

W A S H I N G T O N S T A T E

Wellhead Protection Program Guidance Document



Jan. 2017
DOH 331-018
Revised

Washington State Wellhead Protection Program Guidance Document

January 2017



For more information or additional copies of this publication contact:

Constituent Services Section
Office of Drinking Water
Department of Health
PO Box 47822
Olympia, WA 98504-7822
800-521-0323

For people with disabilities, this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (TDD/TTY call 711).



Acronyms and Abbreviations

BMPs	Best Management Practices
CARA	Critical Aquifer Recharge Area
CCWF	Centennial Clean Water Fund
CFR	Calculated Fixed Radius
COM	Washington State Department of Commerce
CWSRF	Clean Water State Revolving Fund
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	Environmentally sensitive area
GMA	Growth Management Act
GW	Groundwater under the direct influence of surface water
GWMA	Groundwater management area
IGWC	Interagency Groundwater Committee
LEPC	Local Emergency Planning Committee
LHJ	Local health jurisdiction
MCL	Maximum contaminant level
NRCS	Natural Resources Conservation Service
ODW	Department of Health Office of Drinking Water
OTA	Office of Technology Assessment
PWS	Public water system
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
SAL	State Advisory Level
SARA Title III	Superfund Act Reauthorization Amendments
SDWA	Safe Drinking Water Act
SEPA	State Environmental Policy Act
SOC	Synthetic organic compound
SOP	Standard operating procedures

SSA	Sole Source Aquifer
TOT	Time of travel
UIC	Underground Injection Control Program
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WAC	Washington Administrative Code
WFI	Water Facilities Inventory
WHPA	Wellhead Protection Area
WSCC	Washington State Conservation Commission
WSDA	Washington State Department of Agriculture
WSU	Washington State University
ZOC	Zone of contribution





Contents

EXECUTIVE SUMMARY.....	1
Overview	1
Wellhead Protection Area Delineation Methods.....	1
Wellhead Protection Area Zones	2
Roles and Responsibilities.....	2
Wellhead Protection Area Inventory and Management.....	3
Contingency Planning	3
Spill or Incident Response Planning	3
Relationship to Current Planning Requirements	4
New Wells used for Public Water Systems	4
1. INTRODUCTION	5
COSTS OF CONTAMINATION.....	6
WELLHEAD PROTECTION AND MONITORING REQUIREMENTS	7
2. ROLES AND RESPONSIBILITIES.....	9
PUBLIC WATER SYSTEMS.....	9
LOCAL GOVERNMENTS.....	10
LOCAL WELLHEAD PROTECTION COMMITTEES	10
LOCAL AND COUNTY HEALTH JURISDICTIONS	11
STATE AGENCIES.....	12
FEDERAL AGENCIES	16
FEDERAL FACILITIES.....	16
TRIBES.....	17
3. IMPLEMENTATION.....	18
LEGAL BASIS FOR REQUIREMENTS	18
IMPLEMENTATION.....	18
RELATIONSHIP TO PLANNING REQUIREMENTS AND COMPLIANCE MECHANISMS	19
4. DELINEATING WELLHEAD PROTECTION AREAS	20
SELECTED WELLHEAD PROTECTION AREA DELINEATION METHODS.....	23
ASSESSMENT OF SUSCEPTIBILITY	29
ASSESSMENT OF HYDROGEOLOGIC SETTING	30
5. INVENTORY OF POTENTIAL CONTAMINANT SOURCES	36
CONDUCTING AN INVENTORY	36
6. WELLHEAD PROTECTION AREA MANAGEMENT STRATEGIES AND IMPLEMENTATION	43
7. CONTINGENCY PLANS	48
8. SPILL AND INCIDENT RESPONSE PLANNING	50
9. WELLHEAD PROTECTION REQUIREMENTS FOR NEW PUBLIC WATER SUPPLY WELLS	51

10. LOCAL WELLHEAD PROTECTION PROGRAM FINANCING	52
11. HOW THE WELLHEAD PROTECTION PROGRAM RELATES TO OTHER PROGRAMS	54
GLOSSARY	58
RESOURCES	62
APPENDIX A: WELLHEAD PROTECTION RULES	64
APPENDIX B: CHECKLIST OF REQUIRED WELLHEAD PROTECTION ELEMENTS.....	65
APPENDIX C: SAMPLE SCOPE OF WORK FOR WELLHEAD PROTECTION PLANNING	71
APPENDIX D: SAMPLE NOTIFICATION LETTERS	74
APPENDIX E: KEY CONTACTS.....	76
APPENDIX F: SUSCEPTIBILITY ASSESSMENT INFORMATION	78
Introduction to Susceptibility Assessments	79
Instructions: How to complete the <i>Susceptibility Assessment Form</i>	81
Element 1: Creating a Wellhead Protection Map	90
Element 2: Diagram of a Drinking Water Supply Well	93
Element 3: Sample Well Report (Well Log).....	94
Element 4: Tables for Calculating Time of Travel.....	96
Element 5: Maximum Contaminant Levels (MCLs).....	97
Sample <i>Susceptibility Assessment Form</i>	99



Executive Summary

Overview

The Safe Drinking Water Act requires every state to develop a wellhead protection program. The state Department of Health (DOH) administers the wellhead protection program in Washington.

Most public water supply wells are located in or near communities. Washington's wellhead protection requirements are designed to *prevent* contamination of groundwater used for drinking water. The requirements apply to all Group A¹ public water systems that use wells or springs for source water, except those that purchase their water or get their water through interties.

Public water systems must work with local governments and regulatory agencies to develop and implement their own local wellhead protection programs.

In Washington, local wellhead protection programs must include:

- A completed susceptibility assessment.
- A delineated wellhead protection area for each well, well field, or spring.
- An inventory of potential contaminant sources in the wellhead protection area that could threaten the water-bearing zone (aquifer) used by the well, spring, or well field.
- Documentation showing the water system sent delineation and inventory findings to required entities.
- Contingency plans for providing alternate drinking water sources if contamination does occur.
- Coordination with local emergency responders for appropriate spill or incident response measures.

Wellhead Protection Area Delineation Methods

All groundwater-based Group A systems must complete a DOH *Susceptibility Assessment Form*. The DOH susceptibility assessment includes an assessment of the circularity of the zone of contribution. The findings from the assessment and the system size determine the minimum acceptable delineation method for the wellhead protection area. Most systems can use a calculated fixed radius method.

¹ DOH uses the term "Group A" to designate public water systems that serve 25 or more people or 15 or more connections. Please see WAC 246-290-020 for more details.

Wellhead Protection Area Zones

Groundwater time-of-travel criteria are used to define the primary zones of a wellhead protection area. The three principal zones are delineated using 1-, 5- and 10-year time-of-travel factors. The 1-year time-of-travel zone includes a 6-month delineation to focus protection from viral and microbial contamination where loading may pose a higher risk to the drinking water supply such that a higher level of on-site treatment may be appropriate. The two other zones are the currently existing sanitary control area and an additional buffer zone (if warranted). It takes various management strategies to prevent pollution and reduce risk from different types of contaminant threats. State law sets requirements for wellhead protection area zones (WAC 246-290-130 and 246-290-135).

A wellhead protection area may have four or five zones. Each zone represents the length of time it would take a particle of water to travel from the zone boundary to the well.

The sanitary control area: The area immediately around the wellhead.

Zone 1: The 1-year horizontal time-of-travel boundary for groundwater. Zone 1 is managed to protect the drinking water supply from viral, microbial, and direct chemical contamination. **Zone 1 includes a 6-month time-of-travel boundary.**

Zone 2: The 5-year time-of-travel boundary for groundwater. Zone 2 is managed to control potential chemical contaminants. All potential contaminant sources must be addressed with emphasis on pollution prevention and risk reduction. Zone 2 provides information local planners use to site future “high risk” and “medium risk” potential contaminant sources.

Zone 3: 10-year time-of-travel boundary for groundwater. Zone 3 is the outer boundary of the wellhead protection area. In Zone 3, potential high- and medium-risk contaminant sources receive increased regulatory attention and technical assistance, with emphasis on pollution prevention and risk reduction.

Buffer zone: an area sloping up from Zone 3, potentially including the entire zone of contribution. The buffer zone may include additional non-contiguous critical aquifer recharge areas² requiring protection from contamination.

Roles and Responsibilities

The state Department of Health administers the state Wellhead Protection Program. Other state agencies, such as the Ecology and Agriculture, integrate wellhead protection into their programs.

Local governments with zoning authority are responsible for land use planning and zoning. Local agencies, such as planning and health departments, play a major role by helping water systems protect their community’s drinking water supply, and coordinating wellhead protection measures.

Water systems must delineate (define) and take an inventory of their wellhead protection areas.

² As defined in section 36.70A.170 of the Growth Management Act.

Wellhead Protection Area Inventory and Management

After they delineate their wellhead protection area boundaries, water systems must conduct an inventory to locate all potential sources of groundwater contamination in the wellhead protection area. An inventory of potential contamination sources is essential. Water systems can't take pollution prevention and risk reduction steps without identifying potential threats.

Non-governmental entities own or operate many public water systems in Washington. In addition, many wellhead protection areas are in locations outside the jurisdiction of the public water system owner. To help resolve multi-jurisdictional issues, DOH encourages water systems to establish a local wellhead protection committee. Existing community groups such as the Groundwater Advisory Committee³ or the Water Utility Coordinating Committee may serve as the nucleus of a local wellhead protection committee. Coordinating efforts may provide significant cost savings when delineating and conducting an inventory.

An initial inventory for the wellhead protection area must be completed within one year after the water system defines the wellhead protection area boundaries. Land use practices change over time; therefore, the inventory data should be updated at least every two years.

Contingency Planning

As part of a wellhead protection program, public water systems must develop a contingency plan to ensure consumers have an adequate supply of potable water if contamination results in the temporary or permanent loss of the principle source of supply (major well(s) or well field).

Water systems must establish contingency plans within one year after delineating the wellhead protection area.

Spill or Incident Response Planning

The water system must coordinate the contingency plan and the incident- or spill-response measures with:

- Local emergency responders (police and fire departments).
- Department of Ecology's Spill Operations Section.
- The Emergency Management Division of the Washington Military Department.
- Any local emergency planning committee.

Systems should coordinate with local emergency responders within one year after delineating the wellhead protection area.

³ Committee responsible for developing and implementing the local Groundwater Management Program.

Relationship to Current Planning Requirements

All Group A public water systems must prepare a Water System Plan (WAC 246-290-100) or a Small Water System Management Program document (WAC 246-290-105). Both documents require wellhead protection plans.

DOH reviews the Water System Plan on a cycle, which may span up to 10 years.

DOH reviews Small Water System Management Program documents on an “as needed” basis.

New Wells used for Public Water Systems

A delineation and initial inventory are required prior to new source approval (WAC 246-290-130). This ensures existing potential contaminant sources are identified and evaluated before a well is approved for a public water system. All other elements of the Wellhead Protection Program and the Department of Ecology’s Well Construction standards also apply. Delineations for new sources may be done using a calculated fixed radius method.



1. Introduction

Groundwater is the source of drinking water for about 65 percent of Washington citizens. In some counties, dependency on groundwater approaches 100 percent. Groundwater used for drinking water supplies is often vulnerable to contamination. Most public water supply wells are in or around the communities using them as a drinking water source. Therefore, public water systems must take preventive measures to minimize the possibility that land uses will contaminate the groundwater they use.⁴

The federal Safe Drinking Water Act mandates every state to develop a wellhead protection program.⁵ In Washington, the governor designated DOH as the lead agency to develop and administer the wellhead protection program. The Safe Drinking Water Act also requires all federally defined public water systems (Group A systems⁶) that use groundwater as their source to implement a wellhead protection program.

In July 1994, DOH adopted a rule requiring mandatory wellhead protection measures for all Group A public water systems that use wells or springs as their source of supply (Appendix A). The rule excludes systems using purchased sources or interties.

In Washington, local wellhead protection programs must include:

- A completed susceptibility assessment.
- A delineated wellhead protection area for each well, well field, or spring.
- An inventory of all potential sources of contamination in the wellhead protection area that may pose a threat to the water bearing zone (aquifer) used by the well, spring, or well field.
- Documentation that delineation and inventory findings are distributed to required entities.
- Contingency plans for providing alternate sources of drinking water in the event that contamination does occur.
- Coordination with local emergency responders for appropriate spill or incident response measures.

The intent of the wellhead protection program is to prevent contamination of groundwater used for drinking water, thus protecting the health of people using groundwater for drinking water. To

⁴ **Public Water System (PWS):** Any system, excluding systems serving only one single-family residence, providing piped water for human consumption (WAC 246-290-020).

⁵ See section 1428 of the 1998 Amendments to the Safe Drinking Water Act.

⁶ DOH uses the term "Group A" to designate public water systems that serve 25 or more people or 15 or more connections. See WAC 246-290-020 for more details.

accomplish this, systems need to provide management zones around public wells, well fields, and springs to detect and manage potential sources of groundwater contamination.

Pollution prevention is the state's preferred approach to groundwater protection. Washington's Wellhead Protection Program provides a safeguard for groundwater used by public water systems. The program works with other federal, state, and local groundwater protection programs including Sole Source Aquifer Designation, Groundwater Management Area Program, Aquifer Protection Area Designation, Critical Aquifer Recharge Area management under the Growth Management Act, and the state's point source and nonpoint source pollution control programs. This integrated approach, emphasizing intra- and interagency coordination among multiple levels of government, is the best way to protect public drinking water supplies.

Washington's Wellhead Protection Program follows the statutory requirements in Section 1428 of the 1986 Federal Safe Drinking Water Act (SDWA) Amendments. Wellhead protection helps local communities protect their groundwater-based drinking water supplies. A component of the Wellhead Protection Program is delineating wellhead protection areas. A wellhead protection area is defined as the surface and subsurface area surrounding a well or well field that contaminants are likely to pass through and eventually reach the water well(s). In simpler terms, it is the area managed by a community to protect groundwater-based public drinking water supplies.

Potential contaminant sources in wellhead protection areas are identified and managed to eliminate or reduce their risk of contaminating public water supplies. Washington's Wellhead Protection Program advocates a progressive management concept. Education and use of best management practices are important ways to reduce or eliminate the need for restrictive regulatory protection plans. Local land use protection or design standards may be necessary to protect the drinking water supply.

Individuals, organizations, and municipalities seeking information on Washington's Wellhead Protection Program may contact the:

Wellhead Protection Program
Washington Department of Health
P.O. Box 47822
Olympia, WA 98504-7822
(360) 236-3100

Costs of Contamination

A primary motivation for implementing a local wellhead protection program is to avoid the high costs associated with a contaminated public water supply. Experience shows that it is considerably more cost effective to implement a proactive pollution prevention program to guard against groundwater contamination rather than pay for an alternate drinking water supply or initiate groundwater remediation efforts.

The direct costs associated with well contamination include:

- Administrative costs of responding to contamination.
- Loss of developed well field.
- Purchase of water while locating an alternate supply.
- Hydrogeologic studies to locate alternate source water.
- Development of a new water source, if unallocated groundwater is available.
- Application costs for obtaining new water rights.
- Engineering, construction and equipment costs of well replacement.
- Treatment of contaminated groundwater, if possible.
- Investigation and remediation costs.
- Public information and education costs.
- Legal proceedings against responsible party, if identified.
- Unanticipated acceleration of amortization costs.
- Increased monitoring requirements.

The indirect costs associated with groundwater contamination include:

- Loss of (peak) capacity.
- Reduced consumer confidence.
- Lost opportunity costs.
- Potentially increased health risks.
- Potential reduction in development opportunities.
- Potentially lower property values and tax base.

After a well is contaminated, a facility's operations come under increased public scrutiny. Many investors will not locate in an area without conducting an environmental audit. The perception of contaminated water may cause potential developers to look elsewhere. Property values may decline, reducing the tax base.

Most communities recognize their water supplies are vulnerable to contamination. This awareness, coupled with increased information on the direct and indirect costs of well field contamination, is a key force driving implementation of local wellhead protection programs.

Wellhead Protection and Monitoring Requirements

In the 1986 amendments to the SDWA, Congress expanded the contaminant monitoring requirements for many public water systems. If no monitoring waivers are granted, Group A water systems must test for over 80 different volatile organic compounds (VOCs) and synthetic organic compounds (SOCs).

Monitoring requirements can incorporate site variability in hydrogeologic susceptibility to contamination and the history of contaminant loading when determining sampling frequency. These two factors combine to indicate a public water supply's vulnerability (potential for contamination).

DOH developed an approach⁷ to help water systems cope with expanding and expensive monitoring requirements in 1994. The rules allow the Department of Health's Office of Drinking Water (ODW) to adjust the requirements based on how vulnerable a water system source is to contamination. ODW uses monitoring waivers to eliminate unnecessary testing while fully protecting human health.

⁷ DOH publication, *The Source Monitoring Waiver Process* (331-359), describes the approach. (See Resources section.)



2. Roles and Responsibilities

Various local, state, and federal agencies coordinate efforts to protect groundwater in Washington.

Public water systems must develop and implement local wellhead protection programs. Because water systems often have limited jurisdiction or regulatory authority, it is essential that they work with many other agencies and programs, at all levels of government, to ensure effective implementation. Numerous local, state, and federal agencies are responsible for providing technical assistance and outreach, and regulating many of the potential sources of groundwater contamination identified during the inventory process.

Public Water Systems

All Group A public water systems must prepare a Water System Plan (WAC 246-290-100) or a Small Water System Management Program (WAC 246-290-105). Both documents require wellhead protection plans. Local wellhead protection programs are to be developed and implemented by all Group A water systems that use groundwater or springs as source water.

The wellhead protection program portion of a water system's planning document must contain, at a minimum:

1. A completed susceptibility assessment.
2. Wellhead protection areas delineated for each well, well field, or spring with the 1-, 5- and 10-year time-of-travel boundaries marked. Or, if groundwater time-of-travel is not a reasonable delineation criterion, boundaries established using other DOH-approved criteria.
3. A list of known and potential groundwater contaminant sources in the defined WHPA(s) that may pose a threat to the water-bearing zone (aquifer) used by the well, spring, or well field. This list should be updated every two years. It should describe how the inventory of potential contaminant sources was done and how it will be updated.
4. Documentation showing the water system notified all owners and operators of known and potential sources of groundwater contamination within the WHPA boundaries.
5. Documentation of the water system's notification to regulatory agencies and local governments of the boundaries of the WHPA(s) and the finding of the WHPA inventory.
6. A contingency plan for providing an adequate supply of potable water if contamination results in the temporary or permanent loss of the principal source of supply.

7. Documentation of coordination with local emergency responders (such as police, fire and health departments), including notification of WHPA boundaries, susceptibility assessment results, inventory findings, and a contingency plan.

Public water systems owned and operated by local governments have clear authority to protect groundwater through zoning decisions, building and operating standards, land use controls, public health ordinances, and other measures. Other public water systems, however, have no land use authorities. These systems will need to work cooperatively with the local government(s) and regulatory agencies to ensure adequate protection of their wells.

Coordinating efforts between public water systems may provide significant cost savings when delineating and inventorying. An example of such a savings might be during the delineation process. Where there are multiple public water systems in an area required to delineate using analytical or other site-specific methods, it may be substantially less expensive, per system, if several systems contract jointly for delineation modeling.

A checklist of required wellhead protection elements for water system planning documents, a generic “Scope of Work” for a local wellhead protection program, and sample notification letters are included as Appendices B-1, B-2, and B-3.

Local Governments

Most of the responsibility for implementing wellhead protection lies at the local level. In Washington, land use planning occurs at the local government level. Public water systems and the communities dependent on their water supplies have a strong interest in protecting the drinking water resource. This may be accomplished by strong educational programs, use of best management practices and other non-regulatory approaches.

In some settings, it may be necessary to adopt zoning ordinances or codes that limit activities around the water supply, set design or operating standards for facilities in the wellhead protection area, or other regulatory approaches. Local officials with land use authorities will select and implement the necessary steps to protect the community’s water supply. Local community development departments or similar local planning agencies ensure wellhead protection programs are integrated into the overall community planning. An excellent summary of common measures used in local wellhead programs is in the EPA document *Wellhead Protection Programs: Tools for Local Government* (440-6-89-002). (See Resources section.)

Wellhead protection areas are a type of critical aquifer recharge area under the Growth Management Act (GMA). A local wellhead protection program can be a tool to protect critical aquifer recharge areas. The converse is also true: declaring a wellhead protection area a critical aquifer recharge area, subject to local regulations and policies, is a useful part of a local wellhead protection program. The GMA provides an inter-jurisdictional planning mechanism to work on the protection of critical areas⁸.

Local Wellhead Protection Committees

⁸ For more details, contact the Washington State Department of Commerce’s Growth Management Division (Appendix C).

Because many wellhead protection areas are, at least in part, outside the jurisdiction of the water supplier, inter-jurisdictional cooperation is essential for effective wellhead protection. To help resolve multi-jurisdictional issues, a local wellhead protection committee should be established early in the process. You should include representatives from all affected parties, including citizen groups, businesses, media, and regulatory agencies. In many settings, a local government agency is most appropriate as the designated lead agency of the committee. Existing groups in the community such as a Groundwater Advisory Committee or a Water Utility Coordinating Committee may serve as the nucleus of a local wellhead protection committee. In areas with multiple small to medium sized public water systems, a high degree of coordination is essential. Coordinators of local government programs such as watershed management and growth management need to be involved in local wellhead protection implementation efforts beginning in the very early stages. Coordinating efforts may provide significant cost savings when delineating and inventorying.

Local wellhead protection committees' roles may vary. In some counties, the committee may play a major role in almost every aspect of wellhead protection—from coordinating delineation and inventory efforts to prioritizing potential contaminant sources and developing management approaches. In other counties, it may be appropriate for the committee to focus primarily on development of protective strategies, leaving the delineation and inventory up to individual water systems.

Local and County Health Jurisdictions

Local health jurisdictions (LHJs) have authority and responsibility for protecting public health. Most LHJs maintain records on approval of individual septic systems. Most LHJs have assumed some responsibility for administering a drinking water program, with primary focus on individual and Group B public water supplies (fewer than 15 connections and fewer than 25 persons served). The level of LHJ involvement in administering the state drinking water program is defined in a joint operating agreement negotiated between DOH and each LHJ.

In some counties, LHJs play a lead role in implementing wellhead protection. LHJ wellhead protection activities may include assisting in the inventory process, acting as an advocate to the local political jurisdictions, or providing technical assistance to small public water systems.

In several counties, the LHJ is the lead agency for developing a Groundwater Management Area Program. Integrating wellhead protection planning into an overall groundwater management program is one of the best ways to ensure multi-jurisdictional coordination occurs during implementation.

State Agencies

The following state agencies have groundwater protection responsibilities and authorities. Wellhead protection does not transfer authorities for potential contaminant source control away from existing agencies. The agencies use information developed during wellhead protection-area inventories to prioritize technical assistance outreach, field inspections, enforcement actions and other activities.

Interagency Groundwater Committee

The Interagency Groundwater Committee (IGWC) examines groundwater-related issues, programs, or activities with inter-jurisdictional implications. It was formed in 1992 to improve groundwater protection efforts by coordinating between programs, agencies and various levels of government (federal, state, local, and tribal).

IGWC addresses cross-program and cross-agency issues related to wellhead protection implementation. It also helps resolve discrepancies between programs, possible gaps in control mechanisms, and duplicate use of limited groundwater protection resources.

Washington State Department of Health

The Department of Health (DOH) is responsible for protecting public health by “ensuring safe and reliable drinking water.” DOH protects drinking water by monitoring supplies, preventing pollution, and establishing cooperative relationships with water utilities and local health jurisdictions. DOH administers the Wellhead Protection Program, implements other components of the federal Safe Drinking Water Act (SDWA), and establishes monitoring and planning requirements for public water systems.

In Washington, with some exceptions, a public water system is any system providing piped water for human consumption, excluding a system serving only one single-family residence. Group A public water systems have 15 or more connections, or serve 25 or more people. (See WAC 246-290-020 for a complete definition of public water systems.)

DOH oversees the engineering and operational function of public water systems. DOH maintains an inventory of public water supply wells and their legal locations. Systems submit operational reports containing use and drawdown information to DOH. DOH has access to water quality monitoring data, engineering, and aquifer pumping tests, and evaluations of the area surrounding well sites through preliminary engineering reports submitted as part of the permit process.

DOH staff reviews Water System Plans and Small Water System Management Program documents.

