major criteria: the value and use of the resource and the degree of resource protection that can be expected from the proposed water protection strategy.

Vermont

The state is in the process of developing a state wide wellhead protection program. As part of this program, the Agency for Environmental Conservation is developing regulations that will be used to map the cone of influence, the primary recharge areas and the secondary recharge areas of water wells in Vermont. These maps will be used by AEC and other regulatory agencies in their permitting activities.

One tool currently available to state regulatory agencies in making management decisions are the existing maps of recharge areas or Aquifer Protection Areas that were delineated in the Vermont Aquifer Protection Area (APA) Project in the 1970's. The APA project resulted in 209 individual APA's located in 104 of Vermont's towns. These APAs are defined as the land surface area that encompasses the recharge, collection, transmission, and storage zones for a town's well or spring.

Eight categories of APAs were delineated based on hydrogeological factors:

- Wells in unconfined and leaky unconsolidated aquifers with available engineering pump tests.
- Wells in unconfined and leaky unconsolidated aquifers without engineering pump tests.
- Wells in confined unconsolidated aquifers.
- Bedrock wells, using an infiltration model
- Bedrock wells, using a leakage model
- Springs in unconsolidated material and at the interface between unconsolidated material and bedrock, with high relief in the upgradient direction
- Springs in unconsolidated material and at the interface between unconsolidated material and bedrock, with low relief in the ungradient direction
- Springs emanating from bedrock

There are no regulations associated with mapped APAs but existing state regulatory programs use APAs to flag areas needing special consideration during the review process on development applications.

European/Experience

At least eleven European countries have developed some form of wellhead protection concept, with West Germany and the Netherland having the most extensive experience in this area.

In both countries, the first protective zone lies immediately around the wellhead, with a secondary zone representing the distance that ground-water will travel in 50 (West Germany) or 60 (Netherlands) days. This second zone is designed to protect the well from microorganisms.

Each country then has a "water protection" area, comparable to the WHPA boundaries seen in the United States. In West Germany this zone extends to 2 kilometers from the well (until aquifer boundaries are reached) while in the Netherlands, the "protection zone" extends to 10 and 25 year travel times. These correspond approximately to distances of 800 meters and 1200 meters from the wells. Finally, an outermost zone is drawn, in each country, to the recharge area boundary. Within these zones, restrictions are imposed on a number of activities including, but no limited to, waste disposal sites, the transport and storage of hazardous chemicals, wastewater disposal, and the application or leachable pesticides. The degree of restriction decreases as the distance from the wellhead increases.

CHAPTER III

CRITERIA FOR DELINEATION OF WELLHEAD PROTECTION AREAS

CHAPTER III

CRITERIA REQUIRED IN DELINEATING WHPA's

A. Introduction

Many conditions exist which control the manner, rate and volume of ground-water movement in the earth. These conditions greatly influence the amount of water that can be pumped from a well, the impact a pumping well may have on local water resources, the characteristics of recharge to a wellhead, or the extent to which a contaminant might be carried by a ground-water flow system. It is necessary to identify the interrelated criteria on which these conditions are based. This must be done before we can develop methodology to determine "adequate" protective distances around producing wells. Thus, in developing a WHPA programs, an initial step is to evaluate the various criteria that will ultimately be used to provide the basis for boundary determinations. It will be necessary to consider which types of criteria might be specified, should minimum thresholds be set for the criteria and then, what methods should be used to translate the criteria to "on-the-ground" WHPA boundaries.

The Agency's guidance on delineation approaches must, by statute, recognize a wide range of hydrogeologic settings. A comprehensive wellhead protection program would include the delineation of some geographical area across which monitoring, source identification, and control strategies would be applied. While the States need not use the guidance in designing or implementing their programs, the Agency must still decide if the States' approach meets the overall "standard" in the Amendments.

This chapter is divided into three remaining sections. The first two provide background information on WHPA criteria, whereas, the final section will be used to focus team discussions.

B. Definition of Criteria

For simplicity, "criteria" in this workshop identify those hydrogeologic factors which must be considered in establishing a boundary line of protection around a well or wellfield. These criteria are usually related to an overall program goal, examples of which are depicted in Figure III-3.

The most common criteria available or presently used in the United States and in Western Europe to delineate WHPAs involve combinations of: 1) Distance; 2) Drawdown; 3) Time-of-Travel (TOT); 4) Physical Boundaries; and 5) Assimilative Capacity. The following paragraphs discuss these hydrogeologic factors.

1. Distance - Measured length away from a pumping well to the point of concern.

Discussion - The point of concern may be based on either administrative (e.g. fixed radius) or hydrogeologic criteria. For the first example, an administrator may determine that some set distance is preferable over no such set distance, and therefore, select an arbitrary set distance for the WHPA criterion. From a hydrogeologic perspective, the point of concern might be calculated based on state-wide average conditions, or where drawdown effects are considered negligible under average pumping scenarios. One number might be chosen to represent such conditions, and that number be universally applied.

Example - Nebraska has designated a WHPA as a ring having a 1,000 foot radius around a well. Florida has a Zone I area of protection which has a 200 foot radius. West Germany has 2 km (6,560 feet) for Zone III-A.

2. Drawdown - Relative change in the position of the static water level in an aquifer because of ground-water withdrawal.

Discussion - The pumping of a well induces drawdown in the surrounding aquifer. Basing the criteria on drawdown implies that all or a part of the "area of influence" of the well will be included in the WHPA. Areas of zero drawdown are outside the area of influence per se, but may be upgradient and thus still "recharge" the well. Drawdown is directly proportional to the rate of withdrawal and the length of time that the withdrawal has been occurring. It is inversely proportional to the aquifer's hydraulic conductivity, saturated thickness, storativity, and distance between the well and the point at which the drawdown is being observed. Given the asymptotic slope of the drawdown curve, minor changes in the threshold could lead to major changes in the area encompassed by the WHPA.

Example - Massachusetts uses the 0.1 foot drawdown contour while Dade County, FL uses the 0.25 foot drawdown contour and Palm Beach and Broward Counties, FL use 1.0 foot drawdown contour.

3. Time-of-Travel - Time it takes for a molecule of water, or a contaminant flowing at an equivalent rate (i.e., advective flow), to reach a well.

Discussion - Time-of-travel could be independent of drawdown and distance. Commonly however, the Time-of-Travel is directly proportional to the length of the flow path and the effective porosity of the aquifer. The Time-of-Travel is inversely proportional to the aquifer's hydraulic conductivity and the hydraulic gradient.

$$t = \frac{nx}{ki}$$

Where: t = Time-of-Travel
n = porosity
x = distance
k = Hydraulic Conductivity
i = Hydraulic Gradient

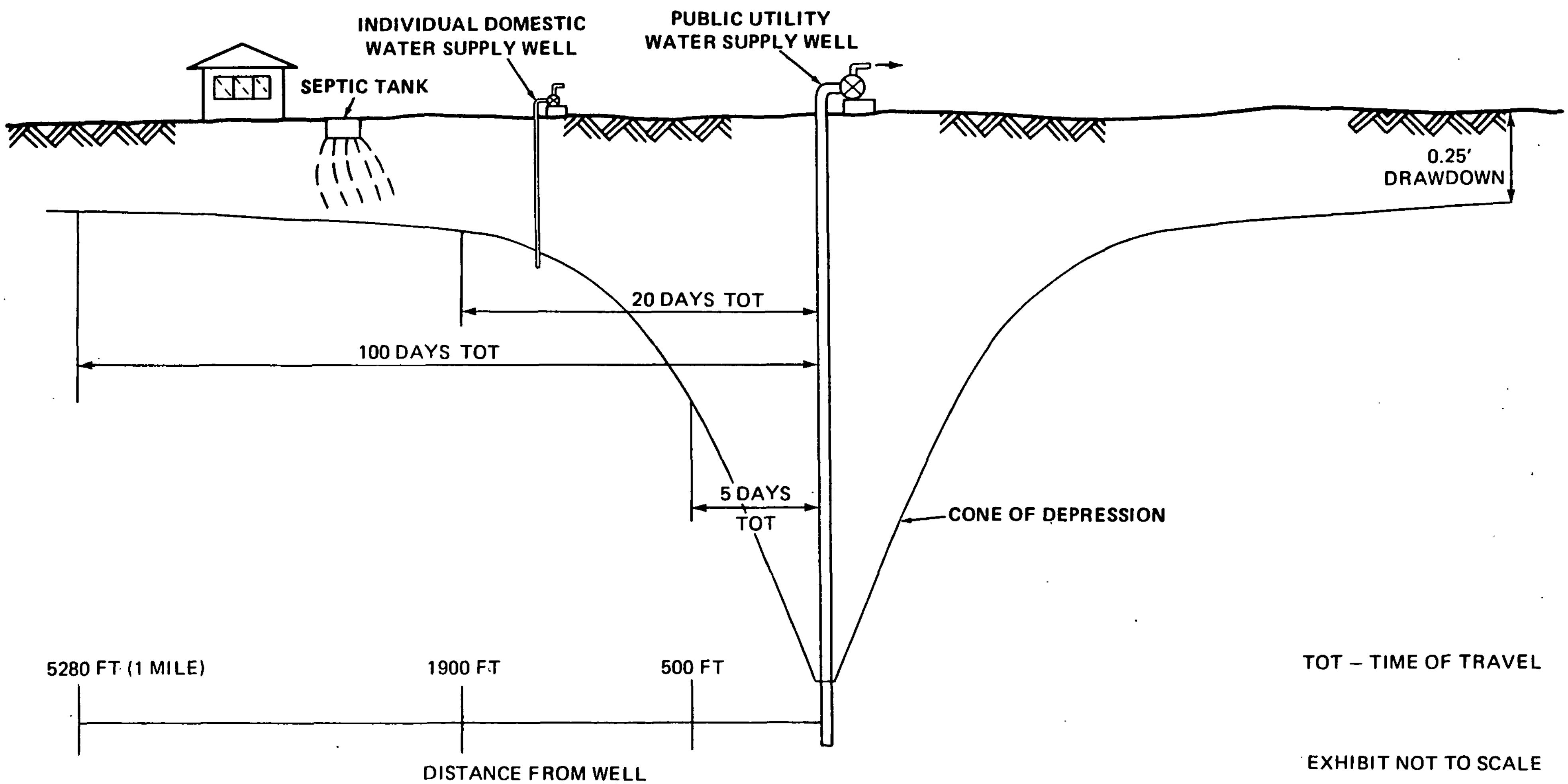
Example - West Germany uses a 50-day travel-time. Palm Beach uses a 30-day travel time for Zone I, a 210-day travel time for Zone II and the greater of a 500-day travel time or a one foot drawdown contour for its Zone III. Broward and Dade Counties use travel times of 10 days, 30 days and 210 days (or 1.0 foot drawdown if larger) to designate their zones. The State of Florida uses five years for their Zone II and the Netherlands use 10-25 years for their Zone IIIa. A conceptual sketch of TOT is shown in Figure III-1.

4. Physical Boundaries - The physical boundaries of the local or subregional ground-water flow system act as no-flow barriers (or assumed no-flow barriers in the case of surface-water divides).

Discussion - Barriers exist which make it nearly impossible for ground water to move from a location towards a pumping well. Examples of conditions which might provide isolation include regional ground-water divides that separate adjoining basins, perennially gaining canals and rivers, or confining units which may separate deeper units from shallower ones. The degree of isolation that exists may be critical in determining the extent to which a potential pollution source could contaminate a well.

Example - Edgartown and Duxbury, Mass. use or are considering methods that include the delineation of upgradient and downgradient divides. The State of Vermont in its prototype also defined a secondary area of protection based on the upgradient recharge area by using the surface water divide as a close approximation for the ground-water divide.

IDEALIZED SKETCH OF WHPA CRITERIA: EXAMPLE FROM SE FLORIDA



TOT – TIME OF TRAVEL

EXHIBIT NOT TO SCALE

FIGURE III-1

SOURCE: Dade Co., FL, Dept. of Environmental Resources Management (1983)

Assimilative Capacity - An area (of protection) where natural attenuation processes are capable of reducing contaminant's concentration to a target level.

Discussion - Attenuation processes such as filtration, biodegradation, dilution, sorption, and volatilization decrease the concentration of contaminants as they pass through the soil, bedrock and ground water. The ability of natural systems to restore ground waters to their original or "acceptable" state varies widely. The nature and volume of the contaminant, the quality of the attenuating materials and the amount of dilution, diffusion and dispersion which can occur are examples of factors which influence assimilation.

Example - No known examples can be cited where assimilation capacity or retardation factors are included in the delineation of WHPA boundaries. However, some ground-water protection efforts have been targeted to reduce nitrate loadings (e.g., Long Island) which might be conceptually utilized. The Amendments imply that such an approach might be valid for WHPA delineation.

C. Matrix of WHPA Criteria/Evaluation Factors

A matrix has been prepared (Figure III-2) to rank the criteria against a number of evaluation factors that could influence the selection and/or application of WHPA criteria. Workshop participants will be asked to comment on this matrix in terms of its overall structure, as well as the tentative assessments within the matrix itself.

The evaluation factors used in the matrix are defined as follows:

WHPA CRITERIA/EVALUATION FACTORS

CRITERIA \ EVALUATION FACTORS	ABILITY TO UNDERSTAND CRITERIA L/M/H		USER SOPHISTI-CATION	EASE OF QUANTIFI-CATION	VARIABILITY UNDER ACTUAL CONDITIONS	FIELD VERIFICATION	ABILITY TO REFLECT AMBIENT GW STD.	SUITABILITY FOR DELINEATION METHODS L/M/H							CRITERIA DEVELOPMENT COST	SUITABILITY FOR GEOLOGIC SETTINGS
	T	N	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	1	2	3	4	5	6	7	L/M/H	L,M,H
DISTANCE	H	H	L	H	L	H	L	H	L	L	L	M	L	L	L	H
DRAWDOWN	H	M-H	M	M-H	M-H	M	L-M	L-M	M	M-H	M-H	M-H	H	L-M	M-H	M-H
TIME OF TRAVEL	L-M	L-M	M-H	M-H	M-H	L-M	H	L	L	M	M-H	L	H	H	M-H	M-H
PHYSICAL BOUNDARIES	M-H	L-M	M-H	L	L	L-H	L-H	L	L	L	L	H	L	M	M-H	M-H
ASSIMILATIVE CAPACITY	L-M	L	M	L	L	L	H	L	L	L	L	L	L	H	H	L-M

1 – ARBITRARY FIXED RADIUS
2 – CALCULATED FIXED RADIUS
3 – SIMPLIFIED VARIABLE SHAPES
4 – ANALYTICAL MODELS
5 – GEOLOGIC/GEOMORPHIC MAPPING
6 – NUMERICAL MODELS
7 – MISCELLANEOUS METHODS-TRACING

L–LOW
M–MEDIUM
H–HIGH
T–TECHNICAL
N–NON-TECHNICAL

FIGURE III-2

1. Ability to Understand Criteria - Degree to which the principles underlying a criterion can be readily comprehended and used by hydrogeologists/non-technical people.

