Oregon Wellhead Protection Program Guidance Manual

Part 2

(The original document has been divided into
three sections to keep file sizes small.)

This document was originally developed in 1996 by OHS–Drinking Water Services (then a part of Oregon Health Division) and Oregon Department of Environmental Quality. It continues to serve as a valuable resource today.

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3

PROCEDURE FOR IMPLEMENTATION

3.1 STEP 1

3.1.1 Initiating Wellhead Protection in Your Community

Local wellhead protection efforts can be initiated by anyone served by the public water system they seek to protect. You do not have to be an owner of a public water system to initiate wellhead protection. Any individual in a local community who wishes to initiate the process, however, should seek the support and involvement of the entities who have local jurisdictional authorities or the "Responsible Management Authorities". In Oregon, the term "Responsible Management Authority" (RMA) refers to any Public Water System or entity with rule- and ordinance-making authority to manage activities within a wellhead protection area. RMAs can be public or private entitities, including a Public Water System, although they do not generally have jurisdictional authorities.

An RMA can be **any** of the following:

- Public Water System (PWS):
    - The Oregon Health Division specifies a PWS as a supply having four or more connections, or being used by more than 10 people for at least 60 days per year. A PWS could be a ***city, community, campground, mobile home park, school, or any other commercial or industrial facility*** with a water supply well or wells.
- County.
- Special district.
- Indian tribe.
- State/Federal government.

Although the Department of Environmental Quality and the Oregon Health Division will provide information and assistance to any individual who requests help with initiating wellhead protection, it will be extremely difficult to successfully develop and implement the plan without the involvement of the RMAs with primary jurisdictional authorities throughout the process. In Step 8 (Section 3.8) of this guidance manual, there are suggestions for what the local community or individual(s) can do to overcome any lack of jurisdictional commitment by one or more RMAs for implementing the plan.

In order to assist in the effort to initiate a Wellhead Protection Plan, it is suggested that the individual or RMA(s) **set up a workshop or meeting to discuss wellhead protection**. This should be an informational meeting open to the public that includes as many local officials and RMA representatives as possible. The Department of Environmental Quality and/or the Oregon Health Division can provide support for presenting information on the basics of groundwater and wellhead protection. The RMA can use the opportunity to present information to the public about the particular water system that provides their drinking water. The overall purpose of the meeting is to increase public awareness of the drinking water supply, groundwater vulnerability to contamination, and benefits and methodology of developing a wellhead protection plan for the local community. The workshop or meeting can be held at a local library, school, grange, or donated meeting space.

- ***Optional Pre-Plan Assessment:***

A preliminary assessment of potential sources can be performed if the individual or RMA initiating a wellhead protection plan believes this may generate more interest and/or support by the local community. This "Pre-Plan Assessment" is optional. **The purpose of the Pre-Plan Assessment is primarily to provide an educational tool for the public and local officials.** In assessing the potential contaminant sources in the vicinity of their well(s) or spring(s), it also serves as an indicator of the level of formal delineation appropriate for the community should they choose to proceed with developing a wellhead protection plan.

It is not uncommon for individuals interested in developing wellhead protection plans in their communities to encounter attitudes such as *"we don't have a problem here"* or *"it won't happen to us"* in the general public. Members of a community are so accustomed to seeing the various businesses, industry and other activities around their neighborhoods that they do not associate any risk to groundwater from that activity.

In many communities, the utility and need for wellhead protection is brought into sharper focus as a result of having some of the potential contaminant sources displayed on a map of the area. It is particularly effective if this map is presented in association with basic education regarding the nature of groundwater and how it can become contaminated.

For purposes of both the Pre-Plan Assessment survey and final display, the community should use as detailed a map as possible. These are generally available from your local jurisdiction, planning office, Chamber of Commerce, etc. The more detailed maps will show streets and features that will be familiar to local residents. If aerial photographs are readily available, they are particularly useful because individuals can easily pick out businesses, the well(s), their own houses, etc.

The Pre-Plan Assessment consists of performing an informal (i.e., windshield or drive-by) survey of activities in an area around the well. The area to be surveyed is a circle with a radius based solely on the population served by the well(s) or spring(s). The specific area to be surveyed in the Pre-Plan Assessment can be determined by the following population ranges:

Population	**Radius (feet)**	**Area (square mile)**
<100	1,320	0.20
100–499	2,640	0.79
500–3,300	3,960	1.77
>3,300	5,280	3.14

This circle does not constitute the formal delineation of the wellhead protection area. The formal delineation of the wellhead protection area will require more site-specific information on the well(s), spring(s), and geology. This is described in Step 3 (Section 3.3).

The survey can be facilitated by using the higher and moderate category sources listed in Table 3-2 (Section 3.4). These are **typical** sources known or suspected to have contributed to groundwater contamination in Oregon and other areas of the country. The individual(s) conducting the Pre-Plan Assessment should simply mark the location of any of these activities on the map. We suggest marking those designated as higher risks in red and those designated as moderate risks in yellow.

Regardless of the radius used for the Pre-Plan Assessment, it may be useful to draw additional circles at 500 foot intervals around the well or spring in order to provide a better estimate of how close the sources are to the well. The end product of the survey will be the annotated map showing potential higher- and moderate-risk sources in relationship to the well or spring. You may wish to make note of the actual numbers of these facilities within 1,000 feet of your well or spring. The area immediately around the wellhead or spring box is the most critical area to be protected. In general, if you have more than five potential sources within 1,000 feet of your well or spring, you will want to accelerate your efforts in developing a wellhead protection plan.

The Pre-Plan Assessment is an indicator of the threat only and cannot be used to quantify actual risks to the drinking water source. It does serve, however, to give the community an overall picture of the potential threats to groundwater in their area and may provide an impetus to develop strategies to protect that resource.

The resulting map from a Pre-Plan Assessment can be a very powerful tool in generating awareness and support from the general public for wellhead protection. We recommend the map be used in conjunction with an informational meeting of the community, at which DEQ and/or OHD provide technical support through presentations and handouts.

3.2 STEP 2

3.2.1 Assemble Team

For a successful wellhead protection plan, it is essential that a concerted effort be made to obtain public input early on and throughout the development process. This next step in the procedure for implementing wellhead protection in your community is the formation of a "Local Wellhead Protection Team" (Team). The Team can serve three very important functions:

1. Ensuring that the concerns of different segments of the community are addressed on an ongoing basis during the entire process;
2. Serving as a focal point for public input during the process of developing a management approach for addressing the wellhead protection area; and
3. Providing a core of leadership for educating the general public and implementing the Wellhead Protection Plan.

DEQ recommends that you seek input from as many diverse interests and perspectives as possible in forming the Team. This will enable broad support from the community. It is suggested that you seek representatives from as many as possible of the following organizations, expertise, and interest areas for the Team:

- Community service organizations (League of Women Voters, RSVP, Rotary Club, etc.);
- Elected officials (Mayor, city council, county supervisor, etc.);
- Farmers/agricultural community;
- Business community (large and small);
- Local environmental groups;
- Water purveyors;
- Local tribal council;
- County planning office;
- City public works department;
- Local technical or scientific community member (academic, consulting, etc.);
- Health district or county sanitarian;
- County or city emergency management;
- Neighborhood associations (residents served by the water system);
- Soil and Water Conservation District;
- County Extension Service;
- School districts.

In many cases, a local Team can be formed by directly soliciting representatives from these organizations. In some (especially small) communities, it may be difficult to find volunteers. In this case, we suggest that an existing board, council, or commission recruit (i.e., appoint) members of the community to serve as Team members. This effort can be facilitated through a series of informational meetings and public outreach.

The first task of the newly formed Team should be to agree upon the objectives and mission. The Team's primary objectives may include coordinating any local informational/educational meetings, planning the inventory strategy, leading the effort to develop an acceptable management approach within the wellhead protection area, and ensuring implementation of the Plan. The primary mission may be to develop and implement a Wellhead Protection Plan that is acceptable to the majority of the community.

The Team should not do all the work, but rather should delegate, coordinate, and integrate the various activities to accomplish each step throughout the development process. Work on the various steps in developing wellhead protection will most likely be performed by either the RMA(s), the Team, a volunteer task force, technical committees, or hired consultants. (This guidance manual includes recommendations on how to most effectively accomplish each step.)

As shown in the wellhead protection process flow chart in Section 1-4, there should be a re-evaluation of the Team after Step 3 (Section 3.3). This will enable you to revise the Team "membership" to ensure representation of all interests affected by the wellhead protection plan based upon the area delineated in Step 3 (Section 3.3). The delineation may, for example, necessitate involving another community or local jurisdiction.

Meetings of the Team should be advertised in a local newspaper, on flyers, or mailings to encourage as much community input as possible. The local media (newspaper, television, radio, etc.) can be extremely helpful in disseminating information about the need for wellhead protection, as well as to inform the public of all activities and meetings as you work through the process.

3.3 STEP 3

3.3.1 Delineate Protection Area

- ***Overview:***

The delineation process is a fundamental step in developing a *Wellhead Protection Plan* in that it identifies the area surrounding the well, wellfield or spring that is at the surface directly above the portion of the aquifer that supplies groundwater to the well, wellfield or spring. The delineation allows for the recognition of the area where protection strategies will have the greatest impact on groundwater quality and allows for more efficient use of limited resources. The Wellhead (citizen) Advisory Committee and the Wellhead Rules and Guidance Committee developed an approach to delineation that considered both protection of the source of their drinking water and the community's available resources.

All delineation techniques acceptable in the Oregon program require consideration of the pumping rate for the well(s). The Oregon program requires the use of an adjusted pump rate of 125 percent of the average daily use over the 3-month period of highest water usage during the year in order to accommodate potential growth in the community. The delineation process frequently results in the identification of the well, wellfield or spring's entire zone of contribution or capture zone (Figure 3-1), an area that ultimately supplies water to the source, but may, because of size, pose significant difficulties with respect to management. Accordingly, Oregon requires only that portion of the capture zone that will supply the water over a 10-year period. That portion of the capture zone that comprises a 10-year time-of-travel (TOT) for groundwater is referred to as the wellhead protection area (WHPA). Delineations must be accomplished by an Oregon registered geologist, engineering geologist, or other licensed professional with demonstrated experience in hydrogeology.

The minimum delineation effort that a system must make in order to obtain a state-certified program is dependent upon the population (Figure 3-2). For communities with populations less than or equal to 500 and obtaining their groundwater through use of a well or wells, delineation can be accomplished through the calculated fixed radius method. This technique uses minimum site-specific data and does not consider important aquifer characteristics or groundwater flow. Systems with significant potential threats to groundwater, evaluated through an optional Pre-Plan Assessment, should choose a more technically defensible method for their delineation.

All other systems, e.g., spring-fed or wells serving more than 500 population, must develop a conceptual model of the groundwater system. This model identifies critical characteristics of the groundwater system and provides for a delineation that is more representative of the actual groundwater conditions. For systems serving populations from 500 to 50,000, the minimum method is combined analytical methods and hydrogeologic mapping. Systems serving 3,300 or more must collect site-specific data (e.g., conduct an aquifer test) to be utilized in the process.

Systems serving more than 50,000 will utilize numerical or comparable analytical methods in the delineation process. These methods are able to handle significant heterogeneities within the aquifer, complex boundaries and variable gradient directions to a much greater degree than analytical methods. These models are also capable of being calibrated to the specific site.

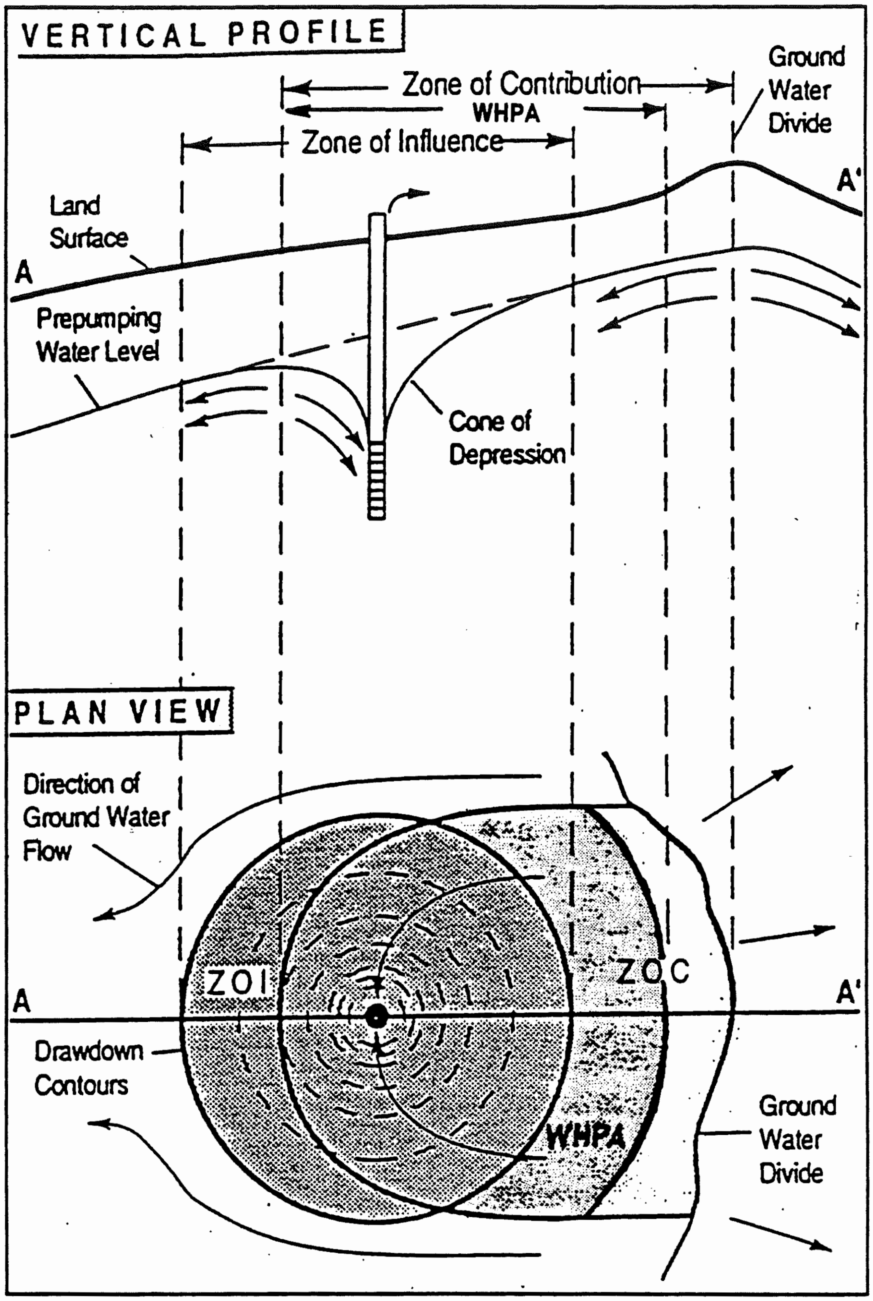
Systems are encouraged to conduct susceptibility analyses within the WHPA. The determination of the WHPA generally considers only travel within the aquifer; i.e., it does not address the travel time from the surface to the aquifer. A susceptibility analysis considers factors related to water movement from the surface to the aquifer and the probability that a given contaminant will migrate to the aquifer. This allows the system to prioritize various parts of the WHPA in terms of the susceptibility and to tailor management strategies to specific activities on the surface.

Communities can reduce the overall expense of the delineation process by conducting parts of the investigation themselves, including the following:

- The development of a well log inventory for the area,
- Compilation of water use and water quality information, and
- The completion of a well-designed aquifer test.

The Oregon Health Division (OHD) will work with the water system/community to complete the delineation process. This includes early discussions regarding the general nature of the system, what the community can do up front, assistance in preparing a Request for Proposals from the consulting community, providing technical input during the delineation and approval of the final delineation product.

Additionally, communities that have groundwater sources close together



NOTE: The WHPA is a portion of the ZOC.

Source: Modified Version of Diagram — Prepared by Horsley and Witten, Inc.

Figure 3-1: Zone of Contribution (ZOC) or Capture Zone, Zone of Influence (ZOI) or Drawdown Area and Wellhead Protection Area (WHPA)

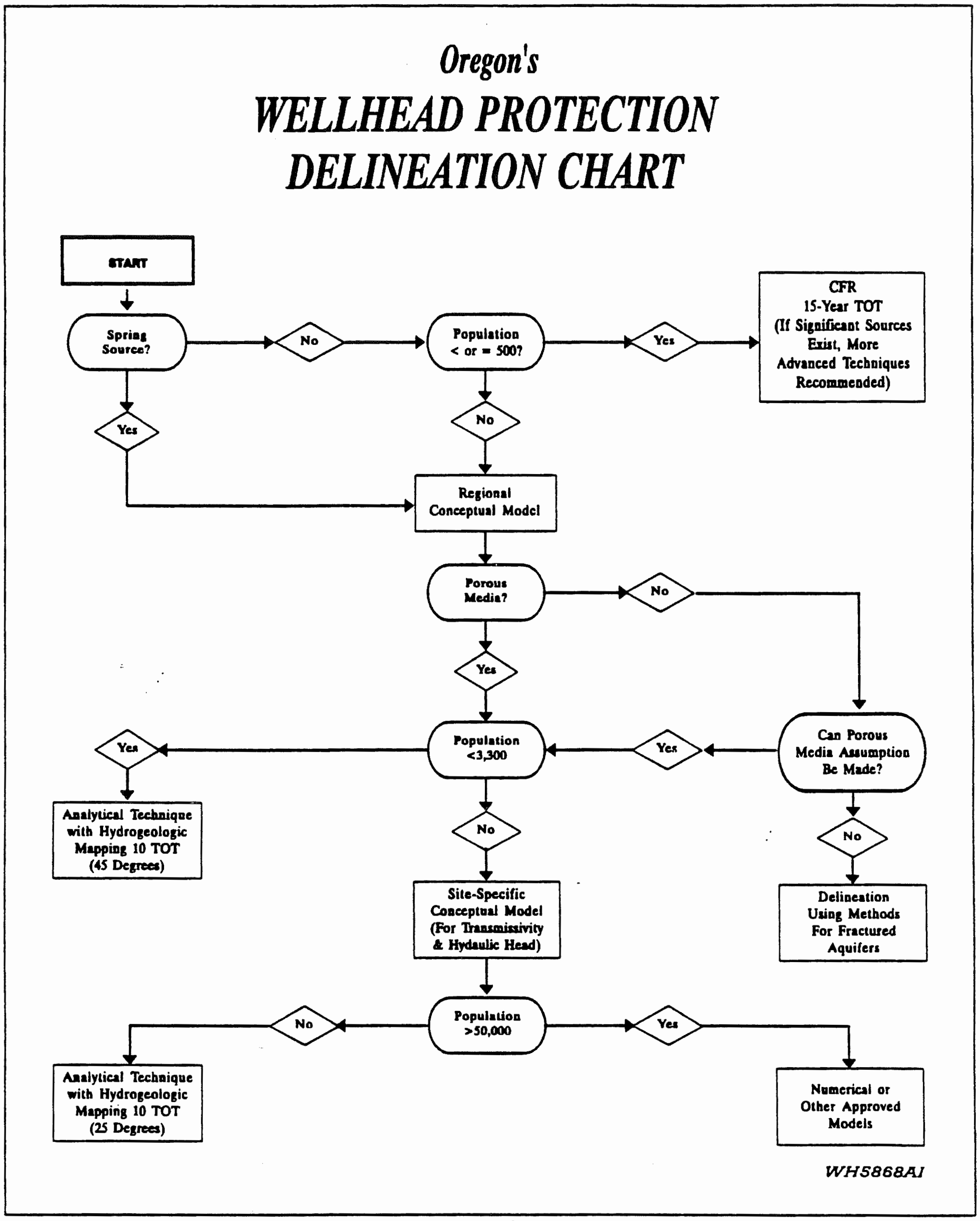


Figure 3-2: Delineation Flow Chart

may wish to pool their efforts, obtaining one consultant to delineate their separate wells. Providing the wells are within the same aquifer and same general hydrologic setting, this combined effort may prove to be less costly than each community developing their own independent delineation. It should be noted, that this effort will be successful only if the consultant is able to use a single conceptual model to describe the hydrogeologic setting of both communities.

- ***Delineation Basics:***

Delineation of a wellhead protection area (WHPA) for the well(s) in question is a fundamental aspect of a Wellhead Protection Plan. The U.S. Environmental Protection Agency (EPA) has defined the WHPA as *"...the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield."* A contaminant released within the WHPA may ultimately reach the water that is being pumped from the well. Therefore, it is within the boundaries of the WHPA that management activities, designed to eliminate or reduce the threat of groundwater contamination from surface or near surface activities, would be concentrated.

Proposed WHPA delineation techniques vary from drawing a circle of arbitrary radius around the wellhead to more sophisticated computer assisted models that account for site-specific characteristics of the aquifer and of groundwater flow (EPA, 1987). Clearly, the utility of the resulting WHPA increases as the level of delineation sophistication increases. However, so does the cost and level of required technical expertise. From a cost-benefit perspective, however, it is in the best interest of the public water supply to invest now in a proactive program of groundwater protection. Experience clearly indicates that the cost and hardships associated with remediating or perhaps losing a groundwater source as a result of contamination far exceeds the cost of implementing a preventative program.

Participation in Oregon's wellhead protection program is voluntary; however, in order to protect their drinking water resource for present and future generations, all public water systems in Oregon should seriously consider developing a WHP program. In order for a water system to have a state-certified program, the system must address all the elements described in *Oregon Wellhead Protection Program Guidance Manual*. Flexibility is allowed in structuring the WHP program, however, so that the individual water system's characteristics and needs can be accommodated. The State will provide guidance, technical assistance and will review for approval the delineation of each system's WHPA. In compliance with ORS 672.505 to 672.705, the delineation will have to be accomplished by a registered geologist, a registered certified specialty geologist (e.g., a registered engineering geologist), or other registered professional with demonstrable experience in hydrogeology.

> ***NOTE:*** At present, Oregon's registration requirements for geologists, engineering geologists, or other professionals do not specifically address hydrogeology, e.g., an individual does not have to be proficient in hydrogeology to become a registered geologist in the state. Therefore, prior to contracting with an individual to perform the delineation, the water system should ascertain that the individual being considered actually has experience in the field of hydrogeology.

What Can Water Systems Do Now?

Water systems can facilitate the delineation process as well as become more informed about their drinking water resource if they play an active role throughout the exercise. It is clear that the water system has a more complete knowledge than anyone else of the history of the system and the occurrence of other wells, irrigation practices, etc., that might affect the delineation. In addition to this expertise, the water system can reduce costs to the community by participating in the data collection process.

- ***Well Inventory*** — An important part of the delineation is the development of a conceptual model of how groundwater occurs and moves in the area. This will need to be accomplished by your consultant. The data your consultant will use will include well reports from the area (see **Appendix A**). Compilation of the well reports may be time-consuming and expensive if accomplished by the consultant. It may be less expensive for the water system to obtain the well reports from the local watermaster's office.

  In addition to compiling the well reports, the consultant will need to have them plotted on a map to show their distribution. Again, it will likely be less expensive for the water system to accomplish this. It is also probable that with the water system's knowledge of the local area, a more complete map will result. The City of Boardman (Morrow County, Oregon) has developed a guide for preparation of a well report inventory. With the City's permission, OHD has made copies and will distribute those to interested water systems. Systems should communicate with OHD, or their consultant, prior to initiating the survey in order to more efficiently design their efforts.

Even after the delineation exercise, the City of Boardman continues to use their well report inventory in day-to-day issues regarding their system. The inventory has proven to be a very useful management tool for the City.

- ***Aquifer Test*** — Additional data that a water system can begin to collect include static water levels for their wells and an aquifer test for their production wells. Procedures and recommendations for aquifer tests are described in Appendix A. Under any condition, aquifer tests are costly and under no circumstance should a water system conduct one without first contacting OHD or the Water Resources Department or their consultant for technical assistance. It is important to note that the 4-hour pump test requirement for groundwater right holders required by the Water Resources Department generally is insufficient to obtain representative aquifer characteristics.

- ***Public Education*** — Lastly, water systems can work with the local community to initiate a public education program. This program should be designed to raise the level of awareness of the citizens of the community regarding groundwater and its vulnerability. Water systems can contact the Department of Environmental Quality or OHD regarding educational materials and programs that might be available to the community.

Request for Proposal

Water systems or communities who are beginning the delineation step in wellhead protection plan development will work with the Drinking Water Program at OHD. OHD will review the delineation requirements with the water system or community and will provide technical assistance in preparing a "Request for Proposal" (RFP) to be distributed to the consulting community.

Prior to and during the delineation process, OHD will provide input to the system and their consultant as needed. The final delineation and supporting documentation must be submitted to OHD for review and approval. OHD may enlist assistance from other agencies, e.g., Water Resources Department, Oregon Department of Geology and Mineral Industries and the Department of Environmental Quality as needed in the review of the delineation procedures.

• *Delineation Method Requirements:*

Figure 3-1 illustrates the distinction between three areas within the aquifer that can be recognized with respect to a pumping well: the zone of influence (ZOI), the zone of contribution (ZOC) and the WHPA. The ZOI, or the drawdown area, is that part of the aquifer where the hydraulic head is lowered as a direct result of the well discharge. For purposes of identification, it is defined here as the area where the drawdown is greater than 0.05 feet (0.6 inches). The ZOC is that part of the aquifer that will supply water to the well in the future. The WHPA is a subset of the ZOC: that part of the ZOC that will supply water to the well for the next 10 years. It is the WHPA, where groundwater protection policies are implemented, that delineation identifies.

In designing the state's delineation requirements, the citizen's advisory committees sought a balance between factors of potential risk, aquifer sensitivity, and available expertise and funds in designing the state's delineation requirements. The delineation requirements also reflect input from the consulting community through demonstration projects at Boardman, Klamath Falls and Springfield, as well as comments solicited by the committee through consultant review of earlier drafts of this document. In subsequent sections, these will be referred to as the "wellhead demonstration projects".

The result of these efforts is a flow chart (Figure 3-2) that bases the delineation method primarily on the population served by the water system. The delineation techniques in the flow chart are discussed in greater detail below. In order of increasing site-specific character, they are: (1) the calculated fixed radius method, (2) combined application of analytical techniques and hydrogeologic mapping, and (3) numerical methods. It must be emphasized that, in most cases, the delineation technique identified in Figure 3-2 is to be considered a **minimum** only. A water system should inventory the data available to them (see below), and if the data allow, a more site specific delineation method should be used. In addition, the potential risk of contamination of the system's groundwater source should also influence the community's decision on the level of delineation used. Systems may wish to complete the Pre-Plan Assessment option described in Step 1 of this document in order to perform a preliminary evaluation of the number and types of potential contaminants that occur in the vicinity of their well(s) or spring(s).

> ***NOTE:*** An important finding of the wellhead demonstration projects was that a more site-specific delineation, though costing more initially, resulted in significant savings later. The savings accrued because the site-specific delineation was more legally defensible and often encompassed a smaller area leading to reduced management costs later in the process.

An important concept to remember, both during and after the delineation exercise, is that the aquifer from which a well derives its water is a three dimensional body that may have considerable regional extent, and from which other water systems, as well as numerous private individuals, derive their water. A truly comprehensive groundwater protection plan should address the entire aquifer rather than targeting a limited portion that contributes water to a well over the next 10 years (i.e., the WHPA). In practice, however, such a comprehensive approach would be difficult to implement and as a result, the delineation of the individual well's WHPA is utilized.

The sections below follow the order of the flow chart in Figure 3-2. Note that various water systems will complete their delineation requirements at different parts of the flow chart. It is not necessary that all systems complete all the phases that are indicated in Figure 3-2. Very little discussion or recommendations are given below regarding the specific model(s) to be used in the more complex situations where analytical or numerical methods are employed. It is accepted that the professionals performing those delineations will be well versed in the available techniques.

More discussion is provided with respect to the Calculated Fixed Radius method because of its limited ability to incorporate even the most basic hydrogeologic data into the model. As a result, recommendations on how to treat some of these more common situations are provided. In addition, some effort is expended on providing minimum expectations regarding the data that will be incorporated into the conceptual model(s). It is hoped that this is viewed as a mechanism to facilitate review by the state as opposed to the state dictating procedures to be followed by the consulting community.

Sources of Information

In addition to the discussion below, the reader may wish to become familiar with the EPA guidance documents that address delineation of wellhead protection areas. These documents include:

- *Guidelines for Delineation of Wellhead Protection Areas.* EPA 440/6-87-010, June 1987.
- *Wellhead Protection Strategies for Confined-Aquifer Settings.* EPA 570/9-91-008, June 1991.
- *Delineation of Wellhead Protection Areas in Fractured Rocks.* EPA 570/9-91-009, June 1991.
- *Wellhead Protection: A Guide for Small Communities.* EPA/625/R-93/002, February 1993.
- *Ground Water and Wellhead Protection.* EPA/625/R-94/001, September 1994.

Copies of these documents can be obtained free of charge by calling the National Center for Environmental Publications and Information at (513) 489-8190.

Parameters Common to All Delineation Methods

- ***Adjusted Pump Rate (Q_a)*** — All WHPA delineation methods acceptable for use in Oregon require incorporating a pump rate in the equations. In order to provide for protection of the groundwater source for potentially expanded use in the future, the minimum pump rate used in the models should be adjusted as follows: 125 percent of the average daily use calculated over the three months that are traditionally the high-demand period for the system. If the average daily use is not available, the adjusted pump rate should be determined by one of the following: 125 percent of the average pump rate based on a comparable size community in the region, the design capacity of the installed pump, or 90 percent of the safe yield of the well (see **Appendix A**), whichever is the smallest. As an example, consider a community using a well with a safe yield of 600 gpm. No daily use data is available. The design capacity of the pump in the well is 500 gpm. The estimated usage based on a community with similar residential and industrial characteristics is 390 gpm. A value of 487 gpm (1.25 × 390) would be used in the delineation exercise. If no other data is available to a water system regarding daily water usage, the system may use a figure derived by multiplying the population served by 125 gallons/day.