The Wellhead Protection Program is in DOH’s Office of Drinking Water. DOH works with appropriate agencies to ensure technical soundness, organizes public meetings and citizen participation efforts, coordinates and promotes pollution control and prevention measures in wellhead protection areas, hosts interagency meetings, acts as a central repository for source

identification and control information, develops technical assistance documents, conducts grant administration activities, and participates on the Interagency Groundwater Committee.

DOH works with the Department of Ecology, the Department of Agriculture and others to identify pollution prevention and risk reduction technical assistance information available for potential contaminant sources in wellhead protection areas. Mechanisms are in place to transfer this information to the potential contaminant sources. DOH also works with various agencies to identify types or classes of potential contaminant sources that lack pollution prevention or risk reduction technical assistance so the need can be noted and addressed as rapidly as possible.

DOH offers technical assistance for tasks such as evaluating the potential of facilities or activities in a designated wellhead protection area to contaminate groundwater and developing management and contingency plans.

If you have questions about the Wellhead Protection Program or ways communities can minimize the probability of contamination, call DOH at:

Headquarters, Tumwater	(360) 236-3100
Eastern Region, Spokane Valley	(509) 329-2100
Southwest Region, Tumwater	(360) 236-3030
Northwest Region, Kent	(253) 395-6750

Washington State Department of Ecology

Department of Ecology (Ecology) is the primary environmental protection agency in Washington. As a result, several Ecology programs—listed below—have significant roles in Washington’s Wellhead Protection Program.

Ecology participates on the Interagency Groundwater Committee.

Water Quality Program: oversees several programs related to wellhead protection and the protection of groundwater quality, including the Underground Injection Control (UIC) program, and administers the state Groundwater Quality Standards. Wellhead protection areas in susceptible hydrogeologic settings may be classified as “Special Protection Areas” as defined by the Groundwater Quality Standards. This enables Ecology to establish additional discharge or monitoring requirements on permitted facilities discharging to groundwater. Details on Special Protection Area designation are in WAC 173-200, Water Quality Standards for Groundwater.

The Water Quality Program manages and controls point and nonpoint pollution sources. When water suppliers identify potential contaminant sources in delineated wellhead protection areas, the program works with DOH and others to help minimize or eliminate the risk of groundwater contamination.

Water Resources Program: works with Water Quality Financial Assistance Program to manage the Groundwater Management Area (GWMA) Program. The GWMA Program is an important complement to the state’s Wellhead Protection Program. A GWMA protects groundwater quality and quantity, and manage the resource over a large area and for all beneficial uses (not just drinking water). Wellhead protection can be an important part of a GWMA, serving as a starting point for implementation efforts. For more details on the GWMA Program, contact Ecology’s Water Resources Program (Appendix E).

The Water Resources Program is also responsible for allocating water rights, permitting well drillers, performing hydrogeology studies on each groundwater basin, licensing groundwater observation and monitoring well drillers, enforcing well construction standards, and other programs that manage and protect groundwater.

The Water Resources Program maintains an inventory of wells in the state including public and private water supplies. The inventory contains location information, such as legal descriptions, longitude and latitude. The well driller submits well construction descriptions and lithologic data to Ecology. They are maintained at Ecology's regional offices. This information may be valuable to public water systems as they model their wellhead protection areas or conduct potential source inventories (locating abandoned wells, for example).

Solid Waste Services Program: Offers technical assistance to local governments on waste management and pollution prevention issues. This program also manages the Moderate Risk Waste program including small-quantity hazardous waste generators (those that fall below thresholds of the State Dangerous Waste Regulations). A primary objective of wellhead protection is to implement pollution prevention and risk reduction measures in wellhead protection areas. For this reason, the Solid Waste Services Program has a key role in technical assistance outreach efforts as potential sources of groundwater contamination are identified.

Hazardous Waste and Toxics Reduction Program: Administers the federal Resource Conservation and Recovery Act (RCRA) Program and provides pollution prevention assistance to businesses. This program and DOH's Wellhead Protection Program jointly implemented a pollution prevention grant from EPA to target technical assistance to RCRA facilities in wellhead protection areas.

Spill Operations Section: Worked with DOH and the Washington Association of Fire Chiefs to develop Standard Operating Procedures (SOP) for emergency first responders to use when reacting to a chemical spill or potential release in susceptible groundwater areas.

Washington State Department of Agriculture

The Washington State Department of Agriculture (WSDA) responsibilities for groundwater protection, include regulating confined animal operations; pesticide registration, usage, storage, and application; and regulation of commercial fertilizer storage, transportation, and use.

WSDA works with the Conservation Commission, Washington State University Cooperative Extension, Ecology Water Quality Program, DOH, and others to develop best management practices for agricultural operations in wellhead protection areas.

Wellhead protection areas in susceptible hydrogeological settings may be classified as "Special Use Areas." In a special use area, WSDA can require additional application or monitoring requirements, or restrict the use of certain agricultural chemicals. For more information, see WAC 16-228.

WSDA participates on the Interagency Groundwater Committee.

Washington State University (WSU) Cooperative Extension

WSU Cooperative Extension has educational centers in all Washington counties. Area agents provide direct technical assistance and information to community residents on many environmental issues, including water quality. Agents can help develop local wellhead programs and, based on available resources, may have a significant role during program implementation.

Washington State Department of Commerce

The Department of Commerce (COM) is responsible for carrying out the intent of the Growth Management Act (GMA). The GMA requires local jurisdictions to identify and protect critical areas, including aquifer recharge areas.

Wellhead protection areas are one type of Critical Aquifer Recharge Area. COM also oversees the Public Works Trust Fund, a state loan program that can be used to fund wellhead protection. COM participates on the Interagency Groundwater Committee.

The Emergency Management Division of the Washington Military Department

The Emergency Management Division works with local emergency management programs, and is an important resource when developing spill response plans.

Washington State Conservation Commission

The Washington State Conservation Commission (WSCC) gives administrative and program assistance to the statewide network of 48 Conservation Districts. Conservation Districts are legal subdivisions of state government that administer programs to conserve natural resources. Conservation Districts are responsible for helping landowners learn and adopt conservation best management practices (BMPs), including those that reduce or eliminate pollutants that leach into groundwater supplies. These BMPs address land use practices such as agriculture, urban construction, and stormwater runoff. WSCC performs BMP development activities in coordination with other federal, state, or local agencies that exercise regulatory authority over these land use categories. Conservation Districts promulgate BMPs through education, technical and other voluntary approaches.

The WSCC, with the Conservation Districts and the U.S. Department of Agriculture, maintains an inventory of soil conditions and land-use patterns across the state. The WSCC will make this data available to help identify potential nonpoint pollution sources that could affect drinking water wells.

Local conservation districts may identify site-specific activities that could contaminate groundwater, and can participate in developing local wellhead programs. They are responsible for promoting groundwater-protective BMPs; therefore, they will have a significant role during implementation of local wellhead programs.

WSSC participates on the Interagency Groundwater Committee.

Federal Agencies

Although the Wellhead Protection Program is a state program, there is a role for federal agencies.

The **U.S. Environmental Protection Agency (EPA)** is the lead federal agency for wellhead protection. EPA reviews and approves state wellhead protection programs. EPA provides federal funding for the state Wellhead Protection Program, develops technical assistance documents, hosts workshops, and has provided grants for wellhead protection to local governments. In addition, if a federal facility is in a delineated wellhead protection area, EPA can help the local program ensure the federal facility takes appropriate steps to minimize or prevent groundwater contamination.

The **Natural Resources Conservation Service (NRCS)** of the U.S. Department of Agriculture (USDA) offers technical assistance for groundwater quality protection to landowners in wellhead protection areas. USDA can enroll some agricultural areas in wellhead protection areas in its Conservation Reserve Program. NRCS is an excellent source of technical information concerning water quality protection from agricultural operations. NRCS employees work on programs with local Conservation Districts.

The **U.S. Geological Survey (USGS)** is a research-oriented agency with technical expertise in groundwater hydrogeology. USGS has collected detailed information on the geology of various formations and subsurface hydrogeologic conditions. USGS works with communities across the state in modeling hydrogeologic settings. These studies often provide the technical information needed to delineate wellhead protection areas, as well as aid in data collection and analysis. Other USGS groundwater quality studies may help local government protect groundwater quality. USGS has assisted with technical review of the proposed delineation methods.

Federal Facilities

Any federal department or agency with jurisdiction over any potential contaminant source in wellhead protection areas is subject to, and must comply with, all requirements of the state's Wellhead Protection Program. This includes paying reasonable charges and fees levied in connection with the management or remediation of potential contaminant sources.

Federal facilities that control areas in a delineated wellhead protection area (from an adjacent public water supply or from their own public water supply) must comply with all applicable regulations. DOH encourages federal facilities to develop their own rules beyond the minimum legal requirements to protect Washington's groundwater and drinking water resources.

Tribes

On request, DOH will provide technical assistance to Indian tribes within Washington's boundaries. Tribes may be eligible for state water-quality grants and loans. DOH will work with tribes to address inter-jurisdictional questions when wellhead protection areas cross reservation boundaries. EPA and the Indian Health Service offer technical and financial assistance to tribes for wellhead-protection implementation efforts.



3. Implementation

Legal Basis for Requirements

Public water systems are the only entities with direct legal requirements under the state Wellhead Protection Program. All new and existing Group A systems that use wells or springs as their supply source must develop local wellhead protection programs. The rule excludes systems that use purchased sources or interties. While Group B systems (fewer than 15 connections and fewer than 25 persons served) have elements of wellhead protection incorporated into their new source approval requirements, the state Wellhead Protection Program applies only to Group A systems.

The legislative authority to require wellhead protection planning is in the Revised Code of Washington (RCW) chapters 43.20.050, 70.119A.060, and 70.119A.080. DOH has authority through RCW 70.119A.080 to administer a drinking water program

The State Board of Health has authority and responsibility to adopt rules necessary to ensure safe and reliable public drinking water. These rules establish requirements on topics such as water quality, reliability, management, planning, emergency response, and reporting.

State law requires public water systems to protect water sources used for drinking water, ensure the availability of safe and reliable drinking water, and take any investigative action necessary to ensure a safe, reliable drinking water supply is continuously available to users (RCW 70.119A.060).

Implementation

DOH expects all groundwater-based Group A systems to complete a susceptibility assessment, which includes an assessment of the circularity of the zone of contribution. The findings from the assessment and system size determine the minimum acceptable delineation method. Most systems can use a calculated fixed radius method. See Chapter 4 for minimum delineation requirements.

Concurrent with the delineation process, the public water system should establish a local wellhead protection committee.

Within one year after the water system defines its wellhead protection area boundaries, it must complete an initial inventory for the entire wellhead protection area (within the 10-year time-of-travel boundary). The purpose of the inventory is to locate potential sources of groundwater contamination in the wellhead protection area.

Land use practices change over time; therefore, you should update the inventory data every two years. If the wellhead protection area is large, the initial emphasis should be on detecting potential contaminant sources in Zone 1 (the 1-year time-of-travel), and detecting high-risk sources in Zones 2 and 3 (the 5- and 10-year time-of-travel). The inventory must be expanded to cover all potential contaminant sources in the entire wellhead protection area as soon as possible.

Within one year after defining the wellhead protection area boundaries, the water system must notify the identified potential contaminant sources—and the agencies or jurisdictions that regulate them—that they are in the wellhead protection area. Notification must be in writing. The water system must maintain documentation of the required notifications. Sample notification letters are in Appendix D.

Systems must complete the required contingency plans and coordination with emergency responders within one year after delineating the wellhead protection area boundaries, and should update them at least every two years.

Relationship to Planning Requirements and Compliance Mechanisms

Systems must document and include all the elements of a local wellhead protection program in their Water System Plan or the Small Water System Management Program document. DOH reviews the Water System Plans on an up-to-10 year cycle, and the Small Water System Management Program documents on an as-needed basis.

Systems out of compliance with the wellhead protection components of either the Water System Plan or the Small Water System Program document may face:

1. DOH denial of construction documents.
2. DOH denial of Drinking Water State Revolving Funds.
3. DOH determination that the water system is inadequate. This could cause:
 - a. Local governments to deny building permits or subdivisions.
 - b. Lending institutions to deny home mortgages.
 - c. DOH to take receivership action.

When systems fail to comply with the planning requirements, DOH also may take one or more of the following enforcement actions:

1. Issue a notice of violation instructing or requiring appropriate corrective measures.
2. Issue a compliance schedule for specific actions needed to achieve compliance status.
3. Issue an order requiring specific actions.
4. Issue a stop-work order, or order the system to refrain from using any public water supply or making improvements until it obtains all required written approvals.
5. Impose civil penalties for failing to comply with orders.
6. Ask the attorney general or local prosecutor to take criminal or civil legal action.

If the water source is contaminated, and subsequent investigation reveals that the system is out of compliance with wellhead protection requirements, water system customers may be able to seek civil damages for losses such as decreased property value.



4. Delineating Wellhead Protection Areas

A wellhead protection area is the surface and subsurface area around a well or well field that contaminants are likely to pass through to reach the drinking water source. It is the area a community or water system manages to protect groundwater-based drinking water supplies from contamination. As the distance from the pumping well increases, the hypothetical amount of time it would take a particle of water traveling in the aquifer to reach the well also increases.

Establishing the protective boundaries for each well, well field, or spring is an essential element of a local wellhead protection program.

The public water system is responsible for defining (delineating) the wellhead protection area boundary. The *Susceptibility Assessment Form* and help using a calculated fixed radius method to delineate a wellhead protection area are in Appendix F. You can also contact the Wellhead Protection Program or your DOH regional office for help. More sophisticated delineation methods may require a groundwater professional (hydrogeologist, geologist, or civil engineer).

Criteria for setting wellhead protection area boundaries must be selected before delineation can occur. In Washington, wellhead protection areas are based on horizontal time-of-travel rates for groundwater.

A typical wellhead protection area has four or five zones:

- The sanitary control area.
- Three primary zones based on 1-, 5- and 10-year time-of-travel rates. Zone 1 includes an additional 6-month time-of-travel zone.
- A buffer zone, if necessary.

The three primary zones are based on the estimated time it would take a hypothetical water particle to travel through the aquifer to the pumping well. These travel-time-based aquifer management zones create an “early warning system” that gives a public water system time to respond to a contaminant moving in an aquifer before it arrives at the water supply well. It is important to recognize that it will take additional time for contaminants to move from the surface down to the water-bearing zone. However, the calculation used to estimate time-of-travel does not consider the vertical travel time.

There are two important considerations:

1. Time-of-travel calculations based on the rate that water moves through the aquifer. Some contaminants move faster (through volatilization, for example) or slower (through adsorption, for example) than water.
2. Wellhead protection-area delineation calculations ignore vertical time-of-travel, or the time it would take a water particle, or contaminant, to move from the surface down to the aquifer. Therefore, you should consider vertical time-of-travel when developing site-

specific wellhead protection plans. Similar contaminant sources may need to be managed differently in different hydrogeologic settings. For example, an activity located over a shallow water table aquifer, where water moves from the land surface to the aquifer in a matter of hours or days, may need to be managed differently than the same activity in an area where a particle of water may take months or years to travel from the surface, through a series of aquitards (confining layers) before reaching the aquifer.

Wellhead Protection Area Zones

In Washington, a wellhead protection area is based on established times of travel. Each management zone in the wellhead protection area corresponds to an established time-of-travel in the aquifer. Thus, each of the zones represents the interval between the time a particle of water is introduced at the zone boundary and its eventual arrival at the well.

Again, these aquifer travel time zones do not include vertical movement of a water particle or contaminant from the land surface down to the aquifer. DOH did not include them because it is difficult to estimate and predict infiltration rates for all settings. However, if infiltration characteristics are known, wellhead protection area zone management plans can and should consider the implication of vertical movement to the aquifer.

The vertical movement or infiltration rate for an aquifer can be highly variable. In any aquifer setting, the infiltration rate depends on topography, soils, geology, and the nature of land surface activities (relative percent of impervious surfaces versus open space, for example). It may vary significantly over a region and even within an individual wellhead protection zone. By not including the vertical component of contaminant transport to the aquifer, the state creates a more conservative (protective) estimate of travel time.

The Sanitary Control Area

The first component of a wellhead protection area is the protective area required by WAC 246-290-135 (sanitary control area). The public water system should already tightly control this area to minimize any direct contamination at the wellhead. It should be managed to reduce the possibility of surface flows reaching the wellhead and traveling down the casing. All public water systems are encouraged to have a wellhouse or a fenced area around each wellhead. This helps protect individual wells from any direct introduction of contaminants.

Zone 1 = The 1-year horizontal time-of-travel boundary

Proper management of Zone 1 can protect the drinking water supply from viral, microbial and direct chemical contamination. This zone is the surface area overlying the portion of the aquifer that contributes water to the well within a 1-year period. In Zone 1, systems should strictly manage potential sources of **microbial contamination** to eliminate or reduce possible contamination of the water supply. Zone 1 also contains a 6-month time-of-travel delineation.

The 6-month and 1-year time-of-travel thresholds in Zone 1 are appropriate to protect the well field from microbial contamination. Existing literature suggests that bacteria and viruses survive

less than one year in groundwater, therefore travel times longer than one year are not necessary. The 6-month delineation was added to Zone 1 because a threshold shorter than one year may not provide adequate protection against possible microbial or viral contamination.

The 1-year time-of-travel defines the area for intensive management to protect the wellhead from direct chemical contamination. For that reason, Zone 1 serves as a buffer and identifies the area needing a quick response time. Chemicals capable of contaminating groundwater must not be stored or used in Zone 1. A serious chemical release in Zone 1 may provide very limited time for a water system or community to identify the spill, implement emergency actions, and prevent the contamination from reaching the distribution system.

Laboratory confirmation of the contamination, characterization of the contaminant plume, plus development and implementation of an on-the-ground remediation response traditionally takes at least six months. It may take 12 to 24 months for an initial (preliminary) remedial response. Therefore, most management plans for Zone 1 include strong elements for the identification of potential contaminant sources and risk management.

Zone 2 = The 5-year horizontal time-of-travel boundary

Zone 2 is the entire area in the 5-year time-of-travel boundary. This zone must be actively managed to eliminate or reduce **chemical contaminants**. While any significant chemical release in Zone 1 could contaminate the drinking water supply and render it unusable, the area between the 1- and 5-year time-of-travel boundaries also must be managed carefully to protect future water supplies.

The primary difference between potential contaminant sources in zones 1 and 2 is the time available to respond to a release. A release in Zone 2 presents a less acute crisis than a release in Zone 1. All potential contaminant sources must be identified and controlled, with an emphasis on pollution prevention and risk reduction management. Many state and local agencies use the 1- and 5-year zones to prioritize their technical assistance or outreach programs, and target their inspections and enforcement actions.

Zone 3 = The 10-year horizontal time-of-travel boundary

The outer border of Zone 3 defines the boundary of the wellhead protection area. This zone includes the entire area in the 10-year time-of-travel boundary. In Zone 3, an inventory of potential contaminant sources must be conducted. **High-risk operations and facilities** must be identified, and steps must be taken to reduce contaminant loading.

A primary purpose of Zone 3 is to **encourage decision makers and planners to recognize the long-term source of the drinking water supplying community water systems**. This allows the community to plan and site future high risk and medium risk contamination sources outside wellhead protection areas. Zone 3 is also an educational tool for industry, the public, and others to understand the source of their drinking water and how their actions may affect drinking water wells.

Buffer Zone

The buffer zone is an area sloping up from Zone 3. It can include the entire zone of contribution or may focus on selected areas of concern such as recharge areas or locations where the aquifer may be exposed at the surface. The buffer zone is an area of added protection for the wellhead protection area. This zone helps compensate for errors when calculating the wellhead protection area boundaries, and provides information for long-term planning.

A primary goal of the buffer zone is to **provide information to planners on activities or facilities outside Zone 3 that could release contaminants into the wellhead protection area.** Analysis may show the need for contingency plans to respond to uncontrolled surface discharges that may travel overland to enter a stream located in or adjacent to the wellhead protection area. It may also identify other non-contiguous critical aquifer recharge areas requiring protection.

Selected Wellhead Protection Area Delineation Methods

After the boundaries of the Wellhead Protection Area are calculated, they must be displayed on a map of suitable scale.

Not all delineation methods are suitable for all settings. Therefore, it is critical to conduct a susceptibility assessment of the site before selecting a delineation method. Of the delineation methods evaluated, the Wellhead Protection Technical Advisory Committee selected four, listed below in order of complexity, cost and reliability:

1. Calculated Fixed Radius
2. Analytical Models
3. Hydrogeologic Mapping
4. Numerical Flow/Transport Models

EPA compared delineations using the calculated fixed radius method, an analytical model, and a numerical model (See Figure 3). Because hydrogeological settings vary widely, no set of examples should be considered typical

Calculated Fixed Radius

The calculated fixed radius method draws a circular protection area for a specified time-of-travel threshold. A simple volumetric flow equation is used to calculate the radius (Figure 1). (Note that Figure 1 depicts Zone 1 as a single circle. Zone 1 includes an internal 6-month time-of-travel delineation.)

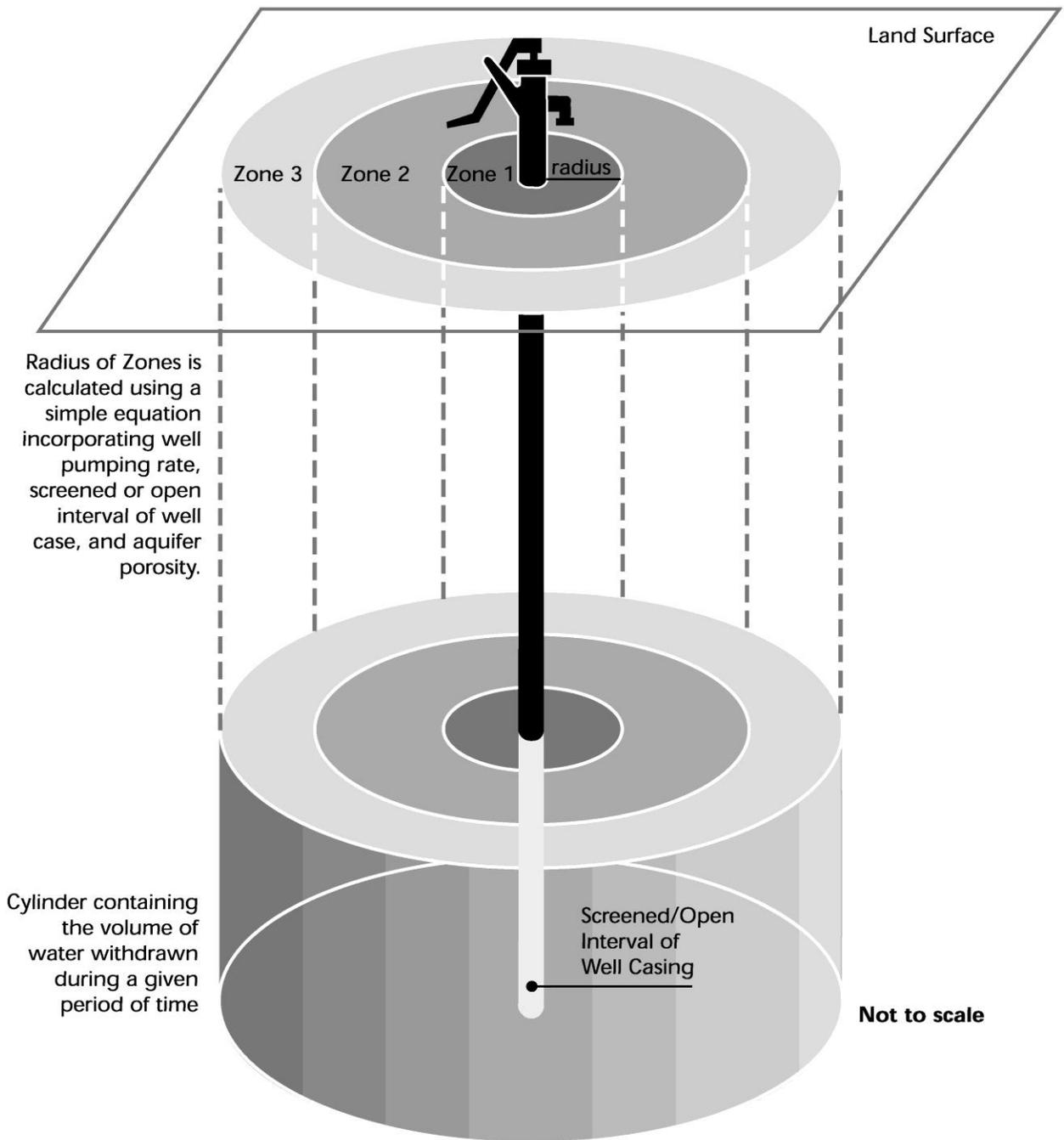
The calculated fixed radius method is part of the basic Washington State susceptibility assessment.

