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CASE STUDIES IN WELLHEAD PROTECTION

Ten Examples of Innovative Wellhead Protection Programs

OFFICE OF GROUND WATER & DRINKING WATER
U.S. ENVIRONMENTAL PROTECTION AGENCY

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ACKNOWLEDGEMENTS

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NOTE TO THE READER

The case studies presented in this document are intended as examples a community might use to design and implement their own wellhead protection program. These examples do not represent the only possible options, nor does EPA or the Office of Ground Water and Drinking Water endorse these approaches over other approaches a community might choose.

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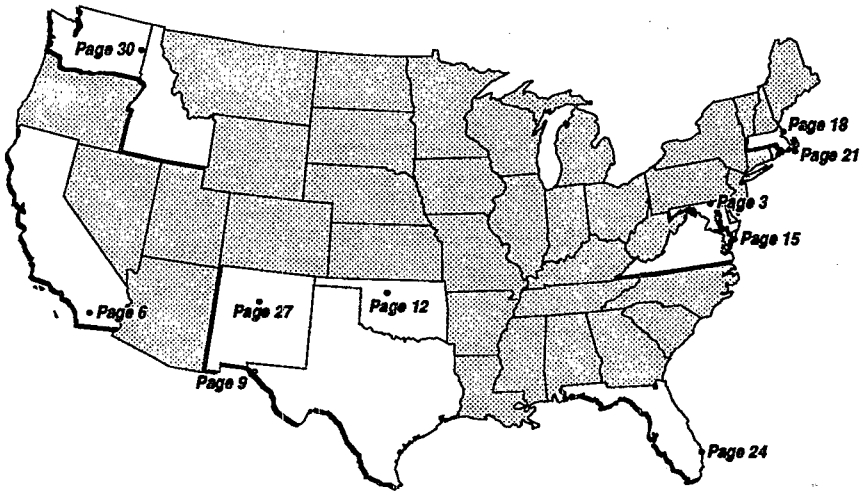


INTRODUCTION

Nearly half of the nation's total population relies on ground water as their primary source of drinking water. As the costs of cleaning up contamination and finding alternative water supplies continues to increase, it is becoming clear that the prevention of ground water contamination is an easier and less expensive alternative. The Wellhead Protection Program is a pollution prevention program intended to protect the ground waters that supply wells and wellfields that contribute drinking water to public water supply systems. EPA views wellhead protection programs as a key component of efforts by states to provide comprehensive protection of ground water resources. To date, over half of the states, several Indian tribes, and many communities have initiated wellhead protection programs.

Within the framework of the Wellhead Protection Program, state, local and tribal governments have the flexibility to design a program that will address their unique geographic conditions in order to protect their ground water supplies. This flexibility makes designing and implementing a wellhead protection program both easier and more difficult because no single approach will work in all situations. This technical assistance document assists state, local, and tribal water managers in developing, refining, and implementing wellhead protection programs by providing examples of programs already in place.

While each wellhead protection program contains the same elements whether you are in Massachusetts, California, Texas, or Florida, no two state programs are exactly alike in their approach to implementation. The same is true of local wellhead programs; each of the programs described in this document is unique in terms of the population, hydrogeologic setting, and approach to wellhead protection. The programs described may help to establish a foundation for another community's decision-making process as they develop their wellhead protection program. For others, these case studies may be the catalyst for yet another approach to a wellhead protection program.

In 1991, EPA released its Ground Water Protection Strategy for the 1990s which sets forth the Agency's goals and principles, and introduces the concept of Comprehensive State Ground Water Protection Programs (CSGWPPs). These CSGWPPs will be the focal point for a long-term joint commitment between EPA and the states to achieve a more coherent and comprehensive approach to protecting the nation's ground water resources.

As a key component of the CSGWPP, the careful structuring of a wellhead protection program at the state and local level will provide a firm "building block" in the foundation of CSGWPPs.

CARROLL COUNTY, MARYLAND
WATER RESOURCE MANAGEMENT PROGRAM

TYPE OF PROGRAM

Assess the impacts of existing and future land development on quantity and quality of county-wide water supplies. Includes surface and ground water resources used as public drinking water supplies.

Carroll County relies on both surface and ground water resources. Carbonate rock formations in much of the County offer productive well sites.

COMMUNITY OVERVIEW

Located in north-central Maryland, Carroll County is 456 square miles in area. It is bordered by the State of Pennsylvania, and by Baltimore, Howard, and Frederick Counties of Maryland. Carroll County is primarily rural and is one of the leading agricultural areas of Maryland.

The county includes eight community planning areas (areas within which growth is encouraged) around its major municipalities: Union Bridge, Taneytown, Finksburg-Sykesville, New Windsor, Mt. Airy, Westminster, Manchester, and Hampstead. Most of the public water systems are operated by the towns; one is operated by the county.

BACKGROUND

Carroll County has chosen to direct future growth in and around its nine municipalities. By the late 1970s, the demand for public water had increased such that new supplies would have to be developed. Studies indicated that water deficits were likely in six of the eight community planning areas by 1995. In response, the county commissioned a water resources study to evaluate existing water sources for the major towns, to project future demand, to identify potential new well sites, and to develop wellfield management plans for each town.

Water supplies in the county include wells completed in fractured rock--schist, saprolite, phyllite, sandstone, siltstone, and shale aquifers, with varying yields--and in carbonate rock. The county also uses surface water supplies, such as springs and reservoirs. Water supplies range from somewhat protected, such as the Manchester wells with public land holdings and open space surrounding the water supply areas, to vulnerable, such as the Hampstead wells, which are adjacent to a highway.

The carbonate rock areas represent potential well locations for those parts of the county where they occur.

PROGRAM DESCRIPTION

Carroll County's water resource management program is organized around the community planning areas (CPAs). These CPAs typically include municipal and adjacent county-controlled land. Public water supply wells commonly are located within the CPAs.

Delineation of Water Resource Protection Areas. The county delineated protection areas for: 1) existing wells; 2) aquifer recharge areas, including land available for future water supply development; 3) carbonate rock aquifers, which are capable of producing large quantities of water; and 4) surface water supplies. The first three types of protection areas were combined to form community ground water recharge areas. All the protection areas were overlayed with county CPA maps for comparison with planned development.

Land Use Evaluation. The county assessed land use impacts on water quality. For each CPA, water supply demand and water quality were evaluated along with a review of the available literature, field visits, and land use analyses. Land uses were assessed for four classes: agricultural, residential, industrial/ business, and conservation. Existing development was quantified from county tax information. Potential development was quantified using local zoning regulations. Nitrogen loading was modelled for the projected saturation development levels. In six of the eight CPAs, populations were projected to increase, putting more pressure on existing water supplies.

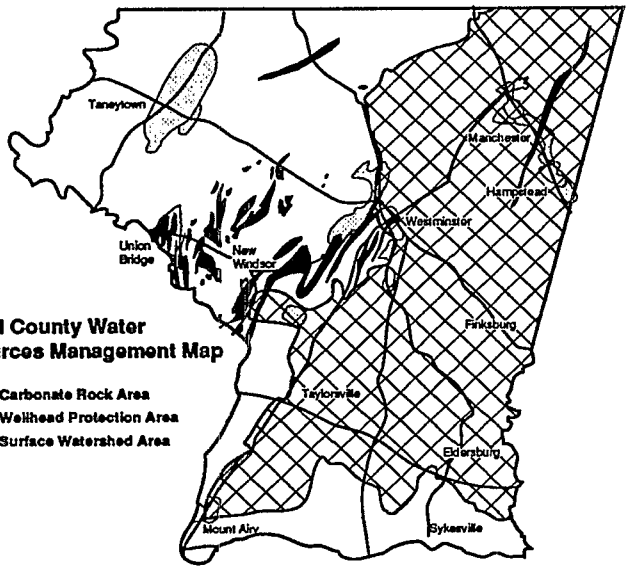
Contamination Evaluation. Contamination problems have occurred in some CPAs, and threaten others. In Hampstead, a series of small capacity wells are located along a highway, in a schist-saprolite aquifer with low recharge. Elevated chlorides, nitrates, and volatile organic compounds have been detected in the water supply. Planned business and industrial growth also represent a source of potential contamination. The main sources of potential contamination in Mt. Airy are high density residential and commercial development, an oil storage tank near one of the wells, and the proximity of a sewage pumping station.

Union Bridge and New Windsor water supplies have experienced elevated nitrate levels and are threatened by increasing nitrogen contamination from the current level of development allowed under existing zoning.

In Westminster, current levels of growth threaten water supplies and may require development of new water supplies in areas not already slated for residential, industrial, and business growth.

Manchester's wells are currently protected by public land holdings and open space, and nitrogen loading to ground water is expected to decrease over time as more of the area is converted from agriculture to residential uses.

Taneytown, with wells located in Triassic sandstone, siltstone, and shale, has experienced water supply contamination from volatile organic compounds and bacteria.



Nitrogen contamination from agricultural and commercial/industrial land uses also threatens the water quality in Taneytown.

For surface water resources in the county, a phosphorus loading analysis was conducted and the potential impacts from future land development were evaluated. Phosphorus loading reduction techniques were recommended to protect public supply reservoirs in Carroll County.

Management Approaches. In 1988, the Maryland General Assembly adopted an amendment empowering Carroll County Commissioners to initiate action to protect their water resources, including development of a water resources commission. The county developed water management standards that effect the following activities within water resource management areas: nutrient application or release; on-site wastewater disposal; ground water extraction; ground water recharge; erosion and sedimentation; storm water runoff; chemical use, storage, and application; hazardous substance storage and handling; and sinkhole formation.

Management techniques combine prohibition of certain activities, use restrictions, construction standards, performance standards, reporting and record keeping, and inspections and testing to protect identified resource areas from water quality contamination.

Compatibility with County Master Plan. The county Master Plan is designed to concentrate future residential and business development in CPAs. Water supplies are also concentrated in the CPAs in order to lessen water distribution system costs. Consequently, the land areas where recharge to county aquifers occurs are the same land areas where growth is focused. Because urbanization typically leads to water resource contamination, the county sought to identify conflicts between the master plan and the water resources management program. Additional controls at the master plan level may be necessary to ensure county-wide protection of water supplies.

WHAT MAKES THIS PROGRAM UNIQUE?

Several public agencies have participated in water resource protection, including representatives from the Bureau of Water Resource Management, the Department of Permits and Regulations, the Planning Department, and the Department of Economic and Community Development. The county's recommendations include involvement of the public, for example, through a household hazardous waste collection day.

PROGRAM CONTACT

For further information about the Carroll County Water Resources Protection Program, contact:

Ms. Catherine Rappe
Carroll County Bureau of Water Resource Management
225 N. Center St.
Westminster, MD 21157

(301) 857-2150

County planning goals focus development onto the land areas needed for aquifer recharge. Increases in development were projected to cause a demand for additional water supplies and to potentially have negative impacts on water quality in public water supplies.