The determination of Q_a is not, of course, a hard and fast rule. It is in the water system's best interest to delineate a capture zone that will accommodate growth in the future. If for example, the water system's master plan calls for the installation of a larger pump in the future to accommodate projected growth, the delineation should reflect that increased demand.

- ***Time of Travel (TOT)*** — As discussed above, only a portion of the aquifer is delineated by the WHPA methods. For management purposes, the WHPA is generally limited in size by a criterion that is designed to achieve a predetermined protection level. Examples of these criteria are: (1) drawdown of the water table or potentiometric surface imposed by pumping of the well; (2) the aquifer's assimilative capacity (i.e., the distance groundwater must travel through the aquifer to mitigate the contaminant through dilution or breakdown); and (3) the time of travel, a factor related to the time required to respond to the development of a contamination threat at the WHPA boundary.

In all of the Oregon approved techniques the TOT parameter is utilized to constrain the WHPA. The TOT criteria effectively determines the radius of the calculated fixed radius method and the upgradient distance delineated within the analytical and numerical models. For most delineation techniques, a minimum TOT threshold value of 10 years was chosen based on State review of the time required to remediate and/or develop a new source should a significant contamination event take place at, or arrive at, the WHPA boundary. The 10-year TOT should be regarded as a minimum. Longer TOT thresholds are recommended in those cases where the understanding of the groundwater system is more limited (see below) or significant threats to groundwater quality occur.

The water system will probably also wish to determine additional zones within the WHPA based on shorter travel times. After reviewing WHP plans from other states, Oregon recommends the following TOT zones be delineated within the WHPA:

- **6-Month TOT**. Emphasis placed on viral and microbial contaminants as well as the risk of direct contamination from other sources. Evidence is accumulating that some viruses (e.g., Hepatitis A and Echovirus) and micro-organisms (e.g., *crytosporidium*) can survive in groundwater for extended periods of time. If possible, sources of these organisms should be kept at a distance of a 6-month TOT from the wellhead. It is recommended that chemicals capable of contaminating a system's groundwater neither be used or stored within the 6-month TOT because of the inability to respond to a contamination event should one occur. Because of potential changes in gradient direction, the state is requiring that a circular area, with a radius equivalent to the 6-month TOT be added to the well's WHPA (see discussion below).
- **5-Year TOT**. Within the 6-month to 5-year TOT travel zone, a greater emphasis on identification and control of potential contaminants can occur. Pollution prevention and risk reduction should be emphasized. Areas within this zone may be prioritized through the use of a susceptibility analysis (see below).
- **10-Year TOT**. The area within the 5- to 10-year TOT boundaries represents the communities's water supply in the near future and should be treated accordingly. Again, a susceptibility analysis will help prioritize activities within this region.
- **Zone of Contribution (ZOC)**. The water system should realize that the upgradient boundary of the WHPA, defined in terms of the 10-year TOT, does not afford protection of groundwater within the WHPA from upgradient contaminant sources. Said another way, there is nothing to prevent a contaminant plume from moving from a source just outside the TOT boundary into the WHPA and, as a result, ultimately to the well. To provide an improved basis

for decision making in the management phase of the WHP program, the water systems should recognize the source of their groundwater by delineating the entire zone of contribution to their well(s). In some instances, of course, a water system's zone of contribution may be terminated by a hydrologic boundary prior to reaching the 10-year TOT.

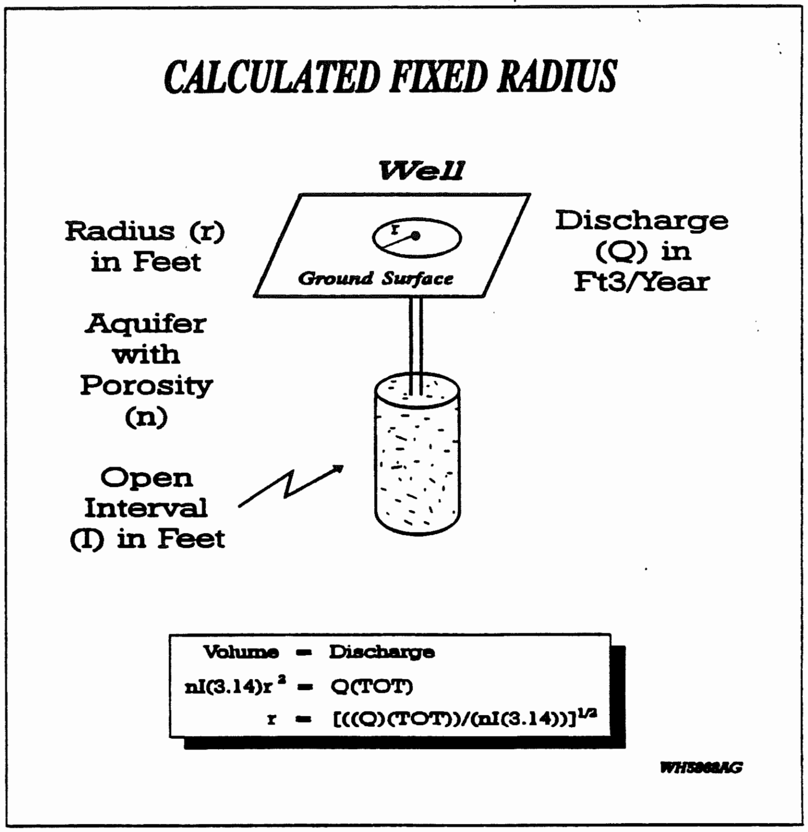


Figure 3-3: Components of the Calculated Fixed Radius Equation

Calculated Fixed Radius

- ***Water Systems Affected*** — For water systems serving a population of 500 or less, and deriving their drinking water from a well or wellfield, a calculated fixed radius (CFR) is an acceptable delineation technique. Water systems should understand that this technique uses only minimal site specific data and does not account for some important aquifer characteristics (e.g., permeability or hydraulic gradient, which control how fast and in which direction groundwater is flowing). As a result of the limitations of using the (CFR) a TOT of 15 years is used for this technique (Figure 3-2). If the pre-Plan assessment indicates a significant number of potential contaminant sources in the vicinity of their well(s), a more site-specific technique should be considered.

- ***Doing the Calculation*** — The CFR technique is shown diagrammatically in Figure 3-3. The technique assumes a static system, i.e., no regional groundwater flow, and that all of the water released to the well comes from storage within the aquifer proximal to the well.

The technique determines the volume of the aquifer that is needed to supply the demand from the well over the TOT period. Because of the above assumptions, the volume of the aquifer supplying the water is in the shape of a cylinder, the radius of which is determined by the demand.

The water demand over the TOT is calculated by multiplying the adjusted pump rate Q_a (in cubic feet per year) by the TOT (15 years). To determine the volume of the aquifer needed to supply the demand, we multiply the area of the circle ($3.14r^2$) times the thickness of the water bearing zone (I). However, only part of that aquifer volume contains water that can drain to a well. That part is determined by multiplying the equation for the volume of a cylinder by the effective porosity (n), that fraction of the aquifer that consists of interconnected pore spaces. We then set the volume expression equal to the demand and solve for "r", the radius of the cylinder (see equation in Figure 3-3 and Calculated Fixed Radius example in **Appendix A**).

Appropriate values are substituted into the equation and the value of "r" is determined. The adjusted pump rate (Q_a) is determined as described above. The effective porosity can be estimated using Table 1 (EPA, 1994). The value of "I" should be obtained as appropriate in one of the following ways:

- From the well report as the thickness of the water-bearing zone(s) or length of screened or perforated interval(s), whichever is less.

- If more than one water-bearing zone or screened or perforated interval is present, then "I" equals the sum of the thicknesses of the zones or lengths of intervals, whichever is less. If there is more than one water-bearing zone and it appears that they likely have significantly differing hydraulic conductivities, the value of Q_s should be partitioned between the water-bearing zones (see Parameter Estimation and Sensitivity Analysis subsection) and separate values of radius calculated for each zone.

- If the well is an open hole (i.e., not cased), and there is no information regarding potential water-bearing zones, set "I" equal to 10 percent of the uncased length.

- If the well is cased throughout, I = 1.0.

After the value of "r" is determined by the equation in Figure 3-3 (see also the Calculated Fixed Radius example in **Appendix A**), a circle with a radius of "r" around the wellhead constitutes the WHPA for that well. This is the area at the surface that directly overlies the cylinder determined above. It is this area where released contaminants might percolate downward to the part of the aquifer supplying the well. It is in this area that protection procedures will be applied.

For examples of determining the CFR, and for special cases where the circles overlap, intersect streams, or when the technique is applied to a wellfield (see **Appendix A**).

Conceptual Model Development

- ***What is a Conceptual Model?*** A conceptual hydrogeologic model is a three-dimensional portrayal of the groundwater system in the study area. Within the model, the distribution and geometries of the hydrogeologic units, their hydraulic properties, including variations in hydraulic head, the direction of groundwater flow and the location(s) of hydrogeologic boundaries, and areas of recharge and discharge are displayed.

  The conceptual model provides the framework for decision making regarding the groundwater system in an area. It provides a vehicle for determining those hydrogeologic features that are especially important in controlling groundwater flow, It also provides for the testing of assumptions and recognizing where more data are needed. A well-conceived conceptual model is fundamental to developing a WHPA delineation that accurately reflects the groundwater system in the area. The components of conceptual models are discussed in **Appendix A**.

- ***Water Systems Affected*** — As a general rule, as the population in a community increases, the potential risks to water quality also increase (population density increases and more industry and businesses are required to serve the community). Because of the greater risk, more detailed information is necessary to provide adequate protection of drinking water resources. Therefore, public water systems that have >500 population must accomplish their delineation using techniques that utilize more site-specific data.

Further, the calculated fixed radius method cannot be used for water systems that derive their drinking water from springs. The discharge of a spring cannot be simply related to circle around that spring. As a result, these water systems must obtain more site-specific data in order to delineate the source of their drinking water. A requirement of all systems that are at this point on the flow chart is the development of a conceptual hydrogeologic model (Figure 3-2).

The flow chart in Figure 3-2 indicates two levels of conceptual model development. The first, required of systems with a population of 500 to 3,299, is developed from existing data, often regional in character. By regional, we mean that aquifer characteristics may have been averaged over a large area and that the hydraulic gradient has been determined over an area of which we are concerned with only a small part. With such an approach, local variations are masked. For a particular WHPA, however, local variations from the norm may be the controlling factors for groundwater flow. For smaller systems, with presumably lower risks to groundwater, the regional approach is considered adequate for the delineation exercise. If the pre-Plan assessment indicates a high risk, the system should consider collecting more site-specific data (see below).

For systems with populations of 3,300 or greater, more site-specific information is required in developing the conceptual model. In the site-specific approach, data are collected through aquifer tests, direct measurement of static water levels and the mapping of spatial variations in aquifer characteristics.

Communities that are located in proximity to one another may wish to pursue the development of a common conceptual model through one consultant. What constitutes proximity varies across the state; however, if communities are within several miles of one another, they should consider the possibility that the data may allow a single conceptual model to be developed that will apply to both areas. As an example, consider two communities separated by three miles. These communities have wells that are within the same aquifer and there is no significant difference in the gradient nor are there any hydrogeologic boundaries that separate them. The application of the analytical models discussed below would be able to delineate the separate wells, using specific pumping characteristics, during the same model run. Such a multiple delineation approach, if appropriate, would certainly be less costly to the communities than if each community approached the conceptual model/delineation step independently.

Porous Media Assumption

- ***What is Being Assumed?*** For the analytical models discussed below, it is assumed that the openings within the aquifer through which the water moves are such that water movement is directly down-gradient, perpendicular to the hydraulic head contours. This assumption is generally valid in an aquifer where the open spaces consist of pore spaces (voids that occur between individual particles that comprise the aquifer). It may not be valid when the open spaces comprise discrete fractures that occur within the rock material that makes up the aquifer.

  In a typical porous material, such as sediment, e.g., sand and gravel, the openings are primary, that is they represent the spaces between grains that were formed when the sediment was originally deposited. Consequently, they are numerous and random in occurrence. As a result, the concentration and orientation of the open spaces tends to be isotropic (uniform in all directions) within the aquifer. Groundwater flow is controlled primarily by gradient direction in porous media (Figure 3-4a).

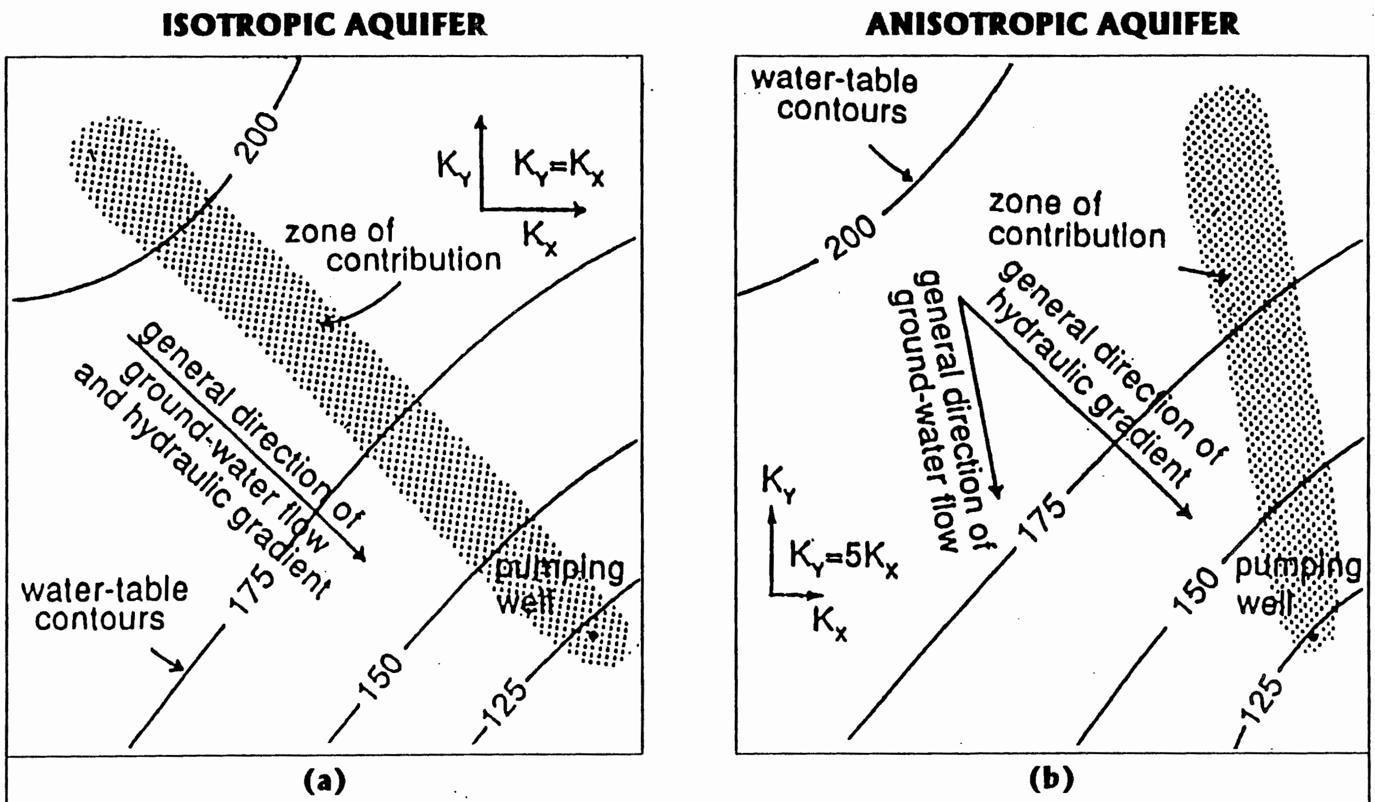
- ***The Impact of Fractures*** — Fractures are secondary features. They are generated after the aquifer formed, often as a result of stresses applied to the aquifer. Fractures tend to develop in a specific orientation with respect to the direction of applied stress. As a result, the fractures may not be random in their orientation and the aquifer's secondary porosity may be anisotropic (not uniform in all directions). Groundwater in an anisotropic medium will be driven in a down-gradient direction; however, it may be forced to move along the fractures which often are at some angle from the gradient direction (Figure 3-4b).

  > ***NOTE:*** A porous medium can still be anisotropic with respect to other characteristics, e.g., hydraulic conductivity and thickness.

  Fortunately, there are a number of settings in which fractured rock behaves as a porous medium with respect to transmitting groundwater. At this point in the flow chart (Figure 3-2), an analysis must be made to determine whether the aquifer can be treated as isotropic with respect to its pore space distribution.

  As reported by Long and others (1982), fractured rocks behave like porous media when: (1) fracture density is high, (2) fracture orientation is not uniform, (3) fracture openings are relatively uniform, and (4) the volume of aquifer concerned is large. Recommendations for evaluating the porous media assumption are provided in the Evaluation of the Porous Media Assumption section in **Appendix A**.

- ***The Impact of Heterogeneities in an Alluvial Aquifer*** — Even alluvial aquifers are not always uniform in character. Highly permeable channel deposits may occur at depth within the deposit. These channels are rarely in a straight line; they meander back and forth across what was the valley floor when they formed. If these channels are surrounded by low permeability sediments such as silts and clays or bedrock, groundwater will preferentially flow along the channel even if this direction is not immediately down gradient. If the conceptual model identifies significant



Source: Bradbury et al — 1991

Figure 3-4: Effect of Fracture Anisotropy on The Orientation of The Zone of Contribution to A Pumping Well

channel deposits, their impact on groundwater flow in the vicinity of the well(s) should be considered.

- ***The Impact of Heterogeneities Within Layered Volcanic Rocks*** - Layered volcanic rocks (e.g., basalts, andesites, etc.) may also exhibit preferential flow directions for groundwater. A typical volcanic section will consist of a sequence of erupted rocks (e.g., lava flows, ash deposits, mudflows, etc). Owing to the character of these rocks and the environment in which they occur, groundwater may not behave as if it was in a porous medium. Lava flows typically have rather dense interiors and highly porous and permeable tops and bottoms. The permeable tops and bottoms originate primarily from the highly porous, i.e., vesicular, nature of these zones within the lava. Therefore, a section of lava flows commonly has very low vertical hydraulic conductivity overall, and high horizontal hydraulic conductivity in these vesicular zones. Groundwater preferentially moves within these interflow zones, even if these zones are not perpendicular to the gradient. For example, a vertical gradient may actually produce significant horizontal flow within an interflow zone.

  Additional complications may arise from the fact that in an area where volcanic rocks have been erupted, significant discontinuities may occur on the scale of a delineated WHPA. These result from the fact that the surface upon which the lava erupts may not be horizontal. It is common in a typical volcanic sequence that sufficient time between eruptions occurs, allowing the redevelopment of drainage systems and canyon development. Subsequent eruptions may be confined largely to those drainages. These intracanyon flows, often underlain by stream deposits are linear in character as opposed to the sheet-like form that is often associated with lava flows. Groundwater will preferentially move along these intracanyon flows in the subsurface. Features such as lava tubes will further complicate groundwater flow.

Analytical Techniques with Hydrogeologic Mapping

- ***Analytical Techniques*** — Analytical methods make use of equations that define groundwater flow and contaminant transport and are frequently used in areas with a sloping water table. The analytical equations require that various hydrogeologic parameters be known or can be reliably estimated. When these parameters are substituted into the equations, the resulting solutions provide information regarding the dimensions of the ZOC with respect to the down-gradient divide and the width of the ZOC in the up-gradient direction.

  Most analytical models assume that the aquifer is uniform in character, the gradient is constant throughout the modeled area and groundwater flow in the aquifer is two-dimensional in a horizontal plane (vertical flow is not considered). If the conceptual model indicates that any of these assumptions is significantly wrong, the use of a more sophisticated model should be considered.

- **The WHPA Software** — The USEPA, through contractors, has developed software designed to facilitate the determination of wellhead protection areas in hydrogeologic settings that include the above assumptions.

  NOTE: There are many programs available commercially and the selection of which one to use will generally be made by the consultant.

  Here we briefly review EPA's software as a basis for discussion of parameter requirements.

  EPA's programs are inexpensive, easy to use and are well documented. Used in the context of the conceptual model, and within individual program limitations they will provide adequate delineations of wellhead protection areas. Graphic output is limited with the programs, however most of the programs will produce hard copies of the delineation that can be scaled automatically to most common maps. The option to save the model results in an ASCII file that may be used as input to the ARC/INFO proprietary GIS developed by the Environmental Systems Research Institute (ESRI) also exists for most of the programs.

  The software package known collectively as WHPA code has the most widespread distribution of EPA's delineation programs. This package consists of four programs: MWCAP, RESSQC, GPTRAC, and MONTEC. All the models are based on an analytical approach and use a particle-tracking routine to delineate the capture zones (Blandford and Huyakorn, 1991). All models assume steady-state groundwater flow. Data input requirements for the techniques are summarized in Table 3-1.

- **MWCAP**. The MWCAP model will produce steady-state, time-related and hybrid capture zones for single or multiple wells within confined or unconfined aquifers. It can accommodate aquifer boundaries (impermeable and stream) but does not consider well interference. Boundaries are modeled as straight lines and fully penetrating. For stream boundaries where the stream is not fully penetrating or if the presence of a clogging layer inhibits the hydraulic connection between the stream and the aquifer, the predicted WHPA will be smaller than the actual capture zone. Forward particle-tracking is an option allowing the path of a given constituent to be determined within the flow field.

- **RESSQC**. RESSQC assumes steady-state groundwater flow conditions and can model multiple discharging and recharge wells. Well interference is determined. The aquifer may be confined or unconfined if the drawdown to initial saturated thickness is less than approximately 0.1 (Blandford and Huyakorn, 1991). The program can also calculate contaminant fronts that migrate away from recharge wells. Boundaries are not addressed automatically and must be modeled through image well placement which must be input by the modeler. Forward and reverse particle-tracking is an option.

- **GPTRAC**. GPTRAC contains both semi-analytical and numerical options. The semi-analytical method is similar to MWCAP and RESSQC in that it assumes a uniform aquifer. Consideration of simple straight line fully penetrating boundaries are options in the routine. It has greater flexibility in that unconfined, semi-confined and confined aquifers can be dealt with directly. Discharging and recharge wells can be modeled and well interference is accounted for. Forward and reverse particle tracking is available. Areal recharge is an option for unconfined aquifers. Multiple straight line boundaries can be considered.

  A word of caution is appropriate for using the semi-analytical option of GPTRAC for an unconfined aquifer. The user is prompted for the radius of influence of the pumping well. The resulting delineation is very sensitive to the value that is used for this variable. It is recommended that unless the user has specific information from either drawdown measurements or calculations regarding the zone of influence of the well, that this routine not be used for determining the WHPA for a well in an unconfined aquifer. The user should use MWCAP, if there are no interfering wells, or RESSQC instead.

  The numerical option of GPTRAC can perform the tasks associated with the semi-analytical mode as well as allow for variations in aquifer characteristics, e.g., transmissivity, and changes in gradient magnitude and direction. Further, the program allows for anisotropic character in terms of the transmissivity (i.e., T_x not equal T_y). The program can be used as a post-processor for numerical programs such as MODFLOW in that GPTRAC will read a head file and calculate flow paths accordingly. The head file can be generated from field data or from published contour maps by interpolating heads on a grid and using the program HEDCON in the WHPA package to generate a file that can be utilized by GPTRAC's numerical option.

- **MONTEC**. The MONTEC routine is similar to MWCAP with the exception that it is based on a stochastic approach, i.e., evaluates the impact of known variations in parameters (e.g., hydraulic conductivity permeability (K), gradient (i), pump rate (Q), etc.) on the delineated capture zone. Input to the program is similar to MWCAP; however, the modeler can enter a range of possible values for parameters of choice during the input. The resulting output consists of a series of capture zones that are presented along with the level of confidence that the actual capture zone is within the delineated area. The program is limited to a single pumping well in a confined or semi-confined aquifer.

Table 3-1: Input Requirements for WHPA Models[1]

Required Input	RESSQC	MWCAP	GPTRAC	
			Semi-Analytical	Numerical
Units Used	X	X	X	X
Aquifer Type[2]			X	
Study Area Limits	X	X	X	X
Maximum Step Length	X	X	X	
Number of Pumping Wells	X	X	X	X
Number of Recharge Wells	X		X	X
Well Locations	X	X	X	X
Pumping/Injection Rates (Q)	X	X	X	X
Aquifer Transmissivity (T)	X	X	X	X
Aquifer Porosity (n)	X	X	X	X
Aquifer Thickness (b)	X	X	X	X
Angle of Ambient Flow	X	X	X	
Hydraulic Gradient (i)	X	X	X	
Areal Recharge Rate				
Confining Layer Hydraulic Conductivity			X	
Confining Layer Thickness		X		
Boundary Condition Type		X	X	
Perpendicular Distance from Well to Boundary		X		
Orientation of Boundary		X	X	
Capture Zone Type[3]		X		
No. of Patholines Used to Delineate Capture Zone	X	X	X	X
Simulation Time	X		X	X
Capture Zone Time	X	X	X	X
Rectangular Grid Parameter				X
No. Forward/Reverse Pathlines	X		X	X
Nodal Head Values				X
No. of Heterogeneous Aquifer Zones				X
Heterogeneous Aquifer Properties				X

[1] From Blandford and Huyakorn, 1991.

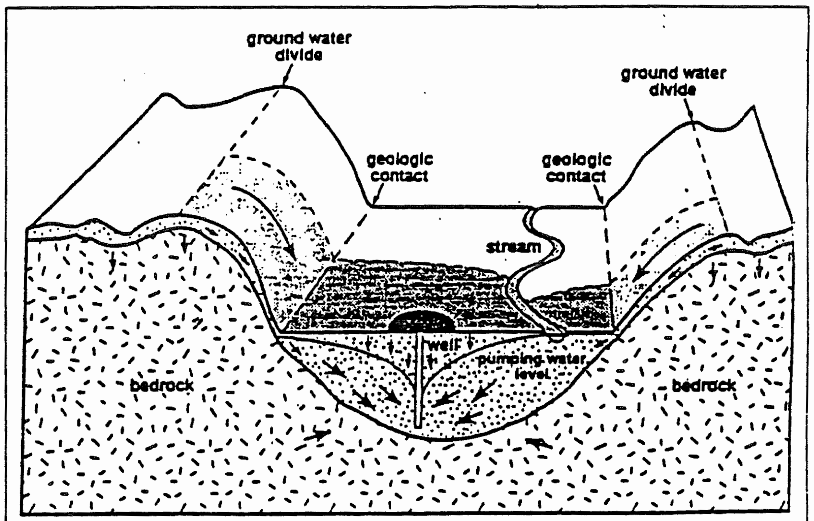
[2] Confined, unconfined or leaky confined.

[3] Time-related, hybrid or steady-state.

- ***Uniform Flow Equation*** — Though not part of the WHPA package, the Uniform Flow analytical model (Todd, 1980) is advocated in several of EPA's documents (EPA, 1987; 1993). The results of this technique can be fit to known hydraulic head distribution and therefore account for variable gradient direction (Bradbury et al., 1991). Values for "K", "b", "i", and "Q" (see Table 3-1) are substituted into appropriate equations yielding the down-gradient stagnation point and the width of the capture zone at any point "X" along the flow path that intersects the well.

- ***Analytic Element Technique*** — A disadvantage of the analytical techniques described above is that they cannot be calibrated to existing conditions. As a result, uncertainty regarding the application of the model to the groundwater flow system remains. The analytic element method (Strack et al., 1994; Wuolo et al., 1995) overcomes some of this concern while maintaining the relative simplicity of the analytical model development.

The EPA has recently distributed the program CZAEM (Strack et al., 1994) which is designed to generate capture zones using the analytic element technique. The method generates a uniform flow field based on limited head and conductivity data. Using that flow field the program will predict head values within the area that can be checked against observations to see if the assumptions inherent in the model are appropriate. The program will also predict changes in head values as a function of model elements (e.g., a well) within the field. Comparing these to observed head changes provides for a means of calibration of the model. The EPA program WhAEM (Haitjema et al., 1994) links CZAEM with a Geographic Analytic Element Preprocessor (GAEP) to facilitate the analysis.



ZONE I — Radius around public supply well.

ZONE II — Land surface overlaying the part of the aquifer that contributes water to the well.

ZONE III — Land surface through and over which water drains into Zone II.

Source: U.S. EPA, 1993

Figure 3-5: Wellhead Protection Delineation Using Hydrogeologic Boundaries

The program CAPZONE (Bair et al., 1991) also provides for calibration of an analytical technique by comparing computed and observed drawdown within a stressed aquifer. The program computes drawdown at rectangular grid points across the area of concern. These drawdowns are compared with observed head values and adjustments to the conceptual model are made if necessary. After calibration is complete, the drawdowns are superposed on the regional head distribution and the resulting hydraulic head map is used as the basis of groundwater flowpath determination.

- ***Hydrogeologic Mapping*** — Hydrogeologic mapping is performed in conjunction with the application of the analytical technique. With the equations alone, there is no provision for determining the up-gradient boundary of the ZOC. Application of Darcy's law using the TOT value is commonly done to terminate the up-gradient position of the WHPA. There may be, however, geological reasons for terminating the ZOC at positions closer to the wellhead than the WHPA boundary, e.g., a lithologic boundary, groundwater divide or a stream boundary (Figure 3-5). Such features are recognized in the process of hydrogeologic mapping and are incorporated into the conceptual model.

The choice of analytical technique used in the delineation exercise is, of course, up to the modeler. In Table 3-1, we provide a table that lists the required input for the WHPA codes RESSQC, MWCAP, GPTRAC Semi-Analytical and GPTRAC numerical options. This table is presented for the purpose of illustrating extent of flexibility that exists within these analytical techniques and should not be construed as either endorsing or requiring these specific procedures.