To use this method, you must have the:

1. Well pumping rate.
2. Porosity of the aquifer. Lacking a site-specific estimate of aquifer porosity, you may substitute a value of 0.22.
3. Open or screened interval of the well. If the actual screened interval is unknown, or the well is constructed with an open interval at its base, use a value of 10 feet.

This delineation method is inexpensive and requires minimal technical expertise. Because of its simplicity, it can be used to delineate moderate and small systems. Many systems should use it as a first-cut way to identify immediate threats to the water quality. A major drawback of this model is that groundwater rarely behaves as simply as this model predicts. See Element 4 of Appendix F for a table to use when calculating times of travel using the calculated fixed radius method.

Figure 1. Illustration of a Calculated Fixed Radius Model



Radius of Zones is calculated using a simple equation incorporating well pumping rate, screened or open interval of well case, and aquifer porosity.

Cylinder containing the volume of water withdrawn during a given period of time

Not to scale

$$r = \sqrt{\frac{Q t}{\pi n H}}$$

Where:
 Q = Pumping Rate of Well (cubic feet per year)
 n = Aquifer Porosity = 0.22
 H = Open Interval or Length of Well Screen
 t = Travel Time to Well (1, 5, 10 years)

Analytical Methods

Analytical methods use simple calculations, graphical methods, or simple analytical solution-based computerized groundwater-flow models to delineate wellhead protection zones (Figure 2). While analytical models require more skill and data than the calculated fixed radius method, they use equations a hydrogeologist or civil engineer can easily understand. Required data includes hydraulic gradient, hydraulic conductivity, saturated thickness, and hydrogeological divides.

A simple analytical model (such as EPA's WHPA Code⁹) can often provide a good approximation of the time-of-travel boundaries. However, settings with significant aquifer boundaries and non-uniform hydrogeological characteristics may require more sophisticated methods, such as detailed hydrogeological mapping or numerical modeling.

Hydrogeological Mapping Methods

EPA loosely defines hydrogeological mapping methods used to define zones of contribution as geologic, geophysical and dye tracing. To use this method you must have geologic maps, aquifer water level mapping, aquifer pumping test data, hydrogeological reports and well reports.

In Washington, hydrogeological and geologic information is often regional or does not exist. Therefore, hydrogeological mapping is often required to characterize aquifer properties, groundwater-flow directions, and aquifer boundaries as a prelude to analytical numeric modeling.

Hydrogeological mapping methods can be useful where hydrogeological conditions preclude application of simple analytical models. Settings where geologic features exert strong control over groundwater flow direction and rates include fractured rock (such as basalt), karst, small valley fill deposits, and irregular river or other barrier boundaries.

These methods require specialized expertise in geologic and geomorphic mapping, and significant judgment on what constitutes likely flow boundaries.

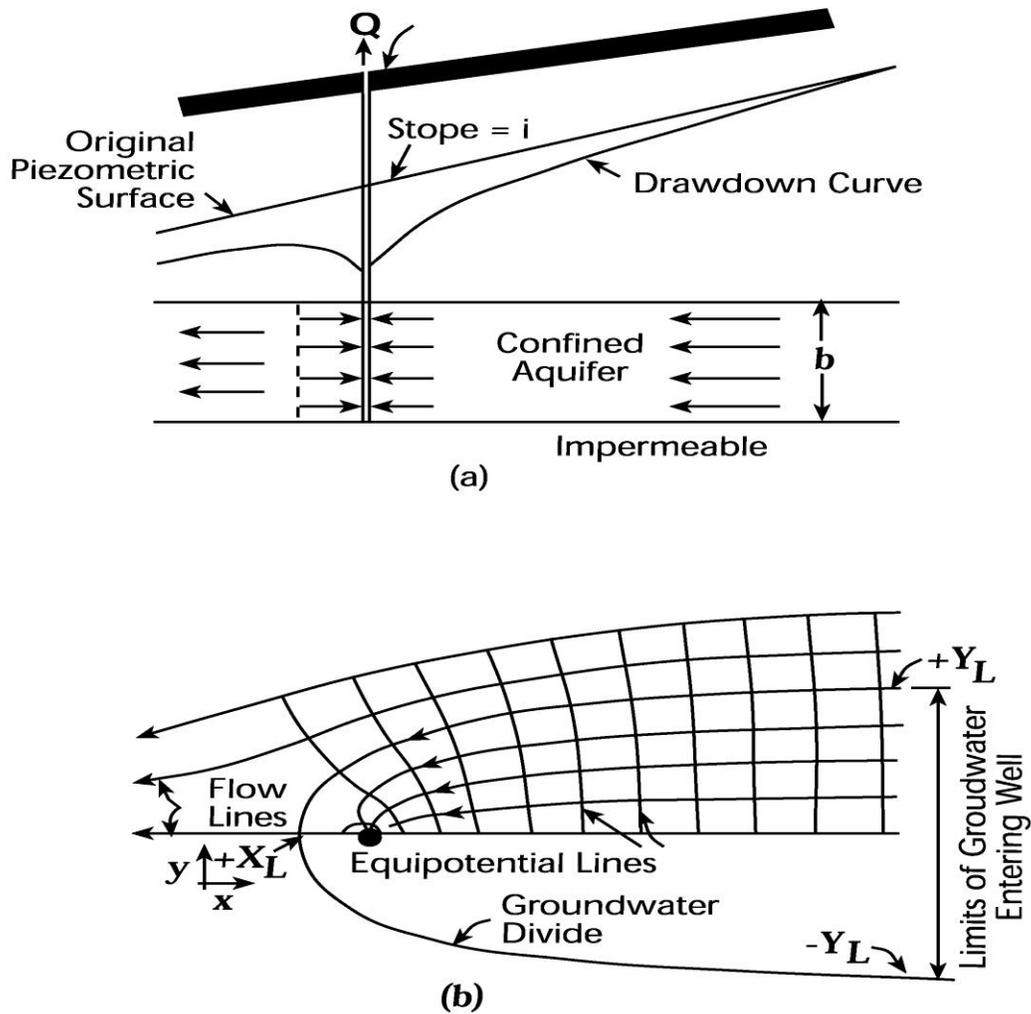
Numerical Flow and Transport Models

Computer models that numerically approximate groundwater flow and solute transport equations can be used to delineate wellhead protection areas. Generally grouped as two- and three-dimensional, computer models require data similar to the hydrogeological mapping and analytical method. However, computer models can incorporate much more of this information. With sufficient data, numerical models are recognized as a technically superior delineation method.

Numerical models provide a very high degree of accuracy. They can be used in nearly all hydrogeological settings. They may be very desirable in areas with other ongoing groundwater management programs in place. This method costs more than other methods and requires considerable technical expertise in hydrogeology and modeling. However, the cost may be warranted in areas where a high degree of reliability is necessary.

⁹ EPA developed software to help delineate wellhead protection areas. You can obtain it from the International Groundwater Modeling Center online at <<http://typhoon.mines.edu/software/igwmcsoft/>> There is a fee to cover reproduction, shipping and handling.

Figure 2. An Analytically Derived Model



$$\frac{-Y}{X} = \tan\left(\frac{2\pi Kbi}{Q} Y\right)$$

Uniform-Flow Equation

$$X_L = -\frac{Q}{2\pi Kbi}$$

Distance to Down-Gradient Null Point

$$X_L = \pm \frac{Q}{2\pi Kbi}$$

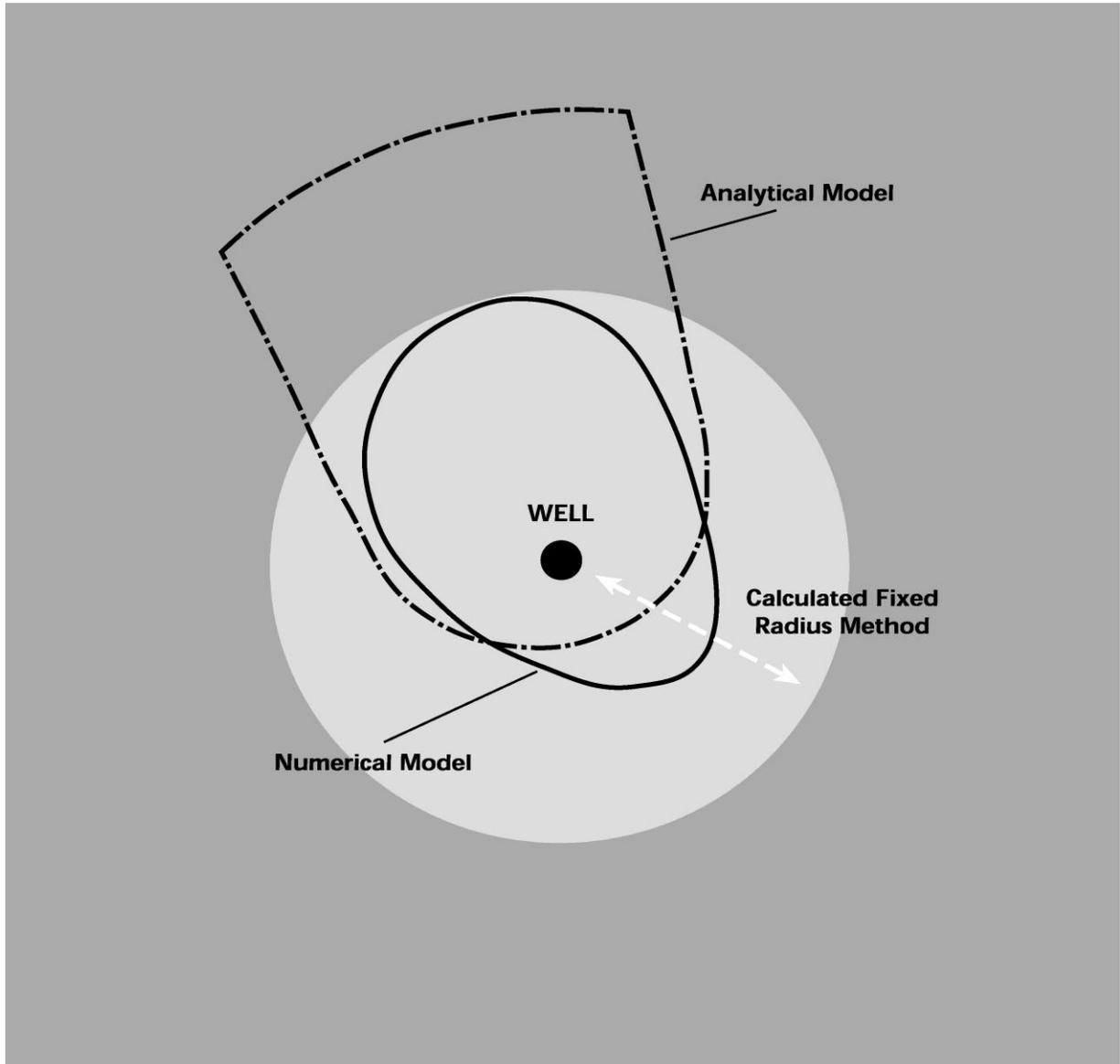
Boundary Limit

Legend:
 • Pumping Well

Where:
 Q = Well Pumping Rate
 K = Hydraulic Conductivity
 b = Saturated Thickness
 i = Hydraulic Gradient
 $\pi = 3.1416$

Source: U.S. Environmental Protection Agency, 1987.
Guidelines for Delineation of Wellhead Protection Areas.

**Figure 3. Wellhead Delineation Method Comparison*
10-Year Time-of-Travel Boundaries**



— · — · — · — Analytical Model
———— Numerical Model

***Note:** This is a sample showing a comparison for 1 water system. Delineation at all wells may not follow this same pattern or exhibit similar differences.

Criteria Influencing Selection of Delineation Method

Site-specific delineation efforts are required for each public water supply well, well field or spring. Due to resource and information constraints, the initial minimum delineation method requirements are relatively unsophisticated (for most systems, the calculated fixed radius method is appropriate).

Analytical methods can provide more reliable predictions of groundwater flow than a calculated fixed radius method because they incorporate more site-specific parameters. When resources, site-specific information and technical expertise are available, water suppliers should use analytical or other sophisticated approaches to delineate their wellhead protection area boundaries as soon as practical.

When translating analytical predictions to boundaries on the ground, it is important to determine whether the results correspond well with the local hydrogeologic setting. Integrating a hydrogeologic mapping component (for example, knowledge of hydrogeologic boundaries) into a model reduces the possibility of making improper assumptions about the groundwater system. Incorporating knowledge of groundwater flow divides and aquifer boundaries into the groundwater model allows more accurate understanding of groundwater flow patterns.

Sophisticated analytical methods, hydrogeologic mapping, and numerical groundwater flow models allow a very site-specific approach to boundary area simulation, but require large amounts of site-specific data and technical expertise to run and interpret the model results. As a result, these types of applications are generally considerably more expensive than many of the simpler models. Detailed models are valuable tools for ongoing resource management and contingency planning and may be a wise investment for communities with available resources.

Assessment of Susceptibility

The initial step in selecting the appropriate delineation method is to evaluate the susceptibility of the wells. DOH prepared a *Susceptibility Assessment Form* water systems must complete for each well. See the end of Appendix F for a sample form. When you are ready to complete and submit a *Susceptibility Assessment Form*, contact our DOH regional office (see Appendix E). **DOH requires this same form from water systems that apply for a source-monitoring waiver.** Susceptibility-assessment responses help determine the most appropriate delineation methods.

Drinking water supplies vary in their susceptibility to contaminants discharged at the surface. A well's susceptibility increases when it is poorly constructed, improperly cased, or located where no confining layer (aquitard or layer of lower permeability) exists between the aquifer and the surface. Conversely, properly constructed and sealed wells, drawing water from deep below the surface, with several different impermeable layers overlying the aquifer are less susceptible to contaminants entering the surface at or near the wellhead.

Washington's wellhead protection program groups wells into three classes:

- 1) High susceptibility
- 2) Moderate susceptibility
- 3) Low susceptibility

Assessment of Hydrogeologic Setting

The initial wellhead delineation method required of most public water systems is the calculated fixed radius method. This is inexpensive method requires only knowledge of a well's annual pumping rate, the length of the well's open (screened) interval, and an estimate of the porosity of the aquifer. The model predicts concentric circles (circular zones of contribution) around the wellhead corresponding to the 6-month and 1-, 5- and 10-year time it would take groundwater to flow to the well.

A major drawback of this model is that groundwater rarely behaves as simply as this model predicts. For this reason, public water systems using the calculated fixed radius method should use the *Susceptibility Assessment Form* to evaluate the extent to which their hydrogeologic setting varies from a circular zone of contribution. The form is available from DOH regional offices (see Appendix E). Susceptibility-assessment responses help determine whether other delineation methods are more appropriate. DOH uses this same assessment process to evaluate a water system's vulnerability for chemical monitoring requirements.

Selection of Delineation Method

Public Water Systems with Fewer Than 1,000 Connections

DOH uses information from the *Susceptibility Assessment Form* to classify each well as having high, moderate, or low susceptibility. If a well has low or moderate susceptibility, the calculated fixed radius method can be used to delineate the 1-, 5- and 10-year time-of-travel zones.

The water system should consider upgrading its initial delineation under three scenarios:

1. The *Susceptibility Assessment Form* indicates the source is highly susceptible.
2. The hydrogeologic setting is strongly non-circular.
3. The inventory results reveal the presence of high-risk potential contaminant sources.

If any of these conditions exist, the public water supplier should plan for an analytical or other more sophisticated groundwater flow model within five years. If the system's contingency plan cannot readily identify an alternate water supply in the event of source water contamination, DOH urges the system to use a more reliable delineation method as soon as feasible.

Public Water Systems with 1,000 or more Connections

DOH uses information from the *Susceptibility Assessment Form* to identify each well as having high, moderate, or low susceptibility. If a well has low or moderate susceptibility, you can use the calculated fixed radius method to delineate the 1-, 5- and 10-year time-of-travel zones. However, you should upgrade to a more sophisticated, site-specific groundwater flow model within 5 years, particularly if the hydrogeological setting is strongly non-circular or if the results of the inventory reveal the presence of high-risk potential contaminant sources.

If the well is highly susceptible, the system should use an analytical or other sophisticated, site-specific delineation method such as semi-analytical numerical or hydrogeologic mapping.

Other Considerations

Delineation of Springs

Group A public water systems using springs as a source of supply are also required to develop a wellhead protection program as part of their water system plan or small water system management program. For technical assistance on delineating wellhead protection areas for springs, please contact DOH's Wellhead Protection Program.

Delineation of Multiple Wells

If the wellhead protection areas of wells overlap, and the calculated fixed radius method was used, the wellhead protection area of the well field should be defined either by combining the wellhead protection areas of those wells (Figure 4) or by treating all the wells (combining pumping rates) as a single well located in the center of the well field. If other, more sophisticated modeling approaches were used, interference of the wells on one another should be incorporated into the modeling.

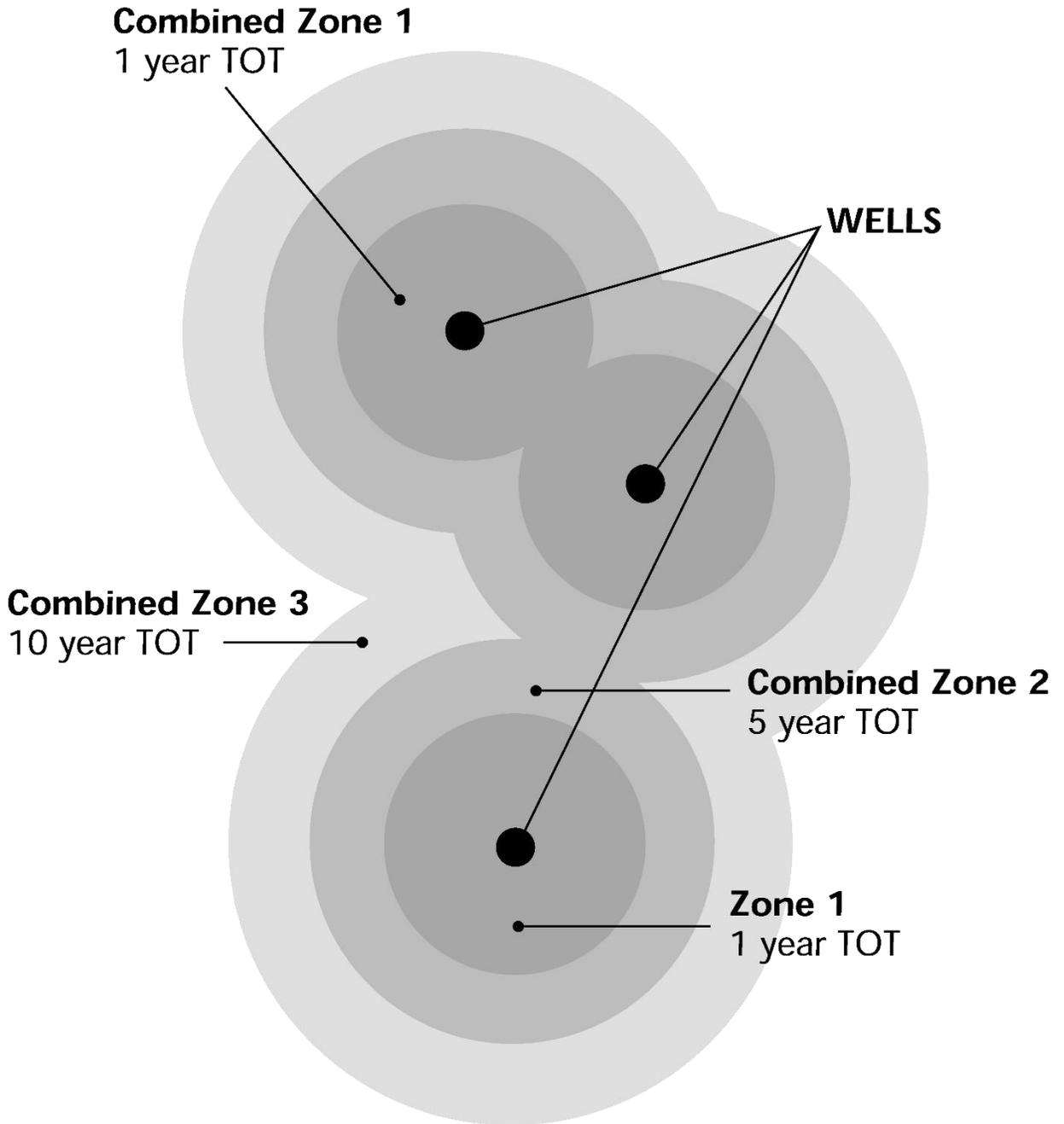
Refinement of Wellhead Protection Areas

Wellhead protection area boundaries should be reviewed periodically for changes. These include revised hydrogeologic data, changes in pumping capacities or rates, and new wells coming on-line. Changes in pumping rates or number of wells will likely require a new delineation of the wellhead protection area. Another reason to review is to confirm or reevaluate the potential contaminant sources in each of the zones. These are expected to change over time based on changes in land use and management practices in place within each zone. The susceptibility assessment should be reevaluated on a periodic basis for the same reasons.

Redefining wellhead protection area boundaries (with the resulting need to update maps, re-inventory and notify owners/operator of potential contaminant sources and regulatory agencies) should be undertaken only when new information changes the boundaries significantly. DOH

suggests systems consider revising wellhead protection area boundaries while updating Water System Plans.

Figure 4. Overlapping Wellhead Protection Area



When the Time-of-Travel Criteria is Inappropriate

There are areas in the state where it may not be appropriate to use the 6-month and 1-, 5- and 10-year travel-time based criteria. This may be due to:

- A capture zone that is recharged in less than 10 years.
- Complicated geologic factors, such as river valley settings, high aquifer transmissivity, or complex geologic conditions that are not conducive to simplified modeling approaches.
- Settings where a significant portion of the contribution to the well is from surface water, including wells adjacent to river systems, Ranney interceptor wells, or water-bearing zones having significant hydrologic continuity with surface water.

In these settings, wellhead protection area zones established using alternative criteria, instead of the basic time-of-travel criteria, might be more appropriate.

Before using alternate criteria, water systems must contact DOH's Wellhead Protection Program to present the rationale for their conclusions. They must also propose alternate criteria or methods to be used for the delineation and wellhead protection zone boundary determinations. Deviations from the 6-month and 1-, 5- and 10-year time-of-travel criteria require DOH's concurrence.

Groundwater and Surface Water Interactions

Groundwater and surface water may be connected. This is called "hydraulic continuity." Wells close to rivers may draw a significant portion of their total withdrawal from the surface source. This is particularly true for lateral collector-type wells such as Ranney wells. A connection between a well and a surface water source may be established by examining water temperature fluctuation, or fluctuations in water chemistry of the well water, which reflect changes in the surface water. Another way to identify hydraulic continuity is by correlating water levels and the effect of pumping on adjacent water levels in surface water and other wells.

If surface water is discharging to the groundwater, or a well is drawing water from surface supplies into its capture zone, DOH may consider that groundwater supply to be "under the direct influence of surface water" (GWI). A groundwater source classified as GWI may be subject to additional protective measures including surface watershed control plans, increased disinfection, and possible filtration requirements to guard against risks traditionally associated with surface water.

Wells in direct hydraulic continuity with surface sources need to incorporate this fact into their delineation effort. Depending on the degree of connection, the surface source (river, lake) may serve as a hydrologic boundary and usually leads to a smaller wellhead protection area defined. Situations such as this will usually require professional assistance in delineation efforts.

Specific Delineation Reporting Requirements

The wellhead protection area boundaries must be plotted on a base map that shows major landmarks and topography, with a scale large enough to adequately display the delineated area(s). A map with a scale of three to four inches per mile is desirable. If you are unable to locate a map of this scale, a 7½-minute U.S. Geological Survey topographic map can be used, if enlarged by photocopying. Prior to enlarging, draw a 1-mile bar of the correct scale on the map. Please ensure that the wellhead protection area boundaries on the map are drawn to scale as well.