DESCANSO, CALIFORNIA, COMMUNITY WATER DISTRICT WELLHEAD PROTECTION PROGRAM

TYPE OF PROGRAM

Preliminary wellhead protection program formulated as part of "hands on" training for three rural communities in southern California.

Under average hydrologic conditions, septic systems return as much as 11 percent of the water withdrawn by public supply wells in Descanso. Under drought conditions, this percentage, and the consequent potential for ground water contamination, increases.

COMMUNITY OVERVIEW

Descanso is a small, rural community in southwestern California, on the intermittently-flowing Descanso and Sweetwater Rivers in San Diego County. Located in the Cuyamaca Mountains, Descanso is approximately 40 miles east of San Diego and approximately 20 miles north of the Mexican border.

BACKGROUND

Descanso is served by the Descanso Community Water District, which maintains seven public water supply wells with approximately 300 service connections, providing water to approximately 900 residents. The wells include shallow wells placed in alluvial sand and gravel and weathered granite as well as deep fractured bedrock wells. The wells are constructed in two different aquifer systems--the Descanso and Sweetwater River valleys.

There is a strong, on-going, environmentally-oriented education program in Descanso. Water quality classes are included in the public schools, and the Descanso Community Water District provides informational brochures.

PROGRAM DESCRIPTION

EPA Region 9 designed a program to provide focused training in wellhead protection to a series of rural communities. The California Rural Water Association suggested locations and assisted with site visits. In Descanso, the Descanso Community Water District was the implementing agency for this wellhead protection pilot program.

Organizational Meeting. Following a presentation on wellhead protection to the Descanso Community Water District Board, the Board took formal action to establish a wellhead protection program. The local planning group, acting as advisors to the County Board of Supervisors, and San Diego County also participated in the program.

Delineation of WHPAs. A regional water table map was drafted using water level measurements from 21 observation wells in the Descanso area, measured by the US Geological Survey (USGS) in 1990. Transmissivity and storativity values for the aquifers were also obtained from the USGS. Future pumping rates were estimated at 75 gallons per minute.

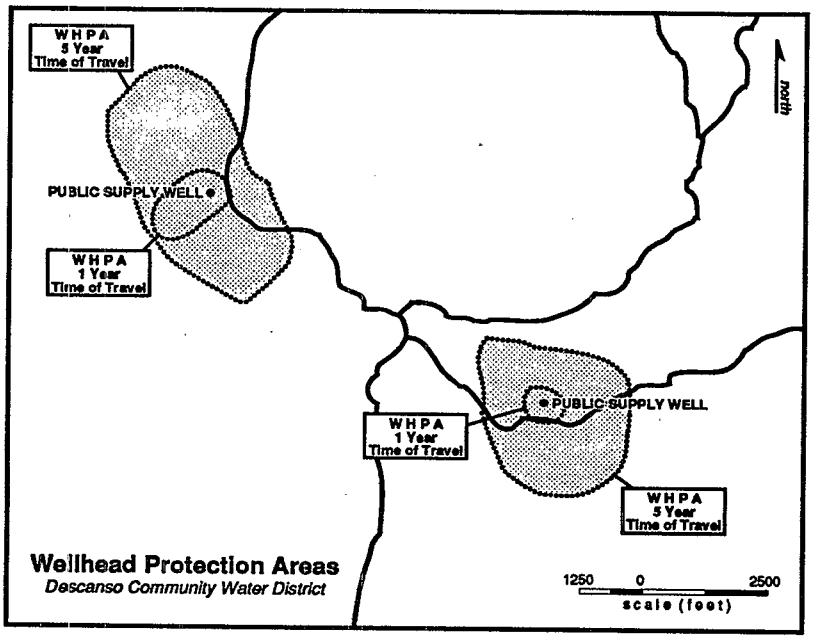
Using this information, WHPAs for two of the three major wells currently in production were delineated based on the Theis distance-drawdown equation for calculation of predicted water level changes. For these calculations, one- and five-year no recharge (drought) conditions were simulated. Under these scenarios, the local rivers were assumed to provide no induced infiltration to the aquifers.

Contaminant Source Identification. In order to determine potential sources of contamination within the delineated WHPAs, topographic maps and proposed zoning changes were reviewed, the Descanso Community Water District Directors were interviewed, and land use surveys were conducted by automobile.

Septic systems were the most common potential contamination source identified. Descanso has no public sewage treatment facility.

Hydrologic Budget. In order to determine the impacts of septic systems on ground water, a hydrologic budget was developed. During an average year, precipitation infiltration to ground water provides 62-66 percent of the recharge; infiltration of stream water provides 27-28 percent; and septic system effluent provides 6-11 percent. These figures suggest that sewage-derived nitrogen will be adequately diluted by other sources of recharge such that drinking water standards will not be exceeded.

Nitrogen Loading Modelling. The impacts of future growth and increased density of septic systems was evaluated for the WHPAs. Zoning maps and proposed zoning changes for Descanso were examined in order to estimate the potential maximum numbers of houses that might be in the WHPAs. A nitrogen loading model was then applied to predict nitrate-nitrogen concentrations at each wellhead. The modelling found that under both the proposed zoning changes and the maximum development allowed by existing zoning, nitrate-nitrogen concentrations will approach or exceed the federal drinking water standard of 10 milligrams per liter.



Management Approaches. The proposed zoning changes are predicted to reduce nitrogen loadings below the loadings estimated for existing zoning. Therefore, zoning amendments may be an effective management tool. However, greater changes than those under consideration may be required to protect ground water quality. The pilot program recommended that the Descanso Community Water District assess zoning changes and consider additional changes within the WHPAs.

A non-regulatory management measure implemented by the Water District is the posting of "Ground Water Protection Zone," signs along roads within the WHPAs. A household hazardous waste collection program was also recommended to the Water District.

Contingency Planning. Because the Descanso public water supply wells are located in two geographically separate aquifers (the Descanso and Sweetwater River valleys), it is unlikely that contamination in one aquifer would result in contamination of wells located in the other. Nitrate-nitrogen contamination in either aquifer may be mitigated by managing pumping rates in relation to climatic conditions. Pumping during wet seasons will induce infiltration from the rivers, and therefore provides an option for reducing threats from septic system nitrogen.

Public Participation. The posting of signs marking the WHPAs will begin an educational process to complement efforts already underway in Descanso.

Project Timing. A key lesson of the Descanso case study is that WHPA delineation and preliminary protection programs do not have to be time consuming. The Descanso program was developed along with programs for two other rural California communities over a four month period.

WHAT MAKES THIS PROGRAM UNIQUE?

Descanso has no known ground water contamination, but is focusing on programmed growth and the potential impacts to ground water quality in an effort to prevent contamination from occurring. Under drought conditions, stream flows are significantly diminished, reducing available recharge to the adjacent aquifers, and thereby magnifying the impacts of septic systems on water quality.

Descanso is a small, rural community providing public water to approximately 900 residents. The wellhead protection program was initiated with minimal time and budget.

PROGRAM CONTACT

For further information about the Descanso wellhead protection program, contact:

Mr. M. Gale Ruffin
Descanso Community Water District
Post Office Box 610
Descanso, CA 91916

(619) 445-2330

The seven elements of wellhead protection were used to rapidly (within four months) formulate a preliminary WHP program, including delineation of WHPAs to two of the three main supply wells in Descanso.

EASTERN SHORE OF VIRGINIA WELLHEAD PROTECTION PROGRAM

TYPE OF PROGRAM

Ground water quality and quantity evaluation and management program for public and private water supplies on the Virginia portion of the Delmarva peninsula.

The hydrogeology of the region--an upper, unconfined aquifer, and a lower, confined aquifer--results in a primary recharge zone at abnormally larger distances from the major wells on the peninsula.

COMMUNITY OVERVIEW

Accomack and Northampton Counties constitute the narrow peninsula known as the Eastern Shore of Virginia. The peninsula lies between the Atlantic Ocean and the Chesapeake Bay, with a network of barrier islands on the Atlantic side.

The region is primarily agricultural, the home of two large poultry farming operations. Use of water by agricultural operators for crop irrigation exceeds water withdrawals for domestic use. The majority of residents rely on private wells because public water service is limited.

BACKGROUND

The Eastern Shore of Virginia lies in the Coastal Plain Province. Soils are primarily sand, clay, and shell fragments. Most of the region's soils are classed as prime farmland and are very productive.

The peninsula is relatively flat, with no major freshwater streams or lakes. Numerous creeks drain the region, becoming tidal estuaries at their mouths. Many farm ponds have been constructed for irrigation purposes.

The Eastern Shore includes two aquifers, one confined, and one unconfined. The unconfined Columbia aquifer is primarily sand with interfingered layers of clay and silt. The confined Yorktown-Eastover aquifer has three producing layers, with confining units of clays and silts.

Annually, 12 to 26 inches of water recharge the unconfined aquifer, with the majority of this water discharging to the ocean or the bay without moving downward to the lower, confined aquifer.

Only about 0.10 feet of water recharge the confined aquifer annually. This equates to approximately 11 million gallons per day (MGD). This recharge derives primarily from the central spine area of the peninsula.

Water quality in the lower aquifer is good. Most of the ground water withdrawn on the Eastern Shore is from this aquifer. Water in the upper, unconfined aquifer is of poorer quality. It is used primarily for individual private wells and for irrigation.

PROGRAM DESCRIPTION

The Eastern Shore hydrogeological investigation and wellhead protection program was commissioned by the Eastern Shore of Virginia Ground Water Study Committee. This committee was formed to assist local government and residents in the protection and management of water resources. The committee serves as an information and educational resource and also initiates studies such as this hydrogeological investigation.

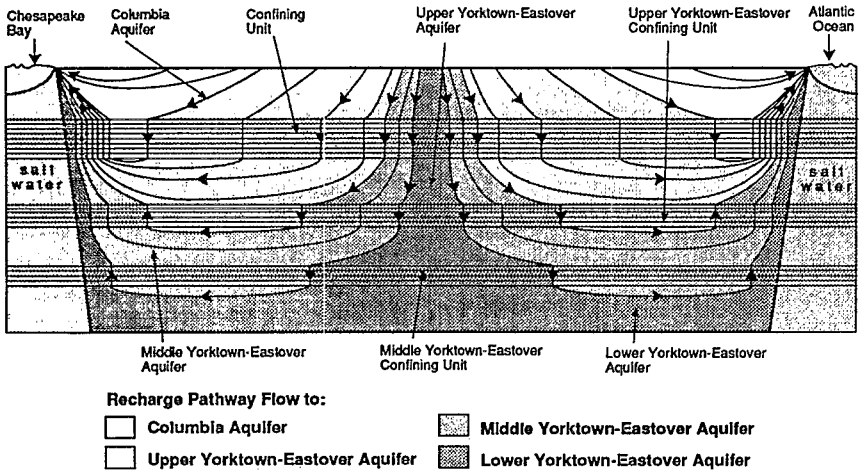
Information Review. The wellhead protection program on the Eastern Shore began with a review of existing information on the hydrology and geology of the area. This review was used to develop an initial, conceptual model of flow patterns and recharge areas on the peninsula.