Comment - How easily a criterion can be understood relates to its application. Only ground-water specialists may be able to apply complex, highly technical approaches to criterion development while others, such as distance, may easily be utilized by policy or program specialists.

2. User Sophistication - Technical abilities of user necessary to understand the basis of criteria, the application of their input data requirements and how their results can be evaluated.

Comment - Compatibility between user knowledge and criterion use is necessary before valid results can be developed and relied on. Thus, the more technologically demanding criteria requires more specialized user abilities.

3. Ease of Quantification - Ability to place a numerical value or threshold on a criterion.

Comment - Certain criteria are expressed in numerical terms such as TOT. Others such as those based on geologic or hydrogeologic boundaries are more difficult to describe in such terms in a regulation, etc. Consequently, the clarity of communicating or legally defining criterion values varies widely.

4. Variability Under Actual Conditions - Extent to which an area resulting from a criterion will vary with time due to changes in hydrologic conditions.

Comment - Criteria, such as Time-of-Travel or drawdown dimensions are influenced by variables which can change if the external conditions on which they are based, e.g., recharge rates, also change. In contrast, an arbitrarily established distance dimension will remain constant regardless of what site specific changes might occur.

5. Field Verification - Ability to confirm values placed on a criterion through actual on-site testing or inspection.

Comment - It is often very difficult to accurately reproduce calculated values in the field, time-of-travel values for example. Others can be reasonably confirmed through inspection such as field checking the surface divide of a basin whose boundaries were originally determined on a topographic map. (Proving the ground-water extrapolation of this boundary is more difficult.)

6. Ability to Reflect Ambient Ground-Water Standards - Degree to which a criterion can be used to define the meeting of a particular ground-water quality standard, either at the well or at some location in the surrounding WHPA.

Comment - One consideration for selecting a WHPA criterion is the potential for relating it to some overall water quality standard (in the well or in ground water). Criteria, such as assimilative capacity, may provide values which can be used to closely approximate the concentration of contaminants and their relation to acceptable limits. Others, however, such as an arbitrary distance, will not (unless very extensive).

7. Suitability for Delineation Methods - Extent to which a criterion can be specified on the ground through application of particular methodologies (discussed in Section IV).

Comment - The viability of a method is dependent on the specific set of criteria which form its basis. Arbitrary, analytical, calculated or geologic/geomorphic methods of WHPA delineation inherently incorporate criteria in their application.

8. Criterion Development Cost - Expenses related to developing criteria values.

Comment - The cost of developing a criterion may inhibit or encourage its use. Generally, criteria which are highly technical, rely on a complex data base, or are labor intensive will be expensive to produce. This may deter their application and acceptance even though their validity may be great.

9. Suitability for Geologic Settings - The ability to apply a criterion under a wide range of hydrogeologic conditions.

Comment - Hydrogeologic controls over ground water under natural conditions vary widely. The extent of confinement, consolidation, fracturing and solution channel development are some of the major physical controls which may influence the appropriateness and ease of criterion development.

D. Guide for Team Discussion Session

Introduction

The previous sections of this chapter discussed the program goals and issues that are related to consideration of criteria selection and use. Before the methods of WHPA delineation can be addressed, the work group teams will focus their attention on the types of criteria that exist, their appropriateness, how they relate to the previously identified goals and issues and any other points the team may wish to discuss.

Two separate items follow which should be individually evaluated. The first is a list of six questions. The second is an issue question with four options. They are being provided to you in order to facilitate team recommendations. EPA is very interested in the opinions of participants on these issues; therefore, it is hoped that you might provide your thoughts on the options and as many of the questions as you can. The team group is not restricted to only these materials and is free to approach the subject in any manner it feels appropriate. Remember, however, that the final summary should assess the relevant issues in a manner that will facilitate EPA's efforts to develop WHPA delineation criteria.

ITEM 1 - SIGNIFICANT QUESTIONS ON WHPA CRITERIA

A. ARE THE CRITERIA IDENTIFIED IN THE MATRIX VALID?

B. ARE THERE ADDITIONAL CRITERIA WHICH SHOULD BE LISTED?

C. ARE THERE OTHER EXAMPLES OF STATES OR LOCALITIES THAT SELECT OR UTILIZE ADDITIONAL THRESHOLDS FOR CRITERIA?

D. HOW ADEQUATE ARE THE THRESHOLDS USED BY THE STATES AND OTHERS?

E. ARE SOME CRITERIA MORE VALID FOR CERTAIN GEOLOGIC SETTINGS? WHAT ARE THOSE SETTINGS?

F. WHAT ARE THE INHERENT ADVANTAGES AND DISADVANTAGES TO EACH OF THE SPECIFIC CRITERIA?

G. WHAT ARE "REASONABLE" SAFE DISTANCES, TOT VALUES AND OTHER CRITERIA THRESHOLDS?

ITEM 2 - ISSUE: HOW SHOULD EPA ESTABLISH THE PRINCIPAL CRITERIA FOR ADEQUATE DELINEATION OF WELLHEAD PROTECTION AREA?

An examination of the wellhead programs in Western Europe and the few localities using or debating such techniques in the United States, points to at least four major program goals (Figure III-3). Each of these goals is approached through the establishment of various technical criteria which delimit the area of protection. The underlying question that considerations should be related to, is the extent to which EPA should establish national goals and criteria for delineation. Six questions and four general options will be evaluated in the team discussion sessions. The options range from the least restrictive approach to the States, to ones where EPA plays a more active role in selecting the actual criteria used in defining the goal.

Option 1 - All or nearly all goals and criteria for delineation are adequate given different circumstances. The States must defend the appropriateness of their choice, and the specific criteria selected.

Advantages/Disadvantages

- o Provides maximum flexibility required by the Amendments;

- o Recognizes that our knowledge in this field is limited and provides a forum for improving basic approaches;

- o Greater chance of "overprotection"/"underprotection" given State conditions.

FIGURE III-3
BROAD GOALS AND CRITERIA
FOR DELINEATING WELLHEAD PROTECTION AREAS

GOALS	EXAMPLE CRITERIA	PRO	CON	ADEQUACY OF DELINEATION (HYDROGEOLOGY)	IMPLEMENTATIONS FOR "MANAGEMENT" PLAN ADEQUACY
Provide a wellfield management area in major portion of recharge area	0.25 foot drawdown contour (Dade Co., Florida) 2Km/10-25 year TOT (W. Europe)	Broadest definition: can be tailored by States as appropriate; can incorporate other options	May lead to "overprotection" in some States; "under-protection" in others	Based on reasonable application of hydrogeologic concepts to data available.	Based on reasonable consideration of relevant management factors.
Provide a renovation zone for contaminant attenuation from sources to well	Meet percentage of MCL in raw water supplying well	Most directly addresses specific contaminants of concern and "standard" in SDWA	Currently viable only for simple problems such as microbial contaminants; conservative parameters (e.g., synthetic organics more problematic)	Analysis sufficiently thorough to show that zone is extensive enough to meet target concentrations at well.	Displays understanding of contamination sources, locations, contaminant characteristics, impacts of controls.
Provide a remedial action zone to protect well from unexpected contaminant releases	5-year TOT to well (State of Florida)	Deals directly with most threatening sources in a manner understandable to regulated community; "compatible" with existing programs	Implies capability/success of corrective action measures at all relevant sources	High confidence in accuracy of time-of-travel determinations at specific wellhead areas.	Possible ban of all high risk activities within WHPA; controls/monitoring of all significant sources within recharge area, especially those beyond WHPA.
Manage entire recharge area under current and foreseeable conditions	Physical limits of aquifer and surface drainage (some parts of Massachusetts)	Can be interpreted as most protective; especially appropriate to small aquifers (e.g., less than 10-20 square miles)	"Overprotective" for moderate to large aquifers	Analysis shows full recharge area under existing and potential pumping scenarios.	"Controls" extend to all potential contamination sources within recharge area.

Option 2 - All or nearly all goals are adequate, but EPA establishes "minimum adequate" criteria (e.g., 1,000 foot radius or 5-year TOT).

Advantages/Disadvantages

- o Provides a base level of protection which provides a significant improvement over current levels;
- o Provides some level of national consistency;
- o Will be underprotective in certain settings, and may present a difficult precedent for States who wish to take a more protective approach;
- o May not meet the full intent of the "standard."

Option 3 - All or nearly all goals are adequate, but EPA establishes or recommends significantly more protective criteria (e.g., 2 mile radius or 25 to 50 year TOT).

Advantages/Disadvantages

- o Provides a moderate to high degree of protection given current knowledge;
- o More closely meets intent of "standard";
- o Will be opposed by States considering more limited criteria; public/private sector concerns of "overregulation."

Option 4 - Only one goal and set of criteria for delineation are adequate (e.g., provide 10 year TOT management area).

Advantages/Disadvantages

- o Establishes most consistency among States;
- o Provides easiest administrative test to approve "adequacy;"
- o Could range in protectiveness depending on goal/ criteria chosen;
- o Least response to Amendment's emphasis on flexibility; States may not pick up WHPA program;
- o Greatest effort for EPA to determine appropriate goal/criteria for entire nation.

IV. METHODS FOR DELINEATING WHPAs

CHAPTER IV

I. METHODS FOR DELINEATING WHPAs

Introduction

This chapter describes some of the methods that can be used to apply a technical criterion in delineating a WHPA boundary. In the development of its hydrogeologic guidance, the Agency plans to analyze the strengths and limitations of each method before recommendations can be developed as to where each one may be most appropriate. Parallel efforts under the direction of OGWP are presently addressing particularly management programs within the zones of protection.

As previously discussed in Figure II-2, information has been collected to determine how various water resource programs in the United States and Western Europe implement their WHPA boundary designation. The delineation methodologies obtained have been categorized into seven general groups: Arbitrary Fixed Radii, Calculated Fixed Radii, Simplified Variable Shapes, Analytical Models, Geologic/Geomorphic Mapping, Numerical Flow/Transport Models and Miscellaneous.

Figure IV-1 shows that more than one approach can be utilized in the application of a single method. It also relates the different approaches used to existing or proposed programs.

The various delineation methods essentially form a continuum with three end points (Figure IV-2). The three points vary in sophistication from the selection of arbitrary values, e.g., a simple fixed radius with no scientific basis; the utilization of complex highly quantified approaches, e.g., analytical, numerical models based on extensive site specific data; and more descriptive approach of studying the physical features of an area to determine the geologic or geomorphic controls on ground-water

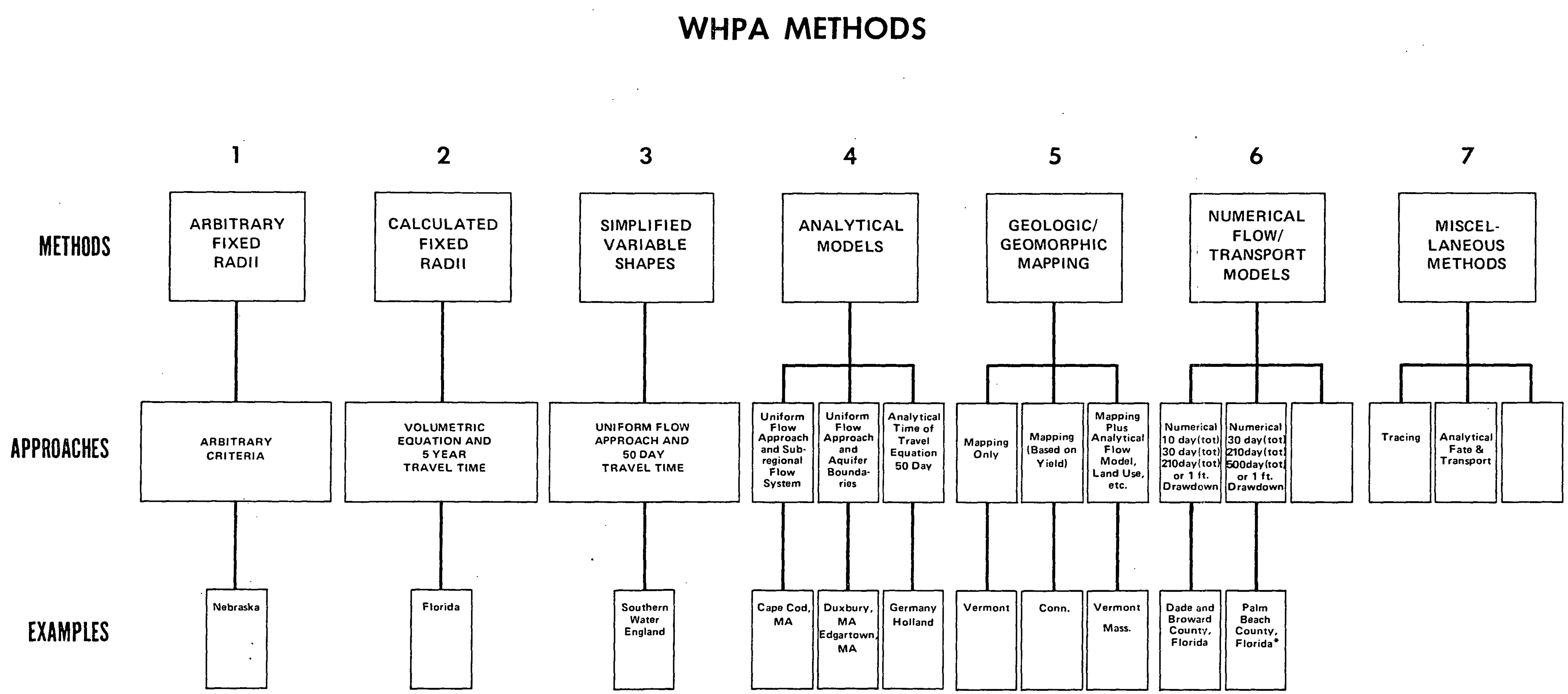

WHPA METHODS
METHODS
APPROACHES
EXAMPLES
1
ARBITRARY FIXED RADII
ARBITRARY CRITERIA
Nebraska
2
CALCULATED FIXED RADII
VOLUMETRIC EQUATION AND 5 YEAR TRAVEL TIME
Florida
3
SIMPLIFIED VARIABLE SHAPES
UNIFORM FLOW APPROACH AND 50 DAY TRAVEL TIME
Southern Water England
4
ANALYTICAL MODELS
Uniform Flow Approach and Sub-regional Flow System
Uniform Flow Approach and Aquifer Bounda-ries
Analytical Time of Travel Equation 50 Day
Cape Cod, MA
Duxbury, MA Edgartown, MA
Germany Holland
5
GEOLOGIC/ GEOMORPHIC MAPPING
Mapping Only
Mapping (Based on Yield)
Mapping Plus Analytical Flow Model, Land Use, etc.
Vermont
Conn.
Vermont Mass.
6
NUMERICAL FLOW/ TRANSPORT MODELS
Numerical 10 day(tot) 30 day(tot) 210day(tot) or 1 ft. Drawdown
Numerical 30 day(tot) 210day(tot) 500day(tot) or 1 ft. Drawdown
Dade and Broward County, Florida
Palm Beach County, Florida*
7
MISCEL-LANEOUS METHODS
Tracing
Analytical Fate & Transport