If the calculated fixed radius method is used, you must include the following in your water system plan:

1. Map of wellhead protection area delineations at the appropriate scale.
2. Screened interval of the well (or statement that well is of open hole construction).
3. Pumping rate of the well.
4. An example of the notification letter used.
5. A list of those notified of the wellhead protection area boundaries.

If a more site-specific method is used, the following must be included:

1. Map of wellhead protection area delineations at the appropriate scale.
2. Explanation of methodology used.
3. An example of the notification letter used.
4. A listing of those notified of the wellhead protection area boundaries.



5. Inventory of Potential Contaminant Sources

An essential element of wellhead protection is an inventory of all potential groundwater contaminant sources in and around delineated wellhead protection areas. The purpose of the inventory is to identify past, present and proposed activities that may pose a threat to the water bearing zone (aquifer) utilized by the well, spring or well field.

The list of potential contaminant sources derived from the inventory identifies threats to the drinking water supply. Depth of the well, its construction, the geology of the area, and the aquifer characteristics are all factors that influence what constitutes a “potential contaminant source.” For example, a properly constructed deep well drawing from a confined aquifer will probably not be significantly at risk from septic systems. However, an improperly decommissioned well, which provides a conduit for contamination transport, does pose a risk to the underlying source of water.

Primary responsibility for the inventory rests with the public water system. The limited abilities of non-governmental systems to conduct an effective inventory points out the need to form a local wellhead protection committee to coordinate inventory and other implementation efforts¹⁰. Water systems could reuse partial inventories that already exist for other purposes such as groundwater management plans or watershed and nonpoint basin plans.

An inventory is a required component of a local wellhead protection program. The Water System Plan or Small Water System Management Program must explain how the inventory was conducted. The explanation must include what the water system did to contact the identified potential contaminant sources and the federal, state, or local agency with jurisdiction over them. An initial inventory must be completed within one year following wellhead protection area delineation. An initial inventory must include, at a minimum, all potential sources of contamination in Zone 1 (the 1-year time-of-travel), and all high-risk potential contaminant sources in Zone 3 (the 10-year time-of-travel). The inventory must be updated at least every two years. In settings experiencing significant growth or land use changes, the inventory should be updated more frequently.

Conducting an Inventory

The federal Office of Technology Assessment (OTA) developed a comprehensive list of potential contaminant sources. This list classifies potential contaminant sources into six major categories, based on the general nature of contaminants that could be released to groundwater (Table 1). An advantage of the category list is that it is not limited to specific sources. It enables one to look at facilities and activities with an eye toward all potential sources of groundwater contamination.

¹⁰ Private systems often lack legal authority to obtain information from facilities located outside of their sanitary control area. If requests for information are refused, the fire marshal's office or the local health department may be better able to obtain the necessary information based on their public health and safety statutes.

Another important tool is an alphabetical list of contaminant sources (Table 2). This list allows you to easily find contaminants by name. Neither list is exhaustive. There may be sources in a particular municipality not mentioned here.

When conducting an inventory of potential contaminant sources, it is important to note that one facility may have several potential contaminant sources. For example, a gas or service station may have an underground storage tank, a shallow drain or dry well, and an onsite septic system.

There are many ways to identify contaminant sources, either independently or in conjunction with other approaches. Common techniques use existing data, surveys, and field studies.

Existing Data

In most municipalities, a lot of information on past, current or potential contaminant sources exist in routine records or documents. It is important to include past land uses in the inventory. For example, you may find leaking underground storage tanks at the site of an abandoned or converted gas station. Information on past land uses from such sources as old aerial photographs, historical maps, tax assessor's maps/plats, and interviews with long-term community residents.

Sources of information for current land uses:

- Recent aerial photographs
- Telephone directories
- Business licenses
- Federal, state and local databases dealing with commercial permits
- Zoning regulations
- Health regulations
- Construction permits
- Real estate title searches

State and local regulatory agencies maintain various databases to track permitted activities or facilities within their jurisdiction. These databases range from computerized systems to file drawers.

It is important to remember that even if information from databases is readily available, the lists will identify only facilities required to file information under existing regulations *that have complied with the requirements*. You must use other inventory approaches to identify non-permitted facilities.

Table 1. Potential Contaminant Sources Listed by Type

Adapted from: U.S. Environmental Protection Agency 1989 *Wellhead Protection Programs: Tools for Local Governments* (440-6-89-002). (See Resources section.)

Category I—Sources designed to discharge substances

Subsurface percolation (septic tanks and cesspools)

Injection Wells

- Hazardous waste
- Non-hazardous waste (brine disposal and drainage)
- Non-waste (for example, enhanced recovery, artificial recharge solution mining, and in-site mining)

Land application

- Wastewater (for example, spray irrigation)
- Wastewater by-products (for example, sludge)
- Hazardous waste
- Non-hazardous waste

Category II—Sources designed to store, treat, and/or dispose of substances; discharge through unplanned release

Landfills

- Industrial hazardous waste
- Industrial non-hazardous waste
- Municipal sanitary

Open dumps, including illegal dumping (waste)

Residential (or local) disposal (waste)

Surface impoundments

- Hazardous waste
- Non-hazardous waste

Materials stockpiles (non-waste)

Graveyards

Animal burial

Above ground storage tanks

- Hazardous waste
- Non-hazardous waste
- Non-waste

Underground storage tanks

- Hazardous waste
- Non-hazardous waste
- Non-waste

Containers

- Hazardous waste
- Non-hazardous waste
- Non-waste

Open-burning sites

Detonation sites

Radioactive disposal sites

Category III—Sources designed to retain substances during transport or transmission

Pipelines

- Hazardous waste
- Non-hazardous waste
- Non-waste

Materials transport and transfer operations

- Hazardous waste
- Non-hazardous waste
- Non-waste

Category IV—Sources discharging substances as a consequence of other planned activities

Irrigation practices (for example, return flow)

Pesticide applications

Fertilizer applications

Animal feeding operations

De-icing salts applications

Urban runoff

Percolation of atmospheric pollutants

Mining and mine drainage

- Surface mine-related
- Underground mine-related

Category V—Sources providing conduit or inducing discharge through altered flow patterns

Production wells

- Oil (and gas) wells
- Geothermal and heat recovery wells
- Water supply wells

Other wells (non-waste)

- Monitoring wells
- Exploration wells

Construction excavation

Improperly abandoned wells

Category VI—Naturally occurring sources whose discharge is created and/or exacerbated by human activity

Groundwater – surface water interactions

Natural leaching

Saltwater intrusion/brackish water

- upconing (or intrusion of other poor-quality natural water)

Table 2. Potential Contaminant Sources Listed Alphabetically

Above ground storage tanks

Hazardous and non-hazardous waste treatment
Hazardous and non-hazardous waste storage
Hazardous and non-hazardous material storage

Animal feedlots

Containers

Hazardous and non-hazardous waste storage
Hazardous and non-hazardous material storage

Deep injection wells

Wastewater disposal wells
Oil and gas activity disposal wells
Mineral extraction disposal wells

De-icing salts and storage piles

Fertilizer applications

Graveyards

Groundwater or surface water cross contamination

Irrigation practices (return flow)

Land application

Wastewater application (spray irrigation)
Wastewater by-product (sludge) application
Petroleum refining waste application
Hazardous and non-hazardous waste application

Landfills

Industrial hazardous and non-hazardous landfill
Municipal sanitary landfill

Material transfer operations

Hazardous and non-hazardous waste transfers
Hazardous and non-hazardous material transfers

Material stockpiles

Hazardous and non-hazardous material

Mining and mine drainage

Natural leaching

Open Dumps

Pesticide applications

Pipelines

Hazardous and non-hazardous waste storage
Hazardous and non-hazardous material storage

Radioactive disposal sites

Saltwater intrusion

Septic tanks

Houses
Apartments
Small businesses

Shallow injection wells

Agricultural drainage wells
Automobile service station disposal wells
Industrial process water disposal wells

Stormwater drainage wells

Surface impoundments

Hazardous and non-hazardous waste
Cesspools, ponds, lagoons, and other
impoundments

Transportation of materials

Hazardous and non-hazardous waste
Hazardous and non-hazardous material

Underground storage tanks

Hazardous and non-hazardous waste treatment
Hazardous and non-hazardous waste storage
Hazardous and non-hazardous material storage

Urban runoff

Waste piles

Hazardous and non-hazardous waste piles

Waste tailings

Heap leaching piles
Non-heap leaching piles

Source: United States Environmental Protection Agency. 1991.
Guide for Conducting Contaminant Source Inventories for Public Drinking Water Supplies.

Surveys

After existing data for wellhead protection areas has been researched and recorded, data gaps can be identified. The need to gather additional information or verify recorded data can be assessed. A survey is the most comprehensive way to get additional information. Survey types include:

- Mail questionnaires
- Telephone surveys
- Windshield surveys
- Door-to-door surveys
- Personal interviews

Field Searches

Inventories for potential contaminant sources often include field searches of some or all of the area being inventoried. Field searches allow inventory workers to look at the survey area themselves, without relying on landowners to identify and provide information about sources. Field searches are conducted much like door-to-door surveys and require the same amount of planning but often require more time to complete. Field searches consist of an extensive foot survey of an area, and are often used when a particular situation calls for a detailed inspection of land uses.

Modifying Inventory Approaches to Address Local Settings

Few public water supplies or communities need to conduct mail, phone, door-to-door surveys, *and* field searches, as this would gather a large amount of repetitious information at a high cost. The methods used will depend on the situation of the community conducting the inventory. If resources are not available for some of the more labor-intensive methods, there are ways to reduce the efforts without losing their value. Consider using volunteer organizations or local public service groups when resources are limited.

It is important to update the information gathered from the inventory regularly, perhaps more frequently than the required two-year minimum. The intervals between updates will vary with each municipality; rate of growth will be a big factor in making this determination. It may be possible to update the inventory automatically. For example, when a new business opens in a wellhead protection area, you could enter it into the database immediately.

Prioritizing Inventory Efforts

Public water systems must document the method(s) used to inventory the wellhead protection area, and their efforts to notify identified potential contaminant sources and the agencies that

regulate them in their Water System Plan or Small Water System Management Program document. DOH recognizes that conducting a comprehensive inventory for all potential sources of groundwater contamination within a large wellhead protection area requires time. Inventory efforts should be prioritized using two criteria:

First, work outward from the wellhead. The most intensive efforts should focus on Zone 1, which includes the 6-month and 1-year time-of-travel areas. Then, expand the inventory outward to include Zones 2 and 3.

Second, focus on high and medium risk facilities and activities in the entire wellhead protection area. What constitutes a high-risk potential contaminant source varies from location to location, but some types of operations pose a potential threat in almost all settings. For example, improperly decommissioned (abandoned) wells, underground storage tanks, dry cleaning operations, chemical wholesale operations, and electroplating facilities, all have a high potential for seriously affecting groundwater quality. Because the total number of high and medium risk operations is typically low, detecting and contacting them should not be a labor-intensive task.

If the inventory or outreach effort is inadequate, DOH will not approve the planning or management document.

Prioritizing Inventory Findings

Information gathered through the inventory process can be used to evaluate risks posed to the wellhead protection area, and to prioritize actions and management efforts directed towards high priority sources. When assessing the relative risks posed by potential contaminant sources, the type of material or activity, quantity, and method of storage and handling should all be taken into account.

A relative risk assessment will help the water supplier or community:

- Determine a risk “score” for each potential source.
- Rank each source according to the level of risk associated with it.
- Determine the relative level of threat that a given source poses (high, medium, or low).

This approach allows an initial screening of potential contamination sources on the basis of relative risk, without complicated risk assessments. It may not, however, be an adequate substitute for site-specific, detailed risk assessments. Using this technique, local managers can develop an initial priority list for focusing implementation efforts without allocating substantial funds. This process can be used either for potential contaminant sources in a single wellhead protection area, or over a larger geographic area for multiple wellhead protection areas.

Documenting Inventory Efforts

The following must be included in the wellhead protection program portion of either the Water System Plan or the Small Water System Management Program:

1. A list of all potential and known sources of groundwater contamination (past and present) in the wellhead protection area boundaries that may pose a threat to the water bearing zone (aquifer) used by the well, spring or well field. The inventory findings should be prioritized and grouped by time-of-travel zones. This list must be updated at least every two years.
2. Documentation showing the water supplier notified the correct regulatory agencies and local governments of the location of potential and known sources of groundwater contamination in the wellhead protection area boundaries. An example notification letter must be included, along with a list of all entities notified.
3. Documentation that all owners/operators of known and potential sources of groundwater contamination have been notified of their location in the wellhead protection area boundaries. An example notification letter must be included, along with a list of all entities notified.

Highly susceptible systems with 1,000 or more connections must also include:

1. Current land use/zoning designation of the wellhead protection area(s).
2. A priority ranking of potential contaminant sources (high to low).



6. Wellhead Protection Area Management Strategies and Implementation

Management Overview

Without implementing risk reduction measures or pollution prevention efforts, a local wellhead protection program will not protect the water supply. Management strategies cannot be focused until a clearly defined wellhead protection area has been established and specific potential sources of groundwater contamination identified.

Dissemination of the findings of the inventory to regulatory agencies and the owners/operators of the facilities and activities constitutes an important implementation component of local wellhead protection programs. A public education outreach program should be tailored to address local needs and situations.

Effective implementation of a local wellhead protection program can be accomplished through existing authorities at the local, state, and federal levels. Because land use control is an essential component of wellhead protection implementation, municipal tools such as inspections, permitting, enforcement, and zoning are important. By exercising these mechanisms at the local level, a community serves notice that the local wellhead protection program is an “official” program important to its citizens. It sends a clear message that persons responsible for potential contaminant sources within wellhead protection areas are accountable for managing their activities and facilities responsibly.

At the state and federal level, DOH and EPA are working with other state and federal agencies to ensure that local wellhead protection programs, and their inventory data, are integrated into existing state and federal contamination source control measures.

Establishing a Local Wellhead Protection Committee

Private entities own or operate many public water systems. Many wellhead protection areas in Washington are, at least in part, in areas outside the water system’s jurisdiction. And, other communities, counties, states, or nations may control land use. Cooperation from authorities in other jurisdictions is essential for effective protection of the resource. To help resolve multi-jurisdictional issues, DOH encourages systems to establish a local wellhead protection committee. Participants should include jurisdictions with land use controls over the wellhead protection area; public water system(s); local planning and regulatory agencies; tribes; industrial, commercial, and agricultural organizations; and citizen action groups. In many locations, an existing group such as a Water Utility Coordinating Committee or a Groundwater Advisory Committee may serve as the core membership of the local wellhead protection committee.

By coordinating the efforts of independent water systems, jurisdictions, and affected parties as the local program evolves, a consensus can develop as to what constitutes an appropriate management program. Coordinating efforts may also provide significant cost savings when

delineating and inventorying. Spill response plans and contingency plans also benefit from coordinated, integrated planning efforts.

It is important to designate a lead agency to coordinate local wellhead protection activities. Often, an appropriate lead may be the local health department or local planning agency.

Individual Potential Contaminant Source Management

After conducting an inventory, the public water system must notify potential contaminant sources that they are in a wellhead protection area. In addition, they must notify the proper local, state, or federal regulatory agency. If the system is not able to identify the agency that regulates the potential contaminant source, it must notify the local health jurisdiction and DOH. When available, potential contaminant sources will get technical assistance on pollution prevention and risk reduction steps to minimize the possibility of causing groundwater contamination¹¹. Start implementing protective measures by educating water system owners and operators about potential contaminant sources and voluntary adoption of best management practices (BMPs) .

Federal, state and local agencies and programs will determine the best way to manage potential contaminant sources in wellhead protection areas based on jurisdictional responsibilities, hydrogeological settings and other factors.

Some potential contaminant sources can't be managed effectively with education or voluntary BMPs. The agency with regulatory responsibility over these contaminants must develop procedures for wellhead protection. If no agency appears to be responsible for the contaminant, then the Interagency Groundwater Committee will appoint a subcommittee to research the question of jurisdiction. It will share the results of its research with appropriate agencies or the Legislature.

Developing a Pollution Prevention Program

After identifying potential contaminant sources, water systems must take steps to prevent the contaminants from entering their water supply. DOH encourages communities to adopt pollution prevention strategies. Pollution prevention is a long-term waste management technique that reduces or eliminates waste at its source. Data from the potential contaminant source inventory may reveal facilities that will benefit from pollution prevention technical assistance.

There are three categories of pollution prevention:

- 1. Source reduction** involves several industrial process modifications designed to reduce the amount of waste generated. These include: changes to input materials, equipment and other technical changes; redesigning processes to reduce waste generation; maintaining and managing equipment and materials to minimize accidental releases; waste separation

¹¹ The agency with jurisdiction over the potential contaminant source will do this. DOH will work with public water systems, other agencies, and potential contaminant sources to identify and help distribute technical assistance information.

- to improve recovery of usable materials; and employee waste minimization training and supervision.
2. **Recycling** involves the use, reuse, or reclamation of a waste product as a substitute for raw materials or ingredients. Recycling can occur on-site or off-site by recycling services or waste exchanges.
 3. **Treatment** involves processing hazardous waste after it is produced to reduce toxicity or volume. This is the least preferred pollution prevention technique because treatment produces waste. However, treatment is preferred over the disposal of raw waste materials.

For help developing a pollution prevention program, call Department of Ecology's Recycling Hotline at (800) RECYCLE. For more information, or to request an onsite assessment of pollution prevention opportunities for your facility, call the nearest Ecology regional office (Appendix E), and ask to speak with a toxics reduction specialist.

Management Tools for Local Governments

Local governments have a key role in implementing local wellhead protection programs. Many potential contaminant sources can be managed effectively only through local land use planning, local performance standards, or other local measures. Such measures may be developed as part of a local groundwater management area plan.

The wellhead protection program should establish policies and procedures to protect groundwater used as public drinking water. Several factors will define management options, including:

- Size of system (number of connections)
- Type of system (community, noncommunity, transient)
- Vertical travel time
- Hydrogeological setting (susceptibility)
- Lack of alternate sources of supply

Because each water system faces different groundwater threats, implementation issues and hydrogeological settings, there is no single wellhead protection tool or set of tools. Rather, local conditions dictate the tools available for groundwater protection.

The following regulatory and non-regulatory management options are useful in various settings:

- Bonding
- Design standards
- Groundwater monitoring
- Household hazardous waste collection
- Operating standards
- Overlay zones (for example, Environmentally Sensitive Areas affecting SEPA review process)

- Public education and outreach
- Purchase of property or development rights
- Site plan reviews
- Source prohibitions
- Spill reporting requirements
- Subdivision ordinances
- Voluntary or mandatory use of Best Management Practices
- Water conservation measures
- Wellhead protection area boundary signs for transportation corridors
- Zoning ordinances

An overview of many of these management options is in Table 3. More information is in EPA's *Wellhead Protection Programs: Tools for Local Governments* (440-6-89-002). (See Resources section.)

EPA put wellhead protection ordinances from many states online at http://cfpub.epa.gov/safewater/sourcewater/sourcewater.cfm?action=Publications&view=filter&document_type_id=105

Table 3. Management Tools for Local Governments

Best Management Practice. BMPs are voluntary actions with a long tradition of use, especially in agriculture. Technical assistance for farmers wishing to apply them is available from local Cooperative Extension and SCS offices.

Bonding. Facilities may be required to post a bond prior to operation in a WHPA. The bond can cover costs associated with spill response or remediation efforts.

Building Codes. Local building codes offer protection through special standards applicable to facilities remodeled or constructed in the WHPA. Building codes can also require low flow fixtures, backflow preventers and other design features to conserve and protect groundwater.

Contingency Planning. Local governments can develop their own contingency plans for emergency response to spills and for alternate water supply following contamination of the current well field.

Design Standards. Design standards typically are regulations that apply to the design and construction of buildings or structures. Use this tool to ensure new buildings or structures placed in a WHPA are designed not to pose a threat to the water supply.

Groundwater Monitoring. Groundwater monitoring includes selecting appropriate sampling sites sloping up from a well and developing an ongoing water quality monitoring program.

Inspection and Testing. Local governments can use their statutory home rule power to require more stringent control of contamination sources in WHPAs.

Operating Standards. Operating standards are safety or environmental protection regulations that apply to ongoing land-use activities. Such standards can minimize the threat to the WHPA from ongoing activities such as the application of agricultural chemicals or the storage and use of hazardous substances.

Public Education. Public education often consists of brochures, pamphlets, or seminars designed to present wellhead area problems and protection efforts. This tool promotes the use of voluntary protection efforts and builds public support for a community protection program.

Purchase of Property or Development Rights. The purchase of property or development rights is a tool used by some localities to ensure complete control of land uses in or surrounding a WHPA. This tool may be preferable if regulatory restrictions on land use are not politically feasible and the land purchase is affordable.

Site Plan Review. Site plan reviews are regulations requiring developers to submit for approval plans for development occurring in a given area. This tool ensures compliance with regulations or other requirements made within a WHPA.

Source Prohibitions. Source prohibitions are regulations that prohibit the presence or use of chemicals or hazardous activities within a given area. Local governments can use restrictions on the storage or handling of large quantities of hazardous materials within a WHPA.

Subdivision Ordinances. Subdivision ordinances are applied to land divided into two or more subunits for sale or development. Local governments use this tool to protect WHPAs where ongoing development is causing contamination.

Training and Demonstration. These programs complement many regulations. For example, training underground storage tank inspectors and local emergency response teams, or demonstrating agricultural BMPs.

Waste Reduction. Residential hazardous waste management programs can be designed to reduce the quantity of household hazardous waste being disposed of improperly.

Zoning Ordinances. Zoning ordinances typically are comprehensive land-use requirements designed to direct the development of an area. Many local governments have used zoning to restrict or regulate certain land uses.

Zoning Overlay. Overlay zones can be used with conventional zoning to create special districts to protect the WHPA. Overlay zones are applied to areas singled out for special protection. They add regulations to controls already in place. This method helps address “grandfathered” potential contaminant sources in WHPAs.

Source: U.S. Environmental Protection Agency, 1989.

Wellhead Protection Programs: Tools for Local Governments (440-6-89-002)



7. Contingency Plans

Drinking water rules require public water systems to develop contingency plans “...for the location and provisions of alternate drinking water supplies for each public water system in the event of well or well field contamination...”. In Washington, contingency plans are required in Water System Plans (WAC 246-290-100) and Small Water System Management Programs (WAC 246-290-410).

Contingency planning is important for all systems because, even with careful planning, unforeseen incidents can occur. Groundwater contamination can occur due to leaks, spills, accidental releases, illegal discharges and other activities in and around the wellhead protection area. A properly prepared and updated contingency plan helps ensure the water system, and local officials, are prepared to respond to emergency situations and able to provide alternative sources of drinking water.

Developing a long-term contingency plan can be an educational experience. Jurisdictions that cannot identify economically feasible alternative long-term drinking water supplies may require and desire a more stringent management program to prevent contamination.

The contingency plan should identify both short and long-term alternative drinking water supplies. For example, to prevent contaminants from reaching a well, a water system may need to cease pumping until it can take remedial actions. In the worst-case scenario, a water supplier may need to abandon a well due to contamination. When developing contingency plans, the water supplier must:

1. Identify maximum water system capacity in relation to source, distribution system, and water rights restrictions. Assume loss of largest groundwater source.
2. Evaluate the water system’s expansion options within current water rights and availability.
3. Identify existing or potential interties¹² with other public water systems and evaluate the ability to deliver water if the largest groundwater source is lost, including costs associated with the purchase or delivery of alternate supplies.
4. Evaluate current procedures and make recommendations on contingency plans for emergency events.
5. Identify future potential sources of drinking water, and describe quality assurances and control methods to be applied to ensure protection of water quality prior to utilization as a drinking water supply.
6. Maintain a current list of appropriate emergency phone numbers.

The contingency plan section should include the estimated cost of obtaining short and long-term alternative sources of supply. If the analysis shows no alternative sources or interties, the contingency plan should clearly state this. Next, it should analyze treatment options for the potential contaminant sources determined to pose the highest risk to the source of supply.

¹² Interties are physical connections (pipes) between different water systems allowing for the transfer of water. Prior to water being shared between systems, careful investigation of engineering considerations and issues related to water rights and use of water outside of designated service area is required.

Efforts should be made to coordinate contingency plan development with other existing or on-going contingency planning such as the work your Local Emergency Planning Committee¹³ conducts under SARA Title III. To develop a realistic contingency plan, many systems will have to work with the local or regional wellhead protection committee.