- ***Delineation Considerations*** — There are several decision points encountered by the modeler during the construction of the model. These are often critical in that they may result in very different delineations depending on the decision. It is of importance that the decision made be the one that most accurately reflects the aquifer and well in question. Listed below are several of these decision points with some directions indicated in order to resolve the questions that arise:

- **Confined Versus Unconfined Aquifer**. In many analytical techniques, the modeler must specify directly or indirectly whether the aquifer of concern is confined or unconfined. Further, in developing management strategies appropriate for a given area, it is very useful to know the level of natural protection (i.e., confinement) that characterizes the aquifer (Kreitler and Senger, 1991).

  For purposes of classification, this document will adopt the Water Resources Department's definition of "artesian aquifer" [OAR 690-200-050(8)] for that of a confined aquifer. Using that definition, a confined aquifer is one in which groundwater is under sufficient head to rise above the level at which it was first encountered. Clearly, this definition does not make the distinction between various levels of confinement, a characteristic that would have to be addressed in some of the analytical techniques.

  An unconfined aquifer is defined as an aquifer in which the upper surface, the water table, is at atmospheric pressure. The systems will be expected to have accomplished an extensive evaluation of existing information in making the distinction of confined or unconfined conditions.

  It is important that the distinction between confined and unconfined be supported by the conceptual model and not be based on a single well report. It is not uncommon for a driller to bore through a finer-grained portion of the aquifer and, because of low seepage rate, not recognize that the zone is saturated. The water-bearing zone identified on the driller's log may reflect only a higher permeability part of the aquifer. Because of this, it may appear that the static water level is higher than the water-bearing zone when in fact the entire section is saturated and in hydraulic connection.

  Many of the analytical techniques provide for modeling semi-confined situations and such an approach should be used if indicated by the conceptual model.

- **Granular Versus Fractured Aquifer**. The distinction between granular and fractured relates primarily to how the physical character of the aquifer impacts groundwater flow. The flow equations used in the analytical models assume that the aquifer can be modeled as a porous medium, is isotropic in its characteristics and that groundwater flow direction is in a direct and predictable relation to the hydraulic head distribution within the aquifer. This is often the case in a granular aquifer, e.g., unconsolidated and consolidated sedimentary materials. Rocks hosting closely spaced and intersecting fractures may in fact be modeled as granular, but may still be anisotropic in character and therefore not lend themselves to direct application of analytical techniques. Special techniques are available that will allow the use of analytical methods to these water systems (Fetter, 1981; EPA, 1994).

  Analytical techniques, however, are not generally applicable to those aquifers that contain widely spaced or discrete fractures, or to rocks that have well developed preferred orientations (e.g., some metamorphic rocks), or in geologic terrains consisting of highly deformed interbedded units of differing conductivities. In these cases, groundwater may be constrained by such anisotropic features to flow in directions other than 90° to hydraulic head contours. As a result, the zone of contributions may be significantly different than that predicted by uniform flow equations, and travel times may be difficult to predict. As stated above, water systems will be required to supply supporting documentation with regard to their assignment of the aquifer of concern.

- **Aquifer Thickness**. All models used to delineate WHPAs require input of the thickness of the aquifer. In the analytical models, this should be the average value, however a sensitivity analysis (see below) should be conducted to determine how much difference in the resulting WHPA would be observed by using the range of observed thicknesses.

The analytical methods are based on the assumption that the well is fully penetrating with respect to the aquifer, i.e., is open to the full thickness of the aquifer. For wells that are only partially screened in the aquifer it is recommended that the combined screened intervals or thickness of water bearing zones (whichever is less) be utilized as the aquifer thickness in the model development. The rationale for this is that groundwater flow to the well tends to be horizontal, owing to the fact that horizontal conductivity generally exceeds vertical conductivity by approximately an order of magnitude or more. A typical ratio of vertical to horizontal conductivity is 0.01.

In areas where the water-bearing zones are in volcanic rock, e.g., basalt, it is not uncommon for the well to be cased to the volcanic rock and then constructed as an open hole for the remainder of the well. Often, there is no information on the well report to indicate the nature of the water-bearing zones. Clearly it is inappropriate to use the entire length of open hole as the aquifer when experience tells us that the water is normally derived from interflow zones, consisting of the more porous and brecciated (i.e., broken up) flow tops.

Observation indicates that the interflow zones within basalt range from <5 percent to >25 percent of the total flow thickness. If there is no information on the well report to indicate the thickness of the water-bearing zones in an open-hole basalt well, a thickness equivalent to 10 percent of the open hole should be used for aquifer thickness or open interval.

- **Hydrogeologic Boundaries.** An important step in adequately determining the ZOC of a pumping well is the recognition of the impacts to groundwater flow of hydrogeologic boundaries. These boundaries can generally be considered to be combinations of two limiting cases: constant head and no-flow boundaries:

  1. ***Constant Head Boundary.*** The most common example of a constant head boundary is a stream (Figure 3-5). In the case of a perennial stream, largely supported by surface flow through a drainage basin, the water level in the stream may show only minor variations over short time intervals. If the ZOC of a proximal pumping well intersects the stream, a hydraulic connection may be established whereby a portion of the water being derived from the well originates within the stream. The net effect is to reduce the size of the ZOC (i.e., less water is being derived directly from the aquifer). The actual impact will depend on the extent the stream penetrates the aquifer and how well developed the clogging layer is.

     Although activities within the watershed upstream from where the hydraulic connection is established could impact the water quality of the groundwater derived from the well, it is unlikely that the community will be able to exert control over the entire watershed as a means of protecting their drinking water supply. As an alternative, we recommend that the community include as part of their management strategy and contingency plan development, a procedure that will protect the aquifer should an event occur upstream that releases a contaminant to the stream. This may be in the form of assuring that the public water system is immediately notified of such a release and has sufficient storage so that the use of the well could be discontinued until the threat of drawing the contaminant into the aquifer is past.

     In the WHPA 2.0 package, the programs MW CAP and GPTRAC will simulate a stream boundary directly. The program RESSQC is capable as well; however, the boundary must be simulated by the modeler through the use of image wells. Importantly, the MWCAP and GPTRAC programs assume that the stream is linear and fully penetrates the aquifer, a situation that is rarely encountered in real settings. Also, the programs do not consider the reduced flow to the aquifer from the stream as a result of the presence of the clogging layer, e.g., fines in the steam bed that reduce the permeability of the materials through which stream water must flow to reach the aquifer. Approximation of a partially penetrating stream and the presence of a clogging layer may be accomplished through variable placement of an image well using RES SQC, supplemented by reducing the recharge rate of that well.

2. ***No-Flow Boundaries.*** These boundaries are those across which groundwater movement is either prevented or reduced to negligible over the period of observation. No-flow boundaries are generally associated with groundwater divides or permeability contrasts (Figure 3-5). A groundwater divide is analogous to a topographic divide that separates surface water drainage basins. A groundwater divide (Figure 3-1) is an elevation high on the water table or potentiometric surface; groundwater moves away from the divide in both directions. Groundwater cannot flow across the divide, consequently, the divide represents a no-flow boundary.

Three types of no-flow boundaries formed by permeability contrasts have been recognized in Oregon. No-flow boundaries resulting from geologic contacts are perhaps the most common. These occur when the aquifer is limited in its lateral extent, either by pinching out, i.e., thins to negligible thickness as in a sand lense, or being in contact with a less permeable rock type:

- **Valley Fill**. An example of the latter is river valley fill. In a typical valley, the valley floor consists of river deposits, sands and gravels. At the margin of the valley, however, we find the bedrock into which the valley was eroded (Figure 3-5). At some sites, this bedrock is relatively impermeable.

- **Fault Boundary**. The second type of no-flow boundary is a fault, where either impermeable material has been produced along the fault during rock movements, or the fault has moved an impermeable rock mass next to the aquifer. In some instances, a significant change in hydraulic head across the fault reflects the no-flow character of the boundary. In other cases, no head loss is recorded; however, on a short-time scale groundwater flow across the fault may be impeded. This boundary may be recognized during an aquifer test. In such cases, the long-term effect of the fault must be carefully evaluated in order to properly delineate the well's capture zone.

- **Change in Aquifer Characteristics**. The third type of no-flow boundary occurs when the characteristics of the aquifer change laterally in a manner that reduces the permeability. An example would be where the proportion of silt in a aquifer increases to the point where water yield is negligible.

- **Modeling Hydrologic Boundaries**. In all three of these cases, groundwater flow across the boundary is inhibited because of the difference in the permeability of the materials. Water will not flow across the bedrock-alluvium contact to supply the well. As in the stream boundary, MWCAP and GPTRAC will model the no-flow (barrier) boundaries directly, making the assumption that the boundary is linear and fully penetrating. Because no-flow boundaries do tend to penetrate the aquifer, these assumptions are not as critical in the no-flow case as they are in the constant head boundaries. RESSQC can simulate the barrier boundaries through the use of image wells. Leaking boundaries can also be accommodated through image well modeling (Bair et al., 1991).

- ***Parameter Estimation and Sensitivity Analysis*** — The key to a quality delineation clearly is the use of data that is representative of the system being modeled. Two weaknesses of the analytical approach are: (1) the models generally assume uniform characteristics within the aquifer (see GPTRAC - Blandford and Huyakorn, 1991), and (2) it is not possible in general to calibrate and validate the model (see CZAEM - Strack et al., 1994) and CAPZONE (Bair et al., 1991). As a result, it is often not possible to test whether the assumptions made in the model development accurately reflect the system.

It is not our intent to detail how one estimates all the parameters utilized within the individual techniques or repeat recommendations made elsewhere (See **Appendix A**). Rather, we are requiring that a sensitivity analysis be performed to determine the relative importance of each parameter. This may provide information on where to expend limited resources to improve the quality of the data used and make the delineation as representative as possible.

- **Parameter Uncertainty**. In this document, we are using sensitivity analysis to mean the provisional calculations of the WHPA using the range of uncertainty associated with each parameter. Specifically, if estimates or independent measurements of a hydraulic parameter indicate a range of possible values, an assessment of the impact of using one value or the other on the shape, extent or orientation of the WHPA should be evaluated. Unfortunately, as with any estimate, there will be a range of values for most of the parameters of interest. As such, there will be a large number of possible combinations of values that could be substituted into the equations.

As discussed above, the WHPA code MONTEC program is capable of incorporating these uncertainties into the WHPA delineation for single wells in a semi-confined or confined aquifer setting and providing a delineation that gives an estimate of the probability that the true delineation falls within the boundaries of the calculated WHPA. For other settings, or other programs within the WHPA code package, such an evaluation is not available.

As an example, you may have specific capacity data from an alluvial aquifer that indicates a significant range of hydraulic conductivity (K) values or you are uncertain regarding the value to use for the effective porosity of a basalt aquifer (Table 3-1). You should first try to limit the variability through careful analysis of the data in the context of the conceptual model to try to determine which value(s) within the range may be most applicable (EPA, 1994). You should then use the ranges of values in the appropriate models to determine the sensitivity of the area of the WHPA. If there is only small variations here, it may be sufficient to simply choose the most protective version of the WHPA.

If there are large differences in the areas of the calculated WHPAs, it may be more cost-effective to try to gather additional information (e.g., an aquifer test), rather than choosing, and then of course, managing the area within the larger WHPA.

- **Multiple Water-Bearing Zones**. An additional example concerns a situation where a well is screened in two water-bearing zones with significant (i.e., an order of magnitude) differences in hydraulic conductivity. Using an average transmissivity value for the two units may yield a WHPA that does not represent the actual time-related capture zone.

As an alternative, the discharge from the well could be partitioned between the two water-bearing zones (zones 1 and 2) in the following manner (Golder Associates, 1994):

$$Q_1 = w_1 \times Q$$

where,

$$w_1 = \frac{(K_1 \times b_1)}{[(K_1 \times b_1) + (K_2 \times b_2)]}$$

Q_1 represents that part of the total discharge (Q) that can be attributed to water-bearing zone 1. K_1 and K_2 and b_1 and b_2 represent the hydraulic conductivities and thickness of water-bearing zones 1 and 2, respectively. The discharge derived from water-bearing zone 2 (Q_2) is derived in an analogous manner.

Using the discharge data thus derived and l_i and transmissivities ($T_i = l_i \times K_i$) of some water-bearing zone (i), the WHPA associated with each zone may be determined using Q_i and compared with that derived by assuming average values. In many cases it will be seen that the bulk of the water is derived from the high-K zone and, as a result, the WHPA associated with that water-bearing zone will be larger than that derived from average values. Note that in terms of transmissivities:

$$w_1 = \frac{T_1}{(T_1 + T_2)}$$

- ***Modification of WHPA Orientation*** — The orientation of the WHPA in the analytical models is based on the input data concerning the direction of groundwater flow. This information is derived either from regional considerations or from the direct measurement of static water levels (SWLs) in appropriate wells at some particular time. It has been the observation of many hydrogeologists in the state that the gradient in a given area may change direction dramatically (up to 180°?) on a seasonal basis, particularly for shallow unconfined systems. The change in gradient direction (and magnitude) may be the result of a change in recharge pattern or a change in the pattern and amount of withdrawals from the aquifer.

- **Incorporating Gradient Variations in the Model.** Because of the uncertainty attached to the gradient direction, the state is requiring that the water system incorporate the potential variability in one of two ways:

  1. ***Evaluation of the gradient quarterly for at least 12 months.*** In this step, wells within the aquifer of concern will be monitored for SWLs every 3 months for at least a year. If possible, wells that are screened in the same interval of the aquifer should be used in the monitoring process. The SWLs will be contoured and the direction of groundwater flow will be determined. WHPAs will be generated along each of the gradient directions determined. The area used for wellhead protection will be the entire area encompassed by the quarterly WHPAs.

  2. ***Arbitrary rotation of the gradient direction.*** In the absence of quarterly SWL determinations, a community may elect to recalculate WHPAs along gradient directions that are rotated an arbitrary amount from the gradient direction determined in the conceptual model development.

     - If the conceptual model is based on regional data, the gradient direction is rotated 45° either side of the gradient direction in the conceptual model. WHPAs are developed along these supplementary directions using 10-year TOTs.

     - If the conceptual model is based on site-specific data, the gradient direction is rotated 25° either side of the gradient direction in the conceptual model. WHPAs are developed along these supplementary directions using 10-year TOTs.

The supplementary delineations in practice do not require a significant amount of program development. We anticipate that these extra delineations would only require changing the program input for the gradient and direction, no other modifications would be necessary (unless demanded by the conceptual model). Time investment at this step would be minimal.

As an added precaution regarding changing gradient directions, OHD is requiring that a circular area surrounding the wellhead, with a radius equivalent to the 6-month TOT using the CFR method, be included in the well's WHPA.

Numerical Methods

Numerical methods provide a high degree of accuracy and can be applied to almost all types of hydrogeologic situations. Accordingly, these methods are able to incorporate complex boundary conditions and variations in hydraulic properties within the aquifer. A large number of numerical models are presently available (van der Heijde and Beljin, 1988).

- ***Developing the Model*** — The process involves dividing the area into cells or elements with each element located uniquely by the coordinates of its corners. Some numerical model codes also allow for vertical division the model into multiple layers. Each cell is characterized in terms of the aquifer's (or bounding material's) hydraulic characteristics, e.g., hydraulic conductivity, thickness, storage, recharge, etc.). Boundaries to groundwater flow can be simulated by specifying cells (elements) with specific boundary conditions (e.g., constant head) or permeability characteristics. The modeler is provided with a significant degree of flexibility in the model development as a result of her/his having the option to design the grid to fit the conceptual model, e.g., making the grid spacing smaller in areas where significant variations occur or where detail is desired.

  After the model is designed, it is run (probably several times) until it converges on a solution that is within a specified error criterion. Typically, error criteria for heads and water balance are evaluated. Discrepancies may indicate that the error criterion is too small (e.g., heads) or the model does not adequately characterize the hydrogeologic system being modeled. The numerical model uses the hydraulic data to calculate head and flux values for each cell within the groundwater flow model.

- ***Calibration*** — An important characteristic of numerical models is the ability to calibrate the model to fit observed data. In the calibration process, the modeler identifies specific calibration targets, usually known values of hydraulic head or fluxes into and out of the groundwater system. The modeler compares the head field and fluxes generated by the numerical model to the observed water levels and fluxes. The comparison is generally done statistically so that the degree of agreement between the modeled and observed conditions can be evaluated quantitatively. It is also useful to plot the areal distribution of the differences. When an acceptable comparison is achieved, the model is said to be calibrated.

  Calibrated values for hydraulic conductivity, storage, boundary conditions, etc., are then systematically changed during a process called a sensitivity analysis. The sensitivity analysis is done to quantify the uncertainty in the calibrated model caused by the uncertainties in the estimates of aquifer parameters, boundaries and stresses (e.g., pumping) on the aquifer. A sensitivity analysis is usually done by changing one parameter value at a time and observing how much change in the model result occurs, i.e., how sensitive the model is to that parameter. The results of the sensitivity analysis should be reported as part of the model development summary.

  The calibrated model can then be used to delineate the WHPA, through the use of particle tracking routine. The particle tracking routine calculates groundwater flow as a function of the head distribution developed by the numerical method. Capture zones as a function of time-of-travel can be delineated.

- ***Validation*** — The numerical model can be further refined through the validation process. In this step, the impact of some perturbation to the model is explored, e.g., increased pumping from one or more wells, etc. The resulting new head field simulation can be compared to the actual situation when it occurs. Modifications to the input data or to boundary conditions can be made in order to reach agreement between predicted and observed head distributions.

  Once a numerical model has been calibrated and validated, it becomes not only a tool for WHPA delineation, but also a planning tool for the community. Through the use of the model, the impact of new wells, infiltration lagoons, potential contaminant releases, etc., can be evaluated with much greater certainty.

Evaluation of Delineation Techniques

In this section, advantages and disadvantages of the above three techniques are described.

- ***Calculated Fixed Radius:***

  Advantages — Simplicity, low cost, does not require significant amount of data acquisition.

  Disadvantages — Generally not representative of the groundwater system, prone to legal challenges, tends to over protect downgradient and under protect upgradient, often yields larger area than other techniques.

- ***Analytical Techniques/Hydrogeologic Mapping:***

  Advantages — Incorporates hydrogeologic characteristics of the aquifer, groundwater flow and hydrogeologic boundaries into the model, provides for a defensible delineation of the WHPA, is based on site-specific information. Often produces a WHPA that is smaller than the one produced using the calculated radius method.

  Disadvantages — Assumes a uniform aquifer (note that some exceptions to this do exist), requires significant expertise and is moderately costly.

- ***Numerical Models:***

  Advantages — 3-D modeling of groundwater flow, can account for evapotranspiration and recharge, groundwater-surface water interaction can be quantified, provides a more accurate delineation of the WHPA, accounts for variation in hydraulic parameters and boundary conditions, can be used for predicting the impact of natural and human-related activities on the flow field. Often produces a smaller area to manage than other techniques.

  Disadvantages — Costly relative to other techniques, requires significant amount of data collection and high level of expertise to set up the grid.

- ### *Factors That May Influence the Delineated Area in the Future:*

A WHPA is delineated based on a set of conditions with regard to hydraulic properties of the hydrogeologic units, fluxes into and out of the system and stresses applied to the aquifer. Although it may seem unlikely that the hydraulic properties of the aquifer could change appreciably, it is possible that surface-related activities could lead to a significant change from conditions assumed to exist in the initial conceptual model.

Prolonged drought and/or overdrafting of an unconfined aquifer could result in a decrease in the thickness of the saturated zone or variations in gradient. Both parameters could cause a change in the size and orientation of the WHPA.

Changes in recharge, either in amount or pattern of application may alter the dimensions of the WHPA. Recharge could be a function of natural precipitation or result from changes in irrigation or application of waste water in the area.

Any addition of high-volume wells in the WHPA or in proximity to its boundary may alter the shape of the WHPA. Significant changes in the pump rate will obviously have an impact on the size of the well's capture zone. Figure 3-6 portrays the change in shape of the original delineation (a) as a result of the addition of a single well immediately upgradient (b) and two wells in proximal positions (c). Details of the models are given in the figure caption.

After the WHPA has been delineated, the community should have as part of their management strategy a method by which the above influences can be recognized and evaluated.

Susceptibility Analysis

The delineations discussed above are based on water movement within the aquifer only. In fact, a contaminant released at or below the surface must travel or be transported across the unsaturated zone to the aquifer. Absent a direct communication to the aquifer, e.g., an improperly constructed well or a through-going fracture system, the characteristics of the unsaturated zone control the time and probability that the contaminant will reach the aquifer. Accordingly, it is recommended that a susceptibility analysis be conducted within the WHPA.

- ***Use of the Analysis*** — The utility of the susceptibility analysis is that it indicates areas within the WHPA in which the aquifer is most susceptible to contamination, i.e., has the highest potential of being impacted by surface activities. When the susceptibility analysis is combined with the results of the potential contami-

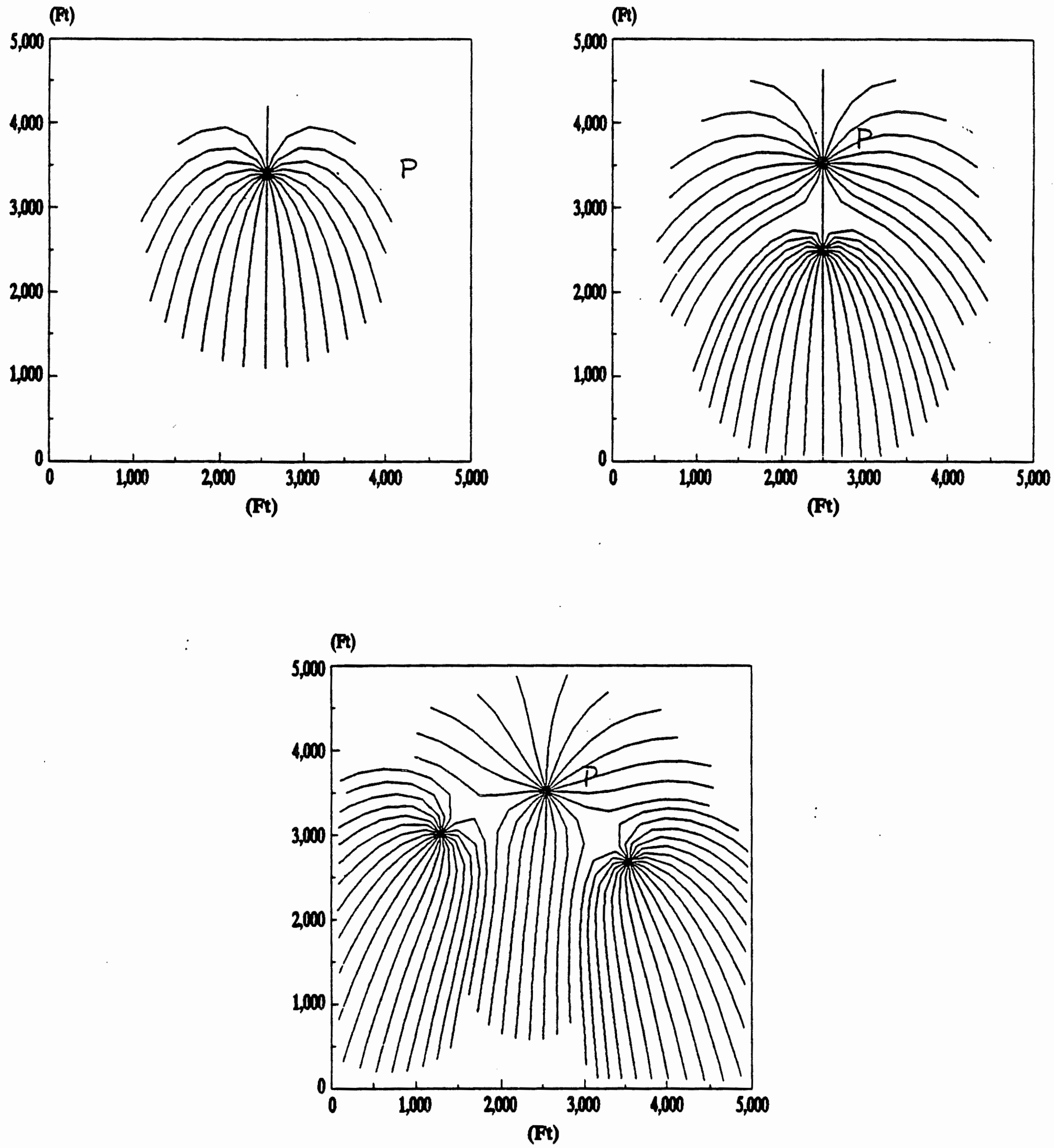


Figure 3-6: Modification of Capture Zone of Primary Production Well (P) as A Result of Proximal Well

nant inventory (Step 4), the highly vulnerable areas can be recognized. A high vulnerability would be indicated where a high-risk surface practice occurs in an area where the aquifer has a high susceptibility.

Several methods exist for determining aquifer susceptibility on a site-specific scale. The EPA has developed a technical document on "Managing Ground Water Contamination Sources in Wellhead Protection Areas" that incorporates both susceptibility and risk rankings into its determination. Not all potential sources of contaminants are considered; however, in some cases the risk triggers are somewhat high.

Oregon State University has developed a decision aid that is designed to help producers consider groundwater protection when using various agricultural chemicals in crop production. The Oregon Water Quality Decision Aid utilizes soil characteristics such as sorption capacity and permeability and chemical characteristics of the contaminant such as its sorption potential and persistence to arrive at an estimate of the aquifer's vulnerability to that chemical. Much of the data has been compiled by OSU and the decision-making process is very user-friendly. (More information can be obtained by calling OSU at 541-737-5713.) The OHD developed a susceptibility analysis in conjunction with a monitoring reduction program for public water systems (OHD, 1992). The determination of susceptibility makes use of information regarding the hydrogeologic characteristics of the area and the chemical characteristics of the contaminant of concern (Figure 3-7). Decision points are assisted through the use of matrices.

- ***Hydrogeologic Characteristics*** — The OHD process begins by using available soil data from Soil Survey Reports. Within the area of a mapped soil type, the depth to the aquifer and weighted hydraulic conductivity would be estimated from well reports (or other available information). These two parameters would be compared in a matrix to yield a traverse potential score. The traverse potential score is then utilized in conjunction with the hydraulic surplus, the difference between water applied, as irrigation or precipitation, and the water lost through evapotranspiration and runoff, to yield an infiltration potential. The infiltration potential is an estimate of the probability that water will migrate from the surface downward to the aquifer.

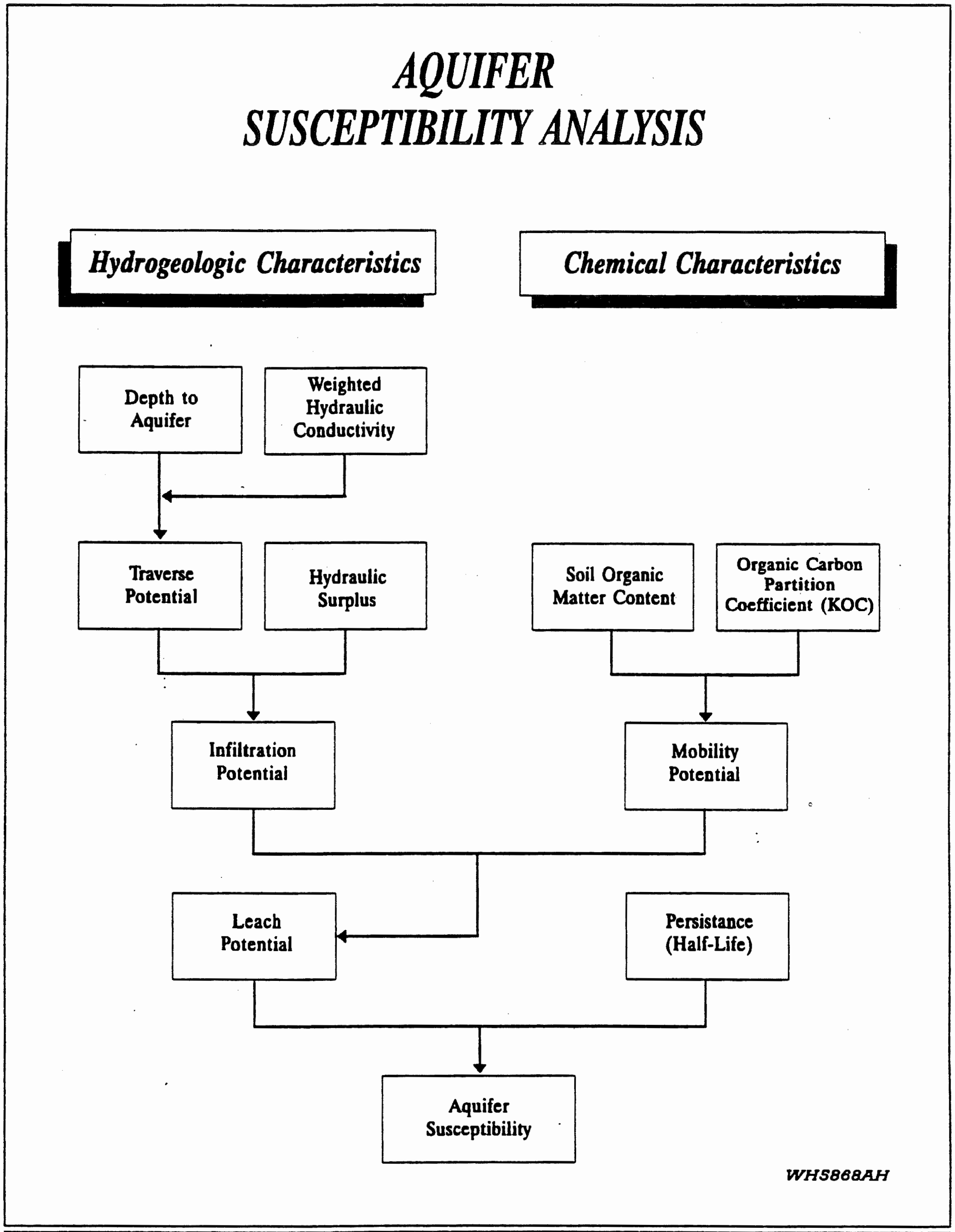
- ***Chemical Characteristics*** — Consideration of the chemical characteristics begins with using the tendency for the contaminant to sorb (attach itself) to organic matter along with the amount of organic matter in the soil (as reported in the soil survey). These parameters combine to yield the mobility potential, the probability that the chemical will move through the soil zone.