Delineation of WHPAs. Initially, a time of travel criterion was selected for use in delineation of WHPAs. However, this approach could not be applied to the three-dimensional flow patterns found on the Eastern Shore and was abandoned. Instead, a numerical model (US Geological Survey's MODFLOW) was used. This model requires input parameters such as aquifer thickness, permeability, and recharge rates. Different scenarios were modelled, including non-pumping, pumping at existing rates, and pumping at permitted rates.

An immediate protection zone of 200-foot radius was delineated for each well. A second zone was mapped for the 26 wells and wellfields that account for most of the ground water use on the peninsula. These 26 wellfields were divided into five regions, based on location, permitted pumping, and modelled contributing areas. The protection zone for each of the five areas was determined on the basis of recharge: the amount of land area needed to balance water withdrawals under permitted pumping. Interference effects from pumping of adjacent large wells were considered in the delineations.

Five WHPAs were delineated. It was discovered that under both the existing and permitted water withdrawal rates, the WHPAs include salt water on both the Atlantic Ocean and Chesapeake Bay sides of the peninsula, raising the possibility of salt water intrusion to supply wells in the near future.

Development of Water Budget. Calculation of the regional water budget showed that the lower, confined aquifer receives limited recharge, approximately 0.10 foot per year (a total of 11 MGD). Pumping at the permitted rate (15 MGD) could cause a water deficit. As a result, the study commission concluded that requests for additional water withdrawal permits for the lower aquifer must be carefully evaluated and perhaps the existing permits should be re-evaluated.



Identification of Contaminant Sources/ Land Use Analysis. A land use evaluation was conducted to inventory potential contamination sources for the Eastern Shore. These sources are primarily non-point sources, including public and private sewage disposal facilities; underground storage tanks; landfills; and agricultural sources including fertilizers, pesticides, animal wastes, and animal carcasses (poultry).

An area around the central spine of the peninsula provides the critical recharge to sustain the confined aquifers. An analysis of developable lots was conducted in this area to determine the impacts of future growth on water resources of the Eastern Shore. This analysis estimated the number of future units on the spine area, based on existing zoning. The estimate exceeds the number of existing housing units on the entire peninsula.

Nitrogen Loading Analysis. An analysis of nitrate-nitrogen inputs to ground water from existing and potential land uses was conducted. Under the potential saturation development conditions, the nitrate-nitrogen concentration in ground water was predicted to exceed the federal drinking water limit (10 milligrams/liter) in all but one of the five WHPAs. Agricultural fertilizers are the primary nitrogen contamination source.

Management Recommendations. Management recommendations focused on the peninsula spine because the spine is the primary recharge area to the confined aquifer, which is the principal source of drinking water on the Eastern Shore. Recommendations included development of an overlay protection district; required registration of underground storage tanks; site plan review to include consideration of ground water issues; a private well setback ordinance; revision of state ground water legislation and regulations; open space acquisition; agricultural water and nutrient management; and public education.

WHAT MAKES THIS PROGRAM UNIQUE?

The Eastern Shore ground-water protection program represents forward-thinking action in an environmentally sensitive area. The program was enacted by a grass-roots organization: a committee including representatives of two counties, the Virginia Water Control Board, the US Geological Survey, industry and farmers--technical and lay people cooperating to protect a regional resource.

The program focused on water quality and quantity issues, including analysis of water use by sector (industrial, agricultural, residential) and evaluation of the water withdrawal permitting process for the limited recharge water supply.

PROGRAM CONTACT

For further information about the Eastern Shore of Virginia Ground Water Protection Plan, contact:

Mr. Paul Berge
Accomack-Northampton Planning District Commission
P.O. Box 417
Accomac, VA 23301

(804) 787-2936

Funding sources for the Eastern Shore wellhead protection program included an EPA grant, two state programs, two counties, and the planning district.

EL PASO, TEXAS
WELLHEAD PROTECTION PROGRAM

TYPE OF PROGRAM

Wellhead protection program including delineation of wellhead protection areas (WHPAs), identification of potential sources of contamination, water-quality sampling, public education, and WHPA best-management practices.

El Paso successfully used retired senior volunteers to identify sources of potential contamination. Some of these volunteers have continued their involvement through service on a best-management practices task force.

COMMUNITY OVERVIEW

Located in the western tip of Texas, bordered by New Mexico and Mexico, El Paso is the 26th largest city in the United States. Its population is approximately 591,000. The City's 138 public water supply wells provide water to its 128,000 residents. Agriculture, industry, military installations and tourism are the main economic activities in the region. The climate is arid to semi-arid, with an average annual rainfall of eight inches.

BACKGROUND

Water for El Paso's public supply wells is drawn primarily from aquifers in the basin and range geologic province. The Rio Grande Rift created down-dropped basins (bolsons), which serve as depositional areas for sands and gravels from streams. These deposits hold water that can be withdrawn for public supplies. Water quality varies within these aquifers.

In some areas, weathering has resulted in calcareous soil zones, or caliche. When combined with water, caliche may form an impermeable layer that can provide protection to the aquifer if no hydrological connections to contamination sources exist and if dry conditions have not opened large pores within the caliche.

Approximately 20 percent of the city's water is drawn from the Rio Grande River. River withdrawals are limited by international and interstate water rights agreements.

The Texas Water Commission and Texas Department of Health assist local governments in protection of ground water within designated WHPAs. The City of El Paso was selected as a site for a US EPA wellhead protection demonstration project.

Delineation of WHPAs. In October 1989, the Texas Water Commission delineated WHPAs for the 138 public supply wells in the City of El Paso. The protection areas were delineated using the calculated fixed radius method and data on well pumping, construction, and location. A ground water travel time of five years was used in the calculations. Five years was judged a sufficient response time for potential contamination events outside the WHPAs.

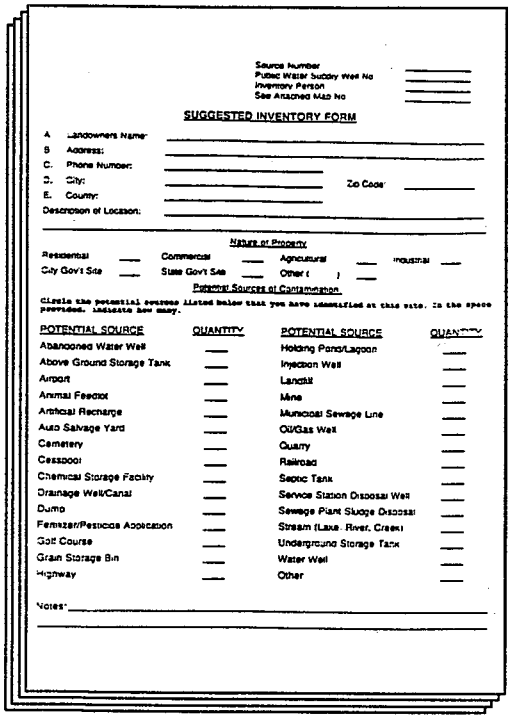
Identification of Contamination Threats. Staff and funding for contamination source inventories are limited in many municipalities. The use of volunteers is one solution to this constraint. The City of El Paso utilized the Retired Senior Volunteer Program (RSVP) for its contamination source inventory.

RSVP is a national program with area coordinators who recruit volunteers for specific projects. RSVP coordinates some 750 programs across the country, and is partially federally funded.

In order to recruit source inventory volunteers, contacts were made with retirees from El Paso Natural Gas Company, Chevron, Inc., Southwestern Bell Pioneers, El Paso Electric Company, City Planning and Engineering, the County Historical Society, the Archeological Society, Ft. Bliss, the El Paso Water Utilities, the Sierra Club, the Audubon Society, the local Gem and Mineral Society, the Retired Officers Association, and the National Association of Retired Federal Employees. Through a networking effort, 23 retired geologists, planners, engineers, and others were recruited for assessment of potential contamination sources in El Paso. The volunteers were trained in contamination source inventory methods and provided with inventory forms (in both Spanish and English), maps and instructions. An inventory chief was designated to coordinate each volunteer group's activities and to avoid any duplication of effort.

The media--television, radio, and newspapers in both English and Spanish--were used to inform the public about the project and to encourage cooperation with the inventory volunteers.

The inventory was completed in three and a half days and provided reliable, comprehensive information. Maps were developed based on the inventory results. Within WHPAs, contamination sources are shown by location and type. These maps facilitate appropriate management of threats to ensure high quality ground water. Potential contamination sources in the City of El Paso WHPAs include: abandoned and active wells; underground and surface storage tanks; contaminant spills; pipelines and municipal sewage lines; septic tanks; landfills; fertilizers and pesticides; injection wells; stormwater runoff; feedlots; artificial recharge; air pollution; cemeteries; and polluted surface waters.



Source Number
Public Water Supply Well No
Inventory Person
See Attached Map No

SUGGESTED INVENTORY FORM

A. Landowners Name:
B. Address:
C. Phone Number:
D. City: Zip Code:
E. County:
Description of Location:

Nature of Property

Residential ___ Commercial ___ Agricultural ___ Industrial ___
City Gov't Site ___ State Gov't Site ___ Other ( ) ___

Potential Sources of Contamination

Circle the potential sources listed below that you have identified at this site. In the space provided, indicate how many.

POTENTIAL SOURCE	QUANTITY	POTENTIAL SOURCE	QUANTITY
Abandoned Water Well	___	Holding Pond/Lagoon	___
Above Ground Storage Tank	___	Injection Well	___
Airport	___	Landfill	___
Animal Feedlot	___	Mine	___
Artificial Recharge	___	Municipal Sewage Line	___
Auto Salvage Yard	___	Oil/Gas Well	___
Cemetery	___	Quarry	___
Cesspool	___	Railroad	___
Chemical Storage Facility	___	Septic Tank	___
Drainage Well/Canal	___	Service Station Disposal Well	___
Dump	___	Sewage Plant Sludge Disposal	___
Fertilizer/Pesticide Application	___	Stream (Lake, River, Creek)	___
Golf Course	___	Underground Storage Tank	___
Grain Storage Bin	___	Water Well	___
Highway	___	Other	___

Notes:

Management Approaches. Following the inventory, several of the volunteers formed a wellhead protection task force.

The task force coordinates with city and county officials to manage known contamination sources via the use of best-management practices. To date, the City of El Paso has passed a hazardous materials storage ordinance, has plugged three abandoned wells, and is implementing other best-management practices.