The contingency plan must be complete within one year after the wellhead protection area boundaries are delineated. DOH recommends an update every two years, more often if the situation warrants.



¹³ LEPCs were established under the Superfund Act Reauthorization Amendments (SARA Title III).

8. Spill and Incident Response Planning

As part of a local wellhead protection program, the public water system must coordinate with local emergency responders (police or fire departments), the Department of Ecology's Spill Operations Section, the Emergency Management Division of the Washington Military Department, the local health department, and any local emergency planning committee.

Using the results of the susceptibility assessment and the inventory of the wellhead protection area, local emergency responders should evaluate whether changes in incident and spill response measures are needed to better protect groundwater quality in wellhead protection areas. If they determine a public water system's source water is vulnerable to surface activities, they may need to incorporate special procedures into local emergency response plans.

Appropriate spill and incident response measures must be determined before an incident occurs. Changes in response may be as simple as ensuring enough absorbents are on hand to respond to a large transportation spill, or recognizing that—during a fire—it may be best to allow certain facilities or structures to burn rather than have contaminated runoff pollute the community water supply.

Many systems will have to work with a local wellhead protection committee to develop a realistic spill and incident response plan. Coordination with the Local Emergency Planning Committee and other local emergency management entities is also important.

Spill and incident response plans should be reviewed or updated at least every two years, more often if the situation warrants.

You should document this coordination outreach in your water system planning document.



9. Wellhead Protection Requirements for New Public Water Supply Wells

Before a new or modified public water supply receives DOH approval, it must:

1. Complete a susceptibility assessment.
2. Delineate a wellhead protection area.
3. Identify potential sources of contamination for the water-bearing zone (aquifer) used by the well, spring or well field.

As part of the source approval process, the water supplier must delineate a wellhead protection area, using a calculated fixed radius method. The supplier should use the best available data to compute delineation, such as an estimated well screen interval and a pumping-rate based on the water right quantity or the number of connections.

The supplier must then conduct an inventory in the wellhead protection area. The purpose of the inventory is to identify past, present and proposed activities that may pose a threat to the source of supply. The vulnerability of the source water for a proposed new well, along with potentially increased and on-going monitoring requirements, should be weighed against the costs of selecting an alternate well site.

DOH may require monitoring and controls in addition to those specified in this section if it believes a potential risk exists to the water quality of a source.” DOH will use information generated during the inventory to determine whether additional water quality monitoring is needed.

Also, water suppliers must tag all new public water wells with a Washington Well Identification Tag¹⁴ and report the tag number to DOH.

When DOH approves a new source, the water supplier must develop a complete wellhead protection program (WAC 246-290-135).



¹⁴ Contact Ecology's Water Resource Well ID program for more details on well tagging (Appendix C).

10. Local Wellhead Protection Program Financing

This is an overview of potential funding for local wellhead protection programs. More information is in EPA's *Local Financing for Wellhead Protection* (440-6-89-001). (See Resources section.)

Implementation Costs

The water system's costs for wellhead protection will depend on the number of connections, vulnerability, hydrogeological setting, desired accuracy of groundwater modeling, and the extent and nature of the wellhead protection plan.

The costs of wellhead protection include:

- Delineation
- Conducting the inventory of potential contaminant sources
- Developing an initial management plan
- Contingency and spill response planning
- Public education
- Best management practices

Funding Sources

There are three funding sources for implementing local wellhead protection programs:

- Local taxes or fees
- Private sector investments
- Intergovernmental assistance (grants/loans)

Local Taxes and Fees

Several Washington communities use local taxes or fees to fund local groundwater protection efforts. For example, a county could dedicate a portion of sales tax receipts to groundwater protection efforts or establish impact fees on new development; a local health department could collect fees for permits and facility inspections in wellhead protection areas; and a city could create a service fee to recover the cost of drainage improvements and groundwater protection.

After wellhead protection areas or other aquifer protection areas are established, state law provides a process for fees to be collected to fund groundwater protection efforts (RCW 36.36). For legislative authority to propose a ballot measure to impose a monthly fee on water

withdrawals or on-site sewage disposal, a community must designate an Aquifer Protection Area or Aquifer Protection District. The community can use the money generated to fund various groundwater protection efforts, including wellhead protection. This valuable mechanism allows local governments to establish a stable funding base to implement wellhead protection efforts.

Private Sector Investments

Privately owned public water systems are responsible for financing their own local wellhead protection program. Regardless of regional support, water suppliers may need to cover costs associated with delineation, initial inventory for potential contaminant sources, spill response plan development, contingency planning, and documentation in their Water System Plan. Appropriate unit charges (for example, a fee per connection or a charge per gallon used) and access fees should be evaluated as funding sources. Privately owned public water systems are rarely eligible for local, state, or federal grant/loan programs. They may be able to reduce their implementation costs by working with other water suppliers and local governments.

Grants and Loans

Several state and federal loan and grant programs provide financial support to local governments implementing local wellhead protection programs.

The Department of Ecology administers the Centennial Clean Water Fund (CCWF) and the Clean Water State Revolving Fund (CWSRF). Wellhead protection planning and implementation is eligible under both programs. The CCWF provides loans and, in some cases, grants for planning, design, and construction projects associated with publicly owned wastewater treatment facilities. The CWSRF provides loans for planning, design, and construction projects associated with publicly owned wastewater treatment facilities.

The Department of Commerce's Public Works Trust Fund Program provides low interest loans (0-5 percent) to help local governments finance needed public works projects or planning, including wellhead protection programs. For information, visit <<http://www.pwb.wa.gov/>>

USDA Rural Development provides loans and grants for infrastructure projects for cities or towns with fewer than 10,000 people. These funds are also available to counties, special purpose districts, tribes or nonprofit organizations unable to get funds from other sources at reasonable rates and terms. For information, visit <<http://www.rurdev.usda.gov/wa>>

Rural Community Assistance Corporation provides interim financing and long-term loans for drinking water infrastructure projects. For information, visit <<http://www.rcac.org/>>

The Indian Health Service has funds to assist water system improvements if the system serves Indian families.

EPA's *Catalog of Federal Funding Sources for Watershed Protection* is online at <<http://cfpub.epa.gov/fedfund/>>



11. How the Wellhead Protection Program Relates to other Programs

Several other programs in Washington complement, but do not replace, local wellhead protection programs.

Aquifer Protection Area Program

Aquifer Protection Areas and Aquifer Protection Districts give counties legislative authority to designate an aquifer protection area and propose a ballot measure to impose a monthly fee on water withdrawals or on-site sewage disposal for a specific number of years. Counties can use the money generated for a variety of groundwater programs, including wellhead protection. A major value of this mechanism is that it allows local governments to establish stable funding to implement wellhead protection efforts.

Groundwater Management Area Program

The state Legislature established the Groundwater Management Area (GWMA) program in 1985 (WAC Chapter 173-100). The GWMA program manages groundwater resources at the regional level. A GWMA is a specific geographic area that encloses one or more aquifers and in which there exists a justifiable concern for the quality or quantity of the groundwater.

A GWMA designation:

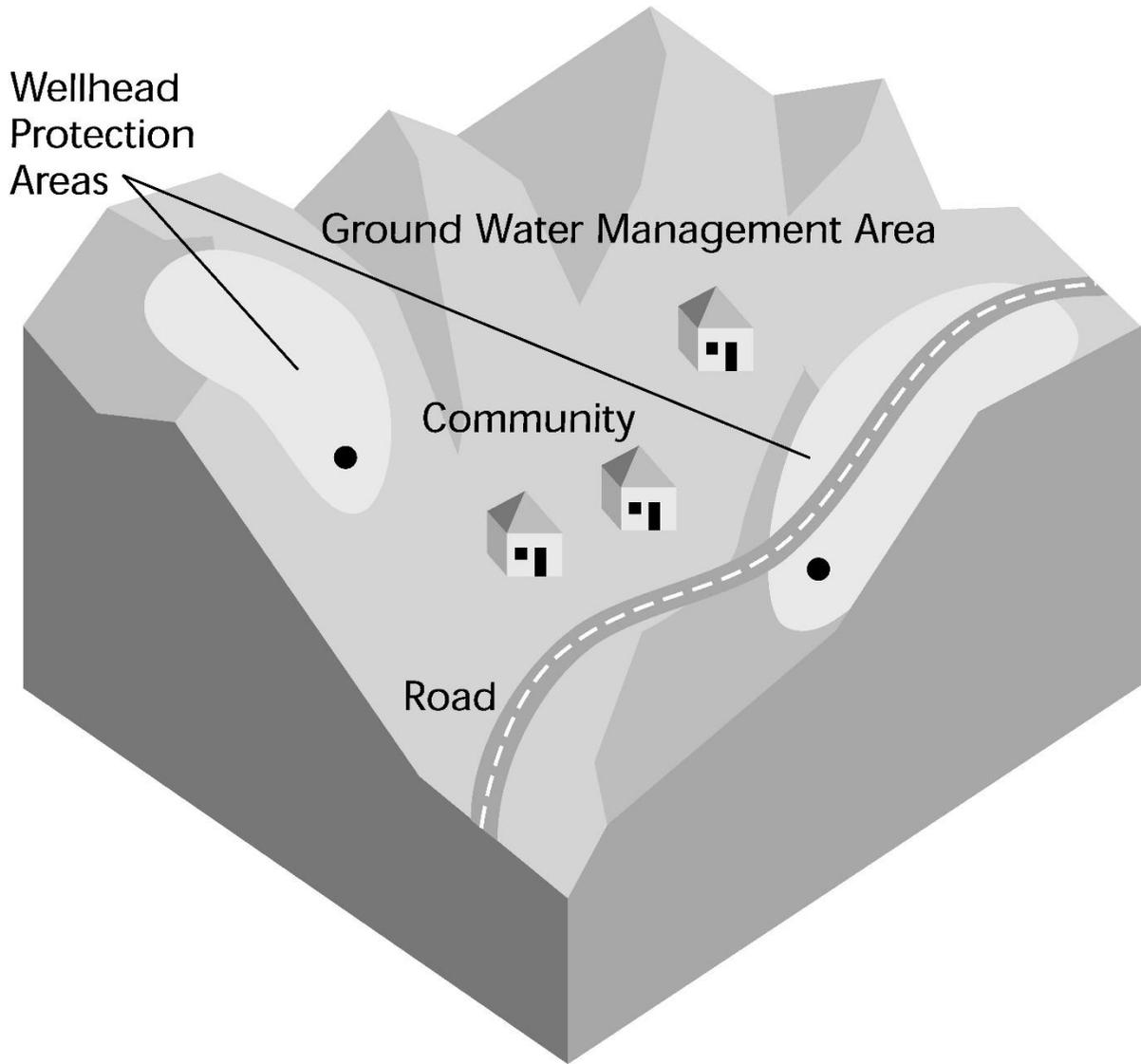
1. Protects the quality and quantity of groundwater.
2. Meets future water needs while recognizing existing water rights.
3. Provides for effective, coordinated management of the groundwater resource.

GWMA's and wellhead protection areas are complementary but have distinct differences (Figure 5). GWMA's cover a large area (county or sub county level) and consider all beneficial uses—not just drinking water supplies. Wellhead protection is often an integral part of the implementation plan of a GWMA, but is not a required component. For more details on the GWMA program, contact Department of Ecology's Water Resources Program (Appendix E).

Critical Aquifer Recharge Areas and the Growth Management Act

Local jurisdictions planning under the Growth Management Act (GMA) must identify Critical Aquifer Recharge Areas (CARAs). The GMA requires all counties and cities to classify, designate and regulate to protect “areas with a critical recharging effect on aquifers used for potable waters.”

Figure 5. Wellhead Protection Areas and Groundwater Management Areas



Wellhead protection areas meet the definition of critical aquifer recharge areas. A local wellhead protection program can protect critical aquifer recharge areas. At the same time, a critical aquifer recharge area is a useful tool in a local wellhead protection program. This is due, in part, to the GMA requirement that jurisdictions develop local regulations and policies to protect critical areas. In addition, the GMA provides an inter-jurisdictional planning mechanism to protect critical areas that cross jurisdictions. This can be important for municipal wellhead protection areas that extend beyond the water supplier's jurisdictional boundaries. CARA designation may also be used to protect noncontiguous buffer zones. CARA designation under the GMA can provide important protection for the long-term quality, and quantity, of public water supplies.

Not all wellhead protection areas are equal. Local governments should keep that in mind when considering the use of critical area designations to protect wellhead protection areas. They may wish to define the criteria they will use to evaluate the significance of specific wellhead protection areas. Possible criteria include the number of connections, system ownership (municipal or private), susceptibility of the source water to contamination and whether the source is irreplaceable.

For more information on CARAs, contact the Department of Commerce (Appendix E).

Sole Source Aquifer Program

EPA administers the Sole Source Aquifer Program. When EPA designates an aquifer the “sole or principle source” of drinking water for a given aquifer service area, it means the aquifer is needed to supply 50 percent or more of the drinking water for that area, and there are no reasonably available alternative sources if the aquifer becomes contaminated.

The following benefits stem from Sole Source Aquifer (SSA) designation:

- If a proposed project that could contaminate the SSA will receive federal financial assistance, it is subject to EPA review. The review can prevent a commitment of federal funding or cause a redesign of the project. Designation has no effect on proposed projects that do not receive federal financial assistance such as projects funded by state, local, or private entities.
- The public is more aware of the source for the community's drinking water and, presumably, more willing to protect it.
- SSA designation may enhance a local government's ability to receive state grants through the CCWF.
- EPA assembles available hydrogeological information on designated aquifers into technical support summaries.

EPA does not initiate SSA designations. Instead, EPA responds to an application or “petition” from a geographic area requesting designation. That means an individual or organization must document the hydrogeologic boundaries and the area's dependency on a sole source aquifer for drinking water, and submit the information to EPA in a formal request. EPA designations do not consider an area's hydrogeological susceptibility or potential for groundwater contamination.

In a SSA area, the value of an effective local wellhead protection program is clear. If the community already recognizes the groundwater resource is irreplaceable, the desire to protect its quality should be high.

Contact EPA Region X's Groundwater Section for more information on the SSA program (Appendix E).

Special Protection Areas

Special Protection Areas require special consideration or protection due to unique or vulnerable characteristics, such as critical recharge areas and wellhead protection areas (WAC 173-200). Designation of a vulnerable wellhead protection area as a Special Protection Area may result in stricter discharge limits placed on state waste discharge permits, and/or increased outreach, regulatory inspections and enforcement actions.

To get information on Special Protection Areas, contact the Groundwater Quality Unit of the Department of Ecology (Appendix E).

State Environmental Policy Act

The State Environmental Policy Act authorizes local governments to designate Environmentally Sensitive Areas (ESAs) (SEPA, WAC 197-11, and related local authorities). ESA designation can provide more protection to specific areas, such as vulnerable wellhead protection areas, than the standard SEPA guidelines. This additional protection occurs because categorical exemptions can be modified. The ESA designation can affect underground storage tanks, stormwater facilities and other potential sources of groundwater contamination.

You can get information on SEPA and ESAs from Ecology's Environmental Review/Sediment Management Section (Appendix E).

Water System Coordination Act

The Water System Coordination Act provides a process to ensure coordinated regional planning for public water systems in defined Critical Water Supply Service Areas. A primary objective of the law is to minimize conflicts between land use and water system plans by integrating water system development with land use planning in a given area. An early activity in this regional planning process is establishment of a Water Utility Coordinating Committee. The committee's purpose is to organize a local partnership between county legislative authority, county planning agency, county health agency, water suppliers, and DOH to develop and implement workable solutions to water system problems. Other interested agencies, organizations, or individuals may also participate in the committee.



Glossary

Access Port: A tapped hole or tube at the wellhead, equipped with a cap, which provides access to the inner casing for measurement of the depth to water in the well.

Alluvial Deposits: Gravels, sands, and silts that accumulate over geologic time in water. They have a high capacity for conducting groundwater.

Annular Space: The space between the outer and inner casing of a well, or the space between the wall of the well and the casing if there is only one casing.

Aquifer: A geologic formation capable of yielding a significant amount of groundwater to wells or springs. A *confined aquifer* is located beneath a formation with significantly lower permeability such that water cannot readily move in a vertical direction between the surface and the aquifer.

Bentonite: A mixture of clay-like minerals which swell in contact with water, often used in constructing surface seals.

Best Management Practices (BMPs): Practices and operating procedures that prevent or reduce the pollution load. They are designed to facilitate voluntary compliance through education.

Casing: A metal or plastic pipe installed in a well to maintain the well opening, especially in loose or unconsolidated formations.

Coliform bacteria: A type of bacteria associated with fecal contamination of water. They are used as an indicator of the sanitary quality of water.

Cone of Depression: The shape formed by lowering the water table in the area directly around a well. It is caused by water movement from the aquifer into the well during pumping.

Consolidated Deposit: A geologic formation of “solid” rock such as granite, basalt, sandstone, shale, or limestone. These deposits may be permeable to water due to fractures in the rock.

Drawdown: The measured difference between the static water level in a well and the water level after some period of pumping.

Dry well: An artificial recharge well, such as a stormwater runoff pit, where collected water is allowed to percolate into the ground.

EDB/DBCP: Ethylene Dibromide and Dibromochloropropane are compounds used in some areas to fumigate soil. They have cancer-causing properties and may threaten groundwater supplies.

Formation: A geologic unit that has relatively uniform characteristics, in this case especially regarding groundwater movement.

Gravel Pack: Gravel or sand placed in the annular space around the well screen to prevent fine materials from entering the well, increase well yield, and support the screen.

Groundwater: Water that occurs in subsurface openings in the earth, such as the spaces between particles in unconsolidated deposits or along fractures in consolidated deposits.

Group A Public Water System: A water system that serves 15 or more connections, or an average of 25 or more persons per day for 60 or more days within a calendar year (WAC 246-290-020).

Grout: A mixture of cement, bentonite, and water used to seal the annular space between the inner and outer casings in a well, or between the casing and the wall of the well if there is only one casing.

Hydrogeology: The study of groundwater, with emphasis on its interaction with geologic materials and settings.

Impermeable Deposits: Formations consisting of material through which water is unable to pass, such as clays and unfractured rock.

Initial Inventory: An inventory completed during the source approval process. At minimum, it must identify all potential and actual sources of groundwater contamination that may pose a threat to the water-bearing zone (aquifer) used by the well, spring, or well field in the 1-year time-of-travel zone, and all high-risk sources within the entire wellhead protection area.

Injection Well: A well used to dispose of fluids underground. Fluids enter either by gravity flow or by injection under pressure.

Nitrates: The compounds formed from nitrogen sources in surface soils and waters. In groundwater, they indicate the infiltration of surface water into an aquifer. Nitrates also have toxic properties themselves, particularly to infants.

Nonpoint Source: A source discharging pollutants into the environment that is not a single, discrete point.

Permeable Deposits: Formations that permit the passage of water, such as gravel and clean sand.

Point Source: Any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, rolling stock, concentrated animal feeding operations, or vessels.

Preliminary Delineation: A wellhead protection area delineation completed during source approval. Calculated fixed radius method can be used, screened area estimated, and pumping rate based on either water right quantity or number of connections.

Public Water System: Defined in Washington State as any system, excluding systems serving only one single-family residence, providing piped water for human consumption.

Recharge Area: Area in which water reaches the zone of saturation by surface infiltration.

Recharge: Surface water that enters into a groundwater system. This can be *natural recharge*, such as from precipitation, or *artificial recharge*, such as from irrigation or dry wells.

Sanitary Seal: See surface seal.

Saturated Zone: The vertical zone beneath the surface where all openings are filled with water.

Screen: A metal or plastic slotted tube used to maintain the well opening in unconsolidated aquifer formations and admit water being pumped from the aquifer.

Static Water Level: The vertical distance from the surface of the ground to the water level in a well when the water level is not affected by drawdown due to pumping.

Surface Seal: The grout seal that encloses the well casing at the surface and extends some distance beneath the surface to prevent surface water from infiltrating the well.

Synthetic Organic Compounds (SOCs): Man-made compounds such as pesticides and various specialty chemicals. Many are regulated in drinking water because of their negative effects on human health, particularly those that could cause cancer.

Time-of-Travel (TOT): The period used to define the area through which groundwater will move and recharge a pumping well. For wellhead protection purposes, TOT is expressed in years.

Trihalomethanes (THMs): A class of compounds that result from the interaction of chlorine in chlorinated drinking water with naturally occurring organic material in water. Some THMs are regulated because they could cause cancer.

Unsaturated Zone: The vertical zone beneath the surface where the openings are filled with both air and water.

Vadose Zone: See unsaturated zone.

Volatile Organic Compounds (VOCs): A type of synthetic organic compound that could vaporize at room temperature, such as solvents, degreasers, fuels, and oils.

Water Table: The water level in the saturated zone where the water pressure is equal to atmospheric pressure. In practical terms, it is equivalent to the static water level.

Well Field: An area containing two or more wells with overlapping zones of contribution that supply a public water system.

Wellhead Protection Area: The surface and subsurface area surrounding a water well, or well field, supplying a public water system, through which contaminants are reasonably likely to move toward and reach the water well or well field.

Wellhead: The physical structure, facility, or device at the land surface from or through which groundwater flows or is pumped from water-bearing geologic formations.

Wells: There are various well types.

Bored Wells: Constructed with screw augers. Usually relatively shallow wells in soft, cohesive formations such as clays and silts.

Cable Tool (Percussion) Wells: Constructed by raising and dropping a heavy weight with a chisel bit. Borehole walls must be supported by temporary casing during construction. More common at shallower depths than rotary drilled wells.

Drilled Wells: Mechanically constructed wells characterized by the use of rotary, cable tool, or auger rigs for drilling. Often completed to depths greater than possible with other methods.

Driven Well: Built by driving a casing with a screened drive point into an aquifer. Used in permeable surface aquifers.

Dug Wells: Hand-excavated wells, commonly wider and shallower than drilled wells. The sidewalls may be supported by materials such as masonry or concrete rings.

Jetted Well: Constructed by using a high-pressure water jet to cut a hole in unconsolidated materials.

Later Collector Well (Ranney): A large-diameter well, sunk to the aquifer, with horizontal boreholes drilled out from the central well. More common in thin aquifers in alluvial deposits, especially adjacent to a river.

Rotary Wells: Drilled using circulating fluid (usually water or mud) in the borehole to support the borehole walls during drilling, eliminating the need for temporary casing.

Drilling is accomplished with a rotating drill bit. Commonly used for construction of deep wells.

Springs: Natural groundwater seeps to the surface where the water table intersects the land surface. Water flow can vary annually and seasonally.

Zone of Saturation: That part of the earth's crust (a geologic formation) beneath the regional water table in which all voids, large and small, are filled with water under pressure greater than atmospheric.



Resources

There are many publications to help you with your wellhead protection program.

Department of Health Office of Drinking Water: To get these and other publications, call (800) 521-0323 or visit the Web site at < <https://fortress.wa.gov/doh/eh/dw/publications/>>

- *Wellhead Protection Requirements* (331-106)
- *Washington State's Source Water Assessment Program* (331-148)
- *Simple Fixes for Wellhead Openings* (331-232)
- *Preventive Maintenance Program - Guide for Small Public Water Systems Using Groundwater* (331-351)
- *The Source Monitoring Waiver Process* (331-359)

The U.S. Environmental Protection Agency: To get these and other publications, call (202) 566-1729, e-mail center.water-resource@epa.gov or visit the Web site at <<http://yosemite.epa.gov/water/owrcatalog.nsf/EPATitle?OpenView&CartID=15235-030339>>

- *Applicability of Wellhead Protection Area Delineation to Domestic Wells: A Case Study* (813-B-95-007).
- *Benefits and Costs of Prevention: Case Studies of Community Wellhead Protection: Volume I* (813-B-95-005).
- *Benefits and Costs of Prevention Case Studies of Community Wellhead Protection: Volume II* (813-B-95-006).
- *Business Benefits of Wellhead Protection: Case Studies* (813-B-95-004).
- *Case Studies in Wellhead Protection: Area Delineation and Monitoring* (600-R-93-107).
- *Investigation of Hydrogeologic Mapping to Delineate Protection Zones Around Springs; Report of Two Case Studies* (600-R-97-023).
- *Seminar Publication - Wellhead Protection: A Guide for Small Communities* (625-R-93-002).
- *The Wellhead Protection Program: Forerunner to Source Water Protection Efforts across the Nation* (813-F-95-001).
- *Wellhead Protection in Confined, Semi-Confined, Fractured and Karst Aquifer Settings* (813-K-93-001).
- *Wellhead Protection Programs: Tools for Local Governments* (440-6-89-002).
- *Wellhead Protection Strategies for Confined-Aquifer Settings* (570-9-91-008).
- *Why Do Wellhead Protection? Issues and Answers in Protecting Public Drinking Water Supply Systems* (570-9-91-014).
- *A Review of Sources of Ground-Water Contamination from Light Industry* (440-6-90-005).