FIGURE IV-1

INTERRELATIONSHIPS OF WHPA METHODS

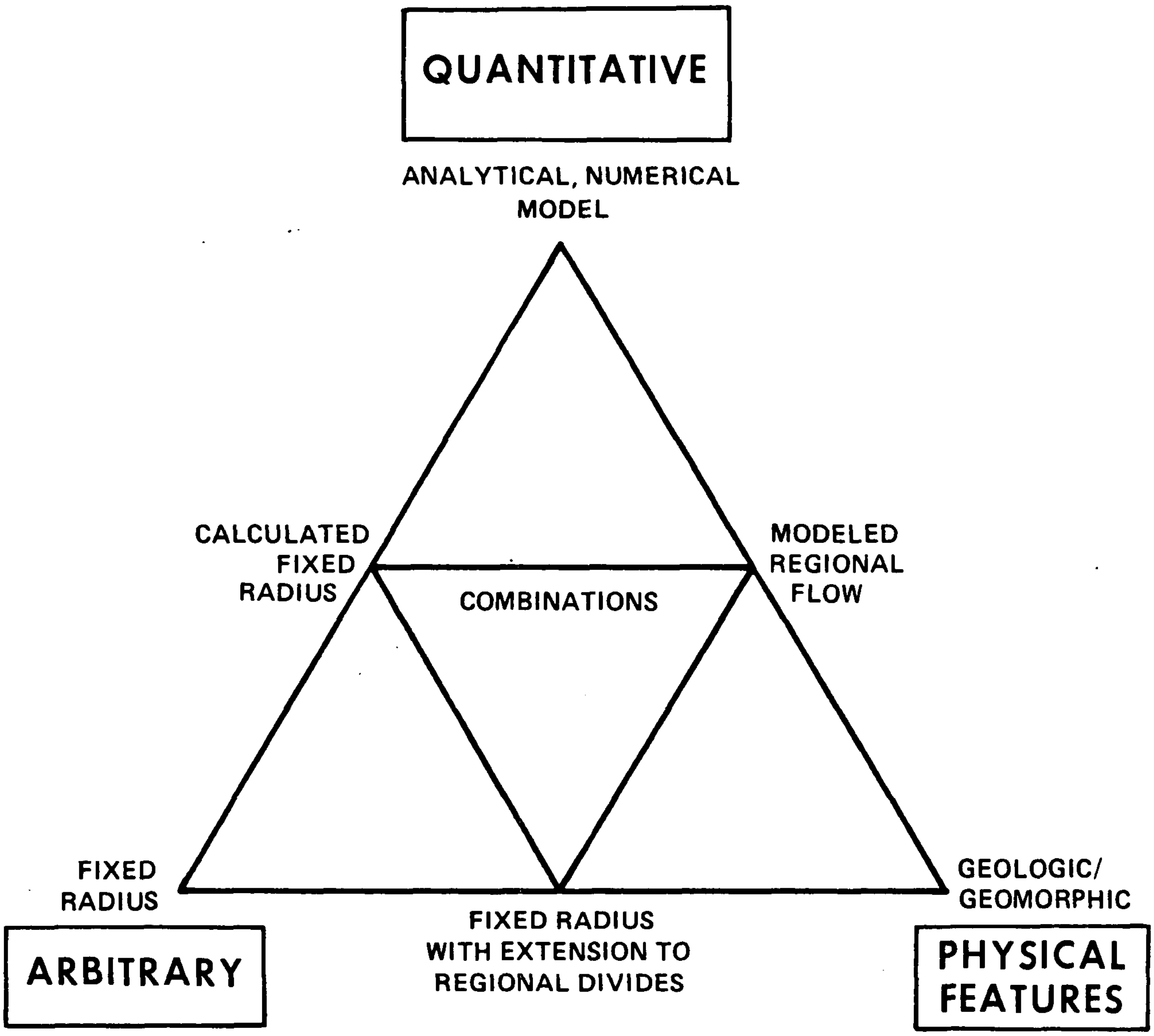


FIGURE IV-2

flow. Intermediate methods are formed when combinations of endpoints are made. WHPAs delineated by a calculated radius based on generalized regional would be a combination of the Arbitrary and Quantitative methods. Regional flow models can be developed by combining the Quantitative and Physical Features methods. An approach which starts with a fixed radius and then extends the area to a basin divide would combine the Arbitrary and Physical Features methods. Numerous permutations can be developed by combining two or three of the endpoints.

Description of WHPA Methods

A brief description of each method presented in Figure IV-1 is provided below:

1. Arbitrary Fixed Radii

General Description: This method is based on an "arbitrary" selection of a circular area around a well to delineate a WHPA. Although, at times, it may appear that the selection of the area is not based on scientific principles, the area may have been selected based on very generalized hydrogeologic considerations and/or professional judgement. The threshold selected is typically applied to all wells uniformly across a county, state, or region.

Example: The state of Nebraska is delineating WHPA's by a circle of 1,000 ft radius. Florida is proposing to use a 200 ft. radius for its Zone I; Duxbury, MA., uses a 400 ft. radius for its Zone I; and Edgartown, MA., used a 2,500 ft. radius for its preliminary zone (until a more detailed analytic method is available).

2. Calculated Fixed Radii

General Description: This method is based on the use of an equation to compute a fixed radius for a circular area of protection around a well or wellfield.

Example: Zone II of Florida's proposed two zone system is defined as a circle of a radius calculated using a volumetric equation that incorporates a time of 5-years, the well pumping rate, and aquifer porosity and saturated thickness.

3. Simplified Variable Shapes

General Description: Any method which attempts to incorporate site specific characteristics will result in an infinity of sizes and/or shapes. This method attempts to simplify the condition by selecting a small number of representative areal forms from the large array of potential possibilities. These standardized forms are then applied where ranges of conditions fit into appropriate categories, e.g., a form of predesignated shape and size is used for a specified range of well yield.

Example: This method of delineating WHPAs is most popular in Europe. For example, a water authority in Southern England uses methods which are based on uniform flow and time of travel equations in determining WHPAs. In these instances, the shapes of the "standardized" forms are developed by applying the analytical ground-water flow equations to sets of representative hydrogeologic parameters, e.g., generalized aquifer properties, directions of ground-water flow, hydraulic gradients and well yields.

4. Analytical Models

General Description: This method is based on the use of equation(s) to define ground-water flow or contaminant transport. For example, a general approach often-used defines the area of contribution to a pumping well in a sloping water table, i.e., the uniform flow equations (Todd, 1980).[1]

Example: Edgartown, MA, calculates the downgradient stagnation point and the envelope of the area of contribution using the uniform flow equations. The upgradient limit is set as the upgradient regional ground-water divide. Duxbury, MA delineates its Zone II using the uniform flow model to calculate distance to the downgradient stagnation point and the envelope of the area of contribution. The upgradient limit of Zone II is drawn as the geologic contact between the unconsolidated aquifer and bedrock having low permeability.

Cape Cod, MA uses a mass-balance approach in conjunction with pumping test data and analytical equations to determine the WHPA.

5. Geologic/Geomorphic Mapping (Combined with Analytical Flow Models, Fixed Radii, Aquifer Yield)

General Description: Geologic/geomorphic mapping is used to delineate the possible physical boundaries of the hydrogeologic system. Boundaries of WHPAs are in some cases divided into primary and secondary protection areas. Primary areas are delineated by known or inferred radii of influence based on simple formulae for various hydrogeologic settings. The applicable method used to outline the primary area depends upon

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1 Todd, D.K., 1980, Groundwater Hydrology, John Wiley & Sons, Inc.

aquifer type and the availability of site specific data. When data on aquifer parameters and/or information on ground-water recharge are available, simple analytical equations are used. When the data are not available, the primary area is drawn using circles of arbitrary distance around the well and/or geologists' experience. Secondary areas extend from the primary areas upslope, primarily based on surficial topography and the location of surface water divides.

Example: Vermont utilizes a method in which geologic/geomorphic mapping is combined with simplified fixed-ring calculations that are then modified by regional flow information. The Midstate Regional Planning Agency in Connecticut mapped its WHPAs using aquifer yield information and surface water basin morphology. Duxbury, MA also utilizes basin morphology to define the upgradient recharge area for its Zone III.

6. Numerical Flow/Transport Models

General Description: Numerical flow/transport models are used to delineate well field protection areas. This is done where boundary conditions are such that analytical models may not provide accurate results or in areas where the importance of the delineation warrants the most sophisticated or costly tools. The use of numerical models to delineate WHPAs is usually accomplished in two steps. First a hydraulic head field distribution is generated with a numerical flow model under a prescribed set of hydrologic conditions. The travel-distance zones are delineated using a solute transport model based in part on the hydraulic head field generated in the first step as input.

Example: The Florida counties of Broward, Dade and Palm Beach utilize a time of travel criterion to delineate their zones of protection. Palm Beach uses a 30 day travel time for Zone I, a

210 day travel time for Zone II and the greater of a 500 day travel time or a one foot drawdown contour for its Zone III. Broward and Dade Counties use travel times of 10 days, 30 days and 210 days (or 1 foot drawdown if larger) to designate their zones (NW wellfield in Dade County is based on 1/4' drawdown contour and/or an approximate 25-40 year TOT.)

7. Miscellaneous Methods

General Description: All of the WHPA delineation methods reviewed which are in current use or being proposed can be grouped in one of the previous six methodology categories. Consequently, only methods which are not normally associated with WHPA designation but which may have potential use are mentioned here.

Two methods may warrant future consideration, tracing (e.g., Isotope Study) and analytical fate and transport modeling. Each has been used in research or specific problem solving usually related to activities such as Karst ground-water flow analysis and characterization of pollution dispersion. The agency would be interested in knowing the suitability and application of these or other miscellaneous methods.

Matrix of WHPA Methods/Evaluation Factors

A matrix (Figure IV-3) has been developed to compare delineation methods against a number of evaluation factors that could influence the selection and/or application of a WHPA method. The blocks have been completed with proposed values for consideration by workshop participants. The factors used to evaluate the methods are defined as follows:

1. Ability to Understand the Method - Degree to which the principles underlying the method can be readily understood by hydrogeologist and non-technical people.

WHPA METHODS/EVALUATION FACTORS

METHOD	ABILITY TO UNDERSTAND METHOD L/M/H T	ABILITY TO UNDERSTAND METHOD L/M/H N	USER SOPHISTICATION L/M/H	EXTENT OF USE L/M/H	EXTENT OF INPUT DATA REQUIRED L/M/H	ABILITY TO INCORPORATE DIFFERENT HYDROGEOLOGIC CONDITIONS L/M/H	ACCURACY L/M/H	TIME TO IMPLEMENT METHOD L/M/H	COST L/M/H	DEGREE TO WHICH THE TECHNICAL BASIS CAN BE CHALLENGED L/M/H
1. ARBITRARY FIXED RADIUS	H	H	L	M-H	L	L	L	L	L	H
2. CALCULATED FIXED RADIUS	H	H	L	L-M	L-M	L	L	L	L	H
3. SIMPLIFIED VARIABLE SHAPES	H	M-H	L-M	L	L	L-M	L-M	M	L-M	M-H
4. ANALYTICAL FLOW MODELS	M-H	L-M	M-H	H	M	M-H	M	M	M	M
5. GEOLOGIC/ GEOMORPHIC MAPPING	M-H	L-M	M-H	M	M-H	M-H	M-H	M-H	M	L-M
6. NUMERICAL FLOW/ TRANSPORT MODELS	M	L	H	L-M	M-H	M-H	M-H	H	M-H	L-M
7. MISCELLANEOUS METHODS (TRACING)	M-H	M-H	M	L	M	L-M	M	M	L-M	L-M

L—LOW
M—MEDIUM
H—HIGH

T—TECHNICAL
N—NON-TECHNICAL

FIGURE IV-3

2. User Sophistication - Technical abilities of user necessary to understand the basis of the method and the input data requirements, to apply the method, and to evaluate method results.

3. Extent of Use - Identifies how commonly the method is used, e.g., whether it is presently used by regulatory agencies or in the process of being adopted.

4. Extent of Input Data Required - Amount and type of data required for method application; data may be site-specific (i.e., developed specifically for method application) or regional (i.e., approximate and already available).

5. Ability to Incorporate Different Hydrogeologic Conditions - Capabilities of the method to be applied to varied hydrogeologic conditions, such as "sources" and "sinks," boundary conditions, or variable aquifer parameters.

6. Accuracy - Degree to which the results from method application can be expected to compare with actual field conditions.

7. Time to Implement Method - Time required to adequately apply the method and evaluate results, in accordance with the qualitative, analytical, or numerical characteristics of the method.

8. Cost - Relative cost incurred in applying the method to one wellhead, well field, or main fields in a state, in terms of data acquisition, professional labor, computer time, graphics, reporting, etc.

9. Degree to Which Technical Basis can be Challenged - Degree to which the principles, accuracy and applicability of the method can be questioned by hydrogeologists and other technical people.

Team Discussion Session

Introduction

During this discussion session, team participants will be asked to focus on the merits of the different methods, the conditions under which they might be suitable, and decision making options that relate to methodology selection. The participant should review the matrix carefully, since many questions will be focused on this item.

A list of eight significant questions follows to help guide team discussions. Participant input is desired on as many of them as possible in the time available. Input and experience of the participants on other method-related information would also be valuable.