  The mobility potential is linked to the infiltration potential (Figure 3-7) to derive the leach potential, an estimate of the probability that water migrates to the aquifer carrying the contaminant. Combining the leach potential with the persistence of the contaminant, i.e., how long the contaminant "survives" before processes in the subsurface cause it to break down. This latter step indicates whether or not the aquifer is susceptible in that area.

- ***Example*** — An example of the application of this method is illustrated in Figure 3-8. The WHPA for a well has been delineated and the soil survey of the area consulted to determine the principle soil types. In this example, only two types dominate, soil A and soil B. A cross section has been drawn from A to A' in the lower figure. Note that there are significant differences in soil thickness and depth to the aquifer. The question being addressed is how does the aquifer susceptibility beneath soil A differ from that below soil B? The contaminant of concern here is trichloroethylene (TCE).

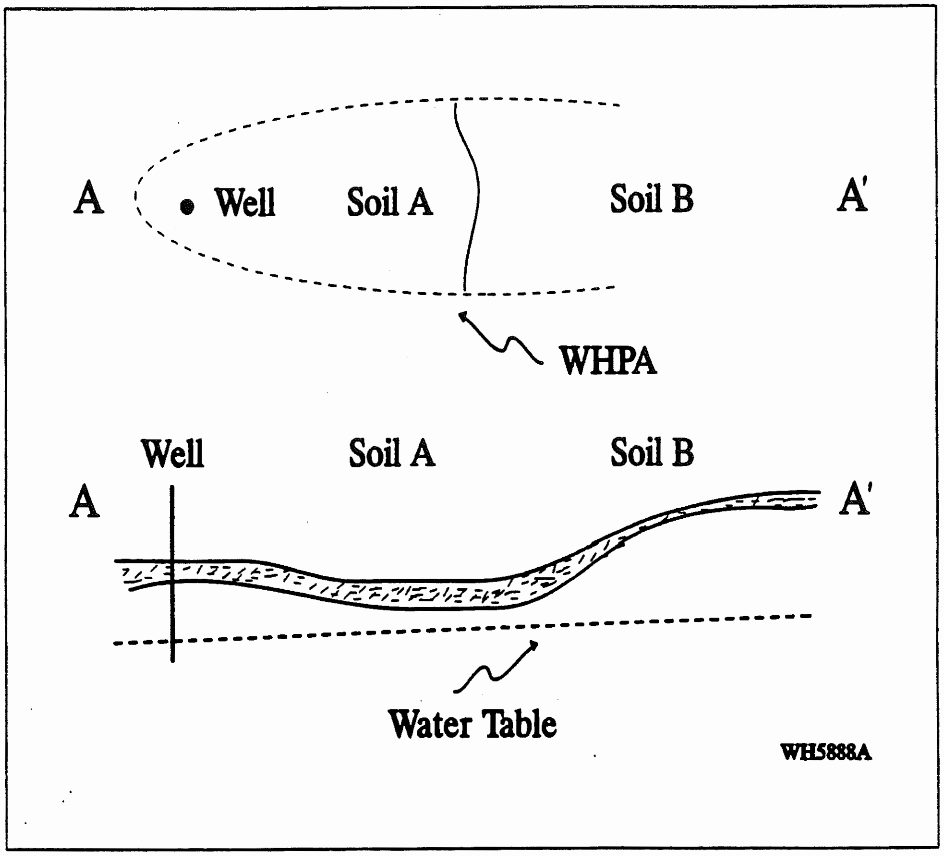
  The comparison is illustrated in the lower table of Figure 3-8. The Traverse Potentials beneath the two soils are quite different based on the different hydraulic conductivities, the potential of movement of water from the surface to the water table being lower beneath soil A. Hydraulic surpluses are considered the same for both soil types, but the lower traverse potential beneath soil A leads to a lower infiltration potential beneath that soil as well.

  The Mobility Potential for TCE through soil B is higher because of the lower organic matter content, which in this process is recorded by a higher organic matter score, in that soil. The combination of



Source: OHD, 1992

Figure 3-7: Aquifer Susceptibility Analysis



Potential Contaminant: TCE with Log Koc = 2.0		
Characterics — Type	**Soil A — Silt**	**Soil B — Silty Sand**
Thickness (in.)	60	12
% Organic Matter	3	0.5
Organic Matter Score	1	10
K (gal/day/ft^2)	0.04	45
Depth to Aquifer (ft)	<50	<50
Hydraulic Surplus (in.)	15	15
Traverse Potential	2	9
Infiltration Potential	3	8
Mobility Potential (TCE)	5	9
Leach Potential	3	9

Figure 3-8: Example of Using The Susceptibility Analysis in Wellhead Protection Strategies

the higher infiltration and mobility potentials beneath soil B lead to a higher leach potential for TCE in that area. This coupled with the high persistence of TCE indicates that the susceptibility of the aquifer is greater under soil B than under soil A.

It is apparent from Figure 3-8 that the value of the infiltration potential provides an estimate of the general susceptibility of the aquifer while the leach potential, coupled with the persistence of the contaminant, will provide an estimate of the vulnerability of the aquifer to contamination from a specific chemical. It is recommended that data from soil surveys and well reports be used to determine the infiltration potential at individual wells selected to provide good coverage throughout the WHPA(s). These values can be contoured to indicate areas of high versus low infiltration potential. General management strategies, particularly those designed to address future land use, can be developed from this data base. Individual potential sources can be further evaluated using chemical specific data to determine the potential of the contaminant of concern migrating to groundwater. Specific management strategies, designed to minimize risks associated with a specific existing land use, can be developed from this information.

- ***General Application*** — Within a wellhead protection area, communities will want to focus their limited resources on those areas where the risk of contamination is greatest. Determination of the infiltration potential (see Figure 3-7) across the WHPA will indicate those regions where rapid infiltration of water from the surface is most likely. A contaminant release in these areas would pose a greater risk than in areas where the infiltration potential is low.

  OHD's guidance manual suggests selecting representative wells within the WHPA that penetrate the aquifer of concern and calculating the traverse potential for each based on well logs and soil survey reports. Ideally the distribution of wells will be sufficient to provide at least one value of the traverse potential per quarter-quarter section (i.e., 16 wells per square mile). Using precipitation data and/or irrigation data (see OHD's guidance), the hydraulic surplus could be calculated and combined with the traverse potential to yield the infiltration potential (Figure 3-7). If data is sufficient, the WHPA area could be contoured with respect to the infiltration potential to more readily identify those regions where the risk of infiltration of a contaminant release to the aquifer is greatest. Communities could use this information to prioritize the area for purpose of protective management.

  Individual sites could be more specifically evaluated by considering further the chemical characteristics of the contaminant of concern. This would be done by combining the infiltration potential at the site with the leach potential of the specific chemical, i.e., the tendency for the chemical to attach itself to the organic matter present in the soil, and the chemicals persistence in the environment. OHD's guidance manual provides pertinent data for those chemicals that are routinely monitored for drinking water purposes. The procedure will result in an estimate of the susceptibility, high, moderate or low, of the aquifer for that specific chemical. A facility where the susceptibility is low will obviously need less oversight than a facility where the susceptibility is high.

- ***Submitting the Delineation for OHD Certification*** — The final delineation should be submitted to the groundwater coordinator of OHD's Drinking Water Program. The report submitted to OHD should include a map showing the delineated area and a report that provides documentation of the model parameters used and justification for the assumptions made in the modeling effort. Well locations and delineated areas must also be submitted digitally, in DXF or ArcInfo GIS compatible format. For those delineations involving the development of a conceptual model, the report should include well logs with locations keyed to a map, cross-sections (fence diagram), aquifer test results and a discussion of the hydrologic units, boundaries, groundwater flow direction and gradient, etc. OHD will expect that the issues, concerns and required tasks and decision points discussed in this chapter will be addressed in the report.

It is recommended that a line of communication between the local wellhead protection committee, or their consultant, and OHD's groundwater coordinator (503-731-4010) be established early on in the delineation process. This provides OHD the opportunity to provide technical assistance and will facilitate the submission and review process.

OHD will make every effort to review the delineation report in a prompt and timely manner. In the event that the report cannot be reviewed within 60 days, OHD will provide the submitter in writing with an estimate of the date in which the review will be completed.

The final delineation should be submitted to:

Groundwater Coordinator
Drinking Water Program
Oregon Health Division
800 NE Oregon Street
Portland, OR 97232

- ***Delineation References:***

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3.4 STEP 4

3.4.1 Inventory Potential Sources of Contamination

After the wellhead protection area has been delineated, the next step is to identify and locate potential sources of groundwater contamination in that area. Inventorying sources in a wellhead protection area is essentially creating a map of the features and land uses. Groundwater contamination, and resulting threats to your drinking water, can occur as a result of many types of land uses and activities. **A source is a location where there is any activity having the potential to release contaminants into groundwater at a level of concern. Those activities may include transporting, storing, manufacturing, or using any potential contaminants.**

An inventory of potential sources can serve several important purposes:

- Provide a very effective means of educating the local public about potential problems,
- Provide information on the locations of all potential sources, especially those that present the greatest risks to the water supply, and
- Provide a reliable basis for developing a local management plan to reduce the risks to the water supply.

- ***Groundwater Contaminants:***

There are three broad categories of contaminants that reduce the quality of groundwater in Oregon. The three categories, with subcategories and common examples of each, are as follows:

1. **Micro Organisms:**
   - Viruses (Hepatitis A, Norwalk type);
   - Protozoa (Giardia lamblia, Cryptosporidium);
   - Bacteria (Coliform - Escherichia coli, fecal, enterococcus).
2. **Inorganic Chemicals:**
   - Nitrates;
   - Metals (lead, arsenic, chromium).
3. **Organic Chemicals:**
   - Volatileorganiccompounds:
     - Chlorinated solvents (trichloroethylene/TCE, tetrachloroethylene/PCE);
     - Aromatics (benzene, toluene).
   - Petroleum compounds:
     - Fuels (diesel, gasoline);
     - Lubricants (oil).
   - Semi-volatiles:
     - Pesticides (herbicides, insecticides);
     - Polynuclear aromatic hydrocarbons/PAHs;
     - Phenols (pentachlorophenol/PCP).

Contaminant releases to groundwater can occur on an area-wide basis or from a single point source. Major contaminants of concern on an area-wide or "nonpoint source" basis in Oregon are nitrates and pesticides. Nitrates are currently the most pervasive nonpoint source groundwater problem in Oregon. Sources that potentially contribute nitrates to the groundwater include high densities of septic systems, agricultural activities such as fertilizer application and confined animal feeding operations, and disposal of food processing wastes.

Major contaminants of concern on a "point source" basis in Oregon are volatile organic compounds (VOCs) and petroleum compounds. Point source groundwater contamination can come from not only industrial facilities, waste disposal sites, and large accidental spills, but from day-to-day operating practices associated with small businesses, abandoned single family water supply wells, and other residential-related activities commonly located in every community in Oregon.

Table 3-2 provides a good overview of potential sources of contamination and the contaminants that are associated with each source. The sources of groundwater contamination can be grouped according to many different criteria. Contaminants can reach groundwater from activities occurring on the land surface or below it. Table 3-2 can be used as a guideline for understanding the potential contaminants from the types of facilities listed on your inventory form.

There are many excellent resources available to provide additional information on groundwater, contaminant sources, and transport issues (see EPA, 1994; OTA, 1984; EPA, 1990). Our recommended approach to identifying potential sources is to be as thorough as possible.

- ***Recruiting Volunteers:***

A thorough inventory of potential contamination sources is an essential step in developing local wellhead protection plans. This process can be tailored to the specific

Table 3-2: Potential Sources of Groundwater Contaminants

Source		Groundwater Contaminants[1,2,3]
Commercial/Industrial		
Automobile	Body Shops/Repair Shops	Waste oils; solvents; acids; paints; automotive wastes[4]; miscellaneous cutting oils.
	Car Washes	Soaps; detergents; waxes; miscellaneous chemicals; hydrocarbons.
	Gas Stations	Oils; solvents; miscellaneous wastes.
Boat Services/Repair/Refinishing		Diesel fuels; oil; septage from boat waste disposal area; wood preservative and treatment chemicals; paints; waxes; varnishes; automotive wastes[4].
Cement/Concrete Plants		Diesel fuels; solvents; oils; miscellaneous wastes.
Chemical/Petroleum Processing/Storage		Hazardous chemicals; solvents; hydrocarbons; heavy metals; asphalt.
Dry Cleaners		Solvents (perchloroethylene, petroleum solvents, Freon); spotting chemicals (trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate).
Electrical/Electronic Manufacturing		Cyanides; metal sludges; caustic (chromic acid); solvents; oils; alkalis; acids; paints and paint sludges; calcium fluoride sludges; methylene chloride; perchloroethylene; trichloroethane; acetone; methanol; toluene; PCBs.
Fleet/Trucking/Bus Terminals		Waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive wastes[4].
Food Processing		Nitrates; salts; phosphorus; miscellaneous food wastes; chlorine; ammonia; ethylene glycol.
Funeral Services/Graveyards		Formaldehyde; wetting agents; fumigants; solvents; leachate; lawn and garden maintenance chemicals[5].
Furniture Repair/Manufacturing		Paints; solvents; degreasing and solvent recovery sludges; lacquers; sealants.
Hardware/Lumber/Parts Stores		Hazardous chemical products in inventories; heating oil and fork lift fuel from storage tanks; wood-staining and treating products such as creosote; paints; thinners; lacquers; varnishes.
Home Manufacturing		Solvents; paints; glues and other adhesives; waste insulation; lacquers; tars; sealants; epoxy wastes; miscellaneous chemical wastes.
Junk/Scrap/Salvage Yards		Automotive wastes[4]; PCB contaminated wastes; any wastes from businesses[6] and households[7]; oils; lead.
Machine Shops		Solvents; metals; miscellaneous organics; sludges; oily metal shavings; lubricant and cutting oils; degreasers (tetrachloroethylene); metal marking fluids; mold-release agents.
Medical/Vet Offices		X-ray developers and fixers[8]; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; dental acids; miscellaneous chemicals.
Metal Plating/Finishing/Fabricating		Sodium and hydrogen cyanide; metallic salts; hydrochloric acid; sulfuric acid; chromic acid; boric acid; paint wastes; heavy metals; plating wastes; oils; solvents.
Mines/Gravel Pits		Mine spills or tailings that often contain metals; acids; highly corrosive mineralized waters; metal sulfides; metals; acids; minerals sulfides; other hazardous and nonhazardous chemicals[9].

Table 3-2: Potential Sources of Groundwater Contaminants (Continued)

Source	Groundwater Contaminants[1,2,3]
Office Buildings/Complexes	Building wastes[6]; lawn and garden maintenance chemicals[5]; gasoline; motor oil.
Parking Lots/Malls (> 50 spaces) (H)	Hydrocarbons; heavy metals; building wastes[6].
Photo Processing/Printing	Biosludges; silver sludges; cyanides; miscellaneous sludges; solvents; inks; dyes; oils; photographic chemicals.
Plastics/Synthetics Producers	Solvents; oils; miscellaneous organic and inorganics (phenols, resins); paint wastes; cyanides; acids; alkalis; wastewater treatment sludges; cellulose esters; surfacant; glycols; phenols; formaldehyde; peroxides; etc.
Research Laboratories	X-ray developers and fixers[8]; infectious wastes; radiological wastes; biological wastes, disinfectants; asbestos; beryllium; solvents; infectious materials; drugs; disinfectants; (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); miscellaneous chemicals.
RV/Mini Storage	Automobile wastes[4]; gasoline and diesel fuel from vehicles and storage tanks
Wood Preserving/Treating	Wood preservatives: creosote, pentachlorophenol, arsenic; heavy metals.
Wood/Pulp/Paper Processing and Mills	Metals; acids; minerals; sulfides; other hazardous and nonhazardous chemicals[9]; organic sludges; sodium hydroxide; chlorine; hypochlorite; chlorine dioxide; hydrogen peroxide; treated wood residue (copper quinolate, mercury, sodium bazide); methanol; paint sludges; solvents; creosote; coating and gluing wastes.
Agricultural/Rural	
Auction Lots/Boarding Stables	Livestock sewage wastes; nitrates; phosphates; coliform and noncoliform bacteria; giardia, viruses; total dissolved solids.
Confined Animal Feeding Operations	Livestock sewage wastes; nitrates; phosphates; chloride; chemical sprays and dips for controlling insect, bacterial, viral and fungal pests on livestocks; coliform[10] and noncoliform bacteria; viruses; giardia; total dissolved solids.
Farm Machinery Repair	Automotive wastes[4]; welding wastes.
Crops — Irrigated and Nonirrigated	Pesticides[11]; fertilizers[12]; nitrates; phosphates; potassium (can be worsened by over-watering).
Lagoons/Liquid Wastes	Nitrates; Livestock sewage wastes; salts; pesticides[11]; fertilizers[17]; bacteria.
Pesticide/Fertilizer/Petroleum Storage & Transfer Areas	Pesticides[11]; fertilizers[12]; petroleum residues.
Rural Homesteads — Rural	Machine shops: Automotive wastes[4]; welding wastes; solvents; metals; subricants; sludges.
	Septic systems: Septage; coliform[10] and noncoliform bacteria; viruses; nitrates; heavy metals; synthetic detergents; cooking and motor oils; bleach; pesticides;[5,13] paints; paint thinner; photographic chemicals; swimming pool chemicals;[14] septic tank/cesspool cleaner chemicals;[15] elevated levels of chloride, sulfate, calcium, magnesium, potassium, and phosphate.
Residential/Municipal	
Airports (Maintenance/Fueling Areas)	Jet fuels; deicers; diesel fuel; chlorinated solvents; automotive wastes;[4] heating oil; building wastes[6].

Table 3-2: Potential Sources of Groundwater Contaminants (Continued)

Source	Groundwater Contaminants[1,2,3]
Apartments and Condominiums	Swimming pool maintenance chemicals[14]; pesticides for lawn and garden maintenance and cockroach, termite, ant, rodent, and other pest control[5,13], wastes from on-site sewage treatment plants; household hazardous wastes.
Camp Grounds/RV Parks	Septage; gasoline; diesel fuel from boats; pesticides for controlling mosquitoes, ants, ticks, gypsy moths, and other pests[11,13]; household hazardous wastes from recreational vehicles (RVs)[7].
Drinking Water Treatment Plants	Treatment chemicals; pesticides[11].
Fire Stations	General building wastes[6]; hydrocarbons from test burn areas.
Golf Courses	Fertilizers[12]; herbicides[11]; pesticides for controlling mosquitoes, ticks, ants, gypsy moths, and other pests[5].
Housing	Household hazardous wastes[7]: Household cleaners; oven cleaners; drain cleaners; toilet cleaners; disinfectants; metal polishes; jewelry cleaners; shoe polishes; synthetic detergents; bleach; laundry soil and stain removers; spot removers and dry cleaning fluid; solvents; lye or caustic soda; household pesticides;[13] photo chemical; paints; varnishes; stains; dyes; wood preservatives (creosote); paint and lacquer thinners; paint and varnish removers and deglossers; paint brush cleaners; floor and furniture strippers.
	Mechanical repair and other maintenance products: Automotive wastes;[4] waste oils; diesel fuel; kerosene; #2 heating oil; grease; degreasers for driveways and garages; metal degreasers; asphalt and roofing tar; tar removers; lubricants; rust-proofers; car wash detergents; car waxes and polishes; rock salt; refrigerants.
	Lawn/garden care: Fertilizers;[11] herbicides and other pesticides used for lawn and garden maintenance[5] (can be worsened by over-watering).
	Swimming pools: Swimming pool maintenance chemicals[14].
	Urban runoff/storm water[3]: Gasoline; oil; other petroleum products; microbiological contaminants.
Landfills/Dumps	Leachate; organic and inorganic chemical contaminants; waste from households[7] and businesses[6]; nitrates; oils; metals; solvents; sludge.
Motor Pools	Automotive wastes[4]: solvents; waste oils; hydrocarbons from storage tanks.
Parks	Fertilizers[12]; herbicides[5]; insecticides[11,13].
Railroad Yards/Maintenance/Fueling Areas	Diesel fuel; herbicides for rights-of-way[11]; creosote from preserving wood ties; solvents; paints; waste oils.
Schools	Machinery/vehicle serving wastes; gasoline and heating oil from storage tanks; general building wastes[6]; pesticides[11,13].
Septic Systems	Septage; coliform[10] and noncoliform bacteria; viruses; nitrates; heavy metals; synthetic detergents; cooking and motor oils; bleach; pesticides[5,13]; paints; paint thinner; photographic chemicals; swimming pool chemicals[14]; septic tank/cesspool cleaner chemicals[15]; elevated levels of chloride, sulfate, calcium, magnesium, potassium, and phosphate; other household hazardous wastes[7].

Source	Groundwater Contaminants[1,2,3]
Utility Stations/Maintenance Areas	PCBs from transformers and capacitors; oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides from utility rights-of-way.
Waste Transfer/Recycling Stations	Residential and commercial solid waste residues.
Wastewater	Municipal wastewater; sludge[16]; treatment chemicals[17]; nitrates; heavy metals; coliform[10] and noncoliform bacteria; nonhazardous wastes[16].
Miscellaneous	
Above Ground Storage Tanks	Heating oil; diesel fuel; gasoline; other chemicals.
Construction/Demolition Areas (Plumbing, Heating, and Air Conditioning, Painting, Paper Hanging, Decorating, Drywall and Plastering, Acoustical Insulation, Carpentry, Flooring, Roofing, and Sheet Metal etc.)	Solvents; asbestos; paints; glues and other adhesives; waste insulation; lacquers; tars; sealants; epoxy waste; miscellaneous chemical wastes; explosives.
Historic Gas Stations	Diesel fuel; gasoline; kerosene.
Historic Waste Dumps/Landfills	Leachate; organic and inorganic chemicals; waste from households[7]; and businesses[6]; nitrates; oils; heavy metals; solvents.
Injection Wells/Drywells/Sumps	Storm water runoff[3]; spilled liquids; used oils; antifreeze; gasoline; solvents; other petroleum products; pesticides[11]; and a wide variety of other substances.
Managed Forests	Pesticides; fertilizers; total suspended solids.
Military Installations	Wide variety of hazardous and nonhazardous wastes depending on the nature of the facility and operation[3,8]; diesel fuels; jet fuels; solvents; paints; waste oils; heavy metals; radioactive wastes; explosives.
Surface Water — Stream/Lakes/Rivers	Directly related to surface water quality in the stream, lake, or river which is recharging groundwater.
Transportation Corridors	Herbicides in highway right-of-way[11,5]; road salt (sodium and calcium chloride); road salt, anticaking additives (ferric ferrocyanide, sodium ferrocyanide); road salt anticorrosives (phosphate and chromate); automotive wastes[4]; fertilizers.
Underground Storage Tanks	Diesel fuel; gasoline; heating oil; other chemical and petroleum products.
Wells — Such as Water Supply Wells, Monitoring Wells, Unsealed or Abandoned Wells, and Test Holes	Storm water runoff[3]; solvents; nitrates; septic tanks; hydrocarbons; and a wide variety of other substances.

[1] In general, groundwater contamination stems from the misuse and improper disposal of liquid and solid wastes; the illegal dumping or abandonment of household, commercial, or industrial chemicals; the accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; or the improper siting, design, construction, operation; or maintenance of agricultural, residential, municipal, commercial, and industrial drinking water wells and liquid and solid waste disposal facilities. Contaminants also can stem from atmospheric pollutants, such as airborne sulfur and nitrogen compounds, which are created by smoke, flue dust, aerosols, and automobile emissions, fall as acid rain, and percolate through the soil. When the sources list in this table are used and managed properly, groundwater contamination is not likely to occur.

[2] Contaminants can reach groundwater from activities occurring on the land surface, such as industrial waste storage; from sources below the land surface but above the water table, such as septic systems; from structures beneath the water table, such as wells; or from contaminated recharge water.

Table 3-2: Potential Sources of Groundwater Contaminants (Continued)

Source	Groundwater Contaminants[1,2,3]

[3] This table lists the most common wastes, but not all potential wastes. For example, it is not possible to list all potential contaminants contained in storm water runoff or from military installations.

[4] Automobile wastes can include gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils.

[5] Common pesticides used for lawn and garden maintenance (i.e., weed killers, and mite, grub, and aphid controls) include such chemicals as 2,4-D; chlorpyrifos; diazinon; benomyl; captan; dicofol; and methoxychlor.

[6] Common wastes from public and commercial buildings include automotive wastes; and residues from cleaning products that may contain chemicals such a xylenols, glycol esters, isopropanol, 1,1,1,-trichloroethane, sulfonates, chlorinated phenols, and cresols.

[7] Household hazardous wastes are common household products which contain a wide variety of toxic or hazardous components (see also **Appendix** F: Household Waste Fact Sheet).

[8] X-ray developers and fixers may contain reclaimable silver, glutaldehyde, hydroquinone, potassium bromide, sodium sulfite, sodium carbonate, thiosulfates, and potassium alum.

[9] The *Resource Conservation and Recovery Act* (RCRA) defines a hazardous waste as a solid waste that may cause an increase in mortality or serious illness or pose a substantial threat to human health and the environment when improperly treated, stored, transported, disposed of, or otherwise managed. A waste is hazardous if it exhibits characteristics of ignitability, corrosivity, reactivity, and/or toxicity. Not covered by RCRA regulations are domestic sewage; irrigation waters or industrial discharges allowed by the *Clean Water Act*; certain nuclear and mining wastes; household wastes; agricultural wastes (excluding some pesticides); and small quantity hazardous wastes (i.e., less than 220 pounds per month) generated by businesses.

[10] Coliform bacteria can indicate the presence of pathogenic (disease-causing) microorganisms that may be transmitted in human feces. Diseases such as typhoid fever, hepatitis, diarrhea, and dysentery can result from sewage contamination of water supplies.

[11] Pesticides include herbicides, insecticides, rodenticides, fungicides and avicides. EPA has registered approximately 50,000 different pesticide products for use in the United States. Many are highly toxic and quite mobile in the subsurface. An EPA survey found that the most common pesticides found in drinking water wells were DCPA (dacthal) and atrazine, which EPA classifies as moderately toxic (class 3) and slightly toxic (class 4) materials, respectively.

[12] The EPA National Pesticides Survey found that the use of fertilizers correlates to nitrate contamination of groundwater supplies.

[13] Common household pesticides for controlling pests such as ants, termites, bees, wasps, flies, cockroaches, silverfish, mites, ticks, fleas, worms, rates, and mice can contain active ingredients include naphthalene, phosphorus, xylene, chloroform, heavy metals, chlorinated hydrocarbons, arsenic, strychnine, kerosene, nitrosamines, and dioxin.

[14] Swimming pool chemicals can contain free and combined chlorine; bromine; iodine; mercury-based, copper-based, and quaternary algaecides; cyanuric acid; calcium or sodium hypochlorite; muriatic acid; sodium carbonate.

[15] Septic tank/cesspool cleaners include synthetic organic chemicals such as 1,1,1,-trichloroethane, tetrachloroethylene, carbon tetrachlorine, and methylene chloride.

[16] Muncipal wastewater treatment sludge can contain organic matter, nitrates; inorganic salts, heavy metals; coliform and noncoliform bacteria; and viruses.

[17] Municipal wastewater treatment chemicals include calcium oxide; alum; activated alum, cabon, and silics; polymers; ion exhcange resins; sodium hydroxide; chlorine; ozone; and corrosion inhibitors.

Source:

Adapted from EPA (1993); Supplemented with Oregon DEQ database information.

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needs and resources of the individual RMA(s) and Team. If your wellhead protection area is small or an adequate inventory can be conducted by the Public Works Director, for example, or members of the Team, you may not need to solicit volunteers for assistance. Most communities participating in a wellhead protection effort, however, will share the problem of not having the staff or resources to conduct a thorough inventory. One solution to this problem is recruiting volunteers **from your local area**. The knowledge of the citizens living in your local area is essential in identifying many of those activities which pose a threat to the drinking water. Using local citizen volunteers will not only improve the inventory outcome, but will reduce the overall costs of your wellhead protection plan.

Volunteers are precious local resources. They can be recruited from many different existing organizations, such as community service organizations, 4-H Clubs, Boy Scouts, Girl Scouts, League of Women Voters, high school groups, or a Team member can establish and coordinate a new group of volunteers.

One very successful example of using volunteers for an inventory was the recent utilization of the Retired Senior Volunteer Program (RSVP) in El Paso, Texas. This project is highlighted here not only because it successfully used an **existing** organization, but DEQ also strongly recommends the utilization of seniors in your community because they are invaluable sources of information.

Retired citizens of the community can provide the knowledge, manpower, and leadership needed to conduct an inventory of potential sources of contamination. Their availability, historic knowledge of the community, interest in intergenerational environmental concerns, and personal expertise make the retired persons of the community the ideal candidates for groundwater protection activities. Through their tradition of consistently strong local political involvement and numbers, older adults can ultimately affect a change in public opinion concerning the issue of groundwater protection.

RSVP is an ideal candidate for groundwater protection activities because RSVP is structured with a recruiting mechanism. Each RSVP project throughout the United States has an individual available to call and recruit the volunteers needed to conduct an inventory. RSVP also provides its volunteers with an insurance program involving accident, personal liability, and excess automobile liability insurance coverages. Oregon has 14 existing local networks throughout the state. Information on Oregon's RSVP program can be obtained from the RSVP office located at:

2256 NW Lovejoy
Portland, OR 97210
Telephone: 503-229-7787

Communities interested in involving RSVP volunteers should first consult their telephone directory under RSVP or Retired Senior Volunteer Program. If the community is unable to find such a listing they may contact the Portland office or the National Association of RSVP Directors, 703 Main St., Patterson, New Jersey 07503.