Contingency Planning. Water quality testing conducted by the Texas Department of Health in 1988 and 1989 found the city's wells had not been contaminated. In order to protect the city's water quality, a contingency plan was developed, including lists of telephone numbers for emergency contacts and short and long-term responses to water quality emergencies.

Public Involvement. The City of El Paso provides information to the public, in both Spanish and English, on its water protection projects. A "Desert Watch Patrol" is run by the city sheriff's department, to apprehend illegal dumpers in the county desert and inside the city limits. Waste oil collection points are being established at Chevron service stations to provide an alternative to uncontrolled disposal in WHPAs.

WHAT MAKES THIS PROGRAM UNIQUE?

Wellhead protection need not be expensive. Use of volunteers was inexpensive and facilitated widespread community support for the project. The El Paso wellhead protection program successfully used retired volunteers for wellhead protection tasks including inventory of potential contamination sources and follow-up management practice implementation.

This project also represents successful coordination between the Texas Water Commission, the Texas Department of Health, and City of El Paso representatives.

Abandoned drinking water and irrigation wells and poorly constructed active wells are potential conduits for cross contamination between aquifers and from the surface.

PROGRAM CONTACT

For further information about the City of El Paso wellhead protection program, contact:

Mr. Robert Blodgett
Geologist
Texas Water Commission
P.O. Box 13087
Austin, TX 78711

(512) 371-6325

For further information about the Retired Senior Volunteer Program, contact:

Ms. Maureen Mulligan
National Association of RSVP Directors
703 Main St.
Patterson, NJ 07503

or consult the local telephone directory under Retired Senior Volunteer Program.

ENID, OKLAHOMA
AQUIFER MANAGEMENT AND WELLHEAD PROTECTION PROGRAM

TYPE OF PROGRAM

Aquifer management and wellhead protection program focusing on the link between land uses in WHPAs and ground water quality. Program includes public participation in the review process.

Up-to-date computer hardware and software are key components of Enid's Aquifer Management Program.

COMMUNITY OVERVIEW

Located 85 miles north and west of Oklahoma City, Enid is the largest city in the northwest quadrant of the state. Its population is approximately 46,000. Agriculture, the oil and gas industry, and manufacturing provide the basis of Enid's economy, and the city functions as the trade, health care and retirement center for the surrounding rural areas of both Oklahoma and Kansas. Vance Air Force Base and Phillips University are located in Enid. Several railroads and two principal highways pass through the city.

BACKGROUND

The water production system in Enid relies on 162 wells drawing from two aquifers. The Cimarron River Terrace Aquifer provides 80 percent of the water supply, while the Enid Isolated Terrace Aquifer provides the remaining 20 percent.

Average daily demand on the water production system is 11 million gallons per day (MGD), with a peak demand of 18 MGD, and a maximum production capacity of 27 MGD. The production wells are located in five wellfields: Enid, Cleo Springs, Ringwood, Ames, and Drummond. The Cimarron River crosses the Cleo Springs field. The wellfields are scattered through Garfield, Alfalfa, Woods, and Major Counties. Numerous oil and gas fields are also scattered throughout the area.

The Enid water production system serves over 60,000 people, and includes nearby communities and the Air Force Base. Enid is the largest ground water user in the state.

Water quality in the two aquifers is excellent. Water treatment includes preventative chlorination and fluoridation.

PROGRAM DESCRIPTION

The Enid City Commission initiated development of a total aquifer management plan in September of 1989 through the City Engineering Department. The program was developed and ready for presentation by the following March.

Information Review. The aquifer management program includes a comprehensive review of relevant materials such as water quality test results, water production records, lithologic records, geologic and hydrologic reports, and potential contaminant source inventories.

Mapping. The aquifer management program calls for mapping of data as overlays to a digital base map that has been developed for the project area. The City is currently developing a geographic information system (GIS) to process aquifer-related data.

Field Data. In order to monitor aquifer conditions and effects of climate and pumping, the management program includes monthly measurements of ground water levels in 175 wells in the municipal wellfields. Data are also gathered by 17 continually-recording electronic water level meters and three continually-recording precipitation gauges. The data are processed in an extensive computer network including five linked personal computer work stations.

Modeling of WHPAs. A US Geological Survey computer program was calibrated with the field data in order to model aquifer conditions and WHPAs.

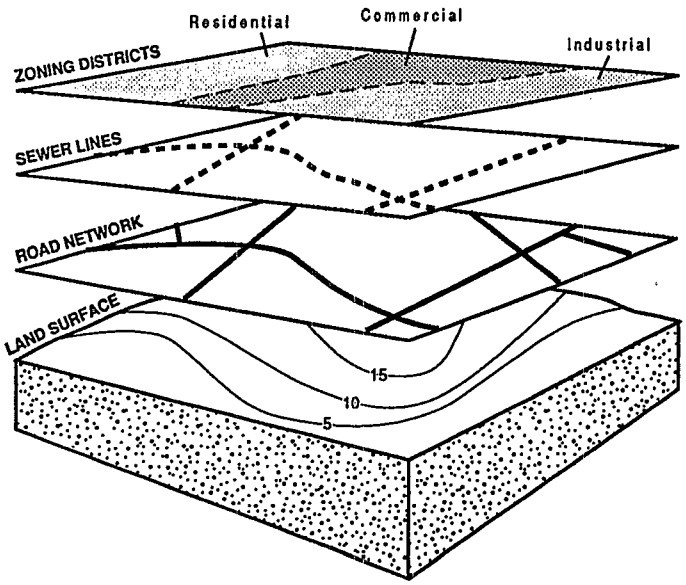
WHPAs were delineated for each public supply well using methods, criteria and thresholds that comply with state Wellhead Protection Plan requirements. One- and ten-year time of travel criteria were used.

Contamination Source Inventory. A database of potential contamination sources is being developed, which will be part of the GIS aquifer management system. An aquifer vulnerability index will also be prepared, to determine susceptibility of ground water to contamination from surface and shallow sub-surface spills or leaks.

This index will incorporate such parameters as depth to water, soil type, recharge rate, topography and land uses.

The aquifer vulnerability index will be incorporated into a larger risk assessment system. This system can be integrated with such programs as SARA Title III and the state ground water standards.

Potential sources of contamination to Enid's wellfields include: drilling, production, storage, pipeline and truck transportation related to oil and gas production; livestock and wheat production, including the use of herbicides and fertilizers; the Cimarron river, which has high levels of total dissolved solids; individual septic systems and municipal wastewater disposal lagoons; municipal and private landfills; an identified hazardous waste site; and spills along transportation routes.



Public Education. The Enid aquifer management program calls for public education on issues and public participation in policy and regulation review. The program seeks to involve all those groups that may impact future water quality.

Transferability. The Enid aquifer management program is computer-based, with the capacity for data storage and retrieval. The personal computer system can be used by technical and non-technical personnel, and is designed so that it can be adapted for application in other municipalities.

WHAT MAKES THIS PROGRAM UNIQUE?

The Enid aquifer management program is a computer-based approach to managing ground water for Oklahoma's largest ground water user. Existing data are supplemented by extensive monitoring. Data are compiled into a user-friendly mapping and analysis system that can be adapted for use by other hydrologically similar water supply systems. The Enid program has been divided into 11 sequential phases for implementation over a period of time making it affordable and practical for the City. The program is designed to meet EPA Wellhead Protection Program elements.

PROGRAM CONTACT

For further information about the Enid aquifer management and wellhead protection program, contact:

Mr. Jim Ferree
City Manager
City of Enid
P.O. Box 1768
Enid, OK 73702-1768

(405) 234-0400

or

Mr. Blaine T. Reely, P.E.
Project Officer
Envirotech Services, Inc.
P.O. Box 6029
Enid, OK 73702

(405) 234-8780

Enid's five wellfields are surrounded by oil and gas fields, which represent major potential contamination sources. The management program maps the locations of these sources and assesses their threat to ground water.

MANCHESTER-BY-THE-SEA, MASSACHUSETTS WELLHEAD PROTECTION PROGRAM

TYPE OF PROGRAM

Wellhead protection program incorporating wellhead delineation, contaminant source identification, and comprehensive management strategies.

Manchester's geologic setting does not offer the potential for development of new water supplies.

COMMUNITY OVERVIEW

Manchester-by-the-Sea, Massachusetts, is located on Cape Ann, 30 miles north of Boston. The town is a suburban community with a year- round population of approximately 5,400, which increases slightly during the summer. Most of the town is zoned residential with a downtown commercial area located adjacent to the town's ocean harbor. Approximately 50 percent of the town's drinking water is obtained from the Lincoln Street Well, the only source of drinking water within the town boundaries.

BACKGROUND

The Lincoln Street Well is located near the commercial area of town and is surrounded by the high school, a cemetery, and a golf course, as well as private residences. The remainder of the Manchester-by-the-Sea's water supply is drawn from a surface reservoir located in the neighboring Town of Hamilton. The well is located in a sand and gravel aquifer within a buried river valley. The walls of the valley are comprised of granitic bedrock and glacial till. As shown in the cross-section diagram on the next page, the sand and gravel aquifer lies on top of the till and bedrock, and is overlain by 10 to 40 feet of marine clay. A stream flows through the valley and provides approximately 10 percent of the well's supply by induced infiltration through a gap in the clay layer.

The rest of the town lies over granitic bedrock overlain in some areas with low permeability glacial till. Because the potential for developing a water supply in these materials is low, the importance of the existing well is magnified.