SIGNIFICANT QUESTIONS ON WHPA METHODS

A. HAVE ANY METHODS BEEN MISSED THAT YOU KNOW ARE BEING USED SOMEWHERE? BY WHOM?

B. IS THIS EVALUATION OF METHODS CORRECT IN YOUR EXPERIENCE AND WHAT CHANGES WOULD YOU MAKE IN THE MATRIX?

C. ARE THERE OTHER FACTORS WHICH WE SHOULD USE TO EVALUATE THE METHODS (FIGURE IV-3)?

D. WHAT ARE THE MAJOR WEAKNESSES AND STRENGTHS OF THE DIFFERENT DELINEATION METHODS?

E. WHAT ROLE SHOULD EPA PLAY IN THE SELECTION OF APPROPRIATE DELINEATION METHODS?

F. SHOULD A PHASED APPROACH TO METHOD SELECTION (E.G., AN ARBITRARY FIXED RADIUS REPLACED BY A CALCULATED ZONE AS MORE SITE SPECIFIC INFORMATION BECOMES AVAILABLE) BE UTILIZED? HOW WOULD IT BE STRUCTURED AND IMPLEMENTED?

G. WHAT METHOD PROVIDES THE MOST PROTECTION? THE LEAST?

H. SHOULD DELINEATION METHOD REQUIREMENTS BE RELATED TO DIFFERENT WELL SIZES OR NUMBERS OF USERS DEPENDENT ON A WELLHEAD? WHAT ELEMENTS SHOULD BE CONSIDERED AND HOW SHOULD SUCH METHODS BE STRUCTURED?

V

V.

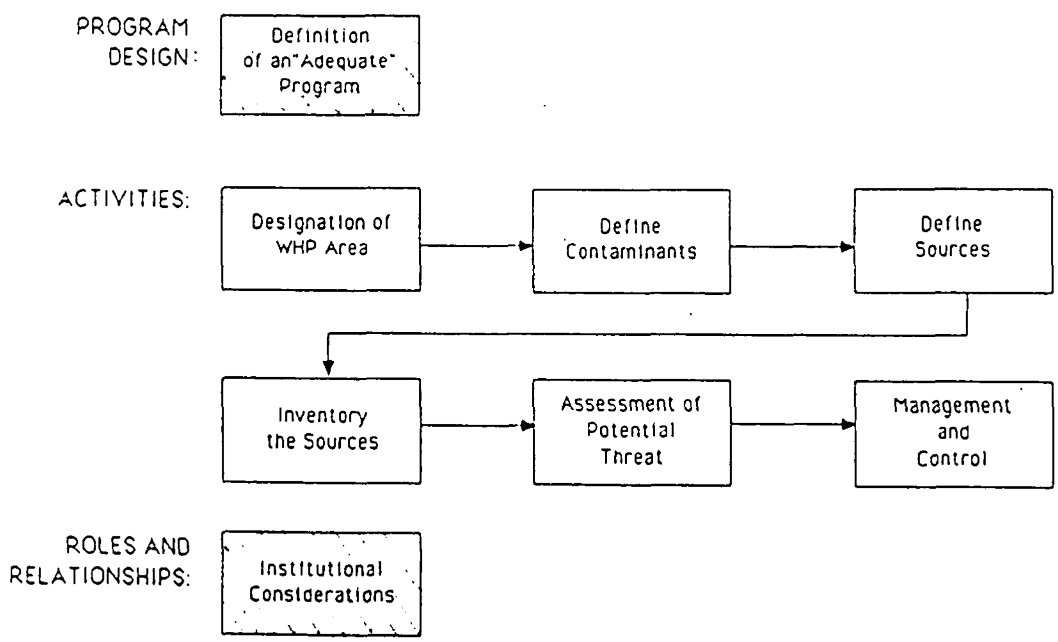
CROSS-CUTTING ISSUES

CHAPTER V
CROSS-CUTTING ISSUES

The previous chapters dealt specifically with questions concerning the guidance that EPA should develop to assist states in the delineation of WHP areas. The determination of the WHPA represents only one of the activities a state must undertake in developing a state WHP program that will be eligible for federal funding, as can be seen in Figure V-I below.

In another workshop to be held next week, participants will focus on the other five activities that make up a state's efforts in designing a WHP program.

FIGURE V - 1
Major Stages in Developing and Implementing a State WHP Program



In addition to specific technical considerations, the EPA would like each workshop to address what it refers to as cross-cutting issues. These additional issues, which are highlighted in Figure V-I above, are the definition of an adequate state WHP program and a review of institutional considerations, specifically the relationship among federal, state and local governments, that must be addressed in designing and implementing a WHP program.

Consideration of these questions is important to participants in both workshops if they are to adequately advise EPA on the development of guidances for both the hydrogeologic criteria and management protection plans.

DEFINITION OF AN "ADEQUATE" STATE WHP PROGRAM

This chapter first addresses the orientation of an "adequate" program to protect wellhead areas. According to Webster, "adequate" is defined as sufficient for a specific requirement, or as barely sufficient. EPA is not, then, charged with approving and providing funds for the best possible program, but for a satisfactory one. The guidance will, by necessity, allow for a great deal of flexibility on the part of various states to develope programs that adequately meet the goals of the Act; those that do are eligible to receive funds.

In this part of the session, participants will address two questions. The first is the key issue in determining whether or not the Administrator will approve a state-submitted program:

1. Which general programmatic approaches should EPA view as adequate?

The second considers the timing of actions taken in a state program:

2. On what basis may an adequate state program phase-in its delineation of wellheads and identification of sources?

ISSUE 1. WHICH PROGRAMMATIC APPROACHES SHOULD EPA VIEW AS ADEQUATE?

According to the statute, the EPA Administrator must disapprove a State program, or any portion of it, which is not adequate to protect public water systems from contaminants which may have any adverse effect on human health. In addition to this rather explicit statutory directive, the Congress has also directed EPA, in the conference report that accompanied passage of the law, to give states a great deal of flexibility in defining wellhead protection areas (WHPAs) and attendant protection programs. In the guidance, EPA must determine what overall standard it will use to determine whether a state program is "adequate" to meet the goals of the Act.

This general view of "adequacy" will have implications for the options discussed in later sessions on questions such as which potential contaminants and sources should be identified and what control measures should be applied.

Unlike later issues, where one or a few options may clearly be best for a particular issue, the question of what makes an adequate program has no single answer. There are many forms that an adequate program could take: it could be linked to a specific standard of ground-water quality, or it could be based on applying certain management practices to various potential pollutants.

In order to help OGWP develop its guidance on this matter, workshop participants will address the following question -- should EPA view the following programmatic approaches as adequate? If yes, are there certain conditions or circumstances under which a particular approach may not be adequate?

Given the breadth of this first issue, participants may conclude that all of the following options are acceptable; on the other hand, some may not fit in. Participants are encouraged to develop additional options as well. In reviewing any options, participants should consider the feasibility of implementing various options, and the statutory language.

Option 1 - One which provides for no degradation of ground-water quality

Advantages

- Would theoretically provide the highest level of protection to the ground-water resource and drinking water supply

- A number of states currently use this standard for the entire state or for highly sensitive areas

Disadvantages

- Implementation may well be infeasible in urban settings and beyond the financial and technical capacity of states and local entities

- States would have to develop elaborate models to show the program was working

Option 2 - One which provides wellhead protection by achieving drinking water standards for raw water entering the wellhead

Advantages

- Allows flexibility for source control measures as long as standards are met at the wellhead

- Extends requirements of the Act for finished water to raw water at the wellhead

Disadvantages

- Protects drinking water, but not necessarily the ground-water resource as a whole

- Does not address contaminants for which drinking water standards have not been issued

- States would have to develop models to apply this approach

- May be infeasible in urban and other areas

Option 3 - One which improves raw water quality to the extent that drinking water standards may be met using existing drinking water treatment technology

Advantages

- Easy to implement

- Would ensure that drinking water at the tap meets standards

Disadvantages

- May be inconsistent with the goals of the Act

- May discourage innovative source controls and encourage treatment of raw water

- Does not address contaminants for which there are no drinking water standards

- Inconsistent with most Federal and State ground-water programs which do not permit degradation of current drinking water supplies below drinking water standards

- Nearly all small systems drawing from ground water lack the ability to finance or maintain the sophisticated level of treatment needed to remove man-made chemicals

Option 4 - One which applies best management practices (BMP)/best engineering judgment (BEJ) to all sources of contamination within the WHPA

Advantages

- Focuses on attainment of technically and economically feasible quality standards in a given location

- Is similar to approach used in other EPA programs such as the Clean Air Act and Clean Water Act

Disadvantages

- BMP/BEJ may not lead to adequate levels of contaminants in ground water

- Requires definition of BMP/BEJ for a variety of sources

Option 5 - One that the State demonstrates is comparable with the approach of an adequate program as defined by the Technical Committee

Options 5 and 6 differ from the first four since adequacy is measured more subjectively. The first four options link adequacy to measurable indicators of water quality or to application of technology standards. Option 5 presumes development, by EPA's management protection plan committee, of a program scenario composed of elements selected from review of the options presented in both workshops. The State must then demonstrate how its program elements will produce effects similar to the EPA scenario.

Advantages

- The State is not limited to an overall goal that is infeasible or impractical in some cases

Disadvantages

- States must demonstrate how the effects of their approach compare with the effects of an acceptable program

- The program must describe the actions to be taken and their implementation; states could expand considerable effort in program development and rationalization

Option 6 - One that the State certifies has an objective that meets the statute's goal and its six specific elements

Like Option 5, Option 6 proposes a more subjective measure of adequacy. The State does not follow specific EPA guidelines, but instead certifies that its program will achieve the goal of the Act and includes the six elements listed in Section 1428(a).

Advantages

- Most flexible for the state

Disadvantages

- EPA would have difficulty ascertaining the effectiveness of the program
- States would lack a basis on which to judge EPA's action on their applications

ISSUE 2: ON WHAT BASIS MAY AN ADEQUATE STATE PROGRAM PHASE IN ITS DELINEATION OF WELLHEADS AND IDENTIFICATION OF SOURCES?

Section 1428(a) states that:

> "The Governor or Governor's designee of each State shall, within 3 years of the date of enactment of the Safe Drinking Water Act Amendments of 1986, adopt and submit to the Administrator a State program to protect wellhead ares within their jurisdiction from contaminants which may have any adverse effect on the health of persons."

Subsection 1428(d) further states that:

> "After the date 3 years after the enactment of this section, no State shall receive funds authorized to be appropriated under this section except for the purpose of implementing the program...."

The statute provides that after June 1989 States may receive funds only to implement their EPA-approved WHP programs that meet each of the program elements described in subsection 1428(a). States, therefore, will be ineligible for development funding after year three. In order to qualify for implementation funding, States will be required to submit their developed program plans to EPA for review and approval by the end of FY 89. Approved plans, then, will be eligible to receive implementation funding for subsequent program years.

EPA may have some latitude in interpreting the program requirements in subsection 1428(a) that States must meet in order to qualify for funding after FY 89. In considering this issue, EPA has determined that four of the six requirements present little problems in determining what must be required by year three. For example, 1428(a)(1) requires States to specify the duties of governmental entities that will have a part in the development and implementation of the State WHP program; States, therefore, would be required to provide EPA with a listing of each governmental unit involved. Such a requirement would place little burden on the State and is feasible within three years. A more complicated requirement is in Section 1428(a)(3):

> "identify within each wellhead protection area all potential anthropogenic sources of contaminants...."

These options deal with the timing of this requirement.

Option 1 - Within three years states must identify each WHPA around all public water systems[1] within its borders and identify specifically all sources of anthropogenic pollution within each wellhead; all activities for these elements are ineligible for funding after FY 89

Advantages

- Is the simplest option for which to provide implementation guidance to States
- Requires States to expedite their programs and would speed actual work for addressing potential WHP problems
- May help direct WHP funds to implementation rather than program development

Disadvantages

- Is not an implementable option in most States
- Does not take into account the limited amount of funds that States will probably receive and have available within the State to accomplish these actions
- Stresses completion of the program at the expense of more thorough planning and priority setting
- May limit State participation in the WHP program because the requirements are too strict

Option 2 - Within three years states must determine, through a mechanism such as a general rule, all WHPAs within its borders and identify generically all sources of anthropogenic pollution within each wellhead

Advantages

- States may refine (e.g., more fully characterize specific characteristics of WHPAs) these elements after FY 89 as a part of program implementation
- May help direct WHP monies to implementation rather than development; also would help expedite the actual "field work" of delineating and inventorying
- Better takes into account a State's financial and other resource limitations

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1 Public water systems include community water supply systems and non-community water supply systems, e.g., truck stops, restaurants, schools.

Disadvantages

- Presents problems in strictly definng "development" vs. "implementation" in guidance to recipients/applicants. Also may complicate EPA audits of recipients' financial records, since it may be very difficult to distinguish where development ends and implementation begins

- May limit State participation in the WHP program because the requirements are too strict

- May still be impractical to implement

Option 3 - Within three years states must determine WHPAs only for large (e.g., serving over 500 people) community water systems, and reserve smaller CWS and non-CWS for FY 90 and after; contamination sources are addressed generically

Advantages

- Provides clear priority for areas with higher population risk

- More realistic to implement

- Consistent with rules regarding public water system testing and State well registration programs

Disadvantages

- Phasing is inconsistent with statute

- Ignores factors other than population that may increase risk in a wellhead

Option 4 - Within three years states must submit only plans for determining WHPAs and identifying pollution sources; costs for developing these plans are ineligible for funding after FY 89, but States can receive funding for implementing these plans later

Advantages

- More time available to set priorities

- Takes into account States' differing capabilities, resource availability, and workloads

- Will allow for more State participation in the WHP program than either Option 1 or 2

Disadvantages

- Does not fulfill the statutory requirements of Section 1428(d)

- Directs a higher proportion of WHP authorized funds to planning rather than delineating wellhead areas and inventorying sources

- Like Option 2, may pose a problem to EPA in defining the exact point where development ends and implementation begins

INSTITUTIONAL CONSIDERATIONS

During the remainder of this session of the workshop, participants will be asked to address the final topics of concern, namely the roles and relationships of state and local authorities in effectively implementing and enforcing a wellhead protection program. The key questions are:

1. To what extent would an adequate program make use of or enhance existing state and local programs and regulatory requirements to carry out protection for WHP areas?

2. To what extent must the implementing agency demonstrate, in the program application, its ability to ensure coordination in implementation of the plan by appropriate state and local entities?

The applicable statutory language, Subsection 1428(a), requires that an adequate program:

> "specify the duties of state agencies, local governmental entities, and public water supply systems with respect to the development and implementation of programs required by this section."

Underlying these issues is EPA's recognition of the sensitivity that it must bring to bear in dealing with the state and local governments in areas such as land use and ground-water protection. To the extent possible, EPA wants to ensure that the WHP program is administered in a manner that is consistent with existing State ground-water protection strategies and plans.