The Department of Environmental Quality can provide more information on the El Paso RSVP project for Oregon communities that are interested in using this as a tool to conduct their inventory. This approach to the inventory would most likely only be necessary in larger communities and/or large wellhead protection areas.

- ***Methodology:***

The methodology for accomplishing Step 4, the inventory of potential sources, can be summarized as follows:

- Develop a detailed base map of the delineated area,
- Collect existing sources of information,
- Divide the wellhead protection area into different land uses,
- Prepare an inventory form,
- Conduct a windshield survey and plot the existing data, and
- Rank the estimated risks or threats.

A detailed description of each step is included below:

A. Develop a detailed base map of the delineated area:

Check with your local county/city transportation, planning department, public works, or chamber of commerce to help you locate the best available map for the delineated area. Your base map used during the delineation step may be detailed enough. If you used a USGS topographic map at the typical 1":2,000' scale, though, you may want to enlarge it to a 1":1,000' scale for use during the inventory step. Even larger scale maps, such as 1":800', are most convenient for urban areas. It is important to have a map at an appropriate scale that allows the Team and/or volunteers to plot each potential source on the map. Each source can be labeled or coded on the inventory map. A simple numbered mark or reference for each source on the map can also be cross-referenced to a separate list. An example of an inventory map is shown in Figure 3-9.

Subsections of the base map can be copied to be used in the "field" during the inventory process. Then the Team and/or volunteers could continuously update one primary base map as they cover small segments within the delineated area. This will help ensure detailed coverage and avoid duplication of effort by the volunteers while conducting the inventory.

B. Collect existing sources of information:

At the local level, a substantial amount of information on historical, current, or future potential contamination sources exists in the form of routine records or documents in the county or city files. This is an excellent place for the Team and/or volunteers to begin. Specific sources of information for local data on land uses and activities may include:

- Planning department/boards;
- Public works;
- Local fire department;
- Historical societies/clubs;
- Library;
- Telephone books;
- Chamber of commerce;
- City or county permit files;
- Property transfer records;
- Health department/districts;
- Transportation department – local;
- Aerial photos (from Corps of Engineers, Soil Conservation Service, etc.);
- Flood control districts;
- Business licenses;
- Construction permits;
- Tax assessor.
- County Extension Service.

When identifying land uses, it is important to consider not only existing uses but also the historical and future uses of the land. The historical uses often play a major role in the land's present capacity to contaminate groundwater. For example, land that was used for agricultural purposes at one stage should be researched to identify chemicals such as pesticides used, stored, or disposed of on-site. Historic or former gasoline stations and dump sites are easy to overlook but are considered high potential risks to groundwater. Searching records and/or interviewing long-time residents will help ensure that you do not overlook past sources of contamination.

Aerial photographs can be extremely helpful in identifying both present and historic land uses and activities. Aerial photos may be available at your county seat, planning, or transportation office. They can also sometimes be obtained from the Corps of Engineers, Soil Conservation Service, or from a commercial aerial photographer (listed in your local phone directory). Other resources include the larger colleges or universities in Oregon. The University of Oregon in Eugene also has an extensive collection of aerial photos of most of Oregon in their Photogrammetric Library.

In collecting existing sources of information, the Team will want to also query the state resource agencies for data which may be available on the wellhead protection area. There are databases at the Department of Environmental Quality, Water Resources Department, State Fire Marshall, Emergency Management, Oregon Health Division, and the Department of Geology and Mineral Industries. These databases contain information on existing permits related to water quality, underground injection, hazardous waste, solid waste, underground storage tanks, air quality, water supply wells, and data on the toxic release inventory, and cleanup sites. **Appendix B** provides a description of what data is available and where to find it. Collecting this type of information prior to conducting any field work should make the field effort much easier.

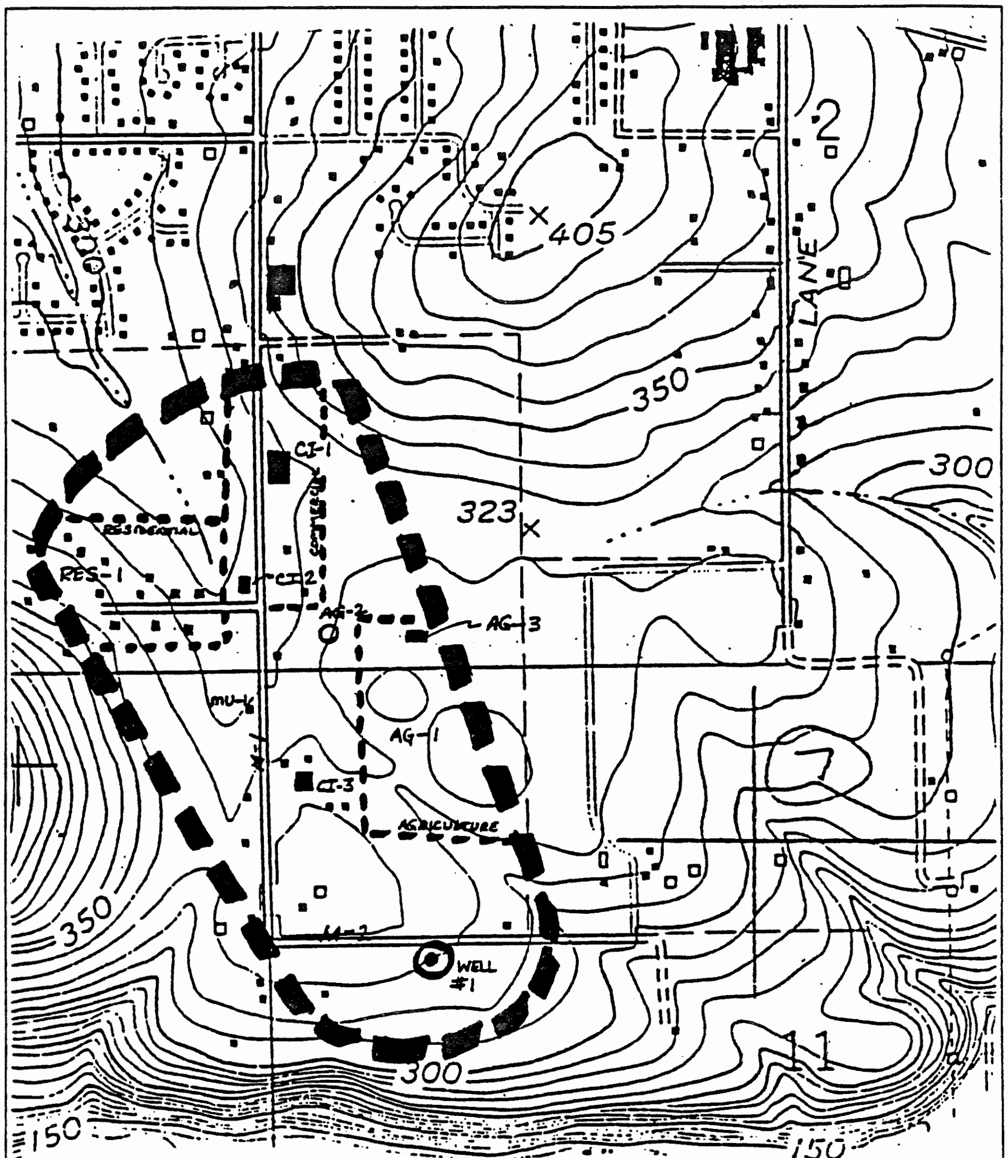
The level of effort necessary for collecting this information will vary according to the density of development. Older, larger communities may need to invest more time obtaining existing data and verifying it.

C. Divide the WHP area into different land uses:

To help structure the inventory approach, it is recommended that you divide your wellhead protection area into the following four land use categories:

- Residential/municipal;
- Commercial/industrial;
- Agricultural/rural;
- Other (sources common to all land uses).

A general land use overlay map can be prepared using the information gathered in Step 4B. This overlay map will help your Team establish the threat that land uses pose to the quality of your water supply. A good starting point for this map, if available, is your community's zoning map or current land use map, which allocates sections of your community for specific land uses, including residential, commercial, and industrial uses. These zones create concentrations of businesses or small industry. If these concentra-



Potential sources can be coded and cross-referenced to Form 3-1.		
Example codes:	CI	Commercial/Industrial
	AG	Agriculture/Rural
	RES	Residential
	MU	Municipal
	M	Miscellaneous
Land-use areas can be color-coded and labelled on the map.		

Figure 3-9: Example Inventory Map

tions are located in close proximity to your well(s), they can potentially increase the threat to your drinking water. Aerial photos may also be very useful for dividing the wellhead protection area into the general land use categories if a zoning map is not available for your community.

The land uses/zones in your wellhead protection area can be fine-tuned or updated as the volunteers conduct the actual inventory. This will also help to make your Team's management strategy or approach easier to develop.

D. Prepare an inventory form:

To adequately identify potential sources of contamination, it is useful to prepare a comprehensive inventory form. This will not only ensure a more consistent approach by the volunteers, but it will help prevent omissions of potential contaminant sources. DEQ recommends that you use **Form 3-1** provided below. This is considered to be a comprehensive list, although all potential sources of groundwater contamination are impossible to list. If the WHP area is subdivided and assigned to different individuals, this list can be copied to produce as many as are needed for volunteers to use. A final tally of each category can be conducted when they are compiled at the end of the inventory step.

The list in Form 3-1 can be expanded or adapted to more adequately apply to your particular wellhead protection area. This extensive list will not be appropriate for many of the drinking water sources in the rural areas of Oregon. It is recognized that there are significant variations in land uses and activities across the state, especially in agricultural activities. The Team may want to adapt this list to more adequately address their local area.

It is important to encourage the volunteers to use the "other" categories on the inventory form as often as needed when they are not sure what a particular land use or activity is. Identifying by address/location and a brief description of the observed activities will allow adequate follow-up if more information is necessary.

E. Conduct a windshield survey and plot the existing data:

The level of actual field reconnaissance or "windshield survey" will depend upon the complexity of your wellhead protection area. In some cases, the entire inventory can be performed by a very knowledgeable individual in the office without any field work required. However, most Teams/volunteers will need to conduct a windshield survey using the inventory form prepared in Step 4D. This simply involves driving through the wellhead protection area, field checking the locations of potential sources identified during the previous data collection Step 4B, and noting any new potential sources that are seen during the survey. Some of the important things to look for during the windshield survey include old gas stations (evidence of pump "islands"), lagoons or basins where water is ponding, locations of long-term machine/auto repair sites, and obvious storage areas for chemicals, pesticides, wastes, etc. The Team may want to re-visit these areas and conduct a more in-depth assessment. It may be helpful for any Team or volunteer member that conducts the windshield survey to review the Table 3-2 list of potential sources. This will help them become familiar with the fact that there are wide varieties of potential sources in virtually every community.

Other tools that can be used to collect information for the source inventory includes door-to-door surveys or mail surveys. This may be particularly useful, for example, in areas where there are many abandoned wells or septic tanks.

Any other approach or combination of approaches that help ensure an accurate and complete inventory will contribute toward the success of your wellhead protection plan. There are many potential contamination sources that are difficult to identify. The Team can get additional technical assistance or information about conducting their inventory from DEQ.

It is important to recognize that local jurisdictions may not have the authority to access or inspect potential sources/facilities. Be sure to gain the property owners permission for access before entering the property for purposes of an inventory.

The primary objective of Step 4 is to prepare a map with the locations of potential sources. Using the detailed base map developed in Step 4A, plot the potential sources as accurately as possible. Figure 3-9 provides an example inventory map with potential sources, as well as the land uses, identified with numbers or codes keyed to the inventory list. Your potential source map will serve as the basis for developing your management strategy. **Appendix C** contains other actual inventory forms and maps from Oregon Communities.

F. Rank the estimated risks or threats:

The last step in the inventory process is to determine which of those potential contamination sources pose the greatest threat to your water supply. Classifying potential sources

Form 3-1
Wellhead Protection Inventory Form

Public Water System/Area: ______________________________

Survey Conducted by: ______________________ Date: ______________

Commercial/Industrial		Key/Number
Automobiles	Body Shops (H)	
	Car Washes (M)	
	Gas Stations (H)	
	Repair Shops (H)	
Boat Services/Repair/Refinishing (H)		
Cement/Concrete Plants (M)		
Chemical/Petroleum Processing/Storage (H)		
Dry Cleaners (H)		
Electrical/Electronic Manufacturing (H)		
Fleet/Trucking/Bus Terminals (H)		
Food Processing (M)		
Furniture Repair/Manufacturing (H)		
Hardware/Lumber/Parts Stores (M)		
Home Manufacturing (H)		
Junk/Scrap/Salvage Yards (H)		
Machine Shops (H)		
Medical/Vet Offices (M)		
Metal Plating/Finishing/Fabricating (H)		
Mines/Gravel Pits (H)		
Office Buildings/Complexes (L)		
Parking Lots/Malls — >50 Spaces (H)		
Photo Processing/Printing (H)		
Plastics/Synthetics Producers (H)		
Research Laboratories (H)		
RV/Mini Storage (L)		
Wood Preserving/Treating (H)		
Wood/Pulp/Paper Processing and Mills (H)		
Others (list)		

Agricultural/Rural		Key/Number
Auction Lots (H)		
Boarding Stables (M)		
Confined Animal Feeding Operations (CAFOs) (H)		
Crops — Irrigated (M)*	Berries, Hops, Mint, Orchards, Vineyards, Nurseries	
	Greenhouses, Vegetables	
Crops — Nonirrigated (L)	Christmas Trees, Grains, Grass Seeds, Hay, Pasture	
Farm Machinery Repair (H)		
Grazing Animals (>5 large animals or equivalent per acre) (M)		
Homesteads — Rural	Machine Shops (H)	
	Septic Systems (L)	
Lagoons/Liquid Wastes (H)		
Land Application Sites (M)		
Pesticide/Fertilizer/Petroleum Storage, Handling, Mixing, & Cleaning Areas (H)		
Others (list)		

* Drip — Irrigated crops, such as vineyards and some vegetables, are considered lower risk (L).

LEGEND:

Suggested ranking of potential contaminant sources; see Table 3-3 for separate category lists.

H = Higher Risks   M = Moderate Risks   L = Lower Risks

Form 3-1
Wellhead Protection Inventory Form
(Continued)

Public Water System/Area: ______________________________

Survey Conducted by: ______________________ Date: ______________

Residential/Municipal	Key/Number	Miscellaneous		Key/Number
Airports – Maintenance/Fueling Areas (H)		Above Ground Storage Tanks (M)		
Apartments and Condominiums (L)		Construction/Demolition Areas (M)		
Campgrounds/RV Parks (L)		Historic Gas Stations (H)		
Drinking Water Treatment Plants (M)		Historic Waste Dumps/Landfills (H)		
Fire Stations (L)		Injection Wells/Drywells/Sumps (H)		
Golf Courses (M)		Managed Forests (M)		
Housing – High Density – > 1 House/.5 Acres (M)		Military Installations (H)		
Landfills/Dumps (H)		Surface Water – Streams/Lakes/Rivers (L)		
Motor Pools (M)		Transportation Corridors	Freeways/State Highways (M)	
Parks (M)			Railroads (M)	
Railroad Yards/Maintenance/Fueling Areas (H)			Right-of-Ways – Herbicide Use Areas (M)	
Schools (L)		Underground Storage Tanks	Confirmed Leaking Tanks – DEQ List (H)	
Septic Systems – High Density – > 1/Acre (H)			Decommissioned – Inactive (L)	
Utility Stations – Maintenance Areas (H)			Non-Regulated Tanks – < 1100 gallons (H)	
Waste Transfer/Recycling Stations (M)			Not Yet Upgraded or Registered Tanks (H)	
Wastewater Treatment Plants/Collection Stations (M)			Upgraded and/or Registered – Active (L)	
Others (list)		Wells (H)		
		Random Dumpsites (M)		
		Sludge Disposal Areas (M)		
		Others (list)		

LEGEND:

Suggested ranking of potential contaminant sources; see Table 3-3 for separate category lists.

H = Higher Risks M = Moderate Risks L = Lower Risks

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into general risk categories will be the simplest way to determine which sources pose the greatest threat. Identifying the high risk threats will provide input for developing a management strategy based on prioritized areas or individual sources.

Values of risk can be assigned to each potential source according to, for example:

- The site-specific susceptibility of the groundwater resource,
- Potential contaminant characteristics (such as transport processes, mobility, toxicity, and type of release),
- The degree of state and local regulatory control over the activity/land use, and/or
- Historic data on the frequency of release from the particular type of activity or land use that you are evaluating.

For a densely developed or complex area, the Team could employ a fairly sophisticated method of ranking potential sources. EPA (1991) developed a risk screening tool to assess and rank the relative threats to groundwater supplies posed by potential contamination sources in 13 different major source categories. A risk score is calculated for each potential contaminant based on the likelihood and severity of well contamination. Scoresheets, datasheets, and forms are provided for use in the scoring process. Although this could provide an excellent tool for ranking individual risks, DEQ does not anticipate that this level of evaluation is necessary for most public water systems in Oregon.

DEQ has used Oregon-specific data, as well as EPA guidance, to develop a list of types of potential sources in each risk category. Table 3-3 provides a list in each higher, moderate, and lower risk categories. In this table, the criteria for placement in the specific categories was limited to historic release data such as (EPA, 1990b; DEQ, 1995), DEQ regulatory control data (Ross, 1994), and potential contaminant characteristics (DEQ, 1995; EPA, 1994). The most common types of facilities that are on the active DEQ cleanup list, for example, are considered higher risks to groundwater.

An essential assumption that must be made when considering **potential** risks to groundwater is that the facility or activity does not now or may not in the future employ good management practices or pollution prevention. This is important because it is the potential risk that we are attempting to determine. Ideally, most of these activities are conducted in a manner that minimizes the risk of a spill or "release" that could result in soil and groundwater contamination, threatening your water supplies. This is obviously one of the goals of developing a wellhead protection plan.

Your Team may want to make modifications to the risk categories in Table 3-3 based on local conditions, knowledge of operating practices, etc.

Keep in mind that the overall success of your WHP Plan is largely dependent upon identifying the potential sources and determining in the management step what, if any, practices should be employed to reduce the risks from these sources. During the management step, the Team will make more detailed assessments of the potential sources and the site-specific practices that may enable you to move many of the higher or moderate risks to the lower category. This can reduce the need for any management efforts for those facilities or activities that are employing good management practices.

- ***Inventory References:****

DEQ, 1995. Waste Management and Cleanup Division, *Environmental Cleanup Site Information (ECSI) Database*, Oregon Department of Environmental Quality.

EPA, 1990a. *Handbook, Ground Water*, "Volume I: Ground Water and Contamination", EPA 625/6-90/0162, Office of Research and Development, Washington D.C. September 1990.

EPA, 1990b. *A Review of Sources of Ground Water Contamination from Light Industry*, EPA 440/6/9/005, Office of Water, Washington D.C., May 1990.

EPA, 1991. *Managing Ground Water Contamination Sources in Wellhead Protection Areas: A Priority Setting Approach*, EPA 570/9-91/023, Office of Water, Washington D.C., October 1991.

EPA, 1993. Seminar Publication, *Wellhead Protection: A Guide for Small Communities*, EPA/625/R-93/002, Office of Research and development, Washington D.C., February 1993.

EPA, 1994. Handbook, *Ground Water and Wellhead Protection*, EPA/625/R-94/001, Office of Research and development, Washington D.C., September 1994.

OTA, 1984. *Protecting the Nation's Groundwater from Contamination*, Vols. I and II, OTA-0-233 and -276, The Office of Technology Assessment, Washington D.C.

Ross and Assoc., 1994. *Enhancing Technical Assistance and Pollution Prevention Initiatives at the Oregon Department of Environmental Quality*, Ross and Associates, April 1994.

**EPA documents can generally be obtained free of charge from EPA by calling 513-489-8190.*

Table 3-3: Ranking The Potential Contaminant Sources*

Commercial/Industrial		Agricultural/Rural	Residential/Municipal	Miscellaneous	
Higher Risks					
Automobile	Body Shops	Auction Lots	Airports — Maintenance/Fueling Areas	Historic Gas Stations	
	Gas Stations	Confined Animal Feeding Operations (CAFOs)	Landfills/Dumps	Historic Waste Dumps/Landfills	
	Repair Shops	Farm Machinery Repair	Railroad Yards/Maintenance/Fueling Areas	Injection Wells/Drywells/Sumps	
Boat Services/Repair/Refinishing		Machine Shops	Septic Systems — High Density — > 1/Acre	Military Installations	
Chemical/Petroleum Processing/Storage		Lagoons/Liquid Wastes	Utility Stations — Maintenance Areas	Underground Storage Tanks	Confirmed Leaking Tanks (DEQ List)
Chemical/Petroleum Processing/Storage		Pesticide/Fertilizer/Petroleum Storage, Handling, Mixing, & Cleaning Areas			Non-Regulated Tanks — < 1,100 Gallons)
Dry Cleaners					Not Yet Upgraded or Registered Tanks
Electrical/Electronic Manufacturing				Wells	
Fleet/Trucking/Bus Terminals					
Furniture Repair/Manufacturing					
Home Manufacturing					
Junk/Scrap/Salvage Yards					
Machine Shops					
Metal Plating/Finishing/Fabricating					
Mines/Gravel Pits					
Parking Lots/Malls — > 50 Spaces					
Photo Processing/Printing					
Plastics/Synthetics Producers					
Research Laboratories					
Wood Preserving/Treating					
Wood/Pulp/Paper Processing and Mills					

Table 3-3: Ranking The Potential Contaminant Sources* (Continued)

Commercial/Industrial		Agricultural/Rural		Residential/Municipal	Miscellaneous	
Moderate Risks						
Automobile	Car Washes	Crops — Irrigated**	Berries, Hops, Mint, Orchards, Vineyards, Nurseries	Drinking Water Treatment Plants	Above Ground Storage Tanks	
Cement/Concrete Plants			Greenhouses, Vegetables	Golf Courses	Construction/Demolition Areas	
Food Processing		Boarding Stables		Housing — High Density — >1 House/0.5 Acres	Managed Forests	
Funeral Services/Graveyards		Land Application Sites		Motor Pools	Random Dumpsites	
Hardware/Lumber/Parts Stores				Parks	Sludge Disposal Areas	
Medical/Vet Office				Waste Transfer/Recycling Stations	Transportation Corridors	Freeways/State Highways
				Wastewater Treatment Plants/Collection Stat's.		Railroads
						Right-of-Ways—Herbicide Use Areas
Lower Risks						
Office Buildings/Complexes		Crops — Nonirrigated	Christmas Trees, Grains, Grass Seeds, Hay, Pasture	Apartments and Condominiums	Surface Water — Streams/Lakes/Rivers	
RV/Mini Storage		Septic Systems — Low Density — <1/Acre		Campgrounds/RV Parks	Underground Storage Tanks	Decommissioned — Inactive
				Fire Stations		Upgraded and/or Registered — Active
				Schools		

* Facility-specific management practices are not taken into account in estimating risks and assigning these categories.

** Note: Drip-irrigated crops are considered lower risks.

3.5 STEP 5

3.5.1 Develop Management Approach

After inventorying the potential sources within the delineated wellhead protection area, you are ready to address those potential risks to your water supply. The primary goal of the management phase of Oregon's Wellhead Protection Program is to reduce the risk of groundwater contamination from potential contaminant sources. It is highly improbable that you can eliminate all risks in the WHPA, but by applying one or more management tools where you determine it is appropriate, you will be able to reduce the likelihood of groundwater contamination impacting your water supply in the future.

One of the key underlying philosophies used in developing this program and guidance manual has been that one of the most effective ways to achieve resource protection will be by developing public/private partnerships. It is recognized that a stronger regulatory or "command-and-control" approach is not necessary to achieve protection of your water system. Although some of the proposed management tools in this section refer to existing regulatory programs, it is the advisory committee's and state agency's opinions that groundwater protection within the wellhead protection areas can best be accomplished by the RMAs developing partnerships with local business, industry, and the agricultural community and focusing on educational/training and pollution prevention concepts.

In Step 4 (Section 3-4), a "source" was defined as a location where there is any activity having the potential to release one or more contaminants into groundwater at a concentration of concern. Any source within your wellhead protection area can be assumed to pose a risk of contamination and possible loss of your water supply. Due to limited resources both at the state and local levels, however, it may be necessary to focus your efforts only on the sources which pose the most significant risks.

The first step in developing your management plan will be to screen out those sources which pose little to no risk to groundwater. Next you will consider the site-specific natural characteristics in your wellhead protection area in an attempt to further reduce the number of sources that need to be addressed. In this process, you will screen out any zones that have an inherently low susceptibility to contamination.

This section will also provide a resource list of general management tools that can be used for the entire wellhead protection area, then specific tools for each land use category or type of potential source(s).

- ***Groundwater Protection Basics:***

Since groundwater can be affected by a wide variety of human activities and sources, a comprehensive groundwater protection program incorporates many different components. We can generally categorize the various components of a groundwater protection program into three areas:

1. Pollution prevention/best management practices (BMPs).
2. Regulatory permitting/project review.
3. Land use controls or restrictions.

The first (and perhaps most important) general category of groundwater protection program elements includes **pollution prevention or best management practices**. Pollution prevention is the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous and nonhazardous materials, energy, water, or other resources as well as those that protect natural resources through conservation or more efficient use. The *Federal Pollution Prevention Act* of 1990 established pollution prevention as a "national objective", recognizing that there are significant opportunities for industries (in particular) to reduce or prevent pollution at the source through cost-effective changes in production, operation, and raw materials use. For example, basic pollution prevention concepts are applied in implementing the Oregon Toxics Use Reduction and Hazardous Waste Reduction Program, which has been in effect since 1989. As will be discussed in more detail later in this section, there are extensive resources available for local governments to use in encouraging pollution prevention concepts to be applied within wellhead protection areas.

Best management practices (BMPs) are typically actions developed for specific operations associated with agriculture and industry that serve to reduce hazardous material usage or risks of release. The term "BMP" is generally used to describe operational practices, such as good housekeeping and spill prevention, or source control practices, such as designing a storm water system that prevents contact with pesticides or hazardous materials. Encouragement of implementation of BMPs through free technical assistance or training may be one very effective tool for local governments to use in reducing the risks of groundwater contamination in wellhead protection areas.

Efforts at the local level to recognize businesses that employ environmentally sound practices and encourage consumers to support those businesses contributes significantly to the success of this program (see subsection "Pollution Prevention Recognition").

Although the wellhead protection program initiated under the federal *Safe Drinking Water Act* (SDWA) was developed to be an active groundwater contamination prevention program, most of the other existing groundwater-related mandates rely upon responses to contamination events. One preventative approach that is incorporated into the existing regulatory programs, however, is **permitting or project review**. The regulatory permitting and project review approach is implemented through federal, state, and local laws. Technical standards are generally used to establish and ensure compliance with permitted discharges to air, soil, and water. Project reviews are conducted as part of environmental impact evaluations required by federal laws and local planning requirements. Permitting and project review can affect the siting, design, construction, operation, and closure of facilities such as buildings, above and underground storage tanks, treatment plants, landfills, and transportation corridors.

Groundwater protection accomplished through the regulatory approach involves many federal and state agencies, laws, and rules. There are six primary federal laws which are designed to help protect groundwater quality by setting standards or permitting uses and activities. The *Safe Drinking Water Act* set maximum contaminant levels in drinking water and established flexible protection programs. The *Clean Water Act* (CWA) sets standards for allowable pollutant discharges to surface water or groundwater. The *Resource Conservation and Recovery Act* (RCRA) regulates transport, storage, treatment, and disposal of hazardous and solid wastes. The *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA, or Superfund) regulates cleanup of contamination from hazardous wastes. The *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA) regulates pesticide use. The *Toxic Substances Control Act* (TSCA) regulates manufactured chemicals. The federal responsibility for implementing these groundwater-related laws rests primarily with the Environmental Protection Agency (EPA).

At the state level, Oregon has a network of laws and rules which are related to protection of groundwater quality. Four state agencies in Oregon administer the majority of the groundwater-related statutes and rules — the Department of Environmental Quality (DEQ), the Oregon Health Division (OHD), the Water Resources Division (WRD), and the Oregon Department of Agriculture (ODA). DEQ has the responsibility of implementing *Oregon's 1989 Groundwater Protection Act*, which focuses on statewide prevention of groundwater contamination, conservation of the resource, and maintaining its quality for present and future beneficial uses. The Act specifically calls for DEQ to implement a wellhead protection program. DEQ also administers regulations for the permitting, treatment, handling, and disposal of wastewaters, hazardous wastes and solid wastes. In addition, DEQ regulates underground storage tanks and injection wells.

OHD administers statutes and rules regulating the sources and quality of drinking water supplies as required by the federal *Safe Drinking Water Act*. OHD also conducts special studies in contaminated groundwater areas and provides public information associated with the health effects of various contaminants in the drinking water. WRD administers the statutes and rules governing well construction, usage, abandonment, and groundwater appropriation.

WRD also conducts extensive water supply, water quality, or water use investigations, issues permits, and takes administrative actions to prevent groundwater problems.

The Oregon Department of Agriculture (ODA), under recent statutes, now has the authority to develop and carry out Agricultural Water Quality Management Area Plans for agricultural and rural lands where any type of water quality management plan is required by state or federal law. Agricultural Water Quality Management Plans outline comprehensive measures that will be taken to prevent and control water pollution from agricultural activities and soil erosion on agricultural and rural lands located in a management area. ODA determines which areas require such a plan and establishes management area boundaries. ODA has the exclusive authority to regulate agricultural operations for prevention and control of water pollution. In some cases, wellhead protection areas may qualify as an area where such a plan will need to be developed. ODA also has the exclusive authority to regulate all activities related to the use and sale of pesticides in Oregon.

A summary of both federal and state environmental mandates relating to groundwater is included as **Appendix D** of this Guidance Manual. These regulations provide the basis of our existing groundwater protection efforts.