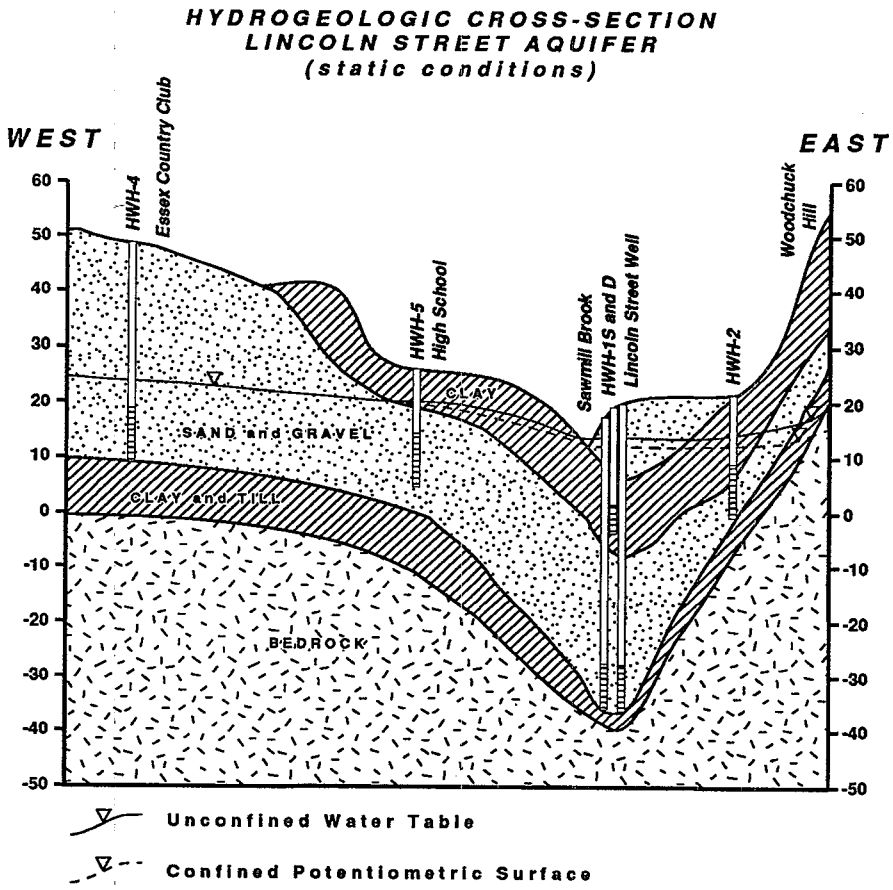
PROGRAM DESCRIPTION

The community established a Water Resource Protection Committee to guide the delineation of the wellhead protection area (WHPA), source identification, and management of the drinking water supply. The program was developed in 1989 and 1990, and the regulatory component of the program was formally adopted in 1990.

Delineation of WHPA. Delineation of the WHPA was conducted according to guidelines developed by the Commonwealth of Massachusetts Department of Environmental Protection. A computer model was used to simulate groundwater flow in the buried valley aquifer with the well pumping under extreme conditions (180 days of pumping at the safe yield rate with no recharge to the aquifer from precipitation). The model was based on geologic and hydrologic conditions observed in the field. A 48-hour pump test was conducted, and measurements from this test were used to determine aquifer properties and to calibrate

the computer model to ensure its accuracy. The model then was used to delineate the portion of the aquifer that contributes water to the well. The bedrock/till areas that contribute surface water to this portion of the aquifer were also identified as areas of water-quality concern.

Identification of Contaminant Threats. Once the WHPA was delineated, a survey of the area identified a variety of land uses that could pose a potential threat to the quality of water pumped by the well. The majority of land within the WHPA is occupied by a golf course, raising concerns of contamination from fertilizers and pesticides. A number of underground storage tanks containing both gasoline and fuel oil are also located within the zone of contribution; some of them over 20 years old, including one known leaking underground storage tank located on the southeast WHPA boundary. This tank, however, is not within the zone of contribution to the well under average pumping conditions. Nevertheless the town, in concert with the state, is actively pursuing the clean-up of the gasoline contamination. Until the remediation is complete, the town is limiting the volume of water withdrawn from the well to avoid drawing the plume into the well.



A developable lot analysis was conducted to determine the total development potential within the WHPA in both residential and commercial areas. This information was then coupled with a nitrogen loading analysis to predict the impacts from on-site septic systems, lawn fertilizers, and road runoff, all significant threats to water quality.

Other contamination threats include a downtown, commercially-zoned area where hazardous materials are used and where the potential exists for accidental spills and the improper disposal of these materials.

Management Approaches. The Manchester-by-the-Sea Town Meeting voted unanimously to adopt an overlay zoning bylaw that established various criteria and performance standards for development within the WHPA. This bylaw includes a special permit requirement for the operation of the existing golf course and other businesses using hazardous materials. The town's planning board recently approved a special permit for the golf course with conditions requiring annual reporting of chemicals used on the course, and semi-annual sampling of ground and surface waters for pesticides in heavily managed areas.

In addition, the town adopted several health regulations, wetlands bylaws, and subdivision control standards to complement the overlay bylaw's water resource protection standards. The health and subdivision regulations require proposed developments to meet nitrogen loading performance standards to ensure that water quality in the well will not be degraded.

WHAT MAKES THIS PROGRAM UNIQUE?

The Manchester-by-the-Sea program represents an example of a small community rallying together to protect the land area of a highly developed WHPA. In addition to regulatory controls, the town has put in place a monitoring program to collect semi-annual water quality samples. Samples are collected by students in an advanced biology class at the high school, under the supervision of the town's Conservation Commission.

The monitoring program supplements the town's aggressive and on-going public education efforts. One such effort was the town-wide distribution, prior to a town meeting, of a brochure describing the proposed protection strategy and requesting the support of residents.

PROGRAM CONTACT

For further information about the Manchester-By-The-Sea Wellhead Protection Program, contact:

Mr. Thomas Walker
Chairman
Water Resource
Protection Committee
Town Hall
Manchester-by-the-Sea, MA
01944

(508) 526-1712

or

Mr. Robert Moroney, P.E.
Director
Department of Public Works
Town Hall
Manchester-by-the-Sea, MA
01944

(508) 526-1712

Manchester recognized that its water systems were unavoidably linked to land development patterns and local land use practices.

NANTUCKET, MASSACHUSETTS
WATER RESOURCES PROTECTION PROGRAM

TYPE OF PROGRAM

Comprehensive water resources protection and management plan, including ground and surface waters, and planning for the future.

Annual recharge contributes 12.5 billion gallons per year to the Nantucket aquifer. The safe yield, or water withdrawal that may occur without unacceptable drawdown of the water table, depletion of the fresh water lens, or salt water intrusion, amounts to 6.25 billion gallons per year.

COMMUNITY

Nantucket is a 14-mile long island located 30 miles off the coast of Massachusetts. The local economy is currently dependent on tourism and second home development. The island has a year-round population of 7,000 and a summer population of over 30,000.

Nantucket was originally developed as small villages, surrounded by extensive areas of open space. Island planners strive to maintain this design in the face of increasing development pressures, coastal erosion, and potential sea level rise.

BACKGROUND

The only source of drinking water on Nantucket is ground water, and the island has been designated a sole source aquifer by the US Environmental Protection Agency. Ground water is commonly found within 10 to 20 feet of the land surface, but depth to water varies from zero at streams and ponds to 100 feet at high points. The lens of fresh water underlying the island is as much as 600 feet thick and floats on sea water. Intrusion of salty sea water can occur in wells near the island shoreline, where the lens thins.

Nantucket's surficial geology is glacial in origin, and includes till, outwash plain, and ice-contact deposits. Older sands, clays, and sedimentary rocks underlie the glacial deposits and are in turn underlain by igneous and metamorphic bedrock at a depth of approximately 1,500 feet below sea level.

PROGRAM DESCRIPTION

In response to a variety of threats to Nantucket's water supply (e.g., septic systems, pesticides and fertilizers, landfills, salt water intrusion, and toxic/hazardous materials), the Nantucket Land Council commissioned a water resources investigation and development of a management plan. The Land Council is a private, non-profit organization that conducts land acquisition and environmental projects on the island.

Water Table Mapping. In order to determine water resource protection areas, a 2-foot contour, island-wide water table map was prepared. Data from depth to water measurements in existing monitoring wells were used for the map. These wells were located with the assistance of volunteers from a local non-profit environmental advocacy group. Four new wells and 15 surface water staff gauges were installed, and ground penetrating radar was also used to obtain water table elevation data. Perched water tables were found at some locations on the island, supporting ponds and wetlands.

Delineation of Protection Areas. Using the water table map, zones of contribution to the island's two principal wellfields were delineated using the nonequilibrium Theis analytical model for unsteady radial flow in a confined aquifer. This equation applies to the unconfined Nantucket aquifer since drawdowns by pumping wells are small relative to the saturated thickness of the aquifer.

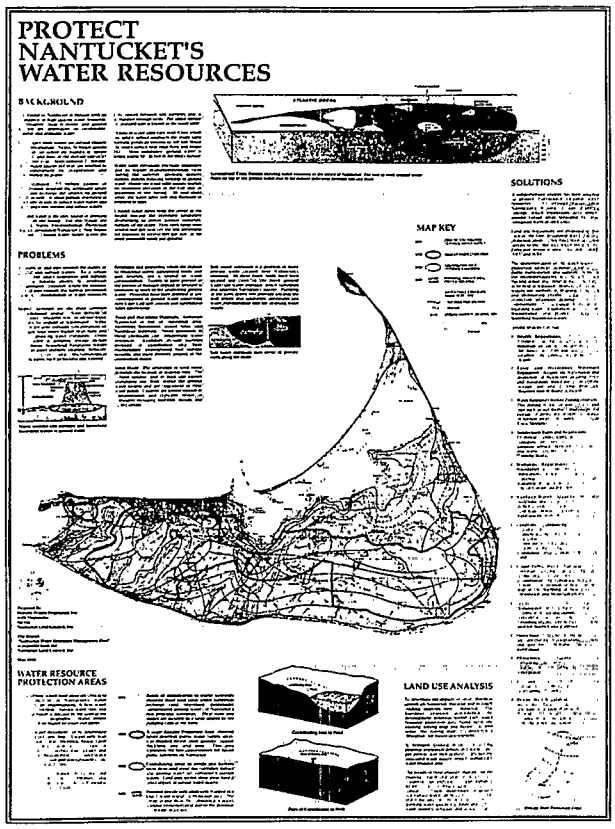
Another aquifer protection area, larger than the two described above, was delineated for potential water supply areas. Additionally, surface areas contributing to ponds and harbors were mapped, as were protection areas for private wells. These latter areas included the entire island. Overall, 12 water resource protection areas were delineated and assessed further.

Contamination Source Inventory. Records review and field investigation were used to determine potential sources of contamination on the island. These sources include eight known hazardous material release sites; two solid waste disposal sites (one active, one abandoned); sewage infiltration beds; salt storage areas; underground storage tanks; industrial/ commercial land uses; and non-point sources including septic systems, golf course and residential lawn and garden fertilizers, pesticides, herbicides, and road runoff.

Buildout and Nitrogen Loading Analyses. In order to evaluate the impacts of both existing and potential future development on Nantucket's water resources, a buildout (saturation development) analysis was conducted. This analysis documented existing development using aerial photographs and assessor's land use data, and estimated future development based on existing zoning and health regulations.

The analysis found that there is considerable difference in potential development if the health regulations are considered in addition to zoning requirements. The 12 water resource protection areas varied from 0 to 52 percent developed under health and zoning requirements, and 0 to 33 percent developed under zoning requirements alone.

Using the buildout analysis results, nitrogen loading to ground and surface water was modelled, based on standard assumptions for loading rates from nitrogen sources including lawn, farm, and cranberry bog fertilizers; landfills; roof and pavement runoff; sewage; and precipitation.



Protection and Management Strategy. Because the island's planners seek to maintain its historic development pattern of villages interspersed among open space, not all parts of the island require intensive land use management to protect ground water quality (e.g., where development lies outside delineated protection areas).