The major question for participants to address is how does EPA, while respecting the primary role of the states, ensure that sufficient coordination will occur to allow for the implementation of an adequate program?

ISSUE 3 - TO WHAT EXTENT WOULD AN ADEQUATE PROGRAM MAKE USE OF OR ENHANCE EXISTING STATE AND LOCAL PROGRAMS AND REGULATORY REQUIREMENTS TO CARRY OUT PROTECTION FOR WHP AREAS

The subquestion to this issue is, in implementing an adequate program, should the state create a new agency or institution, or should it employ existing state and local programs.

Option 1 - An adequate program will utilize, to the maximum extent possible, existing state statutes, regulations, and agencies

Advantages

- No need for new state bureaucracy
- Avoids duplication of effort
- More expeditious implementation

Disadvantages

- May have program conflicts within existing agencies
- May lack authority in dealing with non-related state agencies or with federal agencies

Option 2 - Encourage, where possible, new institutions to implement the programs

Advantages

- Institutions could be specifically tailored to the needs of the program

Disadvantages

- Could lead to duplication of effort with existing State and local programs
- May be more costly to the states

Option 3 - An adequate program need not address this question

Advantages

- Maximum flexibility to state

Disadvantages

- Could limit integration with existing state program
- Would not fulfill statutory requirement to indicate the roles of state and local agencies in developing and implementing the programs

ISSUE 4 - TO WHAT EXTENT MUST THE IMPLEMENTING AGENCY DEMONSTRATE, IN THE PROGRAM APPLICATION, ITS ABILITY TO ENSURE COORDINATION IN IMPLEMENTATION OF THE PLAN BY APPROPRIATE STATE AND LOCAL ENTITIES

Implementation of an adequate program may well require that a number of diverse agencies and services operate together in new ways. For example, local zoning agencies may have to coordinate efforts with public health agencies.

The means of achieving such coordination could include:

- New state legislation authorizing a designated implementing agency to manage and coordinate all State agencies and local entities for the purposes of carrying out the WHP program

- A Governor's executive order establishing a special task force, commission or oversight committee to manage and coordinate all State agencies and local entities participating in the WHP program

- A Governor's designation of a lead agency to manage and coordinate all State agencies and local entities participating in the WHP program

In all cases, the test of adequacy will be whether there is sufficient management and coordination authority to administer the program's operational requirements.

Option 1 - Require that the identified State Implementing Agency demonstrate some statutory authority by which it can manage and coordinate the program among all participating entities

Advantages

- Would provide a legal basis for adequate program management and coordination among several agencies and entities at both the State and local levels of activity

Disadvantages

- May not be legally feasible

- May take too long

Option 2 - Require a demonstration of some administrative mechanism (e.g., a Governor's Task Force or Oversight Committee) by which program management and coordination will occur

Advantages

- Could provide adequate program management and coordination without need for new legislation

Disadvantages

- May not be effective without statutory underpinning

Option 3 - Require identification of a lead agency to be responsible for managing and coordinating the efforts of program implementation

Advantages

- Is the simplest means of providing program management and coordination

Disadvantages

- Mere designation of a lead agency may not adequately ensure needed coordination

- May cause "turf" problems within a state

Option 4 - Require no showing of management and coordination ability: simply require a listing of duties by Agency or jurisdiction

Advantages

- Maximum flexibility to the states

Disadvantages

- This option is the least likely to provide adequate program management and coordination

APPENDIX A: Safe Drinking Water Act Ammendments of 1986

SEC. 203. SOLE SOURCE AQUIFER DEMONSTRATION PROGRAM.

Part C of the Safe Drinking Water Act is amended by adding the following new section after section 1426:

"SEC. 1427. SOLE SOURCE AQUIFER DEMONSTRATION PROGRAM.

"(a) PURPOSE.—The purpose of this section is to establish procedures for development, implementation, and assessment of demonstration programs designed to protect critical aquifer protection areas located within areas designated as sole or principal source aquifers under section 1424(e) of this Act.

"(b) DEFINITION.—For purposes of this section, the term 'critical aquifer protection area' means either of the following:

"(1) All or part of an area located within an area for which an application or designation as a sole or principal source aquifer pursuant to section 1424(e), has been submitted and approved by the Administrator not later than 24 months after the enactment of the Safe Drinking Water Act Amendments of 1986 and which satisfies the criteria established by the Administrator under subsection (d).

"(2) All or part of an area which is within an aquifer designated as a sole source aquifer as of the enactment of the Safe Drinking Water Act Amendments of 1986 and for which an areawide ground water quality protection plan has been approved under section 208 of the Clean Water Act prior to such enactment.

"(c) APPLICATION.—Any State, municipal or local government or political subdivision thereof or any planning entity (including any interstate regional planning entity) that identifies a critical aquifer protection area over which it has authority or jurisdiction may apply to the Administrator for the selection of such area for a demonstration program under this section. Any applicant shall consult with other government or planning entities with authority or jurisdiction in such area prior to application. Applicants, other than the Governor, shall submit the application for a demonstration program jointly with the Governor.

"(d) CRITERIA.—Not later than 1 year after the enactment of the Safe Drinking Water Act Amendments of 1986, the Administrator shall, by rule, establish criteria for identifying critical aquifer pro-

tection areas under this section. In establishing such criteria, the Administrator shall consider each of the following:

"(1) The vulnerability of the aquifer to contamination due to hydrogeologic characteristics.

"(2) The number of persons or the proportion of population using the ground water as a drinking water source.

"(3) The economic, social and environmental benefits that would result to the area from maintenance of ground water of high quality.

"(4) The economic, social and environmental costs that would result from degradation of the quality of the ground water.

"(e) CONTENTS OF APPLICATION.—An application submitted to the Administrator by any applicant for a demonstration program under this section shall meet each of the following requirements:

"(1) The application shall propose boundaries for the critical aquifer protection area within its jurisdiction.

"(2) The application shall designate or, if necessary, establish a planning entity (which shall be a public agency and which shall include representation of elected local and State governmental officials) to develop a comprehensive management plan (hereinafter in this section referred to as the 'plan') for the critical protection area. Where a local government planning agency exists with adequate authority to carry out this section with respect to any proposed critical protection area, such agency shall be designated as the planning entity.

"(3) The application shall establish procedures for public participation in the development of the plan, for review, approval, and adoption of the plan, and for assistance to municipalities and other public agencies with authority under State law to implement the plan.

"(4) The application shall include a hydrogeologic assessment of surface and ground water resources within the critical protection area.

"(5) The application shall include a comprehensive management plan for the proposed protection area.

"(6) The application shall include the measures and schedule proposed for implementation of such plan.

"(f) COMPREHENSIVE PLAN.—

"(1) The objective of a comprehensive management plan submitted by an applicant under this section shall be to maintain the quality of the ground water in the critical protection area in a manner reasonably expected to protect human health, the environment and ground water resources. In order to achieve such objective, the plan may be designed to maintain, to the maximum extent possible, the natural vegetative and hydrogeological conditions. Each of the following elements shall be included in such a protection plan:

"(A) A map showing the detailed boundary of the critical protection area.

"(B) An identification of existing and potential point and nonpoint sources of ground water degradation.

"(C) An assessment of the relationship between activities on the land surface and ground water quality.

"(D) Specific actions and management practices to be implemented in the critical protection area to prevent adverse impacts on ground water quality.

"(E) Identification of authority adequate to implement the plan, estimates of program costs, and sources of State matching funds.

"(2) Such plan may also include the following:

"(A) A determination of the quality of the existing ground water recharged through the special protection area and the natural recharge capabilities of the special protection area watershed.

"(B) Requirements designed to maintain existing underground drinking water quality or improve underground drinking water quality if prevailing conditions fail to meet drinking water standards, pursuant to this Act and State law.

"(C) Limits on Federal, State, and local government, financially assisted activities and projects which may contribute to degradation of such ground water or any loss of natural surface and subsurface infiltration of purification capability of the special protection watershed.

"(D) A comprehensive statement of land use management including emergency contingency planning as it pertains to the maintenance of the quality of underground sources of drinking water or to the improvement of such sources if necessary to meet drinking water standards pursuant to this Act and State law.

"(E) Actions in the special protection area which would avoid adverse impacts on water quality, recharge capabilities, or both.

"(F) Consideration of specific techniques, which may include clustering, transfer of development rights, and other innovative measures sufficient to achieve the objectives of this section.

"(G) Consideration of the establishment of a State institution to facilitate and assist funding a development transfer credit system.

"(H) A program for State and local implementation of the plan described in this subsection in a manner that will insure the continued, uniform, consistent protection of the critical protection area in accord with the purposes of this section.

"(I) Pollution abatement measures, if appropriate.

"(g) PLANS UNDER SECTION 208 OF THE CLEAN WATER ACT.—A plan approved before the enactment of the Safe Drinking Water Act Amendments of 1986 under section 208 of the Clean Water Act to protect a sole source aquifer designated under section 1424(e) of this Act shall be considered a comprehensive management plan for the purposes of this section.

"(h) CONSULTATION AND HEARINGS.—During the development of a comprehensive management plan under this section, the planning entity shall consult with, and consider the comments of, appropriate officials of any municipality and State or Federal agency which has jurisdiction over lands and waters within the special protection

area, other concerned organizations and technical and citizen advisory committees. The planning entity shall conduct public hearings at places within the special protection area for the purpose of providing the opportunity to comment on any aspect of the plan.

"(i) APPROVAL OR DISAPPROVAL.—Within 120 days after receipt of an application under this section, the Administrator shall approve or disapprove the application. The approval or disapproval shall be based on a determination that the critical protection area satisfies the criteria established under subsection (d) and that a demonstration program for the area would provide protection for ground water quality consistent with the objectives stated in subsection (f). The Administrator shall provide to the Governor a written explanation of the reasons for the disapproval of any such application. Any petitioner may modify and resubmit any application which is not approved. Upon approval of an application, the Administrator may enter into a cooperative agreement with the applicant to establish a demonstration program under this section.

"(j) GRANTS AND REIMBURSEMENT.—Upon entering a cooperative agreement under subsection (i), the Administrator may provide to the applicant, on a matching basis, a grant of 50 per centum of the costs of implementing the plan established under this section. The Administrator may also reimburse the applicant of an approved plan up to 50 per centum of the costs of developing such plan, except for plans approved under section 208 of the Clean Water Act. The total amount of grants under this section for any one aquifer, designated under section 1424(e), shall not exceed $4,000,000 in any one fiscal year.

"(k) ACTIVITIES FUNDED UNDER OTHER LAW.—No funds authorized under this subsection may be used to fund activities funded under other sections of this Act or the Clean Water Act, the Solid Waste Disposal Act, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 or other environmental laws.

"(l) REPORT.—Not later than December 31, 1989, each State shall submit to the Administrator a report assessing the impact of the program on ground water quality and identifying those measures found to be effective in protecting ground water resources. No later than September 30, 1990, the Administrator shall submit to Congress a report summarizing the State reports, and assessing the accomplishments of the sole source aquifer demonstration program including an identification of protection methods found to be most effective and recommendations for their application to protect ground water resources from contamination whenever necessary.

"(m) SAVINGS PROVISION.—Nothing under this section shall be construed to amend, supersede or abrogate rights to quantities of water which have been established by interstate water compacts, Supreme Court decrees, or State water laws; or any requirement imposed or right provided under any Federal or State environmental or public health statute.".

SEC. 204. EMERGENCY POWERS.

Section 1431 of the Safe Drinking Water Act is amended as follows:

(1) In the first sentence of subsection (a) add the words "or an underground source of drinking water" after the words "to enter a public water system".

(2) In the last sentence of subsection (a) add "including orders requiring the provision of alternative water supplies by persons who caused or contributed to the endangerment," after the words "including travelers),".

(3) In subsection (b):

(A) Strike "willfully".

(B) Strike "fined not more than" and insert in lieu thereof "subject to a civil penalty of not to exceed".

SEC. 205. STATE PROGRAMS TO ESTABLISH WELLHEAD PROTECTION AREAS.

The Safe Drinking Water Act is amended by adding the following new section after section 1427, as added by section 203 of this Act:

"SEC. 1428. STATE PROGRAMS TO ESTABLISH WELLHEAD PROTECTION AREAS.

"(a) STATE PROGRAMS.—The Governor or Governor's designee of each State shall, within 3 years of the date of enactment of the Safe Drinking Water Act Amendments of 1986, adopt and submit to the Administrator a State program to protect wellhead areas within their jurisdiction from contaminants which may have any adverse affect on the health of persons. Each State program under this section shall, at a minimum—

"(1) specify the duties of State agencies, local governmental entities, and public water supply systems with respect to the development and implementation of programs required by this section;

"(2) for each wellhead, determine the wellhead protection area as defined in subsection (e) based on all reasonably available hydrogeologic information on ground water flow, recharge and discharge and other information the State deems necessary to adequately determine the wellhead protection area;

"(3) identify within each wellhead protection area all potential anthropogenic sources of contaminants which may have any adverse effect on the health of persons;

"(4) describe a program that contains, as appropriate, technical assistance, financial assistance, implementation of control measures, education, training, and demonstration projects to protect the water supply within wellhead protection areas from such contaminants;

"(5) include contingency plans for the location and provision of alternate drinking water supplies for each public water system in the event of well or wellfield contamination by such contaminants; and

"(6) include a requirement that consideration be given to all potential sources of such contaminants within the expected wellhead area of a new water well which serves a public water supply system.

"(b) PUBLIC PARTICIPATION.—To the maximum extent possible, each State shall establish procedures, including but not limited to the establishment of technical and citizens' advisory committees, to encourage the public to participate in developing the protection pro-

gram for wellhead areas. Such procedures shall include notice and opportunity for public hearing on the State program before it is submitted to the Administrator.

"(c) DISAPPROVAL.—

"(1) IN GENERAL.—If, in the judgment of the Administrator, a State program (or portion thereof, including the definition of a wellhead protection area), is not adequate to protect public water systems as required by this section, the Administrator shall disapprove such program (or portion thereof). A State program developed pursuant to subsection (a) shall be deemed to be adequate unless the Administrator determines, within 9 months of the receipt of a State program, that such program (or portion thereof) is inadequate for the purpose of protecting public water systems as required by this section from contaminants that may have any adverse effect on the health of persons. If the Administrator determines that a proposed State program (or any portion thereof) is inadequate, the Administrator shall submit a written statement of the reasons for such determination to the Governor of the State.