One of the tools available to local government in managing potential sources within the wellhead protection area is the review and/or inspection of regulated (locally-permitted) facilities for adequacy and compliance with permit requirements. This is an example of how existing regulations may be used to implement or improve a groundwater contamination prevention program. Another tool may be to restrict or prohibit specified products or activities within certain zones of the wellhead protection area. This can best be accomplished through the permit review process or special permit requirement. Permitting or project review can be a very effective tool for local governments to use in any kind of groundwater protection program. To the maximum extent possible, local governments should consider using existing statutes and regulations to implement wellhead protection in Oregon.

> ***NOTE:*** It is not DEQ's intention to change any permit requirements or standards within wellhead protection areas in Oregon. Any local jurisdiction, though, can use permit reviews or modifications in standards to achieve their goal of protecting groundwater by establishing an ordinance.

With some exceptions, **land use controls or restrictions** can be effective only to the extent that areas have not been developed. Nevertheless, for undeveloped areas, land use controls can be extremely effective in reducing the risk of groundwater contamination by restricting high-risk activities or limiting development densities in sensitive areas. Various examples of land use controls include comprehensive planning, land acquisition, and zoning overlays. Land use controls have been successfully used in Oregon as part of the statewide planning goals on conservation of farm lands, forest lands, natural resources, coastal resources, and policies on development.

Oregon's land use goals are implemented and enforced through local comprehensive planning. State law requires each city and county to have a comprehensive plan and implement zoning and land-development ordinances needed to put the plan into effect. Local governments do the planning, and the State of Oregon, through the Department of Land Conservation and Development (DLCD), reviews the proposed plans for consistency with the statewide planning goals and "acknowledges" or approves the plan. Local governments then administer the land-use regulations specified in their plan, including permitting, variances, and conditional uses.

As part of Oregon's Statewide Planning Program, when a wellhead protection area is delineated (and certified by OHD), it becomes a "Goal 5 Resource". DLCD has determined that Oregon's Wellhead Protection Program is an acceptable and recommended method of addressing those groundwater resources. DLCD is currently (as of May 1996) proposing revisions to OAR 660-23 that will specify that Goal 5 applies to those public water systems that have a service population greater than 10,000 or more than 3,000 service connections that choose to delineate, and then gain OHD's certification of the delineation. Goal 5 will also apply to those WHPAs which are delineated, certified, and are declared locally significant by the local government. A local government may declare locally significant wellhead protection areas only within its own jurisdiction. The wellhead protection program will be relied upon to address these groundwater resources. A DEQ-certified Wellhead Protection Plan will automatically serve to address any DLCD Goal 5 requirements.

For those communities that are developing a Wellhead Protection Plan to address the Goal 5 requirements, the following three topics need to be written as policy and included in your local government's comprehensive land use plan.

1. The factual base and/or background information relied upon in the development of the local wellhead protection plan;

2. A general statement of need, "...to protect public health and safety by minimizing contamination of the low/surficial aquifers...," and of the enabling authorities; and

3. Clear statement(s) of intent. The local government should clearly state the various choices that were made at each stage of the process of developing the local Wellhead Protection Plan. The specific type of local program that is chosen by the local government should also be stated in the policy. Such statements need to also specify any

future courses of action. These statements include, but are not limited to:

- Community objectives agreed to by the local government;
- Objectives and task of the local "Team";
- Any alternative approach to the voluntary wellhead protection program;
- A decision to seek OHD/DEQ Certification(s);
- Any aspects of the program that will be given major emphasis;
- Purpose and type of delineation;
- Specific method(s) of management.

For further information, refer to statewide Planning Goal 1, Citizen Involvement, Goal 2, Part 1, Planning, and local government's enabling authorities under ORS Chapter 97 (for cities), and ORS Chapter 215 (for counties) or by contacting Doug White or Diana Butts, DLCD in Salem (503-373-0083).

- ***Methodology:***

The methodology for accomplishing Step 5, development of the management approach, can be summarized as follows:

A. Screen out any **zones** within the wellhead protection area that have a low susceptibility to contamination by:

   - Conducting a susceptibility assessment using OHD's guidance (OHD, 1992), or
   - Using any other similar technique that incorporates site-specific data on the depth to the aquifer, hydraulic conductivity, infiltration potential, etc. to demonstrate that within certain zones in the wellhead protection area, the groundwater has a low susceptibility to contamination;

B. Screen out those potential **sources** that pose low risks to the groundwater by:

   - Verifying the lack of usage of potential contaminants at individual sources,
   - Verifying existing (and commitment to continue) usage of best management practices, and/or
   - Demonstrating adequate detection measures are in place;

C. Evaluate and consider choosing appropriate **general** management tools for all potential sources within the wellhead protection area;

D. Consider choosing appropriate management tools **specific** to a category or type of source within the wellhead protection area, such as:

   - Residential/municipal,
   - Commercial/industrial,
   - Agriculture/rural,
   - Miscellaneous sources (as listed in Step 4, Section 3.4).

A detailed description of each step is included below. It is not necessary to do any screening if you do not want to reduce the number of potential sources or the area to be addressed through this management plan. For example, screening may not be necessary for wellhead protection areas that include only one or two types of land uses. The screening for agricultural and rural lands will occur **after** their "on-farm assessment" (see Agricultural/Rural Management Options below). ***Skip the screening steps (A and B below) if you want to proceed to the selection of management options.***

A. Screen out any zones that have a low susceptibility to contamination.

As has been discussed previously, any source within your wellhead protection area can be assumed to pose a risk of contamination. The degree of that risk not only depends on the types of and operating practices of sources, but also on the susceptibility of the groundwater to contamination in any given area. An example of a very high susceptibility in an aquifer is a shallow water table aquifer overlain by coarse sands and gravels.

The easiest way to screen out any zones that may have a low susceptibility to groundwater contamination is to use a pre-developed procedure to determine the susceptibility. The Oregon Health Division (OHD) prepared a manual entitled "Guidance Manual for Monitoring Reduction Through A Use and Susceptibility Waiver", October 1992. The purpose of the document is to provide Oregon public water systems with the procedures for conducting a vulnerability assessment with respect to the synthetic organic chemical monitoring requirements as specified in the Phase II/V rule per 1986 Amendments to the *Safe Drinking Water Act*. The document has been revised (January 1996) and provides details of the required procedures for completing a use or susceptibility determination. This document can be obtained by calling OHD's Drinking Water Section at 503-731-4010.

If a susceptibility assessment is performed, a public water system may be able to not only substantially reduce the size of the wellhead protection area needing management, but also acquire a waiver from monitoring requirements for Phase II/V contaminants.

There are also other acceptable ways to screen out zones within the wellhead protection area based on aquifer susceptibility. A good discussion of the important factors involved in such an assessment can be found in "DRASTIC: A Standardized System for Evaluating Groundwater Pollution Potential Using Hydrogeologic Settings" by Aller et al., April 1987. This document can be obtained by calling 800-553-6847 and asking for information on Document No. PB87-213-914. DRASTIC is an example of a methodology which could be applied in a wellhead protection area to screen out low-susceptibility areas. DRASTIC was developed to evaluate the pollution potential of hydrogeological settings in the United States. It uses seven factors that combine with weights and ratings to produce a numerical value for ranking. The numerical value is then used to prioritize areas as to their groundwater contamination susceptibility.

B. Screen out potential sources with low risks:

Of the potential sources listed on your completed inventory form, only the moderate and higher risk sources need to be addressed in the management plan. **Notification shall be provided to the owner/operators of low-risk potential sources that they are located within the wellhead protection area, and the Notification should include any specific concerns.**

Local and state resources can then be directed to more serious potential problems in the wellhead protection areas, instead of addressing all risks.

There are many potential sources associated with Oregon business, industry, and agriculture where best management practices (BMPs) are already being used. In this context, we use the term "BMPs" to represent any waste reduction or prevention activity. Much of this has been accomplished because of individual property owners voluntarily seeking to incorporate these changes into their operations. Incorporating BMPs into an operation is generally accomplished through process or design changes, operational changes such as preventative maintenance, and employee training. The objectives (and subsequent benefits) of incorporating BMPs into the "way of doing business" can be summarized by the following:

1. Improved efficiency and organization,

2. Cost savings by reducing product usage or disposal amounts, and

3. Reduced liabilities associated with spills or releases to the environment.

Because of these benefits, many Oregon businesses, industries, and agricultural land owners have voluntarily incorporated BMPs into their operations.

BMP implementation in Oregon has also occurred as a result of the Toxic Use Reduction and Hazardous Waste Reduction (TURHWR) law requirements, technical assistance offered by DEQ's Toxics Use Reduction staff, DEQ's Pollution Prevention Program, and agricultural-related non-point-source programs, such as those coordinated by Oregon Department of Agriculture and the OSU Extension Service. The TURHWR law requires all businesses which use toxic materials to develop formal plans for reducing or eliminating the use of toxic substances and the generation of hazardous wastes. More information about this program can be obtained from DEQ by calling 503-229-5913 or 1-800-452-4011 and obtaining a TURHWR "Planning Guide" (DEQ, 1993). More information about the TUR technical assistance, the DEQ Pollution Prevention, Program, and agricultural BMPs will be provided in the Commercial/Industrial and Agricultural/Rural subsections below.

Any potential sources where BMPs for groundwater protection have been incorporated will not generally need any additional management attention. Your Team will need to check with the individual business owners and agricultural operators to determine if they are using established BMPs.

There are also Oregon businesses and agricultural operators that have never used, or have eliminated the use of, any potential contaminants in their operations. Your local Team will need to reliably document that there is no potential for groundwater contamination from facilities which do not use the potential contaminating substances; use Table 1-1 (Section 1.1) as a guideline. Since all facilities are required to have Material Safety Data Sheets (MSDS) records, a review of the MSDS records will indicate whether a facility uses any of these chemicals. These sources can be screened out as well, with no follow-up management effort needed in this program.

One additional way individual sources can be screened out is by verifying that there are adequate monitoring or detection measures in place to identify any groundwater contamination originating from a facility within the wellhead protection area. An example of this situation is where as a condition for an existing permit, a facility was required to install a network of monitoring wells upgradient and downgradient from their site, such as a solid waste landfill or an ongoing cleanup process at a facility. Recognize that monitoring wells are not a substitute for employing best management practices for any potential source. DEQ can assist in determining whether the monitoring program is considered adequate. If your Team verifies the active and adequate monitoring of the groundwater immediately downgradient of any potential source, you can screen out these sources as they most likely need no further management attention at the present time.

C. Evaluate and consider choosing appropriate general management tools for all potential sources within the wellhead protection area.

After screening out any low-risk potential sources and low-susceptibility zones within your wellhead protection area, your Team is ready to consider and select the management options for the various sources and land uses. We will begin with general management options that may be used for the entire area to be protected.

Examples of General Management Options

- Public Education;
- Installation of Signs;
- Water Conservation;
- Public/Private Partnerships;
- Hazardous Waste Collection (from small businesses and/or households);
- Spill Response Plans;
- Site Plan Reviews/Permitting;
- Zoning Ordinances;
- Groundwater Monitoring;
- Property Purchases;
- Septic System Upgrades;
- Septic System Cleaner Prohibition;
- Chemical Transport/Use Prohibition;
- Potential Source Restrictions.

Brief descriptions of each can be found in Table 3-4, along with phone numbers and references for more information.

One or more of these management tools can also be applied within certain distances from your well or wellfield. For example, you can create 6-month, 1-year, and 5-year time-of-travel (TOT) zones within the wellhead protection area and choose to apply different management strategies within each zone. A fairly common use of this approach includes a prohibition of hazardous wastes stored within a 6-month or 1-year TOT in the wellhead protection area.

D. Consider choosing appropriate management tools specific to the category or type of source within the wellhead protection area.

In Step 4 (Section 3-4), we recommended that you divide your wellhead protection area into the following four land use categories:

1. Commercial/Industrial;
2. Agricultural/Rural;
3. Residential/Municipal;
4. Miscellaneous.

If your wellhead protection area is divided into these categories, it will make your Team's management strategy easier to develop since **there are tools which can be applied most appropriately by land use category**. These will be discussed in this section. Each category will have a summary of the most common sources and contaminants, management tools, and resources for assistance.

One of the most important functions of your local wellhead protection Team is to ensure that the concerns of different segments of the community are addressed as you develop the management portion of the wellhead protection plan. DEQ recommends that the representative(s) from each of the commercial, agriculture, and residential, etc. segments review the options presented here and select the best tools for your particular community to use in protecting groundwater. It is important that each representative obtain public input and feedback as they select the option(s). In many cases, it may be beneficial to seek outside assistance in addressing specific issues in your community. For ex-

Table 3-4: General Management Tools Available for the Wellhead Protection Area

"Oregon Wellhead Protection's TOP DOZEN List"

1. **Public Education/Notification:**

It is highly recommended that every Team consider implementing this option within the wellhead protection area. Every effort should be made to contact all property owners within the wellhead protection area so they are aware of the need for protection measures. Consider coordinating one or more "Community Groundwater Protection Workshops" where information is available and presentations are made to inform local residents of the connection between drinking water quality and activities on the land surface. DEQ and OHD can provide technical assistance or presentations at any workshop you wish to host. You may want to work with your local newspaper to reach others in a public education effort with public service ads, maps, and data. The DEQ Wellhead Protection Program (503-229-5279) can provide literature for distribution, as well as some excellent examples of ads and brochures.

FOCUS for educational effort:

- Basic information about groundwater and the relationship between surface activities and groundwater quality.
- Familiarity with the location of the protected area.
- Basic information on sources of contamination.
- Effective strategies for safe management of all potentail contaminants.

2. **Sign Installation:**

Information signs should be placed adjacent to all roadways entering the wellhead protection area. The signs should include the name of the water system or jurisdiction along with a phone number where callers can obtain more information. Example sign:

> **Be Careful With Our Drinking Water!**
> You are entering
> Anytown Groundwater Protection Area
> Call XXX-XXXX
> for more information.
> **(Call 911 to report any spills.)**

3. **Water Conservation Program:**

Implementing water conservation measures in your community can significantly benefit wellhead protection efforts by reducing the pumping rates. Lower pumping rates mean reduced flow rates and less risk of moving any contamination. Conserving water may also help reduce the need for additional water sources in the near future. Water conservation can be accomplished through steps such as distribution of flow control devices, retrofitting high-flow toilets and washing machines, and recycling wastewater. Information on developing a water conservation program can be obtained from the Municipal Water Conservation Specialists at the Oregon Water Resources Department, 503-378-8455, Ext. 283.

4. **Public/Private Partnerships:**

It is highly recommended that the RMA (or public jurisdictions) seek partnerships with the private business, commercial, and industrial communities within the wellhead protection area. These public/private partnerships can involve setting up a process for collaboration and finding common goals, such as maintaining low cost clean drinking water, encouraging best management practice applications, and continued economic prosperity in the region. Mutual benefits may include maximizing pollution prevention implementation in the community, public recognition of "green businesses", etc.

5. **Hazardous Waste Collection:**

Establishing a permanent location or holding one-day events to collect hazardous wastes from community residents (both small businesses and households) is a very effective way to reduce risks posed by storing hazardous wastes within the wellhead protection area. This would be a very important element of a local plan addressing any areas with septic tanks as it would potentially reduce the amount of household hazardous wastes dumped into the drains and toilets. More information can be obtained from DEQ's Waste Management and Cleanup Division at 503-229-5913; ask for assistance with household hazardous waste collection. (More information on Household Hazardous Waste will be provided in the Residential/Municipal management section below as well.)

6. **Spill Response Plans:**

In addition to addressing spill response procedures as part of the contingency plan (Step 6 – Section 3-6), jurisdictions within wellhead protection areas could develop specific spill response procedures to allow quicker response and notifications should a hazardous material spill or release occur within the wellhead protection area. These can be integrated into your county's Emergency Management Plan. Emergency Management Plans are

"Oregon Wellhead Protection's TOP DOZEN List"

6. **Spill Response Plans:** (Continued)

required for Oregon counties, but are optional for cities. The Oregon Emergency Management (OEM) staff can help with the development of spill response plans, can help you locate your county's coordinator, and let you know if your county has an existing approved emergency plan. OEM can be reached at 503-378-2911 in Salem.

7. **Zoning/Health Ordinances:**

There are many different types of zoning tools. Your community can identify the wellhead protection area with an overlay map, then potentially use a special permitting requirement to monitor new building applicants and some chemical uses. Alternatively, your Team may want to develop a public health ordinance that minimizes the risk of contaminating the public water supply. **Appendix E** of this document contains a sample ordinance from a small community using an overlay approach to create a wellhead protection district. EPA also compiled an extensive set of sample ordinances from communities across the country. Information about the "Wellhead Protection Compendium of Ordinances" can be obtained by contacting DLCD at 503-373-0050 in Salem.

8. **Groundwater Monitoring Program:**

Collecting data from existing monitoring/supply wells or from newly installed wells can help your community detect any contaminants that may threaten the water supply in the near future. This is especially useful downgradient of the higher-risk sources in the wellhead protection area. Use the resources listed in **Appendix B** of this document to help you locate any wells and active groundwater cleanup sites in the area. You will need to contact DEQ (503-229-5913) and WRD (503-378-8455) for this information.

9. **Property Purchase/Donation Program:**

Community ownership of as much as possible of the land within the wellhead protection area obviously provides some of the best assurances of long-term protection of the public water supply. Protection could be provided by ownership accomplished through methods such as capital or bond fund programs, or through easements and deed restrictions. Acquisitions of land could also be coordinated through private non-profit land conservation organizations in Oregon such as River Network (503-241-3506), Nature Conservancy (503-228-9561), Trust for Public Land (503-228-6620) or local land trusts in your area. These organizations can assist you in acquiring land within your wellhead protection area by conveyance to a trust, seeking donations, or direct land purchases for conservation.

10. **Septic System Upgrades/Maintenance Program:**

Septic systems are discussed in more detail in the Residential/Municipal subsection below. Septic systems are very common sources of nitrate contamination in groundwater. Many areas of Oregon already have nitrate contamination problems. If your wellhead protection area contains high-density areas (>1 septic system/acre) of septic, you may want to initiate an effort to upgrade these, or at least implement a voluntary or mandatory program for maintenance. For example, septic systems should be pumped out every 2–3 years for proper functioning. We would also highly recommend that you consider implementing a septic tank cleaner ban or prohibition within your wellhead protection area. Most septic system cleaners contain solvents which are extremely threatening to your groundwater quality. Any ban on these substances would need to have an educational component associated with it since it will likely be very difficult to enforce, so you'll need to count on voluntary compliance. Information on septic systems and maintenance can be obtained by calling DEQ's Water Quality Division at 503-229-5279.

11. **Special Chemical Use/Transport Prohibition:**

Another general tool for your consideration may be a prohibition of the use or transport of high risk chemical compounds which produce severe groundwater contamination if released into the environment. Compounds called dense non-aqueous phase liquids (DNAPLS) are generally considered to cause irreversible groundwater contamination when they are released into groundwater. Examples of DNAPLS commonly used in Oregon include solvents such as trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1,1-trichlorethane (TCA), vinyl chloride, chlorobenzene, and wood-preservatives such as pentachlorophenol (PCP). These compounds have already been detected in over 80 public water systems in Oregon. Control and/or treatment is typically very expensive for local jurisdictions to address. Your Team may want to consider a threshold amount for the prohibition (such as one gallon) or limiting the implementation of the prohibition to a certain distance from your supply well(s) (such as 2,000'). The DEQ Wellhead Protection Program staff (503-229-5279) can work with any local jurisdiction to assist in developing a site- specific chemical use prohibition plan. ***NOTE:*** Any potential restrictions related to pesticides on properties not owned by the jurisdiction must be administered by the Oregon Department of Agriculture (503-378-3810).

12. **Potential Source Restrictions:**

Local communites may also want to consider establishing and implementing restrictions on the placement of some high-risk potential contaminant sources such as underground storage tanks, dry wells, sumps, injection wells, lagoons, and/or landfills within the wellhead protection area.

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ample, the agricultural representative may want to consult with the local Extension Service and others to help them obtain the best information on any improvements in practices that apply to their site-specific conditions. Many types of industries or commercial establishments also have state or local associations which have already developed pollution prevention tools that apply specifically to that business, such as the dry cleaning industry. Efforts should be made to identify as many of these resources as possible.

Commercial/Industrial Management Options

The commercial and industrial facilities in your wellhead protection area are generally the most highly regulated of any land uses. However, even facilities that are required to have permits for building, material, storage, or waste discharge cannot be assumed to pose no risks to groundwater. The majority of other regulations applicable to commercial and industrial facilities rely upon responses to contamination events, rather than on preventing problems. In your management efforts working with the commercial and industrial facilities, the focus will primarily be on PREVENTION of groundwater contamination.

There are many ways to achieve your goal of raising awareness of the need for protection, and facilitating any potential changes in the day-to-day operations at the existing businesses in order to reduce the risks of groundwater contamination.

Given adequate background information, free technical assistance, and community support, most businesses will voluntarily participate in groundwater protection efforts. We have not attempted to offer tools specific to individual types of businesses, although these are available through DEQ's existing programs. This section will highlight those existing programs related to commercial/industrial activities and groundwater protection, specifically DEQ's pollution prevention and waste reduction programs, as well as provide some handouts for potential use in your wellhead protection efforts.

Led by the commercial/industrial representative(s), your local Team can choose one or more of the following options for management of commercial and industrial facilities:

For all types of commercial/industrial sources:

1. ***Encourage participation in pollution prevention and waste reduction activities offered through Oregon DEQ.***

To facilitate implementation of wellhead protection in your community, your Team should consider utilizing the **existing** resources and programs which can reduce the risks of groundwater contamination. Oregon DEQ has several established programs that can be extremely useful in your management efforts for commercial and industrial facilities located within the wellhead protection area. A significant amount of groundwater protection is already (directly and indirectly) accomplished in Oregon businesses through DEQ's Pollution Prevention Program and the implementation of the Toxics Use Reduction and Hazardous Waste Reduction (TURHWR) law requirements, with technical assistance offered by DEQ's Toxics Use Reduction staff.

Pollution prevention is the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous and nonhazardous materials, energy, water, or other resources as well as those that protect natural resources through conservation or more efficient use. The Federal Pollution Prevention Act of 1990 established pollution prevention as a "national objective", recognizing that there are significant opportunities for businesses to reduce or prevent pollution at the source through cost-effective changes in production, operation, and raw materials use. **Appendix F** of this document contains an introduction to pollution prevention concepts, as well as a list of resources available to businesses or your Team in identifying specific pollution prevention applications for individual facilities.

Oregon DEQ recently commissioned a study of how to enhance pollution prevention and technical assistance initiatives by the agency (Ross & Assoc., 1994). The report provides a good summary of the existing efforts by DEQ to promote pollution prevention. The primary program areas in which these initiatives have been implemented include: toxics use and hazardous waste generation; enforcement; air quality; water quality; and solid waste. Additional information on any of the following pollution prevention applications at DEQ can be found in the Ross & Associates (1994) report or by calling DEQ's Waste Management and Cleanup Division at (503) 229-5913.

Pollution Prevention Planning Requirements: The Toxics Use Reduction and Hazardous Waste Reduction (TURHWR) law of 1989 requires all businesses which use toxic materials to develop formal plans for reducing or eliminating the use of toxic substances and the generation of hazardous wastes. As of 1994, DEQ has a compliance rate of 83 percent (of 2250 facilities) self-certifying that the plan or progress report has been completed. More information about this program can be obtained from the TURHWR "Planning Guide" (DEQ, 1993). Through the planning process, facilities may discover opportunities to pursue pollution prevention or realize the benefits of pollution prevention of which they previously were unaware. This knowledge increases the likelihood that prevention will occur. DEQ also requires pollution prevention planning under the Oil Spill Prevention Plan focused on cargo ships, oil tankers, and oil storage facilities.

Technical Assistance: Technical assistance, when incorporating information on pollution prevention techniques, philosophy, or technologies, can lead to a wider awareness and adoption of pollution prevention techniques. Technical assistance provided by the Toxic Use Reduction (TUR) staff at DEQ primarily promotes pollution prevention by directly recommending lesser polluting practices. This is a free service provided by the agency. More information on this program can be obtained by calling DEQ's Waste Management and Cleanup Division at (503) 229-5913. The Construction Industry Multimedia Pilot Project is also oriented around utilizing technical assistance to address a potential environmental problem. The construction industry project has combined information on the industry's regulatory obligations across all media programs with information on pollution prevention alternatives to simplify compliance and promote prevention (see the Environmental Handbook for Oregon Construction Contractors, 1994). Technical assistance is also provided through outreach from the Groundwater and Surface Water Nonpoint Source Programs and this Wellhead Protection Program.

Financial Incentives: A variety of mechanisms exist to reduce financial expenditures associated with pollution prevention. These include low interest loans, tax credits, and direct subsidies. DEQ utilizes a variety of financial incentives to promote UST upgrades and maintenance (including tax credits, grant, and loan guarantees). Information on the UST program can be obtained by calling DEQ's UST Helpline at (800) 742-7878. Additionally, the Environmental Crimes Act provides an indirect financial incentive by lowering the potential fines and/or liability related to improper practices discovered during a self-imposed environmental audit. Enforcement efforts across all DEQ media programs have recently become subject to a new Oregon environmental crimes statute that allows firms to declare information collected during self-imposed environmental audits "privileged", and thus off-limits in enforcement. This Act helps remove a major disincentive to firms evaluating their practices for potential improvements, including, but not limited to, pollution prevention. More information on this issue can be obtained by calling the DEQ enforcement group at (503) 229-5528.

Pollution Liability: The existing liability for cleaning up any hazardous wastes released or spilled into the environment creates incentives for minimizing risks of groundwater contamination. Measurable reduction in a facility's risks can be achieved through pollution prevention. Any unit of reduction in toxics used or wastes generated is a unit not creating potential liability. Sources which may have spills or releases in the future have been awakened to the need to reduce liability by DEQ and EPA mandating cleanups through federal and state cleanup requirements. Local communities are encouraged to become familiar with DEQ's records and cleanup activities in their area. More information on Oregon's cleanup program can be obtained by calling DEQ's Waste Management Division at (503) 229-5913 or (800) 452-4011.

Disclosure of Release Data: Making pollutant release data available to the public has generated awareness and concern and hence increased the willingness of Oregon businesses to incorporate pollution prevention. DEQ has not implemented initiatives utilizing release data to leverage public concern around specific pollution sources, though the state as a whole has through the Toxic Release Inventory (TRI) process administered by the State Fire Marshal. Information on the TRI process can be obtained by calling the Fire Marshal's office in Salem at (503) 378-3473, Ext. 233.

Fees/Taxes: Fees and taxes can be tied to amounts of pollutant releases, or toxic/hazardous inputs to operating processes. Tying fees and taxes to the amount of pollution created provides a continuous incentive for further reductions in pollution levels. DEQ's Hazardous Waste Generation and Management Fee serves as both a disincentive to waste generation and as an incentive to manage waste in an environmentally preferable manner.

Pollution Prevention Recognition: Officially recognizing environmentally friendly behavior can make pollution prevention a more attractive choice to facilities, as well as help environmentally concerned consumers influence manufacturer's practices. These goals can be accomplished through awards programs, certification programs, green market efforts, labeling requirements, etc. DEQ uses a state-wide recognition in its annual Toxics Use Reduction award event, recognizing significant achievement in the reduction of toxic materials used in operating processes and practices.

Bans: Banning a substance or polluting practice is the "ultimate pollution prevention signal", and is an extreme approach to solving environmental problems. Due to their overreaching impact and rigidity, bans are usually reserved for extremely dangerous or detrimental practices, or for hazardous/toxic substances or practices for which substitutes are readily available. DEQ's use of bans includes the Statewide Phosphate Detergent Ban designed to improve water quality.

2. ***Distribute information on general best management practices that are applicable to the majority of your potential commercial/industrial sources on ways to achieve groundwater protection.***

Best management practices are typically actions developed for specific operations associated with agriculture and industry that serve to reduce hazardous material usage or risks of release. Incorporating best management practices into an operation is generally accomplished through process or design changes, operational changes such as preventative maintenance, and employee training. The objectives (and subsequent benefits) of incorporating best management practices into the "way of doing business" can be summarized by the following:

- Improved efficiency and organization,
- Cost savings by reducing product usage or disposal amounts, and
- Reduced liabilities associated with spills or releases to the environment.

There are many best management practices that are applicable to a wide range of types of commercial and industrial operations since the majority of commercial and industrial operations utilize storage facilities, drains, or dry wells, etc. Table 3-5 summarizes some of these best management practices.

3. ***Send out individual letters with informative attachments about resources available to identify best management practices for specific facilities.***

Appendix G of this manual is a sample letter to a property owner or operator within the wellhead protection area. The purpose of the letter is to tell them that they are located in the wellhead protection area and ask that they take voluntary actions to protect groundwater in this area. Attached to the letter is some general information about the Waste Reduction Assistance Program at Oregon DEQ and a list of free resources.

4. ***Host informative meetings with the leaders of the local business community to raise awareness of the need for groundwater protection.***

Oregon DEQ would be glad to work directly with local businesses, the Association of Oregon Industries, or any other organization in developing materials and a presentation for your local business community. This can be coordinated through the Wellhead Protection Program by calling (503) 229-5279.

5. ***Establish a recognition program for businesses that take voluntary actions to protect groundwater.***

6. ***Facilitate employee training workshops to raise awareness of groundwater and potential impacts from mismanagement of hazardous wastes.***

7. ***Any other approach that the local Team agrees will achieve your goals.***

Commercial/Industrial Resource List

Center for Economics Research — Research Triangle Institute, *Pollution Prevention Resource Guide for Supporting CAA Regulatory Development - Final Report*, Research Triangle Park, NC, United States Environmental Protection Agency, September 1993.

Oregon Department of Environmental Quality, *Benefiting from Toxic Substance and Hazardous Waste Reduction: A Planning Guide for Oregon Businesses*, Portland, OR, Oregon Department of Environmental Quality — Waste Reduction Assistance Program, March 1993.

Oregon Department of Environmental Quality, *Information Clearinghouse*, Portland, OR, Oregon Department of Environmental Quality — Waste Reduction Assistance Program, May 1994.