Ground water protection options included in the Nantucket plan are both regulatory and non-regulatory in nature. Regulatory options include: health regulation of minimum house lot size; proposed sewage service; water resource overlay zoning districts that regulate land uses; private well siting regulations to ensure adequate separation from septic systems (300 feet in the direction of ground water flow); hazardous materials use, storage and disposal regulations; and subdivision and wetlands regulations.

Non-regulatory options include: water quality analysis and on-going monitoring of surface waters; landfill studies and better solid waste management; testing for future public well sites; septic system maintenance for residential systems; decreased use of lawn fertilizers and increased use of alternative landscaping such as wood chips instead of grass, and low-maintenance ground covers (e.g., ivy, vinca); use of non-toxic household products instead of hazardous ones; and decreased use of detergents containing phosphorus.

Public participation was encouraged through the development and distribution of a multi-color poster depicting the island's water resources, findings of the hydrogeological investigation, and the management and protection options. Several of the proposed regulatory strategies required approval at a town meeting, further involving the public in the protection and management process.

WHAT MAKES THIS PROGRAM UNIQUE?

Nantucket's water resources program is comprehensive in nature, including both the island's ground water--a sole source aquifer--and surface waters such as coastal and freshwater ponds.

Management options included both regulatory and non-regulatory tools, such as innovative private well siting regulations based on setback distances needed for virus attenuation.

Nantucket considered both existing and future water supply needs and protection areas.

PROGRAM CONTACT

For further information, contact:

Ms. Linda Holland
Nantucket Land Council
P.O. Box 502
51 Main Street
Nantucket, MA 02554

(508) 228-2818

When managed in accordance with plans, the island's resources could sustain a year-round population of 80,000 to 100,000. Nitrogen concentrations in ground and surface water are projected to double and triple, and in some cases, exceed drinking water quality standards.

PALM BEACH COUNTY, FLORIDA WELLHEAD PROTECTION PROGRAM

TYPE OF PROGRAM

Wellhead protection program focusing on use, storage, and handling of regulated chemicals and on construction activities within protection zones.

The Palm Beach County wellhead protection ordinance requires the use of common sense management practices that protect both ground water and the users of regulated substances.

COMMUNITY OVERVIEW

Palm Beach County is located in southeastern Florida, north of the Everglades. It includes part of Lake Okeechobee (14 feet above mean sea level). The County's population is approximately 860,000. Land uses vary from urban to rural, with development concentrated along the Atlantic coastline and the Lake Okeechobee shoreline. A significant portion of the County is wetlands. Four canals cross the County, and it includes the Loxahatchee National Wildlife Refuge.

BACKGROUND

Palm Beach County lies over an unconfined sand and gravel aquifer. Approximately 80 percent of the County's drinking water is supplied by ground water. Thirty-seven of over 400 public drinking water wells in the County have been contaminated by industrial solvents.

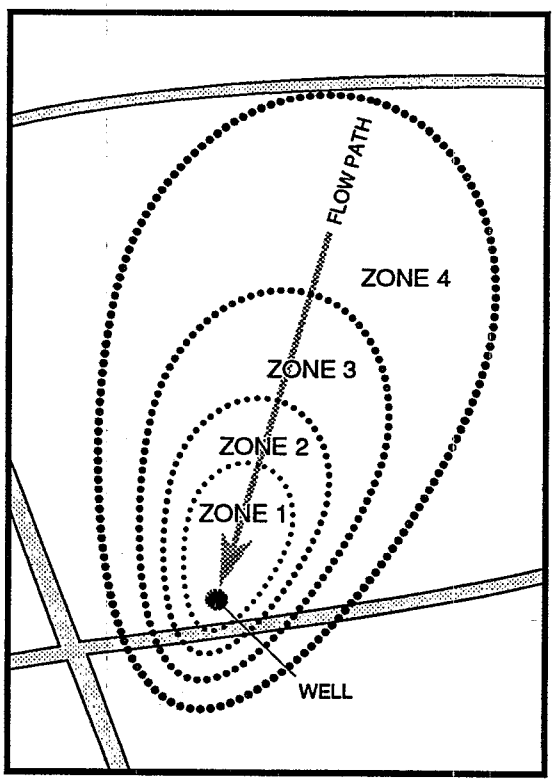
PROGRAM DESCRIPTION

In April 1985, Palm Beach County was denied further increases in its water consumption permit by the South Florida Water Management District until a wellhead protection ordinance was developed. In addition, Florida's growth management legislation requires that communities adopt wellhead protection, and the State Utilities Council requested that the County develop such an ordinance. In response, a Water Resources Management Advisory Board was created by the Board of County Commissioners to address water issues and to develop a wellhead protection ordinance.

Delineation of WHPAs. Palm Beach County designates four regulation zones around each regulated wellhead or wellfield permitted for withdrawal of 100,000 gallons or more per day. The zones are based on time of travel criteria and drawdown. The first zone is the land area surrounding the well out to the 30-day time-of-travel line.

Zone 2 extends from the 30-day line to the 210-day line, and Zone 3 extends to the 500-day line. Zone 4 includes the land area within the 1-foot drawdown contour. Prohibition of regulated chemicals is applied in Zone 1, secondary containment is applied in Zones 2 and 3, and daily monitoring of regulated chemicals is applied in Zone 4.

Wells and wellfields were plotted on aerial photographs using field inspections and utility data. Zone locations were determined with computer modelling that used 1984 pumpage rates. Flow conditions to the year 2010 were modelled.
Four hundred and forty-five present and future wells were located and modelled within 42 wellfields. Some location revisions and remodelling were required because undocumented wells were discovered and the original locations of both existing and future wells were inaccurately modelled.



Contamination Sources. Many industries in Palm Beach County have the potential to contaminate ground water via use, storage, or handling of various hazardous and toxic chemicals. Three hundred and sixty-six drinking water wells were tested in the course of developing the wellhead protection ordinance. Parameters analyzed included 126 organic and 8 inorganic contaminants. The testing results found contamination only in wells known previously to be contaminated.

Management Approaches. In order to protect ground water in Palm Beach County, a wellhead protection ordinance was developed and enacted in 1988. The ordinance applies to wellfields only after the zones of regulation have been mapped and the County Commission incorporates the wellfield into the ordinance. Property owners in the zones are notified as part of the process, and zone maps are reviewed annually and updated when necessary.

The ordinance establishes standards for use, handling, production, and storage of regulated substances in the zones of regulation surrounding a wellfield. Included in the ordinance is a list of the regulated substances and a general definition of the regulation applied to each zone.

The ordinance also includes provisions for general exemptions, for such chemical uses as lawn maintenance and retail sales, and for special exemptions, which can only be granted by the Florida Ground Water and Natural Resources Protection Board.

Businesses in Zone 1 must be able to ensure protection of ground water with appropriate technology, or they may be required to shut down within one year. The ordinance also requires that notification be given for all spills in all zones, and that all quantities of regulated chemicals greater than 5 gallons or 25 pounds must be registered.

Construction operations in all four zones must use best-management practices before and after construction.

Ordinance Results. The terms of the ordinance require that 3,550,000 gallons of regulated substances and 118 pollutant storage tanks must be removed from Zones 1, 2, and 3, or be placed in secondary containment and monitored. Eleven wells have been taken out of service as public supplies to avoid meeting the terms of the ordinances. Nine wells have been closed by the utilities, and two wells have been purchased by industries. Money has been allotted for two wells to be relocated by the County. By reducing their chemical usage below regulatory thresholds, 65 companies have become exempt from the ordinance. Taxes and permit fees pay for annual inspection of industries and inspection of all construction activities within zones of regulation. Sampling, containment, and relocation costs required for implementation of the ordinance are estimated to exceed $1,000,000 over a 10-year period.

Public Education. Seminars, public announcements, inspections, and the media have been used to publicize the wellhead protection program in Palm Beach County.

WHAT MAKES THIS PROGRAM UNIQUE?

Implementation of the Palm Beach Wellhead Protection Ordinance requires coordination among 30 utilities and 25 county and municipal government agencies.

Industries, a primary source of potential ground water contamination in Palm Beach County, have a good record of compliance with the ordinance. The public's enthusiasm for this ordinance was evidenced by an 85 percent approval in a 1987 referendum.

PROGRAM CONTACT

For further information about the Palm Beach County wellhead protection program, contact:

Mr. Allen Trefry
Palm Beach County Board of County Commissioners
Department of Environmental Resource Management
3111 S. Dixie Highway
Suite 146
West Palm Beach, FL 33405

(407) 355-4011

The County received a 1991 National Association of Counties Achievement Award for its success with the ordinance.

SANTO DOMINGO PUEBLO, NEW MEXICO WELLHEAD PROTECTION PROGRAM

TYPE OF PROGRAM

Wellhead protection pilot program for the Pueblo, including delineation of wellhead protection areas (WHPAs), contaminant source identification, and management recommendations.

The Pueblo's water supply is threatened by commercial land uses in the village and by agricultural land uses upstream in the Rio Grande valley.

COMMUNITY OVERVIEW

The Santo Domingo Pueblo is located south of Santa Fe, New Mexico. It is one of eight Pueblos located between Albuquerque and Santa Fe. The tribal reservation includes stretches of the Rio Grande River and of Galisteo Creek, and portions of highways and a railroad. The majority of the Pueblo's population and commercial development is located in the village of Santo Domingo. The Pueblo population is approximately 4,000.

BACKGROUND

Santo Domingo Pueblo village relies on two public water supply wells, yielding 125 and 410 gallons per minute respectively. These wells draw from an alluvial sand and gravel aquifer located in the Rio Grande valley. This aquifer consists of a mix of clay, silt, sand, and gravel. Water quality in this aquifer is generally poor, although it does not present a health hazard. The low quality is caused by high concentrations of dissolved salts and is not thought to be a result of human activities. There is a second aquifer in the area, in the Santa Fe basin fill, also consisting of a mix of sand, gravel, silt, and clay. Depth to water varies from 50 feet in the major valleys to over 350 feet in mesa areas. The regional ground water flow direction is from the northeast.

PROGRAM DESCRIPTION

Under Section 1451 of the 1986 Safe Drinking Water Act Amendments, US EPA is empowered to assist tribes in wellhead protection. EPA Region 6 selected the Santo Domingo Pueblo for a wellhead protection pilot program.

Delineation of WHPAs. The pilot study evaluated different WHPA mapping techniques to assess their appropriateness for the Pueblo's wells. This evaluation concluded that the use of a calculated fixed radius technique in this geohydrologic environment provides a reasonable level of protection. In cases where the hydrogeology is favorable, and where financial resources are unavailable for more complex and accurate mapping methods, the calculated fixed radius is recommended.

WHPAs were delineated for two existing wells in the village area, using the calculated fixed radius method with 5- and 50-year time of travel criteria.