"(2) MODIFICATION AND RESUBMISSION.—Within 6 months after receipt of the Administrator's written notice under paragraph (1) that any proposed State program (or portion thereof) is inadequate, the Governor or Governor's designee, shall modify the program based upon the recommendations of the Administrator and resubmit the modified program to the Administrator.

"(d) FEDERAL ASSISTANCE.—After the date 3 years after the enactment of this section, no State shall receive funds authorized to be appropriated under this section except for the purpose of implementing the program and requirements of paragraphs (4) and (6) of subsection (a).

"(e) DEFINITION OF WELLHEAD PROTECTION AREA.—As used in this section, the term 'wellhead protection area' means the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield. The extent of a wellhead protection area, within a State, necessary to provide protection from contaminants which may have any adverse effect on the health of persons is to be determined by the State in the program submitted under subsection (a). Not later than one year after the enactment of the Safe Drinking Water Act Amendments of 1986, the Administrator shall issue technical guidance which States may use in making such determinations. Such guidance may reflect such factors as the radius of influence around a well or wellfield, the depth of drawdown of the water table by such well or wellfield at any given point, the time or rate of travel of various contaminants in various hydrologic conditions, distance from the well or wellfield, or other factors affecting the likelihood of contaminants reaching the well or wellfield, taking into account available engineering pump tests or comparable data, field reconnaissance, topographic information, and the geology of the formation in which the well or wellfield is located.

"(f) PROHIBITIONS.—

"(1) ACTIVITIES UNDER OTHER LAWS.—No funds authorized to be appropriated under this section may be used to support activities authorized by the Federal Water Pollution Control Act, the Solid Waste Disposal Act, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, or other sections of this Act.

"(2) INDIVIDUAL SOURCES.—No funds authorized to be appropriated under this section may be used to bring individual sources of contamination into compliance.

"(g) IMPLEMENTATION.—Each State shall make every reasonable effort to implement the State wellhead area protection program under this section within 2 years of submitting the program to the Administrator. Each State shall submit to the Administrator a biennial status report describing the State's progress in implementing the program. Such report shall include amendments to the State program for water wells sited during the biennial period.

"(h) FEDERAL AGENCIES.—Each department, agency, and instrumentality of the executive, legislative, and judicial branches of the Federal Government having jurisdiction over any potential source of contaminants identified by a State program pursuant to the provisions of subsection (a)(3) shall be subject to and comply with all requirements of the State program developed according to subsection (a)(4) applicable to such potential source of contaminants, both substantive and procedural, in the same manner, and to the same extent, as any other person is subject to such requirements, including payment of reasonable charges and fees. The President may exempt any potential source under the jurisdiction of any department, agency, or instrumentality in the executive branch if the President determines it to be in the paramount interest of the United States to do so. No such exemption shall be granted due to the lack of an appropriation unless the President shall have specifically requested such appropriation as part of the budgetary process and the Congress shall have failed to make available such requested appropriations.

"(i) ADDITIONAL REQUIREMENT.—

"(1) IN GENERAL.—In addition to the provisions of subsection (a) of this section, States in which there are more than 2,500 active wells at which annular injection is used as of January 1, 1986, shall include in their State program a certification that a State program exists and is being adequately enforced that provides protection from contaminants which may have any adverse effect on the health of persons and which are associated with the annular injection or surface disposal of brines associated with oil and gas production.

"(2) DEFINITION.—For purposes of this subsection, the term 'annular injection' means the reinjection of brines associated with the production of oil or gas between the production and surface casings of a conventional oil or gas producing well.

"(3) REVIEW.—The Administrator shall conduct a review of each program certified under this subsection.

"(4) DISAPPROVAL.—If a State fails to include the certification required by this subsection or if in the judgment of the Administrator the State program certified under this subsection is not being adequately enforced, the Administrator shall disap-

prove the State program submitted under subsection (a) of this section.

"(j) COORDINATION WITH OTHER LAWS.—Nothing in this section shall authorize or require any department, agency, or other instrumentality of the Federal Government or State or local government to apportion, allocate or otherwise regulate the withdrawal or beneficial use of ground or surface waters, so as to abrogate or modify any existing rights to water established pursuant to State or Federal law, including interstate compacts.".

APPENDIX B: SSA Congressional Conference Report

SECTION 203—SOLE SOURCE AQUIFER DEMONSTRATION PROGRAM

Senate bill.—The Senate bill establishes administrative procedures for the development, implementation, and assessment of demonstration programs designed to protect ground water resources within designated sole source aquifer areas.

The Administrator is required, within 16 months of enactment, to establish criteria for identifying "critical aquifer protection areas" within sole source aquifer areas designated under Section 1424(e) of the Act by the date of enactment.

Any government or any planning entity that identifies a "critical aquifer protection area" over which it has authority or jurisdiction may apply to the Administrator for the selection of such area for a demonstration program.

The provision establishes specific elements that are to be included in such application. The Administrator must approve or disapprove the application within 120 days of receipt. Upon approval of an application, the Administrator may enter into a cooperative agreement with the applicant to establish a demonstration program and may provide, on a matching basis, a grant of 50 per cent of the costs of developing and implementing the plan.

An annual authorization of $20,000,000 is provided for grants for fiscal years 1987–1990. The total amount of grants for any designated sole source aquifer in a fiscal year shall not exceed $4,000,000.

Each State participating in the program is required to submit a report to the Administrator no later than December 31, 1989, assessing the impact of the program. No later than September 30, 1990, the Administrator is required to submit a report to Congress summarizing State reports and assessing the accomplishments of the sole source aquifer demonstration program.

House amendment.—The House amendment establishes procedures for the development and implementation of a protection program for any aquifer designated as a sole or principal source aquifer under section 1424(e) of the Act. Upon designation of a sole or principal source aquifer, any municipality within the area may initiate proceedings for the designation of a "special protection area" within such area by petitioning the Governor to apply to the Administrator for such designation. A petition must contain hydrogeologic and other information specified in the provision.

If the Administrator approves the petition, the Administrator is authorized to provide to the State, on a matching basis, a grant of 50 percent of the costs incurred in preparing the petition and developing the plan. After such approval, the planning entity is directed to prepare a comprehensive management plan for the special protection area. Plans are required to include thirteen elements specified in the House bill. The Administrator is authorized to provide to the State a matching grant of 50 percent of the costs of implementing the plan (60 percent in the case of an aquifer serving a population of 10,000 or less).

The amendment also prohibits the disposal of solid waste over the unconsolidated Quarternary aquifer in the Rockaway River Basin, New Jersey, currently designated as a sole or principal source aquifer under section 1424(e) of the Act, or the recharge zone or streamflow source zone of that aquifer.

Conference agreement.—The Conference agreement adopts a provision combining the House and Senate language with modifications.

The provision establishes procedures for the development, implementation, and assessment of demonstration programs designed to protect critical aquifer protection areas located within areas designated as sole or principal source aquifers under section 1424(e) of the Act. A critical aquifer protection area is defined as: (1) all or part of an area located within an area for which an application or designation as a sole or principal source aquifer (pursuant to section 1424(e)) has been submitted and approved by the Administrator not later than 24 months after the date of enactment and which satisfies the criteria established by the Adminstrator; and (2) all or part of an area which is within an aquifer designated as a sole source aquifer, as of the date of enactment of these amendments, and for which an areawide ground water quality protection plan has been approved under section 208 of the Clean Water Act prior to such enactment.

Any State, municipal or local government or political subdivision thereof or any planning entity that identifies a critical aquifer protection area over which it has authority or jurisdiction may apply to the Administrator for the selection of such area for a demonstration program. Applicants, other than the Governor, shall submit an application jointly with the Governor.

The Administrator is required to establish criteria, not later than one year from the date of enactment, for identifying "critical aquifer protection areas." In establishing such criteria, the Administrator shall consider a number of specified hydrogeologic, economic, social and environmental factors.

An application submitted to the Administrator by any applicant is required to: (1) propose boundaries for the critical aquifer protection area within its jurisdiction; (2) to designate a planning entity to develop a comprehensive management plan for the critical protection area; (3) establish procedures for public participation; (4) include a hydrogeologic assessment of surface and ground water resources within the critical protection area; (5) include a comprehensive management plan for the proposed protection area; and (6) include the measures and schedule proposed for implementation of such plan.

The provision specifies elements to be included in a protection plan, the objective of which should be to maintain the quality of the ground water in the critical protection area in a manner reasonably expected to protect human health, the environment and ground water resources. There are a number of additional elements specified that states may choose to include in a plan to meet this objective.

Within 120 days after receipt of an application under this section, the Administrator must approve or disapprove the application based on a determination that the critical protection area satisfies the established criteria and that a demonstration program for the area would provide protection for ground water quality consistent with the stated objectives.

Upon approval of an application, the Administrator may enter into a cooperative agreement with the applicant to establish a demonstration program and provide to the applicant, on a matching basis, a grant of 50 per cent of the costs of implementing the plan. The Administrator may also reimburse the applicant of an approved plan up to 50 per cent of the costs of developing a plan, except for plans approved under section 208 of the Clean Water Act. The total amount of grants under this section for any one aquifer, designated under section 1424(e), shall not exceed $4,000,000 in any one fiscal year.

No funds authorized under this subsection may be used to fund activities funded under other sections of this Act or the Clean

Water Act, the Solid Waste Disposal Act, the Comprehensive Environmental Response, Compensation and Liability Act of 1980 or other Federal environmental statutes.

States are required, not later than December 31, 1989, to submit to the Administrator a report assessing the impact of the program on ground water quality and identifying those measures found to be effective in protecting ground water resources. No later than September 30, 1990, the Administrator is required to submit to Congress a report summarizing the State reports, and assessing the accomplishments of the sole source aquifer demonstration program.

The provision establishes that nothing under this section is to be construed to amend, supersede or abrogate rights to quantities of water which have been established by interstate water compacts, Supreme Court decrees, or State water laws; or any requirement imposed or right provided under any Federal or State environmental or public health statute.

SECTION 204—EMERGENCY POWERS

Senate bill.—The Senate bill has no provision.

House amendment.—The House amendment provides that if the Administrator or the delegated State enforcement authority determines that any person has caused or contributed to the presence of any contaminant that may adversely effect the health of persons in any sole or principal source aquifer (designated under section 1424(e)), which supplies or can be expected to supply a public water system, then either authority may issue an order requiring such persons to provide adequate supplies of potable drinking water to the persons served by the public water system. Provisions for judicial review of such orders and civil penalties are also established.

Conference agreement.—The conference agreement changes the House language to clarify the Administrator's existing authority to take such action as deemed necessary upon receipt of information that a contaminant, which is present in or is likely to enter a public water system or underground source of drinking water, may present an imminent substantial endangerment to the health of persons and that appropriate State and local action have not been taken. Such action may include orders requiring the provision of alternative water supplies by persons who caused or contributed to the endangerment.

SECTION 205—STATE PROGRAMS TO ESTABLISH WELLHEAD PROTECTION AREAS

Senate bill.— The Senate bill has no provision.

House amendment.—The House bill requires States to submit to the Administrator a comprehensive plan to protect current and potential sources of drinking water within three years of the date of enactment.

Each plan must: (1) specify the agency responsible for implementing the plan; (2) identify each underground source of drinking water in the State and describe the characteristics of each source; (3) describe the location and types of human development which affect each source; (4) set out the regulations and other measures (including best management practices) for activities that may contaminate sources; and (5) guarantee or provide for an alternative drinking water supply when an underground drinking water source is contaminated.

Each State is to make every reasonable effort to implement the State plan under this section within two years of its adoption. Within two years after the approval of each State plan under this section, each State is to submit to the Administrator a status report describing the State's progress in implementing the plan.

A State that has not complied with the requirements of this section may not receive assistance for its underground injection control program established under the Act.

Conference agreement.—In a new Section 205, the conference modifies the House provision and requires each State to submit a program within three years to protect wellhead areas within its jurisdiction from contaminants that may have any adverse effect on the health of persons. The purpose of such programs is to protect underground drinking water supplies from such contamination.

Each program must: (1) specify the duties of State and local agencies and public water systems with respect to the development and implementation of programs; (2) determine the wellhead projection area based on all reasonably available hydrogeologic information on flow, recharge and discharge and other information the State deems necessary to adequately determine the area; (3) identify within each protection area all potential anthropogenic sources of contaminants which may have any adverse effect on the health of persons; (4) describe a program that contains, as appropriate, technical or financial assistance, implementation of control measures, education, training and demonstration projects to protect the water supply within wellhead protection areas; (5) include contingency plans for locating and providing alternate drinking water supplies in the event of contamination of a water supply; and (6) require consideration of all potential anthropogenic sources of contaminants within the expected wellhead area of a new water well.

A wellhead protection area is defined as the surface or subsurface area, surrounding a water well or wellfield supplying a public water system, through which contaminants are likely to move toward and reach the well or wellfield. The State is to determine the extent of the wellhead protection area so as to provide protection from contaminants that may have any adverse effect on the health of persons.

Within one year of enactment, the Administrator is to provide technical guidance that the States may use to determine the protection area. The guidance is to reflect factors affecting the likelihood of contaminants reaching the well or wellfield.

Each State has the responsibility for defining the wellhead protection areas within that State as required by the definition in this section. This section does not, however, limit the existing authority of States to manage, regulate, protect, or identify groundwater resources. A State may, in its discretion, identify areas of significant recharge not contiguous to a well or wellfield in defining a wellhead protection area under this section.

With respect to identification of sources of contamination within the protection area, the term "anthropogenic sources" means those sources resulting directly or indirectly from human activities.

Therefore, State inventories of potential sources of contamination should include those sources that are man-made and contribute primarily man-made contaminants and those sources created by human activities that result in the concentration and movement of naturally-occurring contaminants in or toward a well. Specifically, however, the mere drawing down of water in a well should not be considered an "anthropogenic source".

Each State has the responsibility of determining how best to describe a program to protect the water supply within each protection area in the State. The provision is structured to afford States maximum flexibility in formulating a protection strategy. A State is not required to develop a regulatory program unless it chooses to do so; a program incorporating one or more of the following elements—technical and financial assistance, education and training, and demonstration projects—could be determined by a State to achieve the required protection.

States can be expected to take a wide variety of approaches to protection of wellhead areas within their jurisdiction, and it is conceivable that each State could develop its own unique approach. Protection strategies may also vary for different protection areas within one State. The amendment recognizes that States are best able to assess specific problems within their jurisdictions, and to develop and implement necessary protection measures. As a result, no groundwater classification assigned by the Administrator is to lessen the level of protection assigned to an aquifer by the State in a wellhead protection area.