Oregon Department of Environmental Quality, *Oregon's Toxics Use Reduction & Hazardous Waste Reduction Act*, Portland, OR, Oregon Department of Environmental

Table 3-5: General Best Management Practices (BMPs) for Commercial/Industrial Facilities

Source	Description
Design BMPs	
Floor Drains	Eliminate floor drain discharges to the ground, septic systems (except in sanitary facilities), storm sewers, or to any surface water body from any location in the facility.
	If no floor drains are installed, all discharges to the floor should be collected, contained, and disposed of by an appropriate waste hauler in accordance with federal and state requirements.
	Floor drains in sanitary facilities must either discharge to a septic system, a municipal sanitary sewer, or a holding tank which is periodically pumped out.
	Floor drains in work areas can either be connected to a holding tank with a gravity discharge pipe, or to a collection sump which discharges to a holding tank.
Dry Wells	Dry wells should be eliminated in ALL cases unless they receive ONLY CLEAN WATER DISCHARGES which meets all established Maximum Contaminant Levels (MCLs) promulgated under the *Safe Drinking Water Act* and other state and local standards for drinking water, and is in compliance with any other state and local requirements.
Floors	Floor surfaces in work areas and chemical storage areas should be sealed with an impermeable material resistant to acids, caustics, solvents, oils, or any other substance which may be used or generated at the facility. Sealed floors are easier to clean without the use of solvents.
	Work area floors should be pitched to appropriate floor drains. If floor drains are not used, or if they are located close to entrance ways, then berms should be constructed along the full width of entrances to prevent storm water runoff from entering the building.
	Berms should also be used to isolate floor drains from spill-prone areas.
Storage Facilities	Loading and unloading of materials and waste should be done within an enclosed or roofed area with secondary containment and isolated from floor drains to prevent potential spills from contaminating storm water or discharging to the ground. Alternatives to roofing include supplemental holding facilities for spills, grading of the area, use of impact-resistant materials.
	Underground storage tanks should not be used, unless explicitly required by fire codes or other federal, state or local regulations.
	Where underground tanks are required, they should have double-walled construction or secondary containment such as a concrete vault lined or sealed with an impermeable material and filled with sand. Both types of tanks should have appropriate secondary containment monitoring, high level and leak sending audio/visual alarms, level indicators, and overfill protection. If a dip stick is used for level measurements, there should be a protective plate or basket where the stick may strike the tank bottom.
	Above-ground tanks should have 110 percent secondary containment or double-walled construction, alarms, and overfill protection, and should be installed in an enclosed area isolated from floor drains, storm water sewers, or other conduits which may cause a release into the environment.
	Fill-pipe inlets should be above the elevation of the top of the storage tank.
	Tanks and associated appurtenances should be tested periodically for structural integrity.
	Storage areas for new and waste materials should be permanently roofed, completely confined within secondary confinement berms, isolated from floor drains, have sealed surfaces, and should not be accessible to unauthorized personnel.

Table 3-5: General Best Management Practices for Commercial/Industrial Facilities (Continued)

Source	Description
Storage Facilities (Continued)	Drum and container storage areas should be consolidated into one location for better control of material and waste inventory.
Cooling Water	Closed-top cooling systems should be considered to eliminate cooling water discharges.
	Any cooling water from solvent recovery systems should be free of combination from solvent, metals, or other pollutants, and should not discharge to the ground. Cooling water may be discharged to a storm sewer, sanitary sewer, or stream, provided all federal, state, and local requirements are met.
Water Conservation	Flow restrictions and low-flow faucets for sinks and spray nozzles should be installed to minimize hydraulic loading to subsurface disposal systems.
Foundation Drainage & Dewatering	If water from foundation drainage and dewatering is not contaminated, it may be discharged to a storm sewer or stream in accordance with any applicable federal, state, or local requirements.
	Contaminated water from foundation drainage and dewatering indicates a likely groundwater combination problem,. which should be investigated and remediated as necessary.
Storm Water Management	Storm water contact with materials and wastes must be avoided to the greatest extent possible. Storage of materials and wastes should be isolated in roofed or enclosed areas to prevent contact with precipitation.
	Uncovered storage areas should have a separate storm water collection system which discharges to a tank.
	Storm water from building roofs may discharge to the ground. However, if solvent distillation equipment or vapor degreasing is used, with a vent that exhausts to the roof, then roof leaders may become cross contaminated with solvent. These potential sources of cross contamination must be investigated and eliminated.
Cross-Connections	Cross-connections such as sanitary discharges to storm sewers; storm water discharges to sanitary sewers, or floor drain discharges to storm sewer systems, should be identified and eliminated.
Work Areas	Consolidate waste-generating operations and physically segregate them from other operations. They should preferably be located within a confinement area with sealed floors and with no direct access to outside the facility. This reduces the total work area exposed to solvents, facilitates waste stream segregation and efficient material and waste handling, and minimizes cross combination with other operations and potential pathways for release into the environment.
	Waste collection stations should be provided throughout work areas for the accumulation of spent chemicals, soiled rags, etc. Each station should have labeled containers for each type of waste fluid. This provides safe interim storage of wastes, reduces frequent handling of small quantities of wastes to storage areas, and minimizes the overall risk of a release into the environment.
	New solvent can be supplied by dedicated feed lines or dispensers to minimize handling of materials. These feed lines must default to a closed setting to prevent unmonitored release of material.
Connection of Municipal Sanitary Sewers	Existing and future facilities should connect their sanitary facilities to municipal sanitary sewer systems where they are available.
Holding Tanks	Facilities should discharge to holding tanks if they are located where municipal sanitary sewers are not available, subsurface disposal systems are not feasible, existing subsurface disposal systems are failing, or if they are high risk facilities located in wellhead protection areas.

Table 3-5: General Best Management Practices for Commercial/Industrial Facilities (Continued)

Source	Description
	Operational BMPs
Material & Waste Inventory Control	Conduct monthly monitoring of inventory and waste generation.
	Order raw materials on an as-needed basis and in appropriate unit sizes to avoid waste and reduce inventory.
	Observe expiration dates on products in inventory.
	Eliminate obsolete or excess materials from inventory.
	Return unused or obsolete products to the vendor.
	Consider waste management costs when buying new materials and equipment.
	Ensure materials and waste containers are properly labeled. Not labeling or mislabeling is a common problem.
	Mark purchase date and use older materials first.
	Maintain products Material Safety Data Sheets to monitor in inventory and the chemical ingredients of wastes. Make MSDS sheets available to employees.
	Observe maximum on-site storage times for wastes.
Preventative & Corrective Maintenance	A regularly scheduled internal inspection and maintenance program should be implemented to service equipment, to identify potential leaks and spills from storage and equipment failure, and to take corrective action as necessary to avoid a release to the environment. At a minimum, the schedule should address the following areas: • Tanks, drums, containers, pumps, equipment, and plumbing; • Work stations and waste disposal stations; • Outside and inside storage areas, and storm water catch basins and detention ponds; • Evidence of leaks or spills within the facility and on the site; • Areas prone to heavy traffic from loading and off loading of materials and wastes; • Properly secured containers when not in use; • Proper handling of all containers; • Drippage from exhaust vents; • Proper operation of equipment, solvent recovery, and emission control systems.
Spill Control	Use emergency spill kits and equipment. Locate them at storage areas, loading and unloading areas, dispensing areas, work areas.
	Clean spills promptly.

Table 3-5: General Best Management Practices for Commercial/Industrial Facilities (Continued)

Source	Description
Spill Control (Continued)	Use recyclable rags or absorbent spill pads to clean up minor spills, and dispose of these materials properly.
	Clean large spills with a wet vacuum, squeegee and dust pan, absorbent pads, or brooms. Dispose of all clean up materials properly.
	Minimize the use of disposable granular or powder-absorbents.
	Spilled materials should be neutralized as prescribed in Material Safety Data Sheets (MSDS), collected, handled, and disposed of in accordance with federal, state, and local regulations.
	Use shake-proof and earthquake proof containers and storage facilities to reduce spill potential.
Materials & Waste Management	Use spigots, pumps, or funnels for controlled dispensation and transfer of materials to reduce spillage; use different spigots, etc., for different products to maintain segregation and minimize spillage.
	Store materials in a controlled, enclosed environment (minimal temperature and humidity variations) to prolong shelf life, minimize evaporative releases, and prevent moisture from accumulating.
	Keep containers closed to prevent evaporation, oxidation, and spillage.
	Place drip pans under containers and storage racks to collect spillage.
	Segregate wastes that are generated, such as hazardous from non-hazardous, acids from bases, chlorinated from nonchlorinated solvents, and oils from solvents, to minimize disposal costs and facilitate recycling and reuse.
	Empty drums and containers may be reused, after being properly rinsed, for storing the same or compatible materials.
	Recycle cleaning rags and have them cleaned by an appropriate industrial launderer.
	Use dry cleanup methods and mopping rather than flooding with water.
	Floors may be roughly cleaned with absorbent prior to mopping; select absorbents which can be reused or re-cycled.
	Recycle cardboard and paper, and reuse or recycle containers and drums.
	Wastes accumulated in holding tanks and containers must be disposed of through an appropriately licensed waste transporter in accordance with federal, state, and local regulations.
Management	Management involvement in the waste reduction and pollution prevention initiatives is essential to its successful implementation in the work place. By setting the example and encouraging staff participation through incentives or awards, management can increase employee awareness about environmentally sound practices. A first step is to involve management in conducting a waste stream analysis to determine the potential for waste reduction and pollution prevention. This analysis should include the following steps: • Identify plant processes where chemicals are used and waste is generated; • Evaluate existing waste management and reduction methods; • Research alternative technologies; • Evaluate feasibility of waste reduction options;

Table 3-5: General Best Management Practices for Commercial/Industrial Facilities (Continued)

Source	Description
Management (Continued)	Implement measures to reduce wastes; and
	Periodically evaluate your waste reduction program.
	Develop an energy and materials conservation plan to promote the use of efficient technologies, well-maintained inventories, and reduced water and energy consumption.
	Sound environmental management should include the currency and completeness of site and facility plans, facility records and inventory management, discharge permits, manifests for disposal of wastes, contracts with haulers for wastes, and contracts with service agents to handle recycling of solvents or to regularly service equipment.
Employee Training	Training programs should be developed which include the following: • Proper operation of process equipment; • Loading and unloading of materials; • Purchasing, labeling, storing, transferring, and disposal of materials; • Leak detection, spill control, and emergency procedures; and • Reuse/recycling/material substitution.
	Employees should be trained prior to working with equipment or handling of materials, and should be periodically refreshed when new regulations or procedures are developed.
	Employees should be made aware of MSDS sheets and should understand their information.
	Employee awareness of the environmental and economic benefits of waste reduction and pollution prevention, and the adverse consequences of ignoring them, can also facilitate employee participation.
Communication	Posting of signs, communication with staff, education and training, and posting of manuals for spill control, health and safety (OSHA), operation and maintenance of facility and equipment, and emergency response are essential, Storage areas for chemicals and equipment, employee bathrooms, manager's office, and waste handling stations are suggested areas for posting communication. A bulletin board solely for environmental concerns should be considered.
Record Keeping	Facility plans, plumbing plans, and subsurface disposal system plans and specifications must be updated to reflect current facility configuration. Copies of associated approvals and permits should be maintained on file.
	OHSA requirements, health and environmental emergency procedures, materials management plans, inventory records, servicing/repair/inspections logs, medical waste tracking and hazardous waste disposal records must be maintained up to date and made available for inspection by regulatory officials.

Source:

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U.S. Environmental Protection Agency (EPA). 1995. *Pollution Prevention: A Resource Guide for the Northwest*. Brochure. EPA 910/8-95-003.

U.S. Environmental Protection Agency (EPA). 1992. *Managing Chemicals Safely*. Chemical Emergency Preparedness and Prevention Office. EPA 510-K-92-001

Pacific Northwest Pollution Prevention Research Center. Pollution Prevention Northwest. Quarterly newsletter. Seattle, WA Case studies, grand announcements, innovations in process design and environmental regulation.

EPA Pollution Prevention Information Clearinghouse (PPIC) — The PPIC is dedicated to reducing or eliminating pollutants through technology transfer, education, and public awareness. It is operated by EPA's OPPTS. The Clearinghouse is a free, non-regulatory service that consists of a telphone reference and referral service, a distirubiton center for selected EPA documents, and a special collection available for inter-library loan. Contact: Labat-Anderson Incorporated under contract for EPA 202-260-1023

EPA's Environmental Network for Managerial Accounting and Capital Budgeting — For a copy of this directory, which includes more than 600 participants, contact: EPA Pollution Prevention Information Clearinghouse (PPIC) at 202-260-1023.

Introduction to Environmental Accounting: Key Concepts and Terms — Discusses the major concepts underlying environmental accounting and how people are using the terms associated with it. For a copy of this 40-page primer, contact: PPIC at 202-260-1023.

A Primer for Financial Analysis of Pollution Prevention Project, by the American Institute for Pollution Prevention — Published by EPA. For a copy, contact: PPIC at 202-260-1023.

A Workbook for Total Cost Assessment, by Mitch Kennedy — This is a practical guide to calculating the real costs of pollution prevention projects. For a copy, contact: the author at 202-236-4808. The cost is $10.

Green Ledgers: Case Studies in Corporate Environmental Accounting — Edited by Daryl Ditz, Janet Ranganathan and R. Darryl Banks of the Work Resources Institute. To order: call 800-822-0504. The cost is $19.95, plus $3.50 shipping and handling.

Environmental Cost Accounting: Key Definitions and Terms — A 10-page paper available through the Business Roundtable, 1615 L. Street NW, Washington, D.C. 20036-5610.

An ABC Manager's Primer: Straight Talk on Activity-Based Costing, by Gary Cokins, Alan Stratton and Jack Helbling — To order, contact: the Institute of Management Accountants at 800-638-4427. The cost is $15.

Agricultural/Rural Management Options

If your Wellhead Protection Area includes a significant portion of agricultural lands, you may want to consider assembling an "Agricultural Management Group" (Ag Group) as a subcommittee to your Team. This Ag Group would assist the Team in determining how best to address any agricultural or rural lands within the Wellhead Protection Area. The Ag Group might include representatives from the local agricultural community (farmers/landowners), local Extension Service office, the closest Experiment Station, the local Natural Resource Conservation Service (NRCS, formerly SCS), the local Soil and Water Conservation District (SWCD), the local Farm Services Agency (FSA), agriculture services industry, and a representative from the Department of Agriculture.

The Ag Group could provide objective technical information on agricultural issues to the agricultural landowners within the wellhead protection area and the rest of the Team. The Ag Group should be able to provide access to the most current technical information for groundwater protection which is appropriate for the local agricultural practices and conditions, and meets the needs of the local agricultural community. The OSU Extension Service can be used to facilitate education and any agriculture "management" implementation.

The overall management objectives that agricultural lands within wellhead protection area would be expected to meet are:

- Proper handling and application of agricultural chemicals, and other controlled substances;
- Proper siting, installation, and maintenance of septic systems, wells, storage tanks, wastewater lagoons, and solid waste sites;
- Proper management of irrigation and wastewater; and/or
- Proper siting and management of dairies and feedlots facilities.

Ensuring that these objectives are met on agricultural lands within wellhead protection areas would ensure that management of agricultural sources would be consistent with the goal of the Wellhead Protection Plan.

The approach to develop the management plan for addressing agricultural lands and activities within wellhead protection areas includes two main steps:

- Conducting an "on-farm assessment" to identify those sources that pose the most significant risks to the groundwater; and
- Identifying and selecting the most appropriate management tools or measures to apply to the potential sources of contamination, taking into account site-specific conditions.

During the inventory of the wellhead protection area, there will not be any effort to assess specific activities or practices on each farm. Only the most obvious and visible activities will be listed during the inventory for agricultural lands.

Moving from the inventory step to the management step requires that a more detailed assessment of the site-specific sources and practices be performed on agricultural lands. This step will lead to the identification of the most significant sources needing to be addressed and the appropriate management measures with which to address them. The resulting management measures then become the basis of the management plan for agricultural lands within wellhead protection areas.

The Ag Group would be expected to see that the on-farm assessment of agricultural practices is carried out and that a management plan is developed in response to that assessment. They should work with the agricultural landowners in the wellhead protection area and consult with the Team to accomplish these tasks.

The methodology for developing the management approach for agricultural lands is summarized as follows:

1. The Ag Group will assess the specific type of agricultural activities and practices occurring on the agricultural lands within the wellhead protection area by:

    - Identifying individual point sources that are potential sources of groundwater contamination.

    - Identifying the range and extent of the types of agriculture (crops, livestock, nurseries, etc).

    - For each type of agricultural activity, determine prevailing practices (dryland or irrigated crops; confined or grazed livestock, etc.),

2. The Ag Group can screen out those potential sources that pose low risks to the groundwater by:

    - Verifying existing usage of best management practices (BMP);

    - Verifying the lack of usage of potential contaminants at individual farms, ranches, homesteads,

3. The Ag Group can identify and choose appropriate management tools specific to the category or type of agriculture, such as:

    - BMPs to improve irrigation management specific to the crops and conditions of the area;

    - BMPs to improve nutrient management specific to the crops and conditions of the area;

    - BMPs to integrate pest management measures specific to the crops, pests, etc.

To assist with the on-farm assessment, Table 3-6 is provided as a guideline of significant potential sources specific to agricultural and rural lands. It lists common agricultural activities and sources they may be a potential source of contamination to ground water. For each source/activity, the information provided includes why it may be of concern to groundwater quality and the factors that would help determine whether or not it could be an actual threat.

Low risk sources are either those sources that are already being addressed by appropriate control measures or BMPs or where it was determined that the contaminants or activities did not occur within the wellhead protection area. In either situation, the Ag Group will need to reliably document that there is little potential for groundwater contamination from these sources.

Once an assessment of the activities has been made and low-risk sources have been screened out, the Ag Group will next determine the appropriate management practices and measures for medium and high risk sources. Table 3-7 is provided to assist in accomplishing this task. The table lists, by activity or source, management practices and measures that would reduce the risk that the source or practice poses to groundwater contamination.

There are many sources of information available to assist the agricultural community in protecting groundwater. Table 3-8 provides a summary of the principles, strategies, and example BMPs that can be used to protect groundwater. More information on these BMPs is available by obtaining the source publication (National Association of Wheat Growers 202-547-7800).

It should be understood that BMPs, though widely agreed upon and researched, are only suggestions of how agricultural practices might be improved to provide profitability and protect the environment. They are also only as good as the latest research that has been done and may be modified somewhat in subsequent years as new knowledge is gained. Therefore, published BMPs should not be viewed as the only practical solution in every situation.

The Ag Group or agricultural representative of the Team should be flexible in their approach and only base recommendations to farmers on a combination of scientifically sound (and current) information and practical judgment. The Ag Group should serve as a resource to the farmer in helping to locate the latest technical information on BMPs for wellhead protection, and any other technical or financial assistance which might be

1. **Private Wells: (Point Sources)**

These wells might not be drilled to the same depth as a larger community well but if improperly constructed or maintained, may provide a conduit or direct route for contaminant movement into groundwater.

Factors to Assess:

- Position of well in relation to pollution sources.
- Potential of soil around well to protect.
- Depth to the aquifer.
- Condition of casing and well cap (seal).
- Placement of casing or grout seal.
- Well age.
- Well type.
- Backflow prevention.
- Frequency of water testing.

2. **Abandoned Wells: (Point Sources)**

An improperly abandoned well provides a direct route for contaminants to underground water supplies which recharge the aquifer supplying the well which is being protected. The worst scenario occurs when wastes are dumped directly into an old well. Unintentional contaminant flow into an old well should also be prevented. Current owners of a site may not even be aware of wells that were abandoned by the previous owners. Since abandoned wells can provide a direct route for contaminants to the groundwater, not knowing they exist at a site could create a high risk situation. The Local Team may wish to consult historical documents or older community members, if time and resources permit, for the location of abandoned wells.

Factors to Assess:

- Was the well properly abandoned according to the standards of The Oregon Water Resources Department?
- Is the abandonment temporary or permanent?
- Where is the well location relative to stored controlled material; where agricultural chemicals are being applied; to drinking water well?

3. **Pesticide Storage and Handling Areas: (Point Sources)**

Pesticides here would include insecticides, herbicides, fungicides, or any other chemical or biological agent used to control destructive organisms. Storage and handling areas involve placing a large concentration of farm chemicals in a small area. Furthermore, the chemicals may be packaged in concentrated form to be diluted before application. If precautions are not taken to prevent leakage or spillage onto the soil, a much higher risk of groundwater contamination can occur here than when diluted chemicals are correctly applied over a large area of cropland. Even small spills, repeated often in this one area, can add up to a serious problem.

Factors to Assess:

- Amount stored.
- Types stored (the leaching potential of each).
- Liquid or dry formulations.
- Handling procedures.
- Spill or leak control.

3. **Pesticide Storage and Handling Areas:** (Point Sources) (Continued). • Types of containers used and disposal of containers (See: "Pesticide Container Management Program" in the Resource List). • Security of storage area. • Location and slope from any wells. • Mixing pad or containment structure/equipment. • Water source for mixing and backflow prevention. • Supervision/qualifications/training of personnel. • Material transfer system. • Sprayer/tank cleaning and disposal of rinsate. • Appropriate emergency plan.
4. **Fertilizer Storage and Handling Areas:** (Point Sources) Fertilizers should include any type of soil amendment which is being stored or handled in the WHPA. Synthetic fertilizer (bulk or containerized) and organic fertilizer (manure) should be included in the assessment. The same reasoning applies to these areas as to pesticide storage and handling areas. A concentrated amount of a substance in a small area must be safeguarded against leakage and spillage. Factors to Assess: • Amount stored. • Type of storage. • Containers used for storage or cover over storage. • Security of storage area. • Location and slope from any wells. • Spill containment pad or equipment. • Water source for mixing and backflow prevention. • Supervision/qualifications of personnel. • Material transfer system. • Sprayer/tank cleaning and disposal of rinsate. • Appropriate emergency plan.
5. **Livestock Waste Storage and Treatment:** (Point Sources) Even small amounts of solid livestock waste could pose a threat to groundwater if stored. Any water seeping through the solid waste could carry harmful leachate to the wellhead. Factors to Assess: • Duration of storage (short- or long-term). • Cover over storage area. • Contained or stacked in field. • Containment structure (liquid-tight above or below ground or earthen waste pond). • Location and slope to nearest well. • Composting of manure.
6. **Petroleum Product Storage and Handling:** (Point Sources) This category includes the storage of petroleum products other than fuel such as lubricating oils, hydraulic oils and coolants commonly required for farm equipment maintenance and operation. Whether new or used (See also: "Hazardous Waste Man-

6. Petroleum Product Storage and Handling: (Point Sources) (Continued)

agement") these products should be prevented from leaking or spilling onto the soil where they could pose a threat to groundwater.

Factors to Assess:

Fuel Tanks:

- Above or below ground tank.
- Used or abandoned tank.
- Location of tank in relation to nearest well.
- Slope relation to well and position in relation to the water table depth.
- Soil permeability around or under tank.
- Type and age of tank, corrosion protection.
- Overfill protection.
- Piping and hoses.
- Professional or improper/unknown installation.
- Tank enclosure or secondary containment if above ground tank.
- Tank testing or leak monitoring.

Lubricants/Hydraulic Fluids/Coolants:

- If large quantities are stored in tanks the same factors as for fuel tanks listed above may apply.
- Dry storage to prevent rainwater from carrying contaminants to soil.
- Condition of containers and proper labels.
- Spillage and leakage prevention.
- Recycling or proper disposal of used oils/fluids and their containers.

7. Hazardous Waste Management: (Point Sources)

Contaminated fuel, used oil being saved for recycling, used coolant, used hydraulic fluid, old vehicle/tractor batteries and other common farm waste items should be addressed here if they are stored in the WHPA. Any of these items leaking or spilling onto the soil could pose a threat to the groundwater.

Factors to Assess:

- Ash disposal from incineration.
- Disposal of leftover/ineffective adhesives, cleaning solvents, lead-based paint, stain and paint strippers/thinners or other farm chemicals.
- Disposal of containers (See Resource List for information on the container disposal program).
- Vehicle maintenance products such as oil,antifreeze, brake fluid and hydraulic fluid (new and used forms).
- Used vehicle/equipment batteries.

8. Household Wastewater Management: (Point Sources)

This is a category also addressed in residential practices. The location and condition of wastewater drainfields would need to be addressed here if they were located in the WHPA. An overloaded or poorly maintained system could introduce wastewater contaminants to the groundwater.

8.	**Household Wastewater Management:** (Point Sources) (Continued) Factors to Assess: • Quantity generated. • Quality of wastewater. • Collection of wastewater. • Pretreatment system. • Disposal system. • Pump-out of septic tanks or other systems.
9.	**Farm or Farm Household Waste Disposal/Fill Areas:** (Point Sources) Farms traditionally had an area set aside for the convenient disposal of wastes generated on the farm. If such an area exists in a WHPA it should be very carefully managed. Animal burial areas may also be a concern that could be addressed here if within the WHPA. Disposal in unlined earthen pits of any of these wastes may have a high potential of contaminating groundwater. Factors to Assess: • Soil type in disposal area (permeability). • Lining of disposal pit. • Improper disposal of hazardous wastes. • Disposal of liquid wastes. • Animal burial (restricted in many states). • Unmonitored public use of disposal area.
10.	**Milking Center Wastewater Handling Facilities:** (Point Sources) As with household wastewater, the discharge points or area would need to be assessed if within the wellhead protection area. Milking center wastewater could be discharged to underground or surface treatment areas directly or stored for slow release. If stored, the storage tank or lagoon condition would need to be checked for possible threat to groundwater in the wellhead protection area. Unlined earthen storage pits may permit leakage of untreated wastewater to the groundwater. Factors to Assess: • Storage of wastewater (if combined with CAFO wastes see factors in that category). • Milking cleanup practices. • Lining of storage/settling tank. • Storage duration. • Distance of discharge from well. • Discharge method.
11.	**Confined Animal Feeding Operations (CAFO):** (Point Sources) If an area is used to confine livestock and the soil is exposed, excess nutrients from the manure could pose a threat to groundwater. Runoff from this area is a high strength waste and if it enters a permeable area can carry a significant pollutant load to surface water and/or groundwater.

11. **Confined Animal Feeding Operations (CAFO): (Point Sources) (Continued)**

Factors to Assess:

- Distance from well.
- Soil permeability.
- Livestock water source.
- Surface water diversion.
- Lot runoff control.
- Yard cleaning and scraping practices.
- Type of livestock.
- Concentration of livestock (square feet/animal or no. animals/acre).

12. **Livestock Grazing and Pastures: (Non-Point Sources)**

As above, animal wastes may be of concern here or the application of chemicals to pasture lands for weed control. Areas where the livestock congregate for feed, water, or shade become denuded of vegetation. The vegetation which might trap and use the excess manure nutrients, and thus prevent them from leaching to the groundwater, is absent.

Factors to Assess:

- Placement of livestock watering facilities.
- Herd management areas and paddock layout.
- Chemical application to pasture.
- Density of livestock in pasture.

13. **Crop Production – Non-Irrigated & Irrigated: (Non-Point Sources)**

This category is primarily concerned with the improper application of farm chemicals to crops in the field. If care is not taken to carefully manage application of chemicals, the excess materials may leach to the groundwater. The "Oregon Water Quality Decision Aid" may be useful here in the assessment and later on in the management plan. Other Extension documents are available from Oregon State University which might aid in the assessment process with regards to pesticide application and soil vulnerability, namely: EM8559, EM8560 and EM8561 (SEE: Resource List for how to acquire these and other helpful documents).

Irrigation of crops has the potential to increase the rate of travel of materials to the groundwater. Irrigation water is sometimes intentionally used to conveniently distribute chemicals or fertilizer (chemigation, fertigation) precisely when the plants need them. This can have either a positive or negative effect on groundwater depending on management.

Factors to Assess:

- Weed control (including control of "volunteer" crop plants from the previous growing season which may sustain crop pests and thus create a need for greater pesticide use).
- Realistic yield goals.
- Site-specific management of chemical application.

13.	**Crop Production – Non-Irrigated & Irrigated:** (Non-Point Sources) (Continued) • Soil type and regular soil testing; assessment of mineralization. • Nutrient application timing and rates. • Use of integrated pest management for efficiency. • Nitrification inhibitors/slow release nitrogen. • Integration of manure and fertilizer use. • Use of tramlines (designated paths through fields for tractor) for precision application of chemicals. • Sprayer maintenance and calibration. • Pesticide selection and application method, timing, and rates. • Rotating chemicals with different modes of action. • Buffer zones, especially around wells. • Riparian/wetland protection (vegetation which can utilize/filter excess nutrients or chemicals from cropland). • Subsurface drainage. • Crop rotation and post harvest covercrop. • Irrigation management and monitoring. • Amount of water applied matched to soil water holding capacity and crop requirements. • Chemigation/fertigation systems: backflow prevention valves, low pressure drain discharge away from well, chemical injection line check valve, automatic synchronization of chemical injection and water pump.

NOTE:

Each source is labeled as either a potential "point source" of contamination, as might occur near farm buildings and households, or as a potential "non-point" source, as might occur in the fields. Some of the BMP guides will also make this distinction. One is not necessarily more or less of a threat than the other. Point sources are sometimes easier to control because they may be more readily located and identified.