WHPAs were also delineated for two potential wells. For these wells, a 900-foot, 5-year WHPA radius, and a 2,846-foot, 50-year WHPA radius were used.

Identification of Contaminant Sources. Known and suspected sources of contamination were identified for the WHPAs of the two existing and two potential wells. Identification techniques included field inspections by Pueblo staff, review of state and federal permit records, and interpretation of maps and aerial photographs.

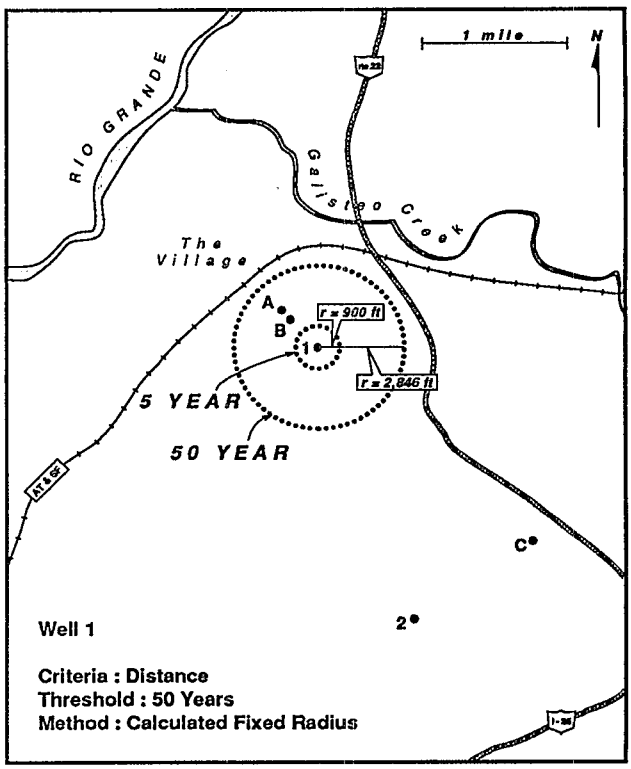
Non-point sources of contamination in the village include family controlled animal corrals, ash piles and sewer line leaks. In the Rio Grande valley, sources include irrigation return flows and other agricultural activities and on-site wastewater disposal systems. Point sources of potential ground water contamination include sewage lagoons, a school, a commercial center, train station sewage and solid waste disposal, active gypsum and abandoned uranium mining operations, underground storage tanks, a landfill, and industrial activities.

Transportation corridor contamination threats include the Atchison, Topeka, and Santa Fe Railroads, Interstate Highway 25, and State Highway 22, which are used to transport hazardous materials.

Management Approaches. Management recommendations were developed to address four general activity areas. To control use of hazardous materials, a ban or restriction on all applicable activities within the WHPAs was recommended. To regulate hazardous materials transport, the Pueblo could support regional, state, and federal initiatives. To control point source discharges to ground water, tribal ordinances could be used. To control non-point sources, monitoring, public education programs, and wellhead demonstration programs were recommended actions.

In response to the management options suggested, the Pueblo took regulatory action. An ordinance was developed to prohibit solid waste disposal except in the existing landfill or other authorized location. The ordinance also specifies operating criteria for the existing landfill and prohibits future landfills near the Rio Grande or in areas with shallow depths to ground water.

The Pueblo is also considering adoption of an ordinance that would control potentially harmful activities in



WHPAs for both existing and future wells.
The ordinance includes control measures for wastewater disposal, underground storage tanks, used oil disposal; hazardous, toxic, and radioactive wastes, agricultural activities, water supply wells, and wood processing facilities.

The Pueblo is considering entering into a joint powers agreement with the Health and Environmental Department of the State of New Mexico. The agreement would make the Pueblo an investigative agency, with powers to investigate and document cases of illegal septage and refuse disposal on tribal lands. The state would be given the authority to enforce state environmental regulations on tribal lands, where applicable. Through this agreement, the Pueblo and the state would work together to protect water quality on and off tribal lands. The Santa Clara Pueblo has developed a joint powers agreement with the New Mexico Environmental Improvement Division, which serves as a model for other tribe-state cooperative agreements.

Contingency Planning. The pilot study reviewed essential steps in developing a contingency plan and recommended that the tribe develop one in the future. Since the study, a contingency plan has been developed to provide the Pueblo with water in the event of contamination of the main supply wells.

New Wells. Since completion of the pilot program, the Santo Domingo Pueblo has shut down an existing well due to water quality concerns. The new replacement well is located in a relatively undeveloped area approximately 10 miles from the Pueblo's village area.

WHAT MAKES THIS PROGRAM UNIQUE?

The Santo Domingo Pueblo wellhead protection program represents efforts by a tribe to protect ground water quality on and off tribal lands, via development of a joint powers agreement with the State of New Mexico.

The pilot program focused on delineation of WHPAs for existing wells as well as on training Pueblo officials in delineation and wellhead protection measures. The Pueblo has taken the pilot program recommendations seriously and developed several ground water protection strategies. The methodology and recommendations from the pilot study may be transferable to other tribal lands in the southwestern United States.

PROGRAM CONTACT

For further information about the Santo Domingo Pueblo wellhead protection program, contact:

Mr. Del Calabaza
Santo Domingo Tribal Business Enterprise
P.O. Box 159
Santo Domingo, NM 87052

(505) 465-2838

Major potential contamination sources include rail and highway corridors that cross Pueblo land. Therefore, coordination with state and federal agencies is required to protect ground water on a regional basis.

SPOKANE, WASHINGTON/PANHANDLE DISTRICT, IDAHO WELLHEAD PROTECTION PROGRAM

TYPE OF PROGRAM

Interstate ground water protection program through regulatory action and public education.

The Spokane Valley/ Rathdrum Prairie Aquifer spans state and municipal boundaries. Management approaches have been successfully coordinated across jurisdictions.

COMMUNITY OVERVIEW

Located in eastern Washington, Spokane lies approximately 25 miles from the Washington-Idaho border. Eastern Washington is primarily open, dry land, while the Idaho Panhandle region includes forests and mountains. The Spokane/ Panhandle area is primarily rural, except for the metropolitan areas of Spokane and Coeur d'Alene. The area includes several lakes and rivers. Interstate 90 and several state highways cross the region.

BACKGROUND

Spokane and the Idaho Panhandle lie over the Spokane Valley-Rathdrum Prairie Aquifer. This aquifer is a deep sand and gravel outwash deposit generated by a catastrophic outburst of glacial meltwater during Pleistocene times. It was designated a sole source aquifer in 1978. The aquifer is unconfined and has high porosity and transmissivity.

Over 355,000 people in Washington and Idaho rely on this aquifer for water supply. Depth to water ranges from 150 to 400 feet, and ground water flow has been measured at 650 to 1000 cubic feet per second through the aquifer. Ground water flow is generally from northeast (Spirit and Pend Oreille Lakes area) to southwest (discharging to the Spokane and Little Spokane Rivers).

PROGRAM DESCRIPTION

Spokane and the Idaho Panhandle Health District have been working jointly since the mid-1970s to protect regional ground water quality on the local level. Although no formal agreements have been signed between the two metropolitan areas, their cooperation in protecting shared ground water resources is a model for others.

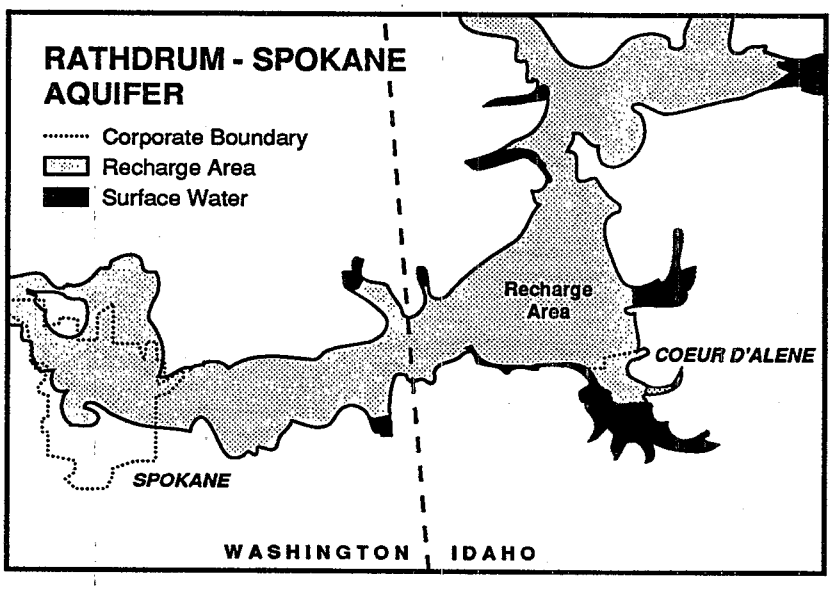
Extent of Recharge Area. Recharge to the aquifer is derived from seventeen watersheds, four adjacent aquifers, and precipitation. The Spokane River acts to both recharge the aquifer and to receive discharge as it crosses the region.

Management Approaches. During simultaneous studies in the City and County of Spokane and the Panhandle Health District in the mid-1970s, it became clear that the aquifer was being contaminated and degraded by residential, agricultural, and commercial activities. As part of a series of studies, a 16-month analysis of 31 wells in the aquifer revealed widespread nitrate contamination. The contamination was linked to an extremely rapid increase in population in the area—new homes relying on on-site septic systems for waste disposal.

Spokane and the Panhandle Health District developed different approaches to protecting the aquifer from further degradation. In Spokane, the County Commissioners adopted the Aquifer Sensitive Overlay Zone—an overlay zoning district that corresponds with the physical boundaries of the aquifer and a portion of the recharge areas to the aquifer.

The Overlay Zone established guidelines for land use and development within the area as well as requirements for the connection of new development to either existing sewers or the installation of "dry mains" for future connection to sewers. If sewers are not available, new developments are required to petition for the formation of a Utility Local Improvement District (ULID). ULIDs are a version of a special taxing or utility district authorized to levy assessments against property owners for the purpose of financing new sewer line extensions.

The Panhandle Health District will not grant permits for on-site waste disposal on lots less than five acres in size outside of incorporated cities and towns. Within incorporated cities and towns, the Health District grants permits for on-site waste disposal if the municipality signs a sewage management agreement (SMA) with the District.



The SMA is a key ingredient in the District's success in ground water protection. The SMA is a civil contract between the District and the community. It establishes a plan—goals and policies—for septic system maintenance and development of centralized sewage treatment facilities as growth and development increases.

While the above-noted regulations may be considered the hallmark of the Rathdrum/Spokane case study, both metropolitan areas have completed and are currently developing many other wellhead and ground water protection elements. These include: coordinating all individuals involved in regulating hazardous materials, managing

stormwater (a significant ground water contaminant) and solid waste, educating the public, and promoting interagency cooperation and coordination within each metropolitan area as well as between the City and County of Spokane and the Panhandle Health District.