- *Delineation of Wellhead Protection Areas in Fractured Rocks* (570-9-91-009).
- *Developing a State Wellhead Protection Program / A User's Guide to Assist State Agencies Under The Safe Drinking Water Act*
- *Guide for Conducting Contaminant Source Inventories for Public Drinking Water Supplies* (570-9-91-014).
- *Guide to Ground-Water Supply Contingency Planning for Local and State Governments* (440-6-90-003).
- *Guidelines for Delineation of Wellhead Protection Areas.* Washington D.C. (440-6-87-010).
- *Managing Ground Water Contamination Sources in Wellhead Protection Areas / A Priority Setting Approach.* (570-9-91-023).
- *Profile of Ground Water Quality Protection 1992 – State of Washington.* (910-9-92-024).
- *Protecting Local Ground-Water Supplies through Wellhead Protection* (570-9-91-007).
- *Wellhead Protection Programs: Tools for Local Governments* (440-6-89-002).
- *Wellhead Protection Strategies for Confined Aquifer Settings* (570-9-91-008).
- *Why Do Wellhead Protection?* (570-9-91-014).

Washington State Department of Ecology

LaSpina, J. and R. Palmquist. July, 1992. *Catalog of Contaminant Databases: A Listing of Databases of Actual or Potential Contaminant Sources.* Washington State Department of Ecology. Olympia, Washington.

For copies of Ecology publications, visit the Web site at <<http://www.ecy.wa.gov/pubs.shtm>>

Additional References

Blandford, T.N. and P.S. Huyakorn. March, 1990. *U.S. EPA WHPA Model: A Modular Semi-Analytical Model for the Delineation of Wellhead Protection Areas.* U.S. Environmental Protection Agency, Office of Ground-Water Protection. Washington D.C.

Cross, B.L. May, 1990. *A Ground Water Protection Strategy: The City of El Paso.* Texas Water Commission.

Swanson, R.D. February, 1992. *Methods to Determine Wellhead Protection Areas for Public Supply Wells in Clark County, Washington.* Intergovernmental Resource Center. Vancouver, Washington.



Appendix A: Wellhead Protection Rules

Washington Administrative Code (WAC) 246-290 defines basic regulatory requirements to protect the health of consumers using public drinking water supplies. These basic regulatory requirements include wellhead and source water protection. The WAC also adopts by reference certain sections and subsections of Title 40 Code of Federal Regulations Part 141 National Primary Drinking Water Regulations.

The complete WAC is online at <<http://apps.leg.wa.gov/WAC/default.aspx?cite=246-290>>

The following portions of WAC 246-290 relate directly to wellhead and source water protection. For more information, consult the WAC directly at the above link.

WAC Number	Heading
246-290-010	Definitions
246-290-025	Adoption by reference
246-290-100	Water system plan
246-290-105	Small water system management program
246-290-130	Source approval
246-290-135	Source water protection
246-290-140	Existing system as-built approval
246-290-300	Monitoring requirements
246-290-668	Watershed control



Appendix B: Checklist of Required Wellhead Protection Elements

Wellhead Protection Requirements

Federal law requires all states to establish a Wellhead Protection Program. The Washington State Wellhead Protection Program was adopted in July 1994.

All Group A public water systems in the state using wells or springs (excluding systems using purchased sources, or interties) must develop a wellhead protection program. The goal of the program is to prevent contamination of groundwater used for drinking water. The strategy used to accomplish this goal involves three main components:

1. Delineation of wellhead protection areas.
2. Inventory of potential contaminant sources.
3. Management of wellhead protection areas to prevent contamination.

Each water system's wellhead protection plan will be incorporated into their Water System Plan or Small Water System Management Program document.

Overview

As part of your wellhead protection plan, briefly explain how you developed and implemented your program. Include relevant information, such as how you coordinated with other water systems or local agencies and whether you established a wellhead protection committee. This information will help DOH staff review your documentation and evaluate the effectiveness of your implementation efforts.

Delineation

A wellhead protection area is the area managed by a community (or private water association, homeowner's association, or the like) to protect its groundwater-based drinking water supplies. If, for example, a spill of hazardous materials occurred in this area, it could pose a direct risk to your drinking water supply.

Wellhead protection areas may consist of four or five zones: the standard sanitary control area, three additional zones based on the 1-, 5- and 10-year time-of-travel rates, and, where appropriate, a larger buffer zone.

The methods used to identify the wellhead protection area will depend on the susceptibility of the well (determined by the *Susceptibility Assessment Form*) and the size of the water system. **A completed susceptibility assessment must be included as part of the wellhead protection**

program. All notification letters should discuss your system's susceptibility rating, what the rating means, and the number of people your system serves. For example, explain your delineation boundaries, inventory findings, and spill response plans.

Delineation Requirements

The wellhead protection area boundaries should be plotted on a base map that shows major landmarks and topography, with a scale large enough to adequately display the delineated areas. A map with a scale of three to four inches per mile is best. If you are unable to locate a map of that scale, a 7-½ minute U.S. Geological Survey topographic map would be appropriate, **if enlarged by photocopying**. Prior to enlarging, draw a 1-mile bar of the correct scale on the map. Please be sure to draw the wellhead protection area boundaries on the map to scale as well.

You must notify local decision makers (elected officials, planning and regulatory agencies) about the wellhead protection area boundaries. For example, notify your local planning and health departments, county commissioners, and public works programs. Document this notification in the wellhead protection portion of your water system plan. A discussion of the susceptibility ranking of your system, the meaning of that determination and the number of persons served by your system should be included.

Public Water Systems with fewer than 1,000 connections:

1. If the source of supply is determined to be of low to moderate susceptibility, you can use the calculated fixed radius method to delineate the 6-month and 1-, 5- and 10-year time-of-travel zones. You should consider using a more sophisticated delineation method within five years.
2. If the source of supply is determined to be of high susceptibility, you can use the calculated fixed radius method to delineate the 6-month and 1-, 5- and 10-year time-of-travel zones. However, you **should upgrade** to a more sophisticated, site-specific method within 5 years.

Public Water Systems with 1,000 or more connections:

1. If you determine the supply source is low to moderately susceptible, you can use the calculated fixed radius method to delineate the 6-month and 1-, 5- and 10-year time-of-travel zones. However, you **should upgrade** to a more sophisticated, site-specific method within five years.
2. If you determine the supply source is highly susceptible, you should use an analytical or other sophisticated, site-specific method (semi-analytical, numerical, or hydrogeologic mapping).

If the calculated fixed radius method is used, you must include the following:

1. Map of wellhead protection area delineations at the appropriate scale.
2. Screened interval of the well (or statement that well is of open hole construction).
3. Pumping rate of the well.
4. An example of the notification letter used.
5. A list of those notified about the wellhead protection area boundaries.

If a more site-specific method is used, you must include the following:

1. Map of wellhead protection area delineations at the appropriate scale.
2. Explanation of methodology used.
3. An example of the notification letter used.
4. A list of those notified of the wellhead protection area boundaries.

Inventory

Water suppliers must inventory potential contaminant sources in their wellhead protection areas. The purpose of the inventory is to identify past (last 10-20 years), present and proposed activities or land uses that may threaten the water bearing zone (aquifer) the well, spring, or well field uses.

The list of potential contaminant sources is long, but includes improperly abandoned wells, the use of fertilizers and pesticides, and facilities such as gas stations and dry cleaners.

Completing this inventory, along with a *Susceptibility Assessment Form*, also may allow you to apply for a monitoring waiver.

After you identify potential threats to your drinking water supply through the inventory, there is a need to prioritize these potential contaminant sources. Interpretation of the inventory information should include some type of hazard ranking system relative to groundwater contamination and the possible effect on your system's source of drinking water.

Inventory Requirements

The following must be in the wellhead protection plan:

1. A list of all potential and known groundwater contamination sources in the wellhead protection area boundaries (past and present) that could threaten the source water. You should prioritize and group the inventory findings time-of-travel zones. You should update this list at least every two years.
2. Documentation showing you notified the appropriate regulatory agencies and local governments that potential and known sources of groundwater contamination they regulate are in the wellhead protection area boundaries. A sample notification letter and a list of those notified should be included.
3. Documentation showing that you notified all owners or operators of known and potential sources of groundwater contamination that they are in the wellhead protection area boundaries. A sample notification letter and a list of those notified should be included.

Highly susceptible systems with 1,000 or more connections should also include:

1. Current land use or zoning designation of the wellhead protection area(s).
2. A priority ranking of potential contaminant sources (high to low).

Management

Without implementing management strategies to prevent **potential** contaminant sources from becoming **actual** sources of groundwater contamination, wellhead protection planning accomplishes little. Because many water suppliers don't own or control all the land that falls within their wellhead protection areas, an effective wellhead protection program must have the cooperation of those who do have control (such as local government agencies, land owners). The required notification to owners, operators, and regulatory agencies is an important step in managing the wellhead protection area.

Public education is an important part of managing wellhead protection areas. When people understand that their activities might affect the water they drink, they are more willing to change their practices.

A local wellhead protection committee is an effective way to involve the public in the program. Committee members can include representatives of jurisdictions with land use controls over the wellhead protection area; water systems; members of industrial, commercial, and agricultural organizations; citizen action groups; tribal representatives; and regulatory agency personnel. By involving members of affected groups from the beginning, it is more likely that your wellhead protection plan will become an accepted, effective, implementable program.

Water systems must undertake two components of managing the wellhead protection area:

1. **Contingency plans** for an alternative supply of water in case the primary well or well field is lost due to contamination.
2. **Emergency spill and incident response coordination.**

Management Requirements

The wellhead protection plan should document that the system has:

1. A **contingency plan** to ensure consumers have an adequate supply of potable water if the contamination results in the temporary or permanent loss of the principal source of supply (major well(s) or well field). At a minimum, the contingency plan should:
 - Identify maximum water system capacity in relation to source, distribution system, and water rights restrictions. Assume loss of the largest well or well field and reevaluate.
 - Identify existing or potential interties with other public water systems and evaluate the ability to deliver water while assuming loss of the largest well or well field. Include the costs associated with the purchase and/or delivery of alternate supplies.
 - Identify future potential sources of drinking water, and describe quality assurances and control methods to be applied to ensure protection of water quality prior to utilization as a drinking water supply.

The contingency plan should include cost estimates associated with obtaining short- and long-term alternative sources of supply. If that analysis shows no alternative sources of supply or interties are available, the contingency plan should clearly state this and proceed to

analyze treatment options for the potential contaminant sources determined to pose the highest risk to the source of supply.

2. An **emergency spill and incident response program**. You must provide a copy of the wellhead protection area boundaries, results of the susceptibility assessment, inventory findings, and contingency plans to local emergency responders (police and fire departments), the local health department, and any local emergency planning committee. They can then evaluate whether changes in spill or incident response measures are needed to better protect groundwater and drinking water quality within the wellhead protection area.

Wellhead Protection and the Waiver Process

Group A public water systems that actively seek monitoring waivers for the Phase II/V regulated compounds are well on their way to also fulfilling the regulatory requirements of wellhead protection. Susceptibility assessments, wellhead protection area boundary establishment, and inventory of contaminant sources are principle elements of both programs. After seeking monitoring waivers, implementing the additional steps required under the wellhead protection program may facilitate future monitoring waivers from DOH. With an on-going program to prevent the contamination of your well or well field, you will be able to demonstrate that your system's drinking water is at a lowered risk of contamination. That may reduce future monitoring requirements.

Wellhead Protection Checklist

SUSCEPTIBILITY ASSESSMENT

1. A complete *Susceptibility Assessment Form* Y

DELINEATION

2. If the calculated fixed radius method is used, the pumping rate (quantity) and screened interval of the well. Y
3. The 6-month and 1-, 5- and 10-year time-of-travel zones plotted on an appropriately scaled map (see text). Y
4. An explanation of the methodology, if site-specific delineation is used. Y
5. A list of those notified of the wellhead protection area (WHPA) boundaries, along with an example notification letter. Y

INVENTORY

6. A list of the potential contaminant sources in the WHPA, grouped by time-of-travel zones, as derived from the inventory. Y
7. List of owners/operators of potential and actual contaminant sources notified of their location in the WHPA (and an example of the notification letter). Y
8. List of regulatory agencies and local governments notified that potential and actual sources of groundwater contamination are in the WHPA. Y

CONTINGENCY AND EMERGENCY RESPONSE PLANS

9. A contingency plan for an alternative source of potable water (see text). Y
10. Documentation of notification to appropriate response agencies. Y



Appendix C: Sample Scope of Work for Wellhead Protection Planning

This scope of work may help water systems develop a local wellhead protection program. The wellhead protection plan must comply with state law (WAC 246-290).

GOAL 1

Characterize the hydrogeologic setting where the well, well field, or spring withdraws water. This includes determining hydraulic conductivity, groundwater-flow gradient, effective porosity, and pumping rate to use for delineating wellhead protection areas as presented by EPA and DOH guidance documents.

- Task 1a:** Map hydrogeologic systems contributing water to your source water. Use existing geologic information and reports to define recharge areas. Present information in report form with (multiple) overlays on a map at a scale appropriate to show meaningful details.
- Task 1b:** Map water levels to determine regional groundwater gradient and direction of flow in the aquifers. Plot the location of existing wells on a base map. Select a set of test wells that will allow creation of a water level map. Access water level information from test wells obtained from/through local government agencies (*water level data collected locally using staff or local well drillers may save considerable money*). Create water level (potentiometric surface) map of the water bearing zone(s) of interest, at a scale appropriate to show meaningful details.
- Task 1c:** Aquifer property definition. Estimate aquifer transmissivity, porosity, flow direction and rate (using all available data). Base estimate on aquifer pumping tests, field tests, or other defined methods. Identify additional data needs and uncertainties in estimates, evaluate trade-offs in data used.
- Task 1d:** Delineate the capture zone and identify recharge areas of your source water. Use approved method (analytical model, hydrogeologic mapping) to delineate 1-, 5- and 10-year time-of-travel (or equivalent) boundaries for your supply source(s). Include model calibration as appropriate.

GOAL 2

Identify known and potential sources of groundwater contamination within the wellhead protection areas that pose threats to your source water.

- Task 2a:** Compile and evaluate locally generated inventory data. (You can save money by using staff or volunteers to collect the initial inventory data.)

- Task 2b:** Identify and fill informational gaps in local inventory.
- Task 2c:** Plot inventory findings at a scale appropriate to show meaningful details.
- Task 2d:** Evaluate and prioritize risks associated with the public water system. If appropriate, determine/estimate the carrying capacity or assimilation capacity of systems for septic nitrate loading or other identified contaminants.

GOAL 3

Recommend management procedures to protect water supplies from potential sources of groundwater contamination within the wellhead protection areas.

- Task 3a:** Prioritize the relative risks of the potential sources of groundwater contamination within each wellhead protection area.
- Task 3b:** Identify jurisdictional responsibilities for the identified risks in conjunction with the local Wellhead Protection Advisory Board.
- Task 3c:** In coordination with local governments, identify existing and proposed management programs (such as the Washington Growth Management Act, Critical Aquifer Recharge Areas, local comprehensive plans, local ordinances, and state programs).
- Task 3d:** Identify and recommend management alternatives available for pollution prevention and risk reduction measures. These recommendations are to include identification of funding source alternatives for the wellhead program.
- Task 3e:** Provide specific examples of suggested options, including sample ordinances. Ensure suggested options and sample ordinances are consistent with enabling legislation. Document that the purpose of the regulation is to advance legitimate government function (public health and safety).
- Task 3f:** Propose follow-up procedures to ensure preventive measures are effective.

GOAL 4

Develop contingency plans to provide alternative drinking water supplies if contamination of existing water supplies occurs.

- Task 4a:** Identify maximum capacities of the existing system(s) in relation to source, distribution system, and water rights restrictions. Assume loss of the largest well or well field and reevaluate.
- Task 4b:** Evaluate the expansion options of the existing system(s)' capacities to meet current water rights/availability.
- Task 4c:** Identify existing or potential interties with other public water systems.

Task 4d: Evaluate current procedures and recommend contingency plans for emergency events.

GOAL 5

Identify future potential sources of drinking water, and recommend quality control methods to ensure of water quality protection before using them as a drinking water supply.

GOAL 6

Define **critical** aquifer recharge areas for the well (well field, spring).

Task 6a: Provide site-specific recommendations on which portions of the recharge areas should be considered “critical” and therefore in need of special protection.

GOAL 7

Develop a spill and incident response plan.

Task 7a: Meet, brief, and coordinate with local emergency responders on the wellhead protection program’s findings (for example, susceptibility assessment, wellhead protection area boundaries, inventory results, contingency plan conclusions). Discuss current response capabilities and resources from a groundwater-protection perspective.

Task 7b: Make recommendations on spill and incident response planning, training and resource needs.

GOAL 8

Complete draft and final reports discussing research conducted, field investigations, actions and recommendations. Include a map of the wellhead protection area showing time-of-travel zones.



Appendix D: Sample Notification Letters

Example Letter 1 **To local jurisdictions / agencies**

Dear (Agency/Local Government):

We are writing to let you know that businesses or facilities you regulate are in our public water system wellhead protection area. Please take all reasonable steps to ensure that land use activities within this area do not contaminate our drinking water sources.

Our water company has 450 service connections, and serves about 1,071 people. The Washington State Department of Health rated our system as “highly susceptible.”

The enclosed map shows the 6-month and 1-, 5- and 10-year time-of-travel boundaries for our wellhead protection area. We’re also sending you a list of the facilities or activities of concern. Any groundwater contamination that occurs within this wellhead protection area has a high potential to reach our well.

Thank you for your support in protecting our drinking water.

Sincerely,

Example Letter 2 **To potential source owners/operators**

Dear (Owner/Operator):

To protect the drinking water supply for the customers of Taylor’s Gulch Water System, we are developing a wellhead protection program as required by state law. As part of our wellhead protection program, we mapped the area overlying the short-term recharge zone of our drinking water supply wells. This is called our wellhead protection area.

Following the mapping of the wellhead protection area, we conducted an inventory of **potential** groundwater contamination sources within the area. The nature of your business and its location within our wellhead protection area means that your activities have the potential to affect our customers’ drinking water supply.

We have notified the agency or agencies that regulate(s) your type of business/facility that you are in our wellhead protection area. You should contact them to request technical assistance to help manage your business in a way that will best prevent groundwater contamination. We realize you are already careful to protect the environment as you conduct your business. We hope that learning that you are in our wellhead protection area will result in more precautions to ensure that your activities will not affect our drinking water quality.

Sincerely,



Appendix E: Key Contacts

State Agencies

Washington State Department of Health <<http://www.wa.gov/ehp/dw>> Wellhead Protection Program

Headquarters

PO Box 47822
Olympia, WA 98504-7822
(360) 236-3100

Northwest Regional Office

PO Box 47800
MS K17-12
Olympia WA 98504
(253) 395-6750

Eastern Regional Office

16201 E. Indiana Ave., Suite 1500
Spokane Valley, WA 99216
(509) 329-2100

Southwest Regional Office

PO Box 47823
Olympia, WA 98504-7823
360-236-3030

Washington State Department of Ecology <<http://www.ecy.wa.gov/>>

Hazardous Waste and Toxics Reduction Program

PO Box 47600
Olympia, WA 98504-7600
(360) 407-6700

Central Regional Office

15 West Yakima Avenue, Suite 200
Yakima, WA 98902
(509) 575-2490

Hazardous Waste Clean-up Sites

(800) 826-7716

Eastern Regional Office

N 4601 Monroe St
Spokane, WA 99205-1295
(509) 329-3400

Water Resources Program/Well Identification

PO Box 47600
Olympia, WA 98504-7600
(360) 407-6648

Northwest Regional Office

3190 160th Avenue SE
Bellevue, WA 98008-5452
(425) 649-7000

Water Quality Program

PO Box 47600
Olympia, WA 98504-7600
(360) 407-6600

Southwest Regional Office

300 Desmond Drive
Lacey, WA 98503
(360) 407-6300

Municipal Research and Services Center

<<http://www.mrsc.org/>>
2601 4th Avenue, Suite 800
Seattle, WA 98121-1280
(206) 625-1300

Department of Agriculture

<<http://www.agr.wa.gov/>>
Pesticide Management Division
PO Box 42589
Olympia, WA 98504-2589
(877) 301-4555

Department of Commerce

<<http://www.commerce.wa.gov/>>
Growth Management Services
PO Box 42525
Olympia, WA 98504-2525
(360) 725-3000

Department of Commerce

Public Works Board
<<http://www.pwb.wa.gov/>>
PO Box 42525
Olympia, WA 98504-2525
(360) 725-3150

Washington State University - Extension <<http://ext.wsu.edu/>>**Agriculture & Natural Resource Program**

P. O. Box 646248
Pullman, WA 99164-6248
(509) 335-8744

Federal Agencies**Department of Agriculture****Rural Development**

<<http://www.rurdev.usda.gov/wa/>>
1835 Black Lake Blvd. SW, Suite B
Olympia, WA 98512-5715
(360) 704-7740

Indian Health Service**Portland Area Office**

<<http://www.ihs.gov/FacilitiesServices/areaOffices/Portland/>>
1220 SW Third Avenue, Room 476
Portland, OR 97204
(503) 326-2020

Department of Agriculture**Natural Resources Conservation Service**

<<http://www.wa.nrcs.usda.gov/>>
316 West Boone Avenue, Suite 450
Spokane, WA 99201-2348
(509) 323-2900

Environmental Protection Agency (EPA)**Office of Water**

<<http://www.epa.gov/r10earth/>>
1200 Sixth Street, Suite 900
Mail Stop: OWW-136
Seattle, WA 98101
(206) 553-1806

Geological Survey**Water Resources of Washington State
Water Science Center Office**

<<http://www.wa.water.usgs.gov/>>
934 Broadway, Suite 300
Tacoma, WA 98402
(253) 552-1600



Appendix F: Susceptibility Assessment Information

This appendix includes:

1. An overview describing how you can use source water susceptibility assessments to implement wellhead protection.
2. An Assistance Packet with:
 - Introduction to Susceptibility Assessments.
 - Instructions: How to complete the *Susceptibility Assessment Form*.
 - Element 1: Creating a wellhead protection map.
 - Element 2: Diagram of a drinking water supply well.
 - Element 3: Sample well report (well log).
 - Element 4: Tables for calculating time of travel.
 - Element 5: Maximum contaminant levels (MCLs).
3. A sample *Susceptibility Assessment Form*.

Introduction to Susceptibility Assessments

EPA and Vulnerability

In 1986, Congress passed amendments to the Safe Drinking Water Act. These amendments were implemented in phases. The most recent—Phase II and Phase V—went into effect between 1993 and 1995. Under Phase II and V, the monitoring requirements for volatile organic and synthetic organic compounds (VOCs and SOCs) increased significantly for public water systems. Realizing that increased monitoring requirements can be very costly to water systems, EPA allows states to reduce or waive monitoring requirements depending on how vulnerable the water system's sources are to contamination.

DOH actively pursues monitoring waivers to eliminate unnecessary testing while still fully protecting human health. That means sources vulnerable to contamination have more monitoring requirements and sources that are not vulnerable have reduced or no monitoring requirements for many chemicals.

What is Vulnerability?

Vulnerability is a water source's potential for contamination. Two factors influence vulnerability:

1. **Physical susceptibility to contaminant infiltration.** Susceptibility depends on conditions that affect the movement of contaminants from the land surface into a water supply. This includes the depth of the well, its construction, the geology of the area, the pumping rate, the source(s) of groundwater recharge, and the aquifer material.
2. **The source's risk of exposure to contaminants.** The risk of exposure is measured by determining whether contaminants were used in the water supply area. However, each type of contaminant may behave differently in the environment, making it difficult to predict groundwater pollution from surface exposure accurately. For this reason, susceptibility is the key factor used in determining vulnerability.

When physical susceptibility data is incomplete, or use of contaminants is highly unlikely, vulnerability is based more on risk of exposure.