The Administrator is granted authority to disapprove a State's program if it does not include one or more of the required enumerated elements and is, therefore, not adequate to protect public water systems as required by this section. If after nine months, the Administrator has not disapproved a program, it will be deemed to be approved.

Because of the important State role in protecting groundwater, the Administrator's disapproval authority should be used judiciously. In the event a program is disapproved, the Administrator must submit to the Governor a written statement of the reasons for disapproval, and the State must modify and resubmit the program within six months.

The penalty for failure of a State to have an approved program is that the State will not be eligible for Federal funds to implement the program, beginning three years after enactment. This is the only penalty for failure to develop an adequate plan.✓

Federal agencies having jurisdiction over any potential source of contaminants identified by a State program must comply with all applicable requirements of the State program, including payment of reasonable charges and fees, in the same manner and to the same extent as any other person. The President may exempt individual sources after determining it to be in the paramount interest of the United States to do so, but no exemption can be made because of a lack of funds unless the President requested adequate funds and Congress failed to appropriate them. This provision is not intended to modify or alter obligations and responsibilities under other Federal or State laws. Moreover, it cannot operate to waive or limit more stringent requirements established under such other laws.

An additional requirement of this section applies to any State in which there are more than 2500 active wells at which annular injection of brines associated with oil or gas production, is used as of January 1, 1986. Any such State must include in its program a certification to the Administrator that a State program exists and is being adequately enforced that provides protection from contaminants which may have any adverse effect on the health of persons and which are associated with the annular injection or surface disposal of brines associated with oil and gas production. The Administrator's review under this provision is to assure that the required certification is submitted by the State and to assure, on the basis of existing information reasonably available to him, that the program is adequately enforced. Such review should be limited to the question of certification and enforcement and will not affect separate determinations under this Act, such as the granting of primacy to a State under the UIC program. Brine presents the most significant problem in the State of Ohio, which has older oil and gas-producing wells. As the product depletes, brine makes up a higher proportion of the fluid pumped and so creates a more pressing disposal problem. This provision, therefore, is particularly aimed at Ohio, which has proven to be remiss in its enforcement of brine-related problems.

The conference substitute clarifies that nothing in this Act authorizes or requires activity by any government entity which would alter existing water rights or priorities. While not authorizing or requiring any such government activity, neither does it limit the existing authority of States to manage, regulate, protect, or identify groundwater resources within their jurisdiction.

In order to assure that the monies authorized to be appropriated under this section are directed toward making state groundwater protection efforts as effective as possible, the conference substitute states that such funds cannot be used to support activities under other Federal Acts or other sections of this Act.

APPENDIX C: List of State WHPA Methods References

STATE	REFERENCE DOCUMENT
MASSACHUSETTS	2. Heath, D.L., "Hydrogeologic Considerations of Zone of Contribution Methods Used By Cape Cod Planning and Economic Development Commission and SEA Consultants, Inc. for Public Supply Wells in Barnstable, Massachusetts," (Office of Groundwater Protection U.S. Environmental Protection Agency)
	3. Gallagher, T. and Nickerson, S., "The Cape Cod Aquifer Management Project: A Multi-Agency Approach to Ground Water Protection," Proceedings of the National Water Well Association Third Annual Eastern Regional Ground-Water Conference, (1986)
	4. Roy, Steven P., and Drake, John T., "Development of the Massachusetts Ground-Water Monitoring Program," p. 145-149
	5. Evaluation of Approaches to Determine Recharge Areas for Public Supply Wells, Report, (Cape Cod Aquifer Management Project Aquifer Assessment Committee, April 1986)
	6. Edgartown Water Resource Protection Program, Final Report, (Anderson-Nichols & Co., Inc., May 1985)
	7. Groundwater Protection Strategy, Report, (Comonwealth of Massachusetts Department of Environmental Quality Engineering Division of Water Supply, January 1983)
	8. Horsley, Scott W., and Cambareri, Thomas C., "Delineating Zones of Contribution for Public Supply Wells to Protect Ground Water in New England," Proceedings of the National Water Well Conference, (Journal NEWWA, March 1986)

Note: *Awaiting Delivery

LIST OF REFERENCES
FOR STATES SURVEY OF WHPA METHODS

STATE	REFERENCE DOCUMENT
CONNECTICUT	*1. EXPLANATION AND EXAMPLE OF AQUIFER MAPPING TECHNIQUE
	*2. EXPLANATION OF CONNECTICUT'S AQUIFER CLASSIFICATION SYSTEM
FLORIDA	1. Wellfield Travel Time Model for Selected Dade, Broward, and Palm Beach Counties Florida, Final Report, 9243-110 (Camp Dresser & McKee, Inc., August 1982)
	2. The Study of Water Supply and The Selection of Future Wellfield Sites in Broward County, Florida, Executive Summary (James M. Montgomery, Consulting Engineers, Inc. in association with Dames & Moore, June 1986)
	3. Palm Beach County Well Field Protection Model, Draft Report, (Dames & Moore, October 1986)
	4. Dade County's Regulatory Approach to Wellfield Protection, Report, (Metropolitan Dade County Environmental Resources Management)
	5. DeHan, R.S., "New Approach to Protection of Sensitive Aquifers in Florida," Department of Environmental Regulation
ILLINOIS	1. A Plan For Protecting Illinois Groundwater, Conceptual Plan, (Ground-Water Section, Division of Public Water Supply)
MASSACHUSETTS	1. New England Project Proposal, Demonstration of the Use of Three-Dimensional Ground-Water Modeling to Delineate Zones of Contribution to Public Supply Wells, Cape Cod, Massachusetts, (Northeastern Water Resources Division, April 1986)

Note: *Awaiting Delivery

STATE	REFERENCE DOCUMENT
MASSACHUSETTS	9. Horsley, Scott W., "Delineating Zones of Contribution for Public Supply Wells to Protect Groundwater," Proceedings of the National Water Well Conference (Journal NEWWA, November 1983)
	*10. Cape Cod Planning and Economic Development Commission, "Water Supply Protection Project Report," 1979.
	*11. Offer, Stuart A. and Grahame J. Larson, "Determination of Recharge Rates to a Drift Aquifer Using Bomb Tritium Within the Saturated Zone," (Michigan State University, 1982)
	*12. U.S. Department of the Interior Geological Survey, "Digital Models of Ground-Water Flow in the Cape Cod Aquifer System, Massachusetts," Open-File Report 80-67, (Water Resources Investigations, 1981)
	*13. Groundwater and Water Resource Protection Plan for the Town of Barnstable, Massachusetts, Report, (SEA Consultants, Inc., 1985)
PENNSYLVANIA	1. Proposals for the Management of Ground-Water Quality in Pennsylvania: Protection and Monitoring, (Division of Water Quality Bureau of Water Quality Management, July 1985)
SOUTH CAROLINA	*1. TECHNICAL PAPER(S) DISCUSSING ISOTOPE AND TRITIUM DATING TECHNIQUES.
SOUTH DAKOTA	*1. PRELIMINARY REPORTS DISCUSSING PROPOSED METHODOLOGY FOR DELINEATING WELL HEAD PROTECTION AREAS
VERMONT	1. Vermont Aquifer Protection Area Reference Document, Aquifer Protection Areas Prototype Project, (Department of Water Resources and Environmental Engineering)
	2. "Groundwater Protection," Ground Water Protection Law, Chapter 48.

Note: *Awaiting Delivery

STATE	REFERENCE DOCUMENT
VERMONT	3. Ground-Water Resources of the Rutland Area, Vermont, Water-Resources Investigations 82-4057, (U.S. Geological Survey, 1983)
	4. Ground Water Favorability Map of the Nulhegan-Passumpsic River Basin, Vermont, (Vermont Department of Water Resources and the U.S. Geological Survey, 1967)
	5. Ground Water Favorability Map of the Otter Creek Basin, Vermont, (Vermont Department of Water Resources and the U.S. Geological Survey, 1967)
	6. Ground Water Favorability Map of the Lamoille River Basin, Vermont, Vermont Department of Water Resources and the U.S.Geological Survey, 1967)
	7. Ground Water Favorability Map of the Missisquoi River Basin, Vermont, (Vermont Department of Water Resources and the U.S. Geological Survey, 1967)
	8. State of Vermont Ground Water Favora-ability Map of the Batten Kill, Walloomsac River and Hoosic River Basins, (Vermont Department of Water Resources and the U.S. Geological Survey, 1966)
WASHINGTON	1. Guidelines for Development of Ground Water Management Areas and Programs, Chapter 173-100 WAC, (Water Resources Planning and Management Section Washington State Department of Ecology, April 1986)

Note: *Awaiting Delivery

APPENDIX D: Glossary of Hydrogeologic Terminology

GLOSSARY

The purpose of this Glossary is to provide to the Workshop Participant a list of terms commonly used by hydrogeologists. The definitions provided in this glossary are not necessarily endorsed by EPA nor are they to be viewed as suggested language for regulatory purposes. Numbers in brackets indicate the reference source.

Adsorption. The assimilation of gas, vapor, or dissolved matter by the surface of a solid [1]. The attraction and adhesion of a layer of ions from an aqueous solution to the solid mineral surfaces with which it is in contact; [2].

Advection. The process by which solutes are transported by the bulk motion of the flowing ground water [1].

Aeration. The process of bringing air into intimate contact with water, usually by bubbling air through the water to remove dissolved gases like carbon dioxide and hydrogen sulfide or to oxidize dissolved materials like iron compounds [1].

Air stripping. A mass transfer process in which a substance in solution in water is transferred to solution in a gas, usually air [1].

Alkaline. Any of various soluble mineral salts found in natural water and arid soils having a pH greater than 7. In water analysis, it represents the carbonates, bicarbonates, hydroxides, and occasionally the borates, silicates, and phosphates in the water [1].

Alluvial. Pertaining to or composed of alluvium or deposited by a stream or running water.[1]

Alluvium. A general term for clay, silt, and sand, gravel, or similar unconsolidated material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope.[1]

Anisotropic. Having some physical property that varies with direction.[1]

Anisotropy. The condition under which one or more of the hydraulic properties of an aquifer vary according to the direction of flow.[2]

Aquiclude. A saturated, but poorly permeable bed, formation, or group of formations that does not yield water freely to a well or spring. However, an aquiclude may transmit appreciable water to or from adjacent aquifers.[1]

Aquifer. A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.[1] Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.[2]

Aquifer, unconfined. An aquifer in which there are no confining beds between the zone of saturation and the surface. There will be a water table in an unconfined aquifer. Water-table aquifer is a synonym.[2]

Aquifer test. A test involving the withdrawal of measured quantities of water from or addition of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition.[1]

Aquitard. A geologic formation, group of formations, or part of a formation through which virtually no water moves.[1]

Artesian well. A well deriving its water from a confined aquifer in which the water level stands above the ground surface; synonymous with flowing artesian well.[1]

Artificial recharge. Recharge at a rate greater than natural, resulting from deliberate actions of man.[1] The process by which water can be injected or added to an aquifer. Dug basins, drilled wells, or simply the spread of water across the land surface are all means of artificial recharge.[2]

Basalt. A general term for dark-colored iron- and magnesium-rich igneous rocks, commonly extrusive, but locally intrusive. It is the principal rock type making up the ocean floor.[1]

Baseflow. That part of a stream discharge derived from ground water seeping into the stream.[2]

Bedrock. A general term for the rock, usually solid, that underlies soil or other unconsolidated material.[1]

Buried valley. A depression in an ancient land surface or in bedrock now covered by younger deposits, especially a preglacial valley filled with glacial drift.[1]

Calibration. Adjustment of the input data until computed heads match the field values.[3]

Capillary fringe. The zone at the bottom of the vadose zone where ground water is drawn upward by capillary force.[1] The zone immediately above the water table, where water is drawn upward by capillary attraction.[2]

Carbonate. A sediment formed by the organic or inorganic precipitation from aqueous solution of carbonates of calcium, magnesium, or iron.[1]

Carbonate rocks. A rock consisting chiefly of carbonate minerals, such as limestone and dolomite.[1]

Cathode. Any negatively charged electrode, as in an electrolytes, characteristically moving toward a negative electrode.[1]

Cation. An ion having a positive charge and, in electrolytes, characteristically moving toward a negative electrode.[1]

Cation exchange. Ion exchange process in which cations in solution are exchanged for other cations from an ion exchanger.[1]

Chlorine. A gas, Cl_2, widely used in the disinfection of water and as an oxidizing agent.[1]

Clastic. Pertaining to a rock or sediment composed principally of broken fragments that are derived from pre-existing rocks or minerals and that have been transported some distance from their places of origin.[1]

Coefficient of permeability. An obsolete term that has been replaced by the term hydraulic conductivity.[1]

Coefficient of storage. The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.[1]

Coefficient of transmissivity. See Transmissivity.[1]

Colloid. Extremely small solid particles, 0.0001 to 1 micron in size, which will not settle out of a solution; intermediate between a true dissolved particle and a suspended solid which will settle out of solution.[1]

Cone of depression. A depression in the ground water-table or potentiometric surface that has the shape of an inverted cone and develops around a well from which water is being withdrawn. It defines the area of influence of a well. [1]

Confined aquifer. A formation in which the ground water is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined ground water is generally subject to pressure greater than atmospheric.[1]

Confining bed. A body of material of low hydraulic conductivity that is stratigraphically adjacent to one or more aquifers. It may lie above or below the aquifer.[2]

Contamination. The degradation of natural water quality as a result of man's activities. There is no implication of any specific limits, since the degree of permissible contamination depends upon the intended end use, or uses, of the water.[1]

Darcy's law. A derived equation for the flow of fluids on the assumption that the flow is laminar and that inertia can be neglected.[1]

Density. Matter measured as mass per unit volume expressed in pounds per gallon (lb/gal), pounds per cubic ft (lb/ft^3), and kilogram per cubic m (kg/m^3).[1] The mass of quantity of a substance per unit volume. Units are kilograms per cubic meter or grams per cubic centimeter.[2]

Diagenesis. The chemical and physical changes occurring in sediments before consolidation or while in the environment of deposition.[2]

Digital computer model. A model of ground-water flow in which the aquifer is described by numerical equations with specified values for boundary conditions which are solved on a digital computer.[2]

Direct precipitation. Water that falls directly into a lake or stream without passing through any land phase of the runoff cycle.[2]

Discharge area. An area in which there are upward components of hydraulic heat in the aquifer. Ground water is flowing toward the surface in a discharge area and may escape as a spring, seep, or aseflow, or by evaporation and transpiration.[2]

Discharge velocity. An apparent velocity, calculated for Darcy's law, which represents the flow rate at which water would move through an aquifer if the aquifer were an open conduit. Also called specific discharge.[2]