WHAT MAKES THIS PROGRAM UNIQUE?

The ground water protection program developed by Spokane County and the Idaho Panhandle Health District represents a regional protection system for a regional resource. Implementation of management measures by one or the other jurisdiction alone would not be effective. Consequently, the two jurisdictions have jointly developed and implemented regulatory and non-regulatory management tools.

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Institution of ground water protection regulations at the local level in Idaho was feasible due to the existence of a local regulatory mechanism--the Panhandle Health District--established in 1971.

GLOSSARY

Aquifer	A saturated geologic formation capable of yielding significant quantities of water to wells or springs.
Aquitard	A saturated but low permeability geologic formation that is not capable of yielding significant quantities of water to wells or springs.
Best Management Practices	Operating procedures used in a specific agricultural, commercial or industrial process to reduce the risk of environmental contamination.
Buildout Analysis	An analysis of the total amount of development that could occur in a specified land area, such as a wellhead protection area, according to present land use regulations and natural environmental constraints (e.g., steep slopes, wetlands).
Community Planning Area	A subset of a county, city, or town that is subject to specific planning programs and regulations (e.g., wellhead protection ordinances). Many community planning areas are also those portions of a county or municipality within which growth and development is encouraged due to available infrastructure such as water, roads, and sewer facilities.
Confined Aquifer	An aquifer bounded above and below by aquitards, thus there is no free ground water surface.
Developable Lot Analysis	See *Buildout Analysis*.
Down-Dropped Basin/Bolson	A large depression into which water drains, causing the depression to fill with sediments. Portions of the sediments constitute aquifers.
Fixed Radius Method	A method of delineating wellhead protection areas (WHPAs) that establishes a protection zone that is a uniform distance from the wellhead in all directions. The distance from the wellhead (i.e., the radius) may be chosen arbitrarily or calculated based on ground water time of travel.
Geographic Information System (GIS)	A computer-based data management system that facilitates the concurrent overlay and comparison of information from different environmental and community data bases.
Overlay Protection District	A process whereby specific use regulations are adopted for the purpose of protecting ground water quality and quantity. The regulations are adopted as an overlay district, such that uses located on land within this district must comply with regulations specified in both the underlying zoning district and the overlay protection district.
Perched Water Table	A water table above an impermeable bed, separated from an underlying main body of ground water by an unsaturated zone.

GLOSSARY (continued)

Permeability	The capacity of a porous medium to transmit water.
Phosphorus Loading Analysis	A quantification of the total mass of phosphorus resulting from land use activities in a given area. Phosphorus sources typically include sewage effluent, lawn fertilizers, agricultural fertilizers, road and roof runoff and precipitation. A loading analysis involves summing the total mass of phosphorus from these sources in order to predict the impact of their discharges on ground water and surface water quality. Phosphorus is typically considered a contaminant in surface waters because excess quantities can accelerate the growth of unwanted algae and aquatic plants.
Porosity	The ratio of the volume of small openings in soil or rock to its total volume; usually expressed in a percentage.
Protection Zone	The land area determined to provide recharge to a public drinking water supply well, designated on maps and usually regulated by ordinance as to allowable land use and activities. Protection zones may comprise all or a portion of a WHPA.
Recharge Zone	The area of land above an aquifer that allows infiltration of water to recharge an aquifer.
Regional Water Budget	A method of accounting for all water inputs and outputs to a regional aquifer system.
Saturation Development Level	The total number of lots or structures that can be developed in a given area according to present or proposed land use regulations.
Secondary Containment	A system or mechanism to prevent the release of a substance (e.g., chemicals, wastes, or leachate) despite failure of a primary containment system. For example, a landfill may be constructed with at least two liners; the second liner acts as a secondary containment mechanism in the event that leachate escapes the first liner.
Sole Source Aquifer	An aquifer that is the sole or principal source of drinking water, as established under Section 1424(e) of the Safe Drinking Water Act, and that if contaminated, would create a significant hazard to public health.
Spine Area	The center of the peninsula comprising the Eastern Shore of Virginia that supplies the majority of recharge water to the lower aquifers on the peninsula. Protection of this area is important to maintain a high quality of water in the wells that pump from the lower aquifers.
Storativity	The ability of an aquifer to release water from or take water into storage, expressed per unit of surface area of the aquifer per unit change in head.

GLOSSARY (continued)

Theis Analytical Model	A mathematical model used to calculate the extent of water drawdown caused by the pumping of a well. The extent of drawdown can be used in delineating a wellhead protection area for the well.
Time of Travel (TOT)	The time required for a contaminant to move in the saturated zone from a specific point to a well.
Transmissivity	The rate at which water is transmitted through a unit width of the aquifer under a given hydraulic gradient.
Unconfined Aquifer	An aquifer characterized by the absence of an aquitard above it, so that the water table forms the upper boundary and is free to move with atmospheric influences such as precipitation.
Wellhead Protection Area (WHPA)	Areas designated by state or local governments for limited development or other protection to prevent ground water contamination. WHPAs are often located around public drinking water wells or recharge areas and may be

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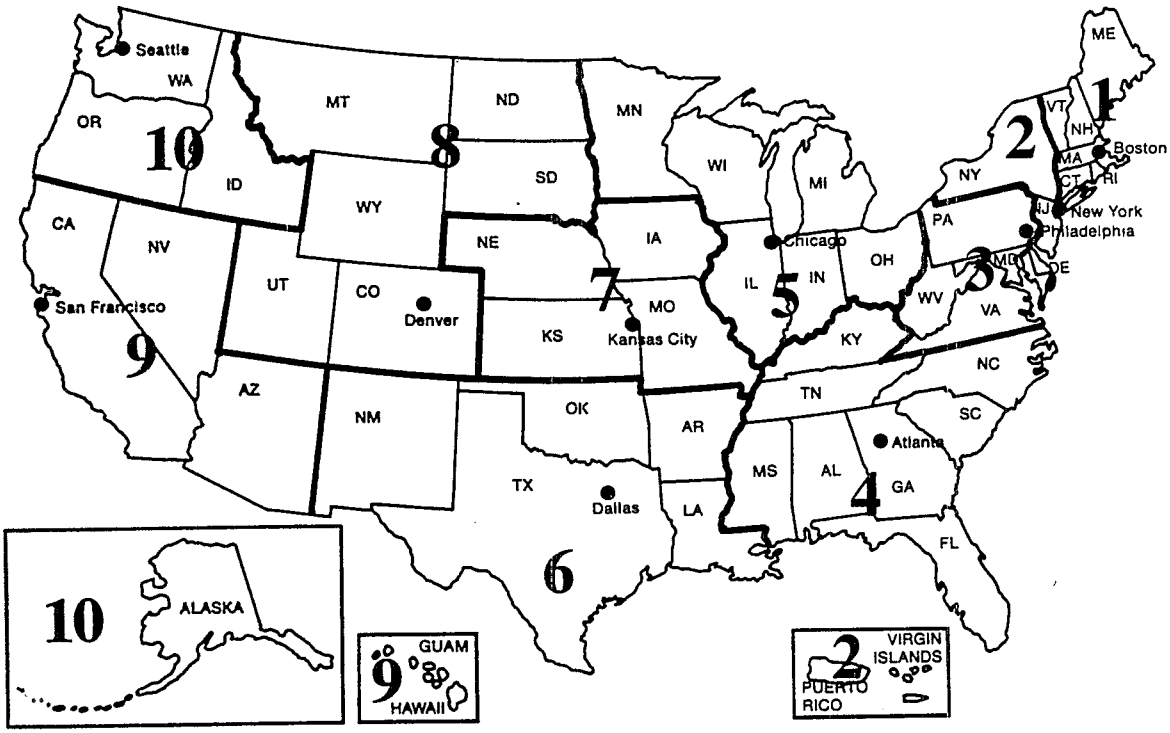

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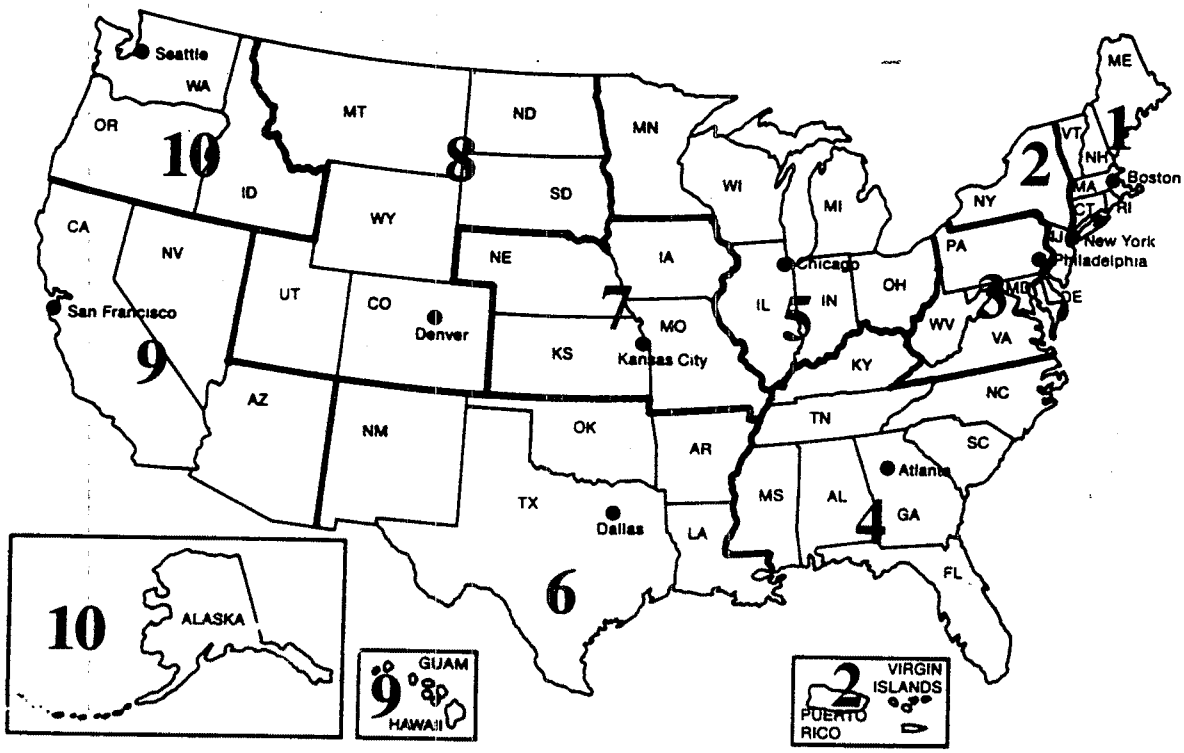

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