Susceptibility Assessments

To determine a drinking water source's vulnerability to surface contamination, DOH developed the *Susceptibility Assessment Form*. This form determines an overall susceptibility rating by cataloging key susceptibility factors for each source.

All of the following information is needed to evaluate hydrologic susceptibility:

- 1) Well logs, or other indicators of aquifer characteristics.
- 2) Depth of open interval.
- 3) Date and description.
- 4) Record of monitoring information (nitrates, VOCs, SOCs, and bacteria).
- 5) A specific (and accurate) location of the source.

- 6) Water level information.
- 7) Estimate of wellhead elevation.
- 8) A general evaluation of land-use surrounding the wellhead.
- 9) Size of the water system.

Monitoring Waivers

The building block of DOH's Monitoring Waiver Program for groundwater sources is the susceptibility assessment. **No matter what the type of waiver you want, to be eligible, you must first complete the *Susceptibility Assessment Form*.**

Depending on the results of the susceptibility assessment, DOH may waive some or all of the monitoring requirements for many chemicals. This type of waiver is a "susceptibility waiver." If source information does not allow a system to qualify for a susceptibility waiver, the system can pursue other types of waivers. One option, the "Contaminant Use Waiver," involves a more intense inventory of the contaminants that may be in the source's recharge area. "Statewide waivers" may also offer some monitoring relief. These are blanket waivers granted for chemicals not commonly detected in the state (such as dioxin).

Another type of waiver is the "Area Waiver." For this waiver, DOH conducted a statewide groundwater-testing program, which provided information on occurrence of SOCs. Susceptible systems in areas where SOCs were detected **must** monitor, whereas DOH reduced or waived sampling in areas where there is little evidence to expect contamination. DOH also considers information from this groundwater study when evaluating surface water sources in these areas. Participation in the Area Waiver system program is voluntary. Systems that choose not to participate must complete the required sampling or use one of the other waiver options. For some susceptible surface water systems, Area Waivers provide a less expensive and less time-consuming alternative to either the required sampling or individual Contaminant Use waivers.

Instructions: How to complete the *Susceptibility Assessment Form*

A sample *Susceptibility Assessment Form* is at the end of this packet. When you are ready to complete a *Susceptibility Assessment Form* for your well, contact your DOH Regional Office to get the most recent version of the form and instructions for completing and submitting it.

DOH will use the information on this form to evaluate geologic and hydrologic factors associated with each of your public water supply sources in order to estimate vulnerability to contaminants regulated under the State Drinking Water Rule (WAC 246-290) and the Federal Safe Drinking Water Act (SDWA).

DOH will consider the information from this questionnaire, records on water quality and water source development, and new SDWA testing results when assigning frequency-of-monitoring requirements to each source for the contaminants regulated under the SDWA. The Wellhead Protection Program uses some of this information to develop comprehensive plans to protect of groundwater resources throughout the state.

You can get the information requested on this questionnaire from a variety of records. Some information is on your Water Facilities Inventory (WFI) and reflects the current information in our computer system. Please take time to verify this information, note any changes, and send a copy to the DOH regional office. Other useful records include your source and system monitoring records, Water Well Reports (well logs), system design plans, water right records, engineering reports, and water quality monitoring records. If your records are not complete, you can get some of this information from the Department of Ecology or our DOH regional office.

The form asks many questions about the construction of your well. If your water system uses only springs, you should still complete the form.

Incorrect information or incomplete questionnaires may raise your susceptibility risk rating and increase your future monitoring costs. For these reasons, it is important that you take some time to complete the form to the best of your ability. If you don't have all of the requested information, you may indicate "information unavailable," or "unknown," or "does not apply."

PART I: System Information

With a few exceptions, you can get all of the information in this section from your WFI form. If you misplaced your WFI, your local health department should have a copy on file. Of particular concern is the information concerning source location and quarter/quarter section, well depth, population served and number of connections. This information is also available on your well log. Please use this opportunity to review your WFI and make sure it is up-to-date. Mark any changes and send a copy to the DOH regional office.

There are optional items in this section, including the Washington Well Identification Number and a latitude and longitude location. This information is not always readily available. If that is the case, leave those areas blank. DOH expects this information to become more available.

PART II: Well Construction Information

You can get most well information from the Water Well Report(s) (well log) and design plans prepared for the water system. In some cases, the information is in other system records, such as your WFI. You can estimate some factors, but you must identify those responses as estimates. See Element 3 for an annotated example of a drilling log.

1) Date Well Constructed/Reconstructed:

You can find this information on the well log by the driller's signature. If you have multiple logs representing reconstruction or redevelopment of the well, use the most recent date. Please include a copy of the well log with this form.

2) Well Driller:

You can find this on the lower right side of the well log. Please enter the name and address if possible.

3) Well Type:

Mark the type of well construction. It can often be found in Part 4 on the left side of the well log. If this area is not filled in, please check system records. Appendix A of this packet contains a list of definitions to assist you determine well type if you have no documentation.

4) Well Report (Well Log):

This would include a driller's log, well log, or a detailed design that includes an engineer's "as built" along with a geologic log. Your Ecology regional office may have a copy of a well log(s) for your system if you cannot locate one in your files. Please attach a copy to your response form.

5) Average Pumping Rate:

This information may appear on your WFI (Box 24), well log (Box 9), or from the system plan. It is an estimate of the pumping rate in gallons per minute. If the current pumping rate is different from that listed on the well log or WFI, or if these documents are absent, please explain how the pumping rate was determined.

6) Source Treatment:

If your water source is treated in any way prior to delivery to your customers, you must record that information here. Many water sources are not treated. Of those that are, chlorination (for disinfection) is the most common. Some other common types of water treatment include other types of disinfection, filtration, fluoridation, or softening (to remove unwanted minerals or chemicals).

Your system could combine multiple sources prior to treatment. If so, record this in the comment section. Please refer to your WFI for treatment information if you are uncertain.

7) Chlorine Residuals:

Complete only for chlorinated sources. If your system is chlorinated, record the average chlorine residual for that source (within the distribution system). If more than one source is combined before treatment, be sure to record the same information on both susceptibility assessments.

PART III: Information of Hydrogeologic Setting

1) Depth to Top of Open Interval:

This is the depth to the top of the screen/perforated area of the well. If there is more than one screened interval, use the depth to the top of the uppermost one. If the well is not fully cased, use the depth to the bottom of the casing. This information is on the well log (part 6) or in an engineer's "as built" design report. If the well is cased but there is no screen(s), simply mark the depth to the bottom of the casing.

2) Depth to Groundwater:

This is in Part 8 of the well log. It is the depth measured from the top of the well to the standing level of water in the well. It may be significantly different from either the depth of the well or the top of the open interval. If this information is not on the well log, you can use a current water level measurement as an estimate. If the well is under pressure, or is a flowing well or spring, please mark the form accordingly.

3) Flowing Wells and Springs:

If this source is a flowing well (artisan or free flowing well) or spring, is there a measure of the flowing or confining pressure? This is an alternative way to measure the aquifer pressure associated with a source. Some artisan wells and springs are under pressure and flow freely at the land surface without the aid of a pump.

This information may be listed in pounds per square inch (psi) or as a flow rate in gallons per minute (gpm). If the information is listed as a flow rate, be sure it is not a pumping rate. The pumping rate will be used to answer questions in Part IV.

4) Surface Impoundment and Reservoirs:

If your source is a flowing well or spring, does its collection system include a surface impoundment, reservoir, pond, catchment basin or lake? For this question, surface impoundments refer to impoundments that are open to the atmosphere—not closed or covered spring boxes.

5) Wellhead Elevation:

This is the elevation above sea level of the top of the well casing (part above the ground). Sometimes this information is on the well log in part 8. An estimate can be made by altimeter or by using a topographic map and (with elevation contour lines) estimating the approximate

elevation of the wellhead. Elevation can also be estimated relative to another known elevation. If an alternative method is used, please explain how the estimate was made.

6) Confining Layers:

You will need a well log or geologic log to complete this section. The log will show the layers of material encountered during drilling. See Element 3 for a Sample Well Log. These layers may be described in the log as cobbles, gravel, sand, rock, fractured rock, basalt, silty sand, till, hardpan, or clay. The log should also identify the layers that yielded water. They may be clearly identified or simply noted as “wet” or “seepage.” Generally, the most productive water-bearing zone is where the well has been screened.

Find the zone where the well is screened or open. Look at the materials encountered above that point. Do any of the layers consist of fine silty sands, clays, un-fractured rock, hardpan, or till? If so, these may be considered to be impermeable (confining) layers which may serve to protect the aquifer from surface contamination.

If you can identify individual layers > 5 ft thick, or a combination of layers > 10 ft thick, mark this as evidence of a confining layer on the form. After you identify this layer(s), you can estimate the effectiveness of the protection afforded by the confining layer(s). To do so, subtract the depth to the static water level from the depth to the bottom of the lowest confining layer. If this number is positive and > 20 ft, there is a high likelihood that the aquifer is at least partially confined. The elevated water level is a simple measure of the pressure in the aquifer due to its confining geology. Generally, the greater the pressure the greater the protection.

Example:

Total amount of confining layers identified in driller’s log: _____ ft
If total is >10 ft for multiple layers or the total is >5 ft for a single confining layer, then...
Depth to bottom of lowest confining layer: _____ ft
Subtract (-)
Depth to static Water level _____ ft
Result (=) _____ ft

If result is greater than (>) 20 ft, the source can be considered confined.

7) Sanitary Setback:

Public water systems must establish a control zone around the well that excludes major potential contaminant sources. Generally, it is approximately 100 ft but may be larger or smaller in some cases. This is the area protected by covenants and easements. This area should exclude buildings, roads, driveways, storage facilities, drainfields, and other possible contaminant sources. Please mark the distance established for the water source(s). This may be identified in records as a sanitary control zone. This data may also be collected by direct measurement.

8) Wellhead Construction:

Note if there is a well house constructed around the pump and wellhead built specifically to protect the wellhead. Is there controlled access to the wellhead (fenced area, locking cap or access port)? If the wellhead is housed in a building used for other purposes (storage of treatment materials and so on), please describe.

9) Surface Seal:

The surface seal (sanitary seal) of a well commonly extends some distance down the annular space (the space between the well casing and the borehole wall) to protect the well from direct infiltration of surface contaminants. Since 1988, Ecology has required 18 feet of surface seal for most well construction. Please indicate if your well was constructed with at least 18 feet of cement, bentonite or grout seal below the surface.

10) Annual Rainfall:

Choose the appropriate estimate of annual rainfall. If you are unsure of your annual rainfall, contact your Chamber of Commerce, a local airport, or the Weather Service.

PART IV: Mapping Your Groundwater Resource

This section introduces a simple way to estimate the size of the area overlying the groundwater resource you will tap over the next six months and the next one, five and ten years. It is called the calculated fixed radius (CFR) method because the area it describes is a circle, with an equal radius in all directions. The radius is the distance from the center to the outer edge of the area. This section will help you decide whether to use the CFR method to describe the shape of the groundwater resource(s) you are using. Data collected here will be applied in future efforts to delineate Wellhead Protection Areas to minimize risk to your water system from groundwater pollutants.

1) Annual Volume of Water Pumped:

Use source water meter data to respond to this question. If your source is unmetered, there are three ways to estimate the annual volume of water your system uses (gal/year).

1. If you know your pumping rate (gal/min) use this calculation to estimate annual usage:

_____ gal/min x 60 min/hr x _____ hr/day x _____ day/year = _____ gal/year

2. Using the same calculation, substitute the pump capacity value for the pumping rate.

3. Use the number of service connections on your system in the calculation below. Average household water use varies widely. For planning purposes, DOH uses 400 gallons a day per connection as an average rate of consumption.

# of service connections	x 400 Gallons per day per connection	x Average use days per year (365 for most)	= Estimated average pumping rate per year
--------------------------	--------------------------------------	--	---

50 connections	x 400 gallons per day per connection	x 365 days per year	= 7,300,000 gallons per year
----------------	--------------------------------------	---------------------	------------------------------

2) “Calculated Fixed Radius” Estimate of Groundwater Movement:

This is a way to define a circular area around your wellhead, which is an estimate of the area overlying the groundwater you will pump through your well over a period of time. The radius of the circle depends on the time it takes groundwater to travel from the edge of the circle to your well.

Use the tables in Element 2 to calculate the 6-month and 1-, 5- and 10-year travel times.

Choose the table with the screened interval length that most closely matches the screened interval length in your well. You must round your numbers to choose the appropriate values for your groundwater travel times. “Screened Interval” refers to the length of the screened water inlet in the well through which water is pumped from the aquifer. If your screened interval length is exactly between two values, choose the smaller length.

Next, choose the “annual volume pumped” that most closely matches your own. If there is more than one screened interval, add the lengths together and use the sum for this value. If your well is unscreened (open interval), your actual screened interval is unknown (check your engineering report or Part 6 of your well logs), or your well is constructed with an open interval at its base, use the table with “Screened Interval = 10 feet.”

Element 1 provides a detailed example of how to calculate and plot the 6-month and 1-, 5- and 10-year time-of-travel zones around a source. As in the exercise, your areas recommend using a 7-½ minute U.S. Geological Survey topographic map or larger. This is a map scaled at 24,000:1 or about 2.5 inches per mile. You may wish to use a map with a larger scale (3-4 inches per mile) to make locating potential contaminant sources easier.

3) Surface Waters in Wellhead Zones:

This question helps identify any obvious surface water bodies in the 6-month travel time zone around the source. An obvious surface water body could be any seasonal or permanent water body such as lakes, ponds, wetlands, reservoirs, lakes and streams. They can be man-made or natural.

4) Stormwater or Wastewater Facilities in Wellhead Zones:

This question identifies any potential biological contaminant source in the 6-month travel time zone that may be associated with waste, wastewater or stormwater disposal systems. This can include wastewater treatment lagoons, stormwater retention ponds, spray fields, and water or manure holding lagoons.

PART V: Assessment of Water Quality

Use this section to evaluate existing evidence of water quality problems in your specific water supply source(s) and to inventory possible threats to future water quality in order to minimize the risk of future contamination. You may have to estimate local conditions.

1) Regional Sources of Risk to Groundwater:

This question addresses the risk of groundwater contamination from human activities (nitrates, coliform bacteria, pesticides, household or industrial solvents, hazardous wastes, and so on). Although contamination can occur at some distance from your water source(s), the emphasis here is on the area around the wellhead represented by a circle with a radius equivalent to a 5-year groundwater time-of-travel.

“Likely pesticide application” refers to those areas, excluding residential areas, where insecticides or herbicides are commonly applied. Examples include agricultural land, managed forestland, nurseries, and recreational areas (golf courses, parks) larger than two acres. Also, consider right-of-ways (state or county highways, railroads, electric or telephone lines) where herbicides are applied and mosquito or vermin control areas. State and county public works departments and county agricultural extension offices can often supply much of this information.

“Other injection wells” can include French drains (stone-lined pits or trenches) into which liquid waste is poured and allowed to percolate into the ground.

Local governments and health departments also may be able to provide information about known contaminant sources in the immediate vicinity of your water supplies. Known sources include landfills, clean-up sites, permitted waste discharge sites, and businesses or industries that store or dispose of significant quantities of dangerous or hazardous waste materials (such as service stations, auto shops, dry cleaners, and chemical manufacturing). You may also get this information from the nearest Ecology regional office. Municipal, county, and state agencies are in the government section of your telephone directory.

Lacking sufficient information from public agencies to respond to this question, a simple alternative is to identify the area on a local map and complete either a walking or driving survey of the area, noting potential sources of contamination such as those described above.

In either case, you should complete a map indicating the locations of these risk sources relative to your water source. A topographic map is best used for this purpose.

2) Source Specific Water Quality Records:

The following five sections will require the review of your water quality testing records. Of primary interest are any records indicating past water quality problems for your source(s). If you do not have source specific records, use the system records for each individual source.

A) Nitrate Monitoring History

In Washington, the maximum contaminant level (MCL) for nitrates is 10 mg/L. Levels between 5 and 10 mg/L may indicate some nitrate leaching from surface sources. Note in the appropriate boxes whether you have had nitrate detections below the MCL.

B) Volatile Organic Compounds (VOCs)

MCLs and state advisory levels (SALs) vary for each VOC. Use DOH or lab notification of MCL violations. VOCs are “reported” (not an MCL violation) at concentrations of 0.5 ug/L (parts per billion), a level that often triggers additional sampling. These are listed on your lab forms as “detections.” Element 5 is a list of all of the organic chemical MCLs. Trihalomethane (TTHM) data should not be considered here.

C) EDB/DBCP

If you have monitoring results for EDB/DBCP, include them in your susceptibility assessment along with the name of your county.

D) Synthetic Organic Compounds (SOCs)

If you completed any pesticide monitoring in addition to EDB and DBCP, record the results in this section.

E) Bacterial Contamination

Use coliform monitoring records to respond. **IMPORTANT:** The main point of these questions is to identify water sources with a history of source-related bacterial contamination. Most bacterial sampling occurs in a system’s distribution system and not at the source. Bacterial contamination in the water system does not necessarily indicate contamination of the groundwater source.

PART VI: Geographic or Hydrologic Factors that Contribute to a Non-Circular Zone of Contribution

The four questions in this section will help a water system identify the sources where a calculated fixed radius (CFR) may not accurately represent groundwater conditions. The CFR delineation method is simple and relatively easy to apply, however, it is based on a number of assumptions about the aquifer and underground conditions. Very rarely are all of these assumptions true. These questions can help you and DOH evaluate the appropriateness of the CFR for wellhead protection planning or for long-term vulnerability assessments. However, for this initial evaluation, the CFR provides a preliminary estimate of the critical time-of-travel zones. Systems that answer yes to some or all of the following questions may need to improve or replace the CFR time-of-travel zones with a more appropriate delineation model.

1) Hydrologic Boundaries:

Hydrologic boundaries are natural features in the earth that shape groundwater flow patterns. Examples include surface streams, lakes, reservoirs, mountains, ridges and other steep changes in elevations. A topographic (topo) map is useful in determining whether such features are present in the 10-year circular travel time area around your source(s). If possible, simply attach to this form a copy of such a map with your water source(s) marked and labeled.

You can purchase topo maps throughout the state at map stores, camping stores and so on. You may need more than one map to include the 6-month and 1-, 5- and 10-year groundwater travel zones around your source(s). If you plan to use a U.S. Geologic Survey topographic map, please select one based on a 7½-minute scale. See Element 1 for tips on using a topo map for this purpose and an example.

Please indicate possible hydrologic boundaries and water source location(s) on the map and attach the map to the response form.

2) Aquifer Material:

These questions help identify how geologic conditions affect the source's overall susceptibility to contamination. You can use the drilling log, well log, or geologic report to answer these questions.

- A) Does the drilling log, well log, or other geologic or engineering report indicate that the well is completed in an area where underground conditions include fractured rock or basalt terrain? (These conditions are very common in central and eastern Washington, especially for deep wells). Besides basalt or lava, other fractured rock conditions may include sandstone, granite, limestone, and shale. These should be identified on the log.
- B) Does the drilling log, well log, or other geologic or engineering report indicate that the well is completed in an area where underground conditions include multiple or extensive layers of coarse sand or gravel? These may be identified in the drilling logs as gravelly sands, sands and gravel, cobbles, gravel, boulders, or pebbles. These materials are often associated with rivers, flood plains, or glacial outwash deposits.

3) Evidence of High Horizontal Flow Rate:

This question will help identify wells located in settings that produce very high natural groundwater flow rates. In these settings, it is possible that the area of contribution around the well is influenced more by the aquifer flow conditions than by the pumping rate of the well. Under these conditions, the time-of-travel zone around the well may be highly elongated and not circular. Examples of these types of setting include flood plains of large river systems, aquifers with very gravelly conditions (Spokane River Valley), artisan wells (deep flowing wells) with high water pressure, and shallow flowing wells or springs.

4) High-Volume Wells:

Indicate whether there are any high capacity wells (> 500 gal/min) withdrawing groundwater in each time-of-travel zone. Also, indicate large recharge wells (such as stormwater runoff or dry wells) or large-scale irrigation operations within each time-of-travel zone. These activities can have a tremendous effect on the aquifer around them. If there are other physical conditions that you believe may affect the flow to your well, you can identify them in this section and reference them to the map that you produced in Part IV.

Element 1: Creating a Wellhead Protection Map

Before purchasing any maps, follow the instructions in Chapter 4 to calculate the distance of your 6-month, 1-, 5- and 10-year groundwater travel time. Record this data in Part IV, question 2 on the Susceptibility Assessment Form. Now, purchase a topo map with a scale large enough to show your 10-year time-of-travel zone. Draw your sources and the 6-month, 1-, 5- and 10-year groundwater time-of-travel zones on the map.

Every topographic map will define the scale used on the map. For example, a common scale used on U.S. Geologic Survey (USGS) maps is 24,000:1, where one inch on the map equals 24,000 inches on the ground (or 2,000 feet). To determine the map length of 923 feet, use the following calculation:

$$24,000 \text{ inches} \times (1 \text{ foot} / 12 \text{ inches}) = 2,000 \text{ feet}$$

$$(1 \text{ inch} / 2000 \text{ feet}) \times (923 \text{ feet}) = 0.0005 \times 923 = 0.46 \text{ inches}$$

So, a distance of 923 feet on the ground is about equal to ½-inch *on a map with a scale of 24,000:1*.

In this case, you would measure a distance of ½-inch from your water source on your map and then draw a circle around your source with this distance for the radius. If you have a well field, remember to treat the wells as a single source.

You can show sources of potential contamination identified in Part V, question 1 of the *Susceptibility Assessment Form*, by designating each type of risk with a number and then including a legend with the map. You may wish to use a map with a larger scale (more inches to the mile) when you plot the areas around your well. A good scale to use is 3 to 4 inches per mile. You can use your existing topographic map and have it enlarged on a copier. Be sure to mark a mile length line on the map before you enlarge it. To determine the scale of the enlarged map in inches per mile, merely measure the line with a ruler.

Sample Map

WATER SOURCE: Example Well 1 MAP SCALE: 14,080:1 or 4.5 inches/mile
Screened Interval: 10 feet
Annual Volume of Water Pumped: 50,000,000 gallons

Using the tables for determining groundwater time-of-travel, we determine that the 6-month and 1-, 5- and 10-year travel times are, respectively, 700, 980, 2,200 and 3,110 feet. The map scale is 14,080:1, thus, we calculate the radii of the travel time zones as follows:

6 month:	0.63 inches (approx. 5/8 inch)
1 year:	0.89 inches (approx. 7/8 inch)
5 year:	2 inches
10 year	2.8 inches (approx. 2 ¾ inches)

With the source at the center, four circles are drawn with these distances as the radius of each consecutive circle.