Dispersion. The spreading and mixing of chemical constituents in ground water caused by diffusion and mixing due to microscopic variations in velocities within and between pores.[1]

Drainage basin. The land area from which surface runoff drains into a stream system.[2]

Drawdown. The distance between the static water level and the surface of the cone of depression.[1] A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of ground water from wells.[2]

Dynamic equilibrium. A condition of which the amount of recharge to an aquifer equals the amount of natural discharge.[2]

Effective porosity. The amount of interconnected pore space through which fluids can pass, expressed as a percent of bulk volume. Part of the total porosity will be occupied by static fluid being held to the mineral surface by surface tension, so effective porosity will be less than total porosity.[2]

Equipotential line. A contour line on the water table or potentiometric surface; a line along which the pressure head of ground water in an aquifer is the same. Fluid flow is normal to these lines in the direction of decreasing fluid potential.[1] A line in a two-dimensional ground-water flow field such that the total hydraulic head is the same for all points along the line.[2]

Equipotential surface. A surface in a three-dimensional ground-water flow field such that the total hydraulic head is the same everywhere on the surface.[2]

Evapotranspiration. Loss of water from a land area through transpiration of plants and evaporation from the soil.[1] The sum of evaporation plus transpiration.[2]

Evapotranspiration, actual. The evaporation that actually occurs under given climatic and soil-moisture conditions.[2]

Evapotranspiration, potential. The evapotranspiration that would occur under given climatic conditions if there were unlimited soil moisture.[2]

Flow lines. Lines indicating the direction followed by ground water toward points of discharge. Flow line are perpendicular to equipotential lines.[1]

Flow Model. A digital computer model that calculates a hydraulic head field for the modeling domain using numerical methods to arrive at an approximate solution to the differential equation of ground-water flow.[3]

Glacial drift. A general term for unconsolidated sediment transported by glaciers and deposited directly or land or in the sea.[1]

Ground water. The water contained in interconnected pores located below the water table in an unconfined aquifer or located in a confined aquifer.[2]

Ground-water basin. A rather vague designation pertaining to a ground-water reservoir which is more or less separate from neighboring ground-water reservoirs. A ground-water basin could be separated from adjacent basins by geologic boundaries or by hydrologic boundaries.[2]

Ground-water, confined. The water contained in a confined aquifer. Pore-water pressure is grater than atmosphere at the top of the confined aquifer.[2]

Ground-water flow. The movement of water through opening in sediment and rock which occurs in the zone of saturation.

Ground-water, perched. The water in an isolated, saturated zone located in the zone of aeration. It is the result of the presence of a layer of material of low hydraulic conductivity, called a perching bed. Perched ground water will have a perched water table.[2]

Ground-water table. The surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.[1]

Ground-water, unconfined. The water in an aquifer where there is a water table.[2]

Hydraulic conductivity. The rate of flow of water in gallons per day through a cross section of one square foot under a unit hydraulic gradient, at the prevailing temperature (gpd/ft2). In the SI System, the units are $m^3/day/m^2$ or m/day.[1] A coefficient of proportionality describing the rate at which water can move through a permeable medium. The density and kinematic viscosity of the water must be considered in determining hydraulic conductivity.[2] Hydraulic Conductivity (K) is a measure of the capacity of a porous medium to transmit water. It is governed by the size and shape of the pores, the effectiveness of the interconnection between pores,and the physical properties of the fluid.[3]

Hydraulic gradient. The rate of change in total head per unit of distance of flow in a given direction.[1] The change in total head with a change in distance in a given direction. The direction is that which yield a maximum rate of decrease in head.[2] The difference in hydraulic heads ($h_1 - h_2$), divided by the distance (L) along the flowpath.[3]

$$i = (h_1 - h_2) / L$$

Hydrodynamic dispersion. The process by which ground water containing a solute is diluted with uncontaminated ground water as it moves through an aquifer.[2]

Hydrogeologic. Those factors that deal with subsurface waters and related geologic aspects of surface waters.[1]

Igneous rocks. Rocks that solidified from molten or partly molten materials, that is, from a magma.[1]

Infiltration. The flow of water downward from the land surface into and through the upper soil layers.[2]

Interference. The condition occurring when the area of influence of a water well comes into contact with or overlaps that of a neighboring well, as when two wells are pumping from the same aquifer or are located near each other.[1]

Intrinsic permeability. Pertaining to the relative ease with which a porous medium can transmit a liquid under a hydraulic or potential gradient. It is a property of the porous medium and is independent of the nature of the liquid or the potential field.[2]

Ion. Any element or compound that has gained or lost an electron, so that it is no longer neutral electrically, but carries a charge.[1]

Isotropic. Said of a medium whose properties are the same in all directions.[1]

Isotropy. The condition in which hydraulic properties of the aquifer are equal in all directions.[2]

Karst topography. A type of topography that is formed on limestone, gypsum, and other rocks by dissolution, and is characterized by sinkholes, caves, and underground drainage.[1]

Kinematic viscosity. The ratio of dynamic viscosity to mass density. It is obtained by dividing dynamic viscosity by the fluid density. Units of kinematic viscosity are square meters pr second.[2]

Laminar flow. Water flow in which the stream lines remain distinct and in which the flow direction at every point remains unchanged with time. It is characteristic of the movement of ground water.[1] That type of flow in which the fluid particles follow paths that are smooth, straight, and parallel to the channel walls. In laminar flow, the viscosity of the fluid damps out turbulent motion. Compare with Turbulent flow.[2]

Leachate. The liquid that has percolated through solid waste and dissolved soluble components.[1]

Leaky confining layer. A low-permeability layer that can transmit water at sufficient rates to furnish some recharge to a well pumping from an underlying aquifer. Also called aquitard.[2]

Limestone. A sedimentary rock consisting chiefly of calcium carbonate, primarily in the form of the mineral calcite.[1]

Metamorphic rocks. Any rock derived from pre-existing rocks by mineralogical, chemical, and/or structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment, generally at depth in the Earth's crust.[1]

Molecular diffusion. Dispersion of a chemical caused by the kinetic activity of the ionic or molecular constituents.[1]

Molecule. A stable configuration of atomic nuclei and electrons bound together by electrostatic and electromagnetic forces. It is the simplest structural unit that displays the characteristic physical and chemical properties of a compound.[1]

Moraine. A mound, ridge, or other distinct accumulation of unsorted, unstratified glacial drift, predominantly till, deposited chiefly by direct action of glacier ice.[1]

Naturally developed well. A well in which the screen is placed in direct contact with the aquifer materials; no filter pack is used.[1]

Observation well. A well drilled in a selected location for the purpose of observing parameters such as water levels and pressure changes.[1] A nonpumping well used to observe the elevation of the water table or the potentiometric surface. An observation well is generally of larger diameter than a piezometer and typically is screened or slotted throughout the thickness of the aquifer.[2]

Outwash. Stratified sand and gravel removed or washed out from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of an active glacier. The coarser material is deposited nearer to the ice.[1]

Outwash plain. A broad, gently sloping sheet of outwash.[1]

Overburden. The loose soil, silt, sand gravel, or other unconsolidated material overlying bedrock, either transported or formed in place; regolith.[1]

Partial penetration. When the intake portion of the well is less than the full thickness of the aquifer.[1]

Perched water. Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.[1]

Percolate. The act of water seeping or filtering through the soil without a definite channel.[1]

Permeability. The property or capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure.[1]

pH. A measure of the acidity of alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. Originally stood for the words potential of hydrogen.[1]

Piezometer. A nonpumping well, generally of small diameter, which is used to measure the elevation of the water table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.[2]

Piezometer nest. A set of two or more piezometers set close to each other but screened to different depths.[2]

Pollutant. Any solute or cause of change in physical properties which renders water unfit for a given use.[2]

Pollution. When the contamination concentration levels restrict the potential use of ground water.[1]

Porosity. The percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.[1] The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.[2]

Potentiometric surface. An imaginary surface representing the total head of ground water in a confined aquifer that is defined by the level to which water will rise in a well.[1] A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.[2]

Pumping cone. The area around a discharging well where the hydraulic head in the aquifer has been lowered by pumping. Also called cone of depression.[2]

Pumping test. A test that is conducted to determine aquifer or well characteristics.[1] A test made by pumping a well for a period of time and observing the change in hydraulic head in the aquifer. A pumping test may be used to determine the capacity of the well and the hydraulic characteristics of the aquifer. Also called aquifer test.[2]

Radial flow. The flow of water in an aquifer toward a vertically oriented well.[2]

Radius of influence. The radial distance from the center of a well bore to the point where there is no lowering of the water table or potentiometric surface (the edge of its cone of depression).[1]

Recharge. The addition of water to the zone of saturation; also, the amount of water added.[1]

Recharge area. An area in which there are downward components of hydraulic head in the aquifer. Infiltration moves downward into the deeper parts of an aquifer in a recharge area.[2]

Recharge basin. A basin or pit excavated to provide a means of allowing water to soak into the ground at rates exceeding those that would occur naturally.[2]

Recharge boundary. An aquifer system boundary that adds water to the aquifer. Streams and lakes are typical recharge boundaries.[2]

Runoff. That part of precipitation flowing to surface streams.[1] The total amount of water flowing in a stream. It includes overland flow, return flow, interflow, and baseflow.[2]

Safe yield. The amount of naturally occurring ground water which can be economically and legally withdrawn from an aquifer on a sustained basis without impairing the native ground-water quality or creating an undesirable effect such a environmental damage. It cannot exceed the increase in recharge or leakage from adjacent strata plus the reduction in discharge, which is due to the decline in head caused by pumping.[2]

Saline-water encroachment. The movement, as a result of human activity, of saline ground water into an aquifer formerly occupied by fresh water. Passive saline-water encroachment occurs at a slow rate due to a general lowering of the freshwater potentiometric surface. Active saline-water encroachment proceeds at a more rapid rate due to the lowering of the freshwater potentiometric surface below sea level.[2]

Sandstone. A sedimentary rock composed of abundant rounded or angular fragments of sand set in a fine-grained matrix (silt or

clay) and more or less firmly united by a cementing material.[1]
Saturated zone. The zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric. The water table is the top of the saturated zone in an unconfined aquifer.[2]

Sedimentary rocks. Rocks resulting from the consolidation of loose sediment that has accumulated in layers.[1]

Seepage velocity. The actual rate of movement of fluid particles through porous media.[2]

Shale. A fine-grained sedimentary rock, formed by the consolidation of clay, silt, or mud. It is characterized by finely laminated structure and is sufficiently indurated so that it will not fall apart on wetting.[1]

Solute Transport Model. Mathematical model used to predict the movement of particles in the aquifer through time.[3]

Specific capacity. The rate of discharge of a water well per unit of drawdown, commonly expressed in gpm/ft or m/day/m. It varies with duration of discharge.[1]

Specific yield. The ratio of the volume of water that a given mass of saturated rock or soil will yield by gravity to the volume of that mass. This ratio is stated as a percentage.[1]

Stagnation point. A place in a ground-water flow field at which the ground water is not moving. The magnitude of vectors of hydraulic head at the point are equal but opposite in direction.[2]

Static water level. The level of water in a well that is not being affected by withdrawal of ground water.[1]

Storage specific. The amount of water released from or taken into storage per unit volume of a porous medium per unit change in head.[2]

Storativity. The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. It is equal to the product of specific storage and aquifer thickness. In an unconfined aquifer, the storativity is equivalent to the specific yield. Also called storage coefficient.[2]

Stream, gaining. A stream or reach of a stream, the flow of which is being increased by inflow of ground water. Also known as an effluent stream.[2]

Stream, losing. A stream or reach of a stream that is losing water by seepage into the ground. Also known as an influent stream.[2]

Total dissolved solids, TDS. A term that expresses the quantity of dissolved material in a sample of water, either the residue on evaporation, dried at 356°F (180°C), or, for many waters that contain more than about 1,000 mg/l, the sum of the chemical constituents.[1]

Transmissivity. The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity values are given in gallons per minute through a vertical section of an aquifer one foot wide and extending the full saturated height of an aquifer under a hydraulic gradient of 1 in the English Engineering system; in the International System, transmissivity is given in cubic meters per day through a vertical section of an aquifer one meter wide and extending the full saturated height of an aquifer under a hydraulic gradient of 1.[1] The rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media.[2]

Transpiration. The process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface.[1] The process by which plants give off water vapor through their leaves.[2]

Turbulent flow. Water flow in which the flow lines are confused and heterogeneously mixed. It is typical of flow in surface-water bodies.[1] That type of flow in which the fluid particles move along very irregular paths. Momentum can be exchanged between one portion of the fluid and another. Compare with Laminar flow.[2]

Unconfined aquifer. An aquifer where the water table is exposed to the atmosphere through openings in the overlying materials.[1]

Unsaturated zone. The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone.[2]

Vadoze zone. The zone containing water under pressure less than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is limited above by the land surface and below by the surface of the zone of saturation, that is, the water table.[1]

Viscosity. The property of a substance to offer internal resistance to flow. Specifically, the ratio of the shear stress to the rate of shear strain.[1] The property of a fluid describing its resistance to flow. Units of viscosity are newton-seconds per meter squared or pascal-seconds. Viscosity is also known as dynamic viscosity.[2]

Water budget. An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or a drainage basin.[2]

Water table. The surface between the vadose zone and the ground water; that surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere.[1] The surface in an unconfined aquifer or confining bed at which the pore water pressure is atmospheric. It can be measured by installing shallow wells extending a few feet into the zone of saturation and then measuring the water level in those wells.[2]

Well, fully penetrating. A well drilled to the bottom of an aquifer, constructed in such a way that it withdraws water from the entire thickness of the aquifer.[2]

Well interference. The result of two or more pumping wells, the drawdown cones of which intercept. At a given location, the total well interference is the sum of the drawdowns due to each individual well.[2]

Well, partially penetrating. A well constructed in such a way that it draws water directly from a fractional part of the total thickness of the aquifer. The fractional part may be located at the top or the bottom or anywhere in between the aquifer.[2]

Well point. A screening device, equipped with a point on one end, that is meant to be driven into the ground.[1]

Well screen. A filtering device used to keep sediment from entering a water well.[1]

Well yield. The volume of water discharged from a well in gallons per minute or cubic meters per day.[1]

<u>GLOSSARY REFERENCES</u>

[1] Driscoll, F.G. 1986
<u>Groundwater and Wells</u>, Second Edition, Johnson Division, St. Paul, Minnesota. 1089 p.

[2] Fetter, C.W., 1980
<u>Applied Hydrogeology</u>. Charles E. Merrill Publishing Company, Columbus, OH 488 p.