On the sample map, possible contaminant sources are designated by number rather than attempting to write directly on the map. A key to the map might look like this:

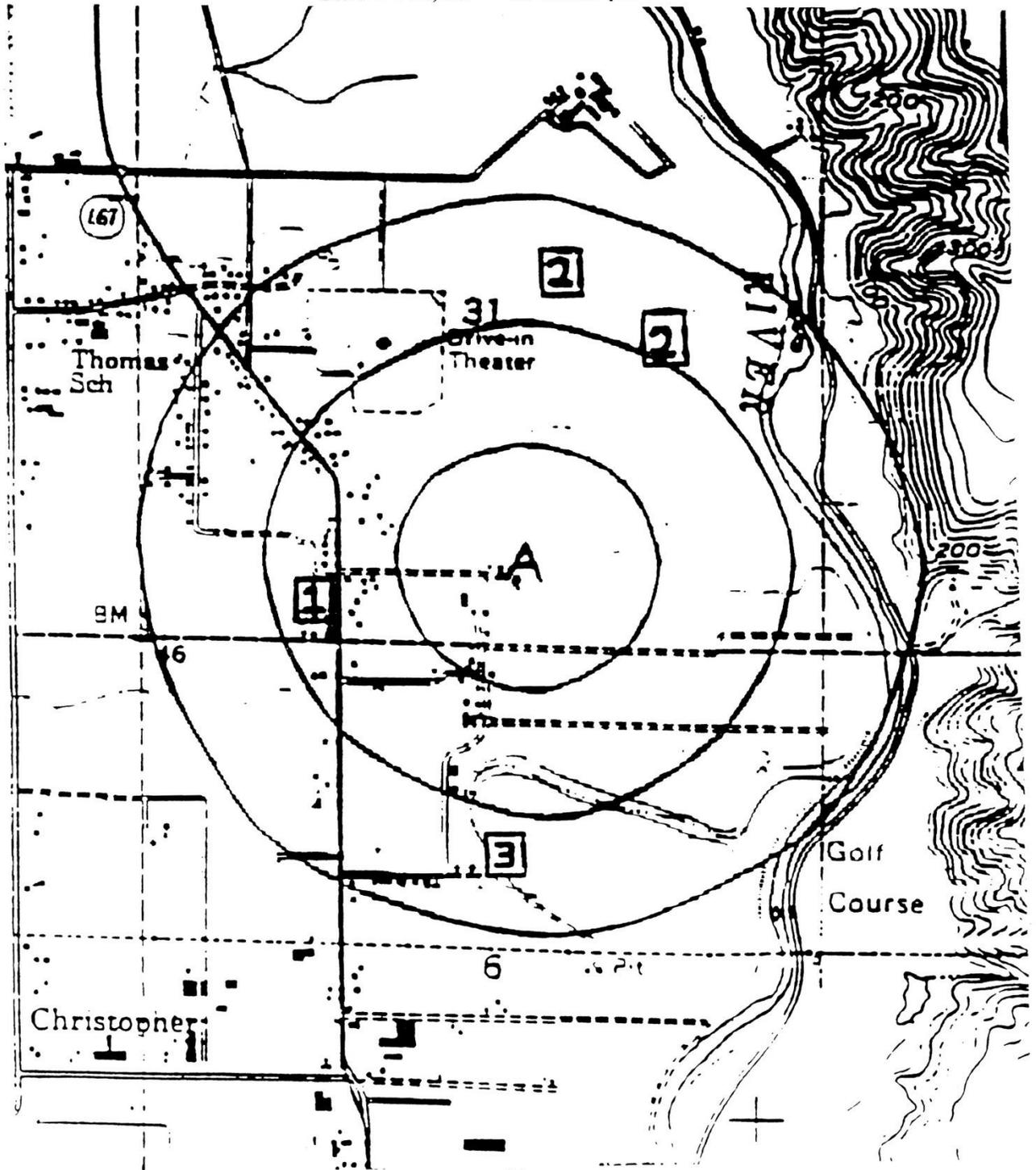
Sample Map Legend

- A – source “example well 1”
- 1 – service station
- 2 – agriculture; corn, irrigated
- 3 – abandoned water well

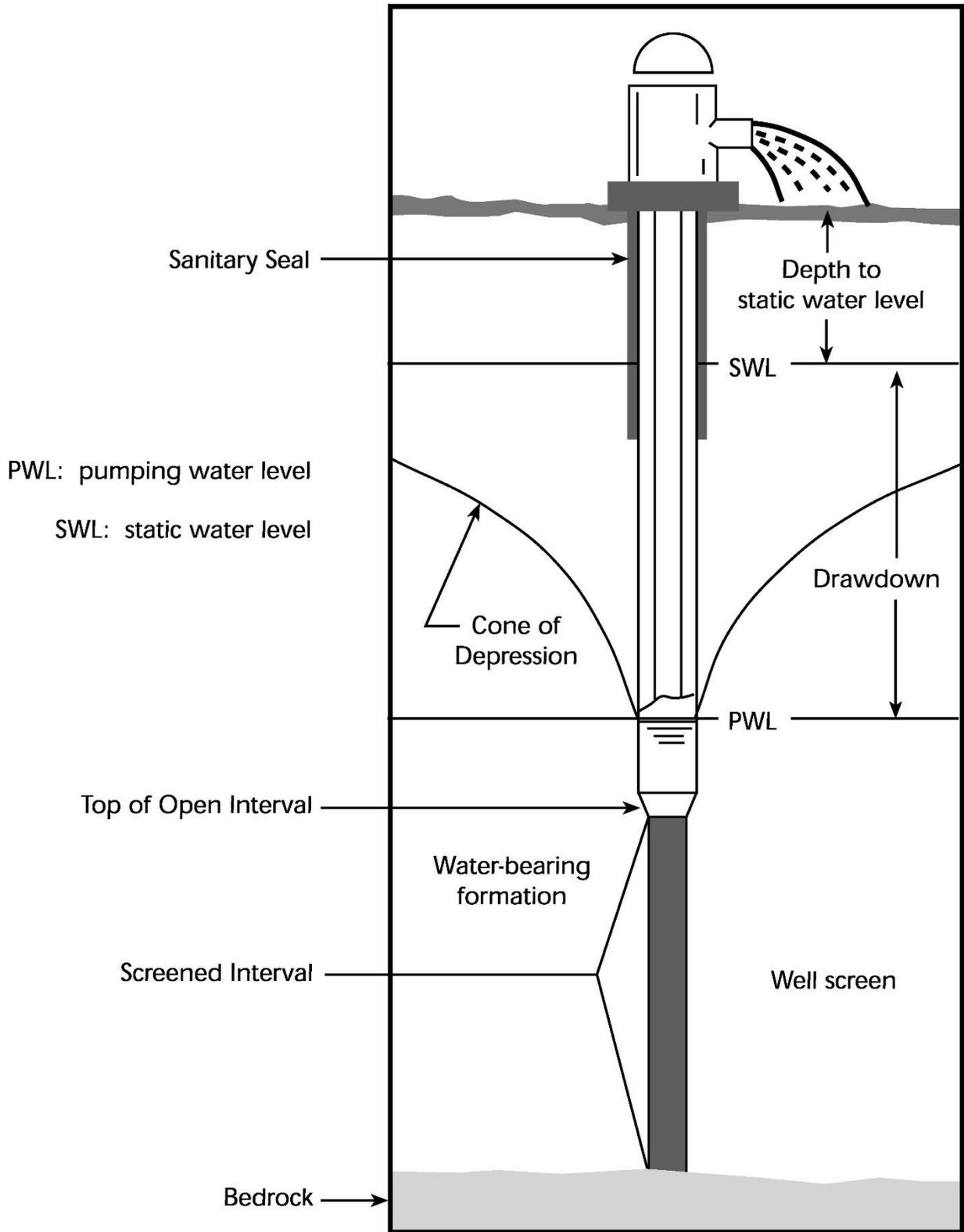
Note that State Highway 167 passes through the 5-year groundwater travel time zone on the west. With a phone call to the state Department of Transportation, we can learn whether pesticides are used on the highway margins. A highway is also a potential source of VOCs in the form of petroleum product runoff. On the east border of the 10-year groundwater travel time zone, the Green River forms a major hydrological barrier.

Sample Map

Scale 1 : 14,080 4.5 Inches per Mile



Element 2: Diagram of a Drinking Water Supply Well



Element 3: Sample Well Report (Well Log)

The following summarizes information collected on a well log when the well is drilled.

Date of construction: If the well report indicates that an existing well is being deepened or reconditioned (Box 4), use the most recent date on your *Susceptibility Assessment Form*.

Well driller: Information found in “well driller’s statement.”

Well type: Drilled well, cable method, found in box 4.

Average pumping rate: Information may also be available on your Water Facilities Inventory form.

Depth to open interval: This is where the casing ends and the screened interval begins.

Depth to groundwater: Static water level.

Wellhead elevation: Height above sea level.

Confining layers:

Surface seal:

Length of screened interval:

Element 4: Tables for Calculating Time of Travel

10 FOOT Screened Interval	Time of Travel			
	6 month (radius in feet)	1 year (radius in feet)	5 years (radius in feet)	10 years (radius in feet)
Annual Volume pumped (GAL)				
< 5,000,000	<u>220</u>	<u>310</u>	<u>700</u>	<u>980</u>
10,000,000	<u>310</u>	<u>440</u>	<u>980</u>	<u>1390</u>
20,000,000	<u>440</u>	<u>620</u>	<u>1390</u>	<u>1970</u>
50,000,000	<u>700</u>	<u>980</u>	<u>2200</u>	<u>3110</u>
100,000,000	<u>980</u>	<u>1390</u>	<u>3110</u>	<u>4400</u>
250,000,000	<u>1550</u>	<u>2200</u>	<u>4920</u>	<u>6950</u>
500,000,000	<u>2200</u>	<u>3110</u>	<u>6950</u>	<u>9830</u>

25 FOOT Screened Interval	Time of Travel			
	6 month (radius in feet)	1 year (radius in feet)	5 years (radius in feet)	10 years (radius in feet)
Annual Volume pumped (GAL)				
< 5,000,000	<u>140</u>	<u>200</u>	<u>440</u>	<u>620</u>
10,000,000	<u>200</u>	<u>280</u>	<u>620</u>	<u>880</u>
20,000,000	<u>280</u>	<u>390</u>	<u>880</u>	<u>1240</u>
50,000,000	<u>440</u>	<u>620</u>	<u>1390</u>	<u>1970</u>
100,000,000	<u>620</u>	<u>880</u>	<u>1970</u>	<u>2780</u>
250,000,000	<u>980</u>	<u>1390</u>	<u>3110</u>	<u>4400</u>
500,000,000	<u>1390</u>	<u>1970</u>	<u>4400</u>	<u>6220</u>

50 FOOT Screened Interval	Time of Travel			
	6 month (radius in feet)	1 year (radius in feet)	5 years (radius in feet)	10 years (radius in feet)
Annual Volume pumped (GAL)				
< 5,000,000	<u>100</u>	<u>140</u>	<u>310</u>	<u>440</u>
10,000,000	<u>140</u>	<u>200</u>	<u>440</u>	<u>620</u>
20,000,000	<u>200</u>	<u>280</u>	<u>620</u>	<u>880</u>
50,000,000	<u>310</u>	<u>440</u>	<u>980</u>	<u>1390</u>
100,000,000	<u>440</u>	<u>620</u>	<u>1390</u>	<u>1970</u>
250,000,000	<u>700</u>	<u>980</u>	<u>2200</u>	<u>3110</u>
500,000,000	<u>980</u>	<u>1390</u>	<u>3110</u>	<u>4400</u>

75 FOOT Screened Interval	Time of Travel			
	6 month (radius in feet)	1 year (radius in feet)	5 years (radius in feet)	10 years (radius in feet)
Annual Volume pumped (GAL)				
≤ 5,000,000	<u>80</u>	<u>110</u>	<u>250</u>	<u>360</u>
10,000,000	<u>110</u>	<u>160</u>	<u>360</u>	<u>510</u>
20,000,000	<u>160</u>	<u>230</u>	<u>510</u>	<u>720</u>
50,000,000	<u>250</u>	<u>360</u>	<u>800</u>	<u>1140</u>
100,000,000	<u>360</u>	<u>510</u>	<u>1140</u>	<u>1610</u>
250,000,000	<u>570</u>	<u>800</u>	<u>1800</u>	<u>2540</u>
500,000,000	<u>800</u>	<u>1140</u>	<u>2540</u>	<u>3590</u>

Element 5: Maximum Contaminant Levels (MCLs)

Contaminants	MCLG (mg/L)	MCL (mg/L)	Potential Health Effects
Phase 1			
1,1-Dichloroethylene	0.007	0.007	Liver/Kidney Effects
1,1,1-Trichloroethane	0.2	0.2	Nervous System Effects
1,2-Dichloroethane	zero	0.005	Cancer
Benzene	zero	0.005	Cancer
Carbon Tetrachloride	zero	0.005	Cancer
p-Dichlorobenzene	0.075	0.075	Cancer
Trichloroethylene	zero	0.005	Cancer
Vinyl Chloride	zero	0.002	Cancer
Phase II			
1,2,4 Trichlorobenzene	0.07	0.07	Liver/Kidney Effects
1,1,2-Trichloroethane	0.003	0.005	Liver/Kidney Effects
1,2-Dichloropropane	zero	0.005	Liver/Kidney Effects
2,3,7,8-TCDD (DIOXIN)	zero	0.00000003	Cancer
2,4-D*	0.07	0.07	Liver/Kidney Effects
2,4,5 – TP	0.05	0.05	Liver/Kidney Effects
Acrylamide	zero	TT	Cancer
Alachlor	zero	0.002	Cancer
Aldicarb Sulfone**	0.001	0.002	Nervous System Effects
Aldicarb Sulfoxide**	0.001	0.004	Nervous System Effects
Aldicarb**	0.001	0.003	Nervous System Effects
Asbestos (fiber > 10um/L)	7MFL	7MFL	Cancer/Lung Tumors
Altrazine	0.003	0.003	Heart/Mammary Glands/Reproductive Effects
Barium*	2	2	Circulatory System Effects
Cadmium*	0.005	0.005	Kidney Effects
Carborfuran	0.04	0.04	Nervous/Reproductive System Damage
Chlorodane	zero	0.002	Cancer
Chlorobenzene	0.1	0.1	Nervous System & Liver
Chromium (total)*	0.1	0.1	Liver/Kidney/Circulatory Disorder
cis-1,2-Dichloroethlyne	0.007	0.07	Liver/Kidney/Nervous System Damage
DBCP	zero	0.0002	Cancer
EDB	zero	0.00005	Cancer
Epichlorohydrin	zero	TT	Cancer
Ethylbenzene	0.7	0.7	Liver/Kidney/Nervous Damage
Heptachlor Epoxide	zero	0.0002	Cancer
Heptachlor	zero	0.0004	Cancer
Lindane	0.0002	0.0002	Liver/Kidney/Nervous/Immune/Circulatory
Mercury (inorganic)*	0.002	0.002	Kidney/Central Nervous System Disorder
Methoxychlor	0.04	0.04	Liver/Kidney/Nervous/Reproductive

Contaminants	MCLG (mg/L)	MCL (mg/L)	Potential Health Effects
Nitrate	10	10	Methoglobinemia
Nitrate	1	1	Methoglobinemia
o-Dichlorobenzene	0.6	0.6	Liver/Kidney Blood Cell Damage
PCBs	zero	0.0005	Cancer
Pentachlorophenol	zero	0.001	Liver/Kidney Effects
Seleium	0.05	0.05	Selonoala
Styrene	0.1	0.1	Liver Effects, Nervous System Damage
Tetrachloroethylene	zero	0.005	Cancer
Toluene	1	1	Liver/Kidney/Nervous/Circulatory
Toxaphene	zero	0.0003	Cancer
Trans-1-2-Dichloroethlyne	0.1	0.1	Liver/Kidney/Nervous/Circulatory
Xylenes (total)	10	10	Liver/Kidney/Nervous System Effects
Phase V			
Adipates	0.4	0.4	Liver/Testes Damage
Antimony	zero	0.006	Decrease Longevity, Altered Blood Levels
Beryllium	0.004	0.004	Bone/Lung Damage
Cyanide	0.2	0.2	Spleen/Brain/Liver Damage
Dalapon	0.2	0.2	Kidney/Liver Damage
Dichloromethane	zero	0.005	Cancer
Dinoseb	0.007	0.007	Thyroid/Reproductive Organ Damage
Diquat	0.1	0.1	Liver/Kidney/Gastrointestinal Tract Damage
Endothall	0.1	0.1	Liver/Kidney/Gastrointestinal/Reproductive Damage
Endrin	0.002	0.002	Liver/Kidney/Heart Damage
Glyphosate	0.7	0.7	Liver/Kidney Damage
Hexachlorobezene	zero	0.001	Cancer
Hexachlorocypentadiene	0.05	0.05	Kidney/Stomach Damage
Nickel	0.1	0.1	Heart/Liver Damage
Oxamyl	0.2	0.2	Kidney/Liver
PAHs (Benzo(a)pyrene)	zero	0.0002	Cancer
Phthalates	zero	0.006	Cancer
Picloram	0.5	0.5	Kidney/Liver Damage
Simazine	0.004	0.004	Cancer
Thallium	0.0005	0.002	Kidney/Liver/Brain/Intestine Damage

Notes:

* Indicates original contaminants with interim standards that have or will be revised.

** Regulation currently not in effect.

TT = Treatment Technique

MFL = Millions of Fibers per Liter

Sample Susceptibility Assessment Form

Contact your DOH Regional Office for the most recent version of this form, and to receive guidance on completing and submitting it.

IMPORTANT! Please complete one form for each groundwater source (well, well field, spring) used in your water system.

PART I: System Information

Well owner/manager: _____

Water system name: _____

County: _____

Water system number: _____ Source number: _____

Well depth: _____ feet (From WFI form)

Source name: _____

WA well identification tag number: _____ - _____

Well not tagged

Number of connections: _____ Population served: _____

Township: _____ Range: _____

Section: _____ ¼ ¼ Section: _____

Latitude/longitude (if available): _____ / _____

How was latitude/longitude determined?

_____ Global positioning device _____ survey _____ topographical map

_____ other: _____

*Please refer to Assistance Packet for details and explanations of all questions in Parts II through V.

PART II: Well Construction and Source Information

1) Date well originally constructed: ___/___/___ month/day/year

last reconstruction: ___/___/___ month/day/year

Information unavailable

2) Well driller: _____

Well driller unknown

3) Type of well:

___ Drilled: rotary bored cable (percussion) Dug
___ other: spring(s) lateral collector (Ranney)
 driven jetted other: _____

4) Well report available Yes (attach copy to form) No

5) Average pumping rate: _____ (gallons/min)

Source of information _____

If not documented, how was pumping rate determined? _____

Pumping rate unknown

6) Is this source treated?

If so, what type of treatment:

disinfection filtration carbon filter air stripper other

Purpose of treatment (describe materials to be removed or controlled by treatment):

7) If source is chlorinated, is a chlorine residual maintained: Yes No

Residual level: _____ (At the point closest to the source.)

PART III: Hydrogeologic Information

1) Depth to top of open interval: [check one]

<20 ft 20-50ft 50-100ft 100-200ft >200ft

information unavailable

2) Depth to groundwater (static water level):

<20ft 20-50ft 50-100ft >100ft

flowing well/spring (artesian)

How was water level determined?

well log other _____

depth to groundwater unknown

3) If source is a flowing well or spring, what is the confining pressure:

_____ psi (pounds per square inch) **or**

_____ feet above wellhead

4) If source is a flowing well or spring, is there a surface impoundment, reservoir, or catchment associated with this source: Yes No

5) Wellhead elevation (height above mean sea level): _____ feet

How was elevation determined? topographic map Drilling/Well Log altimeter

other: _____

information unavailable

6) Confining layers: (This can be completed only for those sources with a drilling log, well log or geologic report describing subsurface conditions. Please refer to assistance package for example.)

_____ evidence of a confining layer in well log

_____ no evidence of a confining layer in well log

If there is evidence of a confining layer, is the depth to groundwater more than 20 feet above the **bottom** of the **lowest confining layer**? Yes No

information unavailable

7) Sanitary setback:

- < 100ft* 100-120ft 120-200 ft >200ft

* If less than 100ft, describe the site conditions:

8) Wellhead construction:

- wellhead enclosed in a wellhouse

controlled access (describe): _____

other uses for wellhouse (describe): _____

- no wellhead control

9) Surface seal:

- 18 ft

<18 ft (no Department of Ecology approval)

<18 ft (Approved by Ecology, include documentation)

depth of seal unknown

no surface seal

10) Annual rainfall (inches per year):

- <10 in/yr 10-25 in/yr >25 in/yr

PART IV: Mapping Your Groundwater Resource

1) Annual volume of water pumped: _____ (gallons)

How was this determined?

meter

estimated: pumping rate (_____)

pump capacity (_____)

other: _____

2) "Calculated Fixed Radius" estimate of groundwater movement:
(see Instruction Packet)

6-month groundwater travel time: _____ feet

1-year groundwater travel time: _____ feet

5-year groundwater travel time: _____ feet

10-year groundwater travel time: _____ feet

Information available on length of screened/open interval?

Yes No

Length of screened/open interval: _____ feet

3) Is there a river, lake, pond, stream, or other obvious surface water body within the 6-month time-of-travel boundary?

Yes No (mark and identify on map)

4) Is there a stormwater or wastewater facility, treatment lagoon, or holding pond in the 6-month time-of-travel boundary?

Yes No (mark and identify on map)

Comments: _____

PART V: Assessment of Water Quality

1) Regional sources of risk to groundwater:

Please indicate if any of the following are present within a circular area around your water source having a radius up to and including the five-year groundwater travel time:

- likely pesticide application _____

- stormwater injection wells _____

- other injection wells _____

- abandoned groundwater well _____

- landfills, dumps, disposal areas _____

- known hazardous materials clean-up site _____

- water system(s) with known quality problems _____

- population density >1 house/acre _____

- residences commonly have septic tanks _____

- Wastewater treatment lagoons _____

- sites used for land application of waste _____

On a map mark and identify any of the risks listed above that are in the 6-month time-of-travel boundary.

If other recorded or potential sources of groundwater contamination exist within the 10-year time-of-travel circular zone around your water supply, please describe:

2) Source-specific water quality records:

Please indicate the occurrence of any test results since 1986 that meet the following conditions:

(Unless listed on assessment, MCLs are listed in assistance package.)

- | | |
|--|-------|
| A. Nitrate: (Nitrate MCL = 10 mg/L) | YES |
| Results greater than MCL | _____ |
| <2 mg/liter nitrate | _____ |
| 2-5 mg/liter nitrate | _____ |
| <5 mg/liter nitrate | _____ |
| Nitrate sampling records unavailable | _____ |
| B. VOCs: (VOC detection level 0.5 ug/L or 0.0005 mg/L) | YES |
| Results greater than MCL or SAL | _____ |
| VOCs detected at least once | _____ |
| VOCs never detected | _____ |
| VOC sampling records unavailable | _____ |
| C. EDB/DBCP: | YES |
| (EDB MCL = 0.05 ug/L or 0.00005 mg/L. DBCP MCL = 0.2 ug/L or 0.0002 mg/L.) | |
| EDB/DBCP detected below MCL at least once | _____ |
| EDB/DBCP detected above MCL at least once | _____ |
| EDB/DBCP never detected | _____ |
| EDB/DBCP tests required but not yet completed | _____ |
| EDB/DBCP tests not required | _____ |
| D. Other SOCs (Pesticides): | YES |
| Other SOCs detected | |
| (pesticides and other synthetic organic chemicals) | _____ |
| Other SOC tests performed but none detected | |

(list test methods in comments)

Other SOC tests not performed

If any SOCs in addition to EDB/DBCP were detected, please identify and date. If other SOC tests were performed, but no SOCs detected, list test methods here: _____

E. Bacterial contamination:

YES

Any bacterial detection(s) in the past 3 years in samples taken from the source (not distribution sampling records)? _____

Has source (in past 3 years) had a bacteriological contamination problem found in distribution samples that was attributed to the source? _____

Source sampling records for bacteria unavailable _____

PART VI: Geographic or Hydrologic Factors Contributing to a Non-Circular Zone of Contribution

The following questions will help identify groundwater systems that may not be accurately represented by the calculated fixed radius (CFR) method described in Part IV. For these sources, the CFR areas should be used as a preliminary delineation of the critical time-of-travel zones for that source. As a system develops its Wellhead Protection Plan for these sources, a more detailed delineation method should be considered.

1) Is there evidence of obvious hydrologic boundaries within the 10-year time-of-travel zone of the CFR? (Does the largest circle extend over a stream, river, lake, up a steep hillside, and/or over a mountain or ridge?)

Yes No

Describe with references to map produced in Part IV:

2) Aquifer Material:

A) Does the drilling log, well log or other geologic/engineering reports identify that the well is located in an area where the underground conditions are identified as fractured rock and/or basalt terrain?

Yes No

B) Does the drilling log, well log or other geologic/engineering reports indicate that the well is located in an area where the underground conditions are primarily identified as coarse sand and gravel?

Yes No

3) Is the source located in an aquifer with a high horizontal flow rate? (These can include sources located on flood plains of large rivers, artesian wells with high water pressure, and/or shallow flowing wells and springs.)

Yes No

4) Are there other high capacity wells (agricultural, municipal and/or industrial) located within the CFRs?

a) Presence of groundwater extraction wells removing more than approximately 500 gal/min within...

	YES	NO	unknown
<6-month travel time	_____	_____	_____
6-month to 1-year travel time	_____	_____	_____
1 to 5 year travel time	_____	_____	_____
5 to 10 year travel time	_____	_____	_____

b) Presence of groundwater recharge wells (dry wells) or heavy irrigation within...

	YES	NO	unknown
<1-year travel time	_____	_____	_____
1 to 5 year travel time	_____	_____	_____
5 to 10 year travel time	_____	_____	_____

Please identify or describe additional hydrologic or geographic conditions that you believe may affect the shape of the zone of contribution for this source. Where possible, reference them to locations on the map produced in Part IV.