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Table 3-7: Agricultural/Rural Best Management Practices Groundwater Protection Assessments

1.	**Private Wells:** Contaminants of any kind should be prevented from entering the well directly. Contaminants should also be prevented from entering the soil in the vicinity of the well. The casing and well cap (seal) should be in good condition. There should be adequate backflow protection in the plumbing carrying water from the well. The water from the well should be periodically tested for contaminants, especially if it is a very old well or a well of questionable design.
2.	**Abandoned Wells:** The well should be checked to see if it was properly abandoned according to the standards of the Oregon Water Resources Department. If it was not, and it is suspected of posing a threat to the groundwater, a judgement should be made as to whether or not additional steps can be taken to correct or improve the abandonment. In any case, contaminants should be prevented from entering the abandoned well directly or through the surrounding soil surface, particularly if the abandonment method is in question.
3.	**Pesticide Storage and Handling Areas:** As the amount of pesticide stored or handled increases, the care with which it is managed should also increase. The more leachable pesticides should also be handled more carefully. If dry or liquid formulations are stored and handled, care should be taken that they not leak or spill onto the soil where they might leach to groundwater. The pesticides should be stored such that only properly trained workers have access to them. They should be stored downslope (or downgradient), and a sufficient distance away from, any wells. There should be adequate containment to prevent spills or leakage from reaching the soil and groundwater. Mixing and loading should be done in such a way as to prevent leaks, spills, or overflows onto the soil. Plans and equipment should be in place for containment or cleanup in case a spill does occur. The water source for mixing should have adequate backflow protection. Sprayer tanks and equipment cleaning rinsate should be properly disposed of (sometimes it can be applied to crops that might benefit from it). Used containers should be properly disposed of (SEE: "Pesticide Container Management Program" in the Resource List).
4.	**Fertilizer Storage and Handling Areas:** Many of the general BMP's for pesticide storage and handling areas can also be applied to fertilizer storage and handling areas. The goal is simply to prevent large amounts of fertilizer from reaching the groundwater. Spills and leaking should be prevented if possible or at least minimized. Any fertilizer not being used by the plants is not only a potential threat to the groundwater, but also a waste of the farmer's money.
5.	**Livestock Waste Storage and Treatment:** If large amounts of manure are being stored outside for an extended period of time, care should be taken to prevent leachate from reaching the groundwater. Large manure piles should be covered and/or on a non-permeable surface such that rainwater can't carry large amounts of leachate to the groundwater. If manure or liquid waste is stored in an unlined lagoon or pit it should be downslope and far enough away from any wells to prevent leachate from reaching the groundwater.
6.	**Petroleum Product Storage and Handling:** *Fuel Tanks:* The volumes of fuel added to, and dispensed from, underground tanks should be checked regularly to determine if leaks are occurring. Abandoned tanks should be properly removed or sealed to prevent leakage to groundwater of any residual fuel. Tanks, especially if underground, should be downslope and far enough away from any wells. Old tanks, without adequate corrosion protection, should be checked more frequently for possible leaks. Protection should exist to prevent overflows, spills and leaks from reaching the groundwater. Pumps, piping and hoses should be checked periodically for

6.	**Petroleum Product Storage and Handling:** (Continued) leaks. If serious questions remain about the integrity of an underground tank, groundwater and/or soil testing in the vicinity may be helpful. Overflows, spills and leaks of fuel can threaten the groundwater. ***Lubricants/Hydraulic Fluids/Coolants:*** If large quantities of these materials are stored or handled the same precautions as for fuel may apply. Smaller amounts should be stored under cover to prevent rainwater from carrying contaminants to the soil or weather conditions from damaging containers. All materials should be labeled properly to prevent misuse. Overflows, spills and leaks should be prevented as much as is reasonably possible. Used materials should be recycled or disposed of properly.
7.	**Hazardous Waste Management:** Farm, vehicle/equipment maintenance, and home chemicals should be recycled or disposed of properly if not used up for their intended purpose. These chemicals should not leak, or be disposed of, onto soil in the vicinity of any wells. Empty containers for chemicals should be recycled or disposed of properly. Temporarily stored hazardous materials (solids or liquids) should be safely transported to a proper disposal facility in a timely fashion. The storage of hazardous materials near wells should be avoided. Used vehicle/equipment batteries should be recycled or disposed of properly.
8.	**Household Wastewater Management:** Chemicals which might harm the organisms in the septic tank, and thus make treatment less effective, should not be disposed of into the wastewater system. Drainfields should be downslope and away from any wells. Septic tanks need to be pumped out periodically (every 2 to 3 years) to maintain proper function.
9.	**Farm or Farm Household Waste Disposal/Fill Areas:** Materials which have the potential to readily leach through the soil and contaminate groundwater should not be disposed of onto the soil in the wellhead protection area. Animals should not be buried in the wellhead protection area if there is a significant chance that infectious organisms or nitrates from decaying corpses might contaminate the groundwater. Rendering companies may be willing to remove dead stock and the poultry industry is studying composting of dead birds. The risks of groundwater contamination may increase with the number or mass of animals buried. There should not be unmonitored public access to a disposal area that could lead to improper, or unknown, disposal.
10.	**Milking Center Wastewater Handling Facilities:** The storage or discharge of untreated milking center wastewater, such that it might contaminate groundwater, should be avoided. Discharge of wastewater should be downslope and away from any wells. If the wastewater is stored in unlined lagoons, or lined lagoons that might leak, there should be confidence that significant amounts are not leaching to the groundwater. These facilities must have permits. In Oregon, permit conditions require that adequate steps are taken to collect, store, and agronomically apply the wastewater.
11.	**Confined Animal Feeding Operations (CAFO):** CAFOs or feedlots should preferably be downslope and away from any wells. If a CAFO is unpaved, it should be determined if excess nutrients from manure pose a threat to groundwater. Runoff from paved CAFOs, if collected, should be diverted into treatment systems, and away from any wells. Where possible, excess solid wastes should be scraped off yards periodically to reduce nutrient concentration of runoff. Greater concentrations of livestock pose a higher threat to groundwater if wastes are not managed properly.

12. **Livestock Grazing and Pastures:**

Livestock watering facilities should be set up such that excess nutrients from manure are not readily leached to groundwater. If chemicals are applied to grazing areas for weed or pest control, management should take any threat to groundwater into consideration. The threat to groundwater may increase with increasing herd density.

13. **Crop Production – Non-Irrigated and Irrigated:**

Targeted control of "volunteer" crop plants (those that sprout in the field prior to planting season) eliminate these hosts of crop pests. Timely control of volunteer plants may reduce the need for pesticides later in the growing season. Application of pesticides and fertilizers should be matched to the actual need and uptake rates. Chemicals with a high leaching potential should be avoided on highly permeable soils. The location of different soil types in the fields should be known and soil tests should be done periodically to ensure proper application of chemicals and fertilizers. Animal waste and plant residue contributions to soil nutrient levels should be taken into account before application of fertilizer. Nitrification inhibitors and slow release nitrogen may protect the groundwater and provide more cost effective fertilization for the farmer's investment. Designated paths through fields for the tractors ("tramlines") can allow for more precise, and therefore efficient, application of fertilizers and chemicals. Any opportunity to apply fertilizers or chemicals more efficiently may reduce the threat to groundwater and save the farmer money in the long run. Sprayers, for example, should be well maintained and calibrated for this reason. Also, the rotation of chemicals used with different modes of action may reduce the total amount of chemicals used while still effectively controlling pests. Private, public and irrigation wellheads should be protected by vegetated "buffer zones" to reduce the chance of contamination.

Dry land, riparian, or wetland vegetation along borders of ag lands help slow surface runoff and trap excess nutrients, and can thus help to prevent their movement from fields to groundwater. Crop rotation and post-harvest cover crops can be helpful in reducing the amounts of pesticide and fertilizer needed. This is another general BMP that can save the farmer money while protecting the groundwater.

Chemical application rates or timing may be adjusted to better protect the groundwater. Information is available from the BMP guides and other resources listed in the Resource List. Organic farming is an alternative that some farmers have chosen over chemical application and if it exists in the wellhead protection area, chemical application would obviously not be a concern there (but nutrient/manure application still might be). Information on this and other ag practices are listed in the Resource List.

Fertilizer application would include applications of any soil nutrients or amendments which might pose a threat to groundwater and could exist on any farm. Some farmers have experienced savings in fertilizer costs, as a result of more frequent soil testing, and the subsequent application rate adjustment of manures and inorganic fertilizers, without a decrease in yield.

Irrigated crops may have the added factors of irrigation equipment, chemigation, fertigation and water management practices to consider. Water should ideally be applied when the plants need it and when it has the lowest tendency to evaporate or run off the soil surface. Application of water should be matched, as well as possible, to crop need and soil water holding capacity. Over watering should be avoided. Chemigation and fertigation systems should have backflow prevention and other safeguards against contaminating their water source. Local Extension agents and/or the Oregon Department of Agriculture should be consulted for the safety requirements for these systems if they exist in a wellhead protection area.

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Table 3-8: Agricultural Principles, Strategies, and Example BMPs for Groundwater Protection

PRINCIPLES	
Availability	
Strategy 1: Reduce Concentration in Soil	**Strategy 2: Limit Exposure Time in the Soil**
BMPs	**BMPs**
• Crop Rotation • Set Realistic Yield Goals • Site Specific Management • Soil Testing and Plant Analysis • Nitrification Inhibitors • Manure Management • Integrated Pest Management • Tramlines • Sprayer Calibration • Application Methods • Pesticide Selection and Rate Determination • Rotating Chemicals with Different Modes of Action • Careful Handling and Mixing • Practices	• Nitrogen Timing • Fertigation / Chemigation • Pesticide Application Timing • Pesticide Selection **Strategy 3: Consider Nonapplication Zones in Sensitive Areas** **BMPs** • Buffer Zones • Riparian and Wetland Protection • Critical Area Planting

Detachment	Transport	Deposition
Strategy 1: Consider Chemical Properties when Making a Product Decision	**Strategy 1: Reduce Amount of Water Leaving Soil Profile**	**Strategy 1: Create a Sink or Physical Barrier to Chemicals Being Transported**
BMPs	**BMPs**	**BMPs**
• Pesticide Selection & Rate Determination • Soil/Site Evaluation	• Soil/Site Evaluation • Irrigation Management • Subsurface Drainage • Other Practices: Cover Crops	**Other Practices:** • Create Physical Barrier • Promote Denitrification below Root Zone

Source:

Best Management Practices for Wheat, 1994. National Association of Wheat Growers Foundation available. In addition, should the assessment turn up practices/activities that are causing groundwater contamination problems for which there is no known BMPs available, the Ag Group might recommend in the management plan that resources are needed to develop BMPs to address the site-specific problem.

The site-specific application of BMPs should reflect the consensus of the landowner, the agriculture member(s) of the Team, and the Ag Group. They should choose the specific BMPs which will work best under local conditions.

Once all of the appropriate management measures have been identified for agricultural/rural lands within the wellhead protection area, the Ag Group will need to document them in a brief report, along with a strategy for implementation. This document will then be submitted to the Team for inclusion in the Wellhead Protection Plan.

Whether an Ag Group or your local Team determines the management recommendations for the agricultural lands within the wellhead protection area, implementation will best be accomplished through voluntary efforts to reduce the risks of groundwater contamination. Any management alternative that seeks to directly regulate farming practices must be developed and implemented by the Oregon Department of Agriculture (ORS 690, Section 62).

- ***Agricultural Resources*** — The following description of various efforts and programs in Oregon are provided because they could be a source of assessment tools and management measures and practices. Oregon has two federally funded Hydrologic Unit Areas (HUA) that have been targeted as sites for federal, state and local efforts to reduce pollution from agricultural activities. In each of these areas, Washington and Malheur Counties, extensive efforts have been devoted to the demonstration of management practices that are consistent with Oregon agricultural production needs and with the local groundwater protection concerns. In each of these areas, research and demonstration efforts related to nutrient management have led to more effective nutrient utilization with less nitrate being lost to the underlying aquifers. Similarly these HUAs have provided an opportunity to demonstrate the benefits of more prudent irrigation management as a way to reduce water consumption as well as nutrient leaching beyond the root zone. Although the results of these demonstrations are widely shared and will probably be known by the people selected to be Ag Group members, more direct interaction may prove helpful. One way to approach these organizations as resources is through the County Extension Offices. Both Washington and Malheur County Extension personnel are actively involved in the HUA programs and can provide access to the locally devised BMPs. Alternatively, the Natural Resource Conservation Service and the Farm Services Agency have offices in each of these counties and can be used as sources of information.

Research and demonstration efforts are underway throughout the state to support the adoption of BMPs that can be used without adverse impact on the rural landowner. Much of this research has been supported by the US Environmental Protection Agency through the Oregon Department of Environmental Quality and conducted by researchers working at the Oregon Agricultural Experiment Stations. In addition to the locations near Corvallis, trials devoted to the demonstration of alternative BMPs for groundwater protection are being conducted at the stations near Aurora, Madras, Ontario, Hermiston and Medford. Station superintendents at each of these stations are available to discuss current research and provide access to what has been done in the past to establish alternative practices that are economically viable in Oregon. Recent work has indicated the opportunity to monitor the leaching of soluble pollutants below the root zone of crops. This is a much more immediate indicator of groundwater pollution than waiting for contaminants to be detected in local wells. These results confirm the need for both nutrient and water management for irrigated agriculture.

The Ag Group or Team can seek assistance from local agricultural product suppliers in developing BMPs or alternative practices which protect groundwater. The local fertilizer and pesticide providers, for example, could assist farmers in making best management choices with special consideration of the groundwater resources. In addition, the local Fire Marshal and/or your Regional DEQ office could be helpful in both inventorying and examining above ground and underground fuel storage tanks for possible safeguards against spills and leaks. Local petroleum product providers could also be helpful in assisting farmers in determining best management strategies for fuel storage and handling to protect groundwater. Local farmers cooperatives could be a valuable resource in helping farmers within the wellhead protection area meet the objectives stated earlier. Including local agricultural youth groups such as Future Farmers of America (FFA) and 4-H Clubs in this program, under the supervision of their teachers, could provide a tremendous opportunity to educate themselves and others about the values and methods of wellhead protection on agricultural lands. The creativity of other local Teams throughout Oregon will undoubtedly generate novel approaches not listed here.

Agricultural/Rural Resource List

- **The Oregon State University (OSU) Extension Service** — Information on best management practices to avoid groundwater pollution is available in each of the Oregon Counties by contacting the local OSU Extension office. You may also contact Ron Miner at OSU in Corvallis who serves as the water quality contact at (541) 737-6295. His office also has a series of publications available.

  For information on county offices, call (541) 737-2711.

- **The Oregon State University Agricultural Experiment Stations** — Agricultural research is carried out in different locations around Oregon, including development of BMPs.

  Dean/Director
  Agricultural Hall
  Oregon State University
  Corvallis, Oregon
  Phone: (541) 737-4251

- **The Natural Resources Conservation Service (NRCS, was SCS)** — A good source of technical information on BMPs, especially as they have been applied in Oregon.

  NRCS
  101 SW Main St., Suite 1300
  Portland, OR 97204
  Phone: (503) 414-3249

- **The Farm Services Agency (FSA)** — A federal agency which offers funding for various agricultural programs.

  FSA
  Tualatin, Oregon
  Phone: (503) 692-6830

- **Soil and Water Conservation Districts (SWCD)** — A good source of local conservation information. Offices in every county. Contact:

  ODA
  Salem, Oregon
  Phone: (503) 986-4700

- **Home*A*Syst, Homestead Assessment System** — "A Program to Help You Protect the Groundwater that Supplies Your Drinking Water" (Developed in Oregon for Oregon Farms and Homesteads. Many useful worksheets and fact sheets designed especially for reduction of point/farm sources of contamination to the landowner's own well.

  Home*A*Syst Program
  Bioresource Engineering
  Gilmore Hall 116
  Corvallis, OR 97331-3906
  Phone: (541) 737-6294

  Document EM 8546 for $12.00 per copy available from:

  Publications Orders
  Agricultural Communications
  Oregon State University
  Administrative Services A422
  Corvallis, OR 97331-2119
  Phone: (541) 737-2513

- **Oregon Water Quality Decision Aid** — Developed in Oregon for Oregon farms. Provides technical information about pesticide use. Guides assessment and management of pesticide use with regards to pesticide leaching potential and soil vulnerability. Associated publications also available to aid in assessment and management plans: EM 8559, EM 8560 and EM 8561.

  Publication Orders
  Agricultural Communications
  Oregon State University
  Administrative Services A422
  Corvallis, OR 97331-2119
  Phone: (541) 737-2513

- **Water Quality Protection Guide** — "Recommended Pollution Control Practices for Rural Homeowners and Small Farm Operators". Provides general BMPs for surface and groundwater protection. 1995.

- **A Guide to Pesticide** — Related Licensing in Oregon August 1995.

  Both available from:

  Oregon
  Department of Agriculture
  Natural Resources Division
  635 Capitol St., NE
  Salem, OR 97310-0110
  Phone: (503) 986-4700

- **Best Management Practices for Wheat—A Guide to Profitable and Environmentally Sound Production**. Written by the Cooperative Extension System and The National Association of Wheat Growers

Foundation. Many of the BMPs are applicable to non-wheat crops. An easy to follow presentation of how BMPs can benefit the farmer while protecting the groundwater. For information or to obtain copies contact:

(See also: The Oregon Wheat Growers League below.)

NAWG Foundation
415 2nd St., N.E., Suite 300
Washington,
D.C. 20002-4993
Phone: (202) 547-7800

- **50 Ways Farmers Can Protect Their Groundwater** — A guide to general and specific BMPs with background information. Several interviews with farmers that have successfully applied BMPs to benefit their operations while protecting the groundwater. Developed by the University of Illinois Cooperative Extension Service.

University of Illinois
Office of Agricultural
Communications and
Education
Information Services
69-DP Mumford Hall
1301 West Gregory Drive
Urbana, IL 61801

- **Transition Document, Standards and Procedures** — Guide for farmers interested in organic farming to minimize threats to groundwater from agricultural practices. Available from:

Oregon Tilth
P.O. Box 218
Tualatin, OR 97062
Phone: (503) 692-4877
Fax: (503) 691-2514

- **National Pesticide Telecommunications Network** — Currently housed at Oregon State University. Provides information on the toxicology, human health effects, and environmental fate of pesticides.

Phone: 1-800-858-7378
Monday through Friday

- **Pesticide Container Management Program** — Sponsored by the Oregon Agricultural Chemicals & Fertilizers Association (OACFA). Collection sites throughout the state in spring and fall. Participants required to rinse containers and to put rinsate in their spray tank; containers recycled.

For information contact:

OACFA
1270 Chemeketa St., N.E.
Salem, OR 97301
Phone: (503) 370-7024

- **The Oregon Department of Agriculture (ODA)** — The ODA is interested in promoting the widespread use of management practices that protect groundwater quality. The ODA also works through the local Soil and Water Conservation Districts.

ODA, Natural Resources
Division
635 Capitol Street, NE
Salem, OR 97310
Phone: (503) 986-4700

- **Future Farmers of America (FFA)** — High School students studying agriculture. May be able to help the ag member(s) of the Team by educating themselves and others about BMPs for groundwater protection. Contact your local High School to see if they have this student group.

- **4H Clubs** — Students involved in agricultural activities in their communities. May be able to help the ag member(s) of the Local WHP Team by educating themselves and others about BMPs for groundwater protection. Contact your local Extension Agent for information.

- **Oregon Wheat Growers League** — Association of wheat farmers. May be able to help implement BMPs presented in "Best Management Practices for Wheat" guide.

OWGL
Rt. 34, Box 421
Pendleton, OR 97801
Phone: (541) 276-9278

- **Beneath the Bottom Line: Agricultural Approaches to Reduce Agrichemical Contamination of Groundwater** — 1990. Office of Technology Assessment, Washington, D.C. OTA-F-418, pp. 337.

Residential/Municipal Management Options

Residential areas are not typically thought of as being potential sources of groundwater contamination. We have tended to look at commercial and industrial operations as the primary potential sources of contamination. As was iscussed in Step 4 (Section 3.4), it is now recognized that residential areas can be significant sources of groundwater pollutants.

Municipal sources are grouped with residential because many of these municipal sources can be found in the same areas as the residential land uses. (In developing your management approach, your Team can group land uses or potential sources according to any other criteria you choose.) Although the tools for managing many of the potential sources in the "Municipal" category will be the same as the "Commercial/Industrial" approach, your Team may choose a different approach in managing these since they are usually publicly-owned facilities. Please refer to the "Commercial/Industrial" tools to address sources such as treatment plants, motor pools, waste transfer stations, and water treatment plants. In this section, we will highlight other common moderate to higher-risk residential and municipal sources and recommend some management tools associated with each of them.

Led by the residential or municipal representative(s), your local Team can choose one or more of the following options for management of residential/municipal sources within your wellhead protection area:

Housing — especially high density areas with >1 house per .5 acre:

- *Household Hazardous Wastes:* see Table 3-2 (Section 3.4) for a list of the potential contaminants)

    1. *Host or facilitate household hazardous waste collection events.*

    Call DEQ's Waste Management and Cleanup Division at 503-229-5913 for more information on collection events in your area or how to coordinate a collection event;

    2. *Increase awareness of safe disposal of household wastes by:*

        - Distributing copies of **Appendix H** — Household Hazardous Waste Fact Sheet;

        - Facilitating community workshops/school projects; call DEQ's Waste Management and Cleanup Division at 503-229-5913 for more information and free literature.

    3. *Increase awareness of less toxic alternatives that can be used in the home:*

        - Distribute DEQ's Hazardless Home Handbook, 1995.

- *Lawn/Garden Care:* see Table 3-2 (Section 3.4) for a list of the potential contaminants:

    1. *Encourage best management practices (BMPs) such as:*

        - *Reducing Fertilizer Use* — addition of nutrients already in sufficient amounts causes the leaching of nutrients into groundwater through soil layers, or into surface water through runoff;

        - *Limiting Mowing* - frequent mowing is stressful to lawns, weakening their resistance to disease and drought;

        - *Selecting Grass Varieties* - grass varieties that grow more slowly and require less fertilizer;

        - *Avoiding Pesticide Use* - physical removal, such as digging weeds and defoliation can work effectively, minimizing the need for chemicals;

        - *Maintaining Natural Shore/Lawn Barriers* — lawn care for areas adjacent to waterways can include using trees, ground cover, and other plants to help minimize runoff and fertilizer loss.

Septic Systems — especially high density areas with >1 per acre; see Table 3-2 (Section 3.4) for a list of the potential contaminants:

1. *Encourage best management practices such as:*

    - Pump out sludges every 2-3 years;

    - Limit use of drain cleaners and phosphate soaps;

    - Never use chemical treatments for septic tanks;

    - Never pour household hazardous wastes down drains or toilets;

    - Call DEQ's Water Quality Division at 503-229-5279 for more information on septic system maintenance or requirements.

2. *Develop long-term solutions to area-wide problems:*

    - Maintain low density through zoning or subdivision requirements;

    - Consider community sewage collection and treatment system installation.

Urban Runoff/Storm Water — NOTE: not listed as a separate source during inventory; see Table 3-2 (Section 3.4) for a list of the potential contaminants:

1. *Encourage best management practices (BMPs) to improve the quality of storm water which infiltrates to groundwater:*

   - *Use Detention Ponds* - earthen embankments or excavated ponds intended for the **temporary** detention of storm water to control peak runoff rates and for the settlement of particulate pollutants;

   - *Use Retention Ponds* - earthen embankments or excavated ponds that usually contain a **permanent** pool intended for the retention of storm water runoff and for the settlement of particulate pollutants;

   - *Use Vegetated Swales* - grassed water courses that retard or impound concentrated runoff to induce infiltration and decreased velocities;

   - *Use Vegetated Filter Strips* - areas of vegetated cover through which runoff containing sediments and other pollutants must flow before leaving a site or entering a storm water management practice;

   - *Encourage The Use of Urban Forestry* - protection of trees and forest land during the construction phase of development; planting of trees after the site has been cleared; or homeowner landscaping after the site has been fully developed;

   - *Use Sand Filters* - self-contained bed of sand underlain with pipe that is designed to treat the first flush of storm water runoff, and may be enhanced by layers of peat, limestone and/or topsoil, and may be overplanted with grass.

2. *Encourage best management practices for road and parking lot construction and maintenance:*

   - Construct water quality inlets that separate oil and sediments from parking lot and street runoff;

   - Street cleaning of paved vehicular traffic areas by the use of sweeping, vacuuming, or flushing equipment/methods.

Golf Courses and Parks — see Table 3-2 (Section 3.4) for a list of the potential contaminants:

1. *Encourage best management practices for handling and applications of pesticides and fertilizers:*

   - Reducing pesticide use in sensitive areas;

   - Reducing fertilizer use — addition of nutrients already in sufficient amounts causes the leaching of nutrients into groundwater through soil layers, or into surface water through runoff;

   - Selecting grass varieties that grow more slowly and require less fertilizer;

   - Maintaining natural shore/lawn barriers - lawn care for areas adjacent to waterways can include using trees, ground cover, and other plants to help minimize runoff and fertilizer loss.

Landfills/Dumps — see Table 3-2 (Section 3.4) for a list of the potential contaminants:

1. *Review status of all operating landfills within your wellhead protection area:*

   - Obtain copy of permit to confirm conditions and requirements: contact Oregon DEQ's Solid Waste staff at (503)229-5913 for information on the landfills in your area;

   - Verify adequate groundwater monitoring is in place to prevent contamination.

Maintenance/Fueling Areas — see Table 3-2 (Section 3.4) for a list of the potential contaminants:

1. *Work with officials from utility company, airport, and railroad facilities to ensure the best management practices are being utilized to prevent groundwater contamination.*

Many of the best management practices highlighted in Table 3-5 (Section 3.5) under Storage Facilities, Spill Control, Materials & Waste Management, and Employee Training can apply to maintenance and fueling areas.

Residential/Municipal Resource List

Oregon Department of Environmental Quality, *Pollution Prevention Begins At Home*, Portland, OR, Oregon Department of Environmental Quality, (brochure — not dated).

Oregon Department of Environmental Quality, *Small Businesses and Hazardous Waste: What you should know — A Handbook for People Who Produce Small Amounts of Hazardous Waste (Conditionally Exempt Generators)*, Portland, Oregon Department of Environmental Quality - Waste Reduction Assistance Program, September 1992.

Oregon Department of Environmental Quality, Oregon Metropolitan Service District, and Washington State Department of Ecology, *The Hazardless Home Handbook*, Portland, OR, Oregon Department of Environmental Quality, and Oregon Metropolitan Service District (METRO), 1995 (call DEQ at 503-229-5913).

Oregon Metropolitan Service District (METRO), *Common Sense Gardening — A Guide to Alternatives to Pesticides*, Portland, OR, City of Portland Bureau of Environmental Services, and Oregon Metropolitan Service District (METRO), (not dated).

Oregon Metropolitan Service District (METRO), *Dispose of Household Hazardous Waste Safely*, Portland, OR, Oregon Metropolitan Service District (METRO), 1994.

Oregon Metropolitan Service District (METRO), *Safer Substitutes for Household Hazardous Products*, Portland, OR, Oregon Metropolitan Service District (METRO), 1990.

Oregon Water Resources Department, *A Consumer's Guide to Water Well Construction, Maintenance, and Abandonment*, Salem, OR, Oregon Water Resources Department 1994.

Ross and Associates Environmental Consulting, Ltd. and GEI Consultants, *Enhancing Technical Assistance and Pollution Prevention Initiatives at the Oregon Department of Environmental Quality*, Seattle, WA, Ross and Associates Environmental Consulting, Ltd., April 1994.

United States Environmental Protection Agency, *Wellhead Protection: A Guide for Small Communities*, Washington, DC, United States Environmental Protection Agency - Office of Water, February 1993.

United States Environmental Protection Agency, *Wellhead Protection Implementation Training - Module 4: Developing Management Approaches*, Washington, DC, United States Environmental Protection Agency - Office of Water, September 1992.

Washington Toxics Coalition, *Alternatives: A Washington Toxics Coalition Fact Sheet*, "A Safer Home: Reducing Your Use of Hazardous Household Products", Portland, OR, Reprinted by Oregon Department of Environmental Quality, 1991.

Miscellaneous Management Options

Several of the potential sources inventoried as "Miscellaneous" sources could present the most serious threats to your drinking water. In particular, if you've identified leaking or unregulated underground storage tanks, historic waste dumps, or any type of well(s), you will need to carefully look at these individual sites as they are considered very high risks. In this section, we will highlight some of the most common and identify basic tools to address them. In many cases, you will want to consider using resources available through Oregon DEQ to assess whether there is a significant threat from an individual site you have identified.

Your Team should review the individual sources identified in this category and consider using some of the following options to address them:

Underground Storage Tanks and Historic Gas Stations — see Table 3-2 (Section 3-4) for a list of the potential contaminants.

> ***NOTE:*** Underground storage tanks can pose a significant threat to groundwater since they are generally located just above the water table in many areas of Oregon:

1. *Verify status of all underground storage tanks identified in your inventory; contact DEQ's tank program with any questions on the status or permit conditions of individual tanks at (503) 229-5913.*

Federal and state regulations require the licensing of underground storage tank service providers, permitting of tanks, notification of tank decommissioning, and prompt notification of spills and specific cleanup procedures. (See "UST Cleanup Manual" DEQ, 1995, for more information on rules and standards for cleanup.) All tanks and piping must have leak detection. Existing USTs must be protected from spills, overfills, and corrosion by December, 1998. (For more information, see "Don't Wait Until 1998 - Spill, Overfill, and Corrosion Protection for Underground Storage Tanks" EPA, 1994.)

2. *Contact DEQ's Site Assessment program at (503) 229-*

5913 for more information on any historic gas stations you identified during the inventory.

Construction/Demolition Areas — see Table 3-2 (Section 3.4) for a list of the potential contaminants.

1. *Obtain copies of "Environmental Handbook for Oregon Construction Contractors" (DEQ, 1994):*

   - To distribute to any large-scale construction or demolition projects identified within your wellhead protection area;

   - To retain and make available for any future projects through the library or city/county offices where permits are issued.

Wells — see Table 3-2 (Section 3.4) for a list of the potential contaminants.

- **Background Information:**

Improperly constructed water supply wells or monitoring wells may either contaminate an aquifer or produce contaminated water. Dug wells, generally of large diameter, shallow depth, and poorly protected, commonly are contaminated by surface runoff flowing into the well. Driven wells (as opposed to drilled wells) do not have a casing seal and may allow shallow contaminated water to enter the aquifer. Other contamination has been caused by infiltration of water through contaminated fill around a well or through the gravel pack. Still other contamination has been caused by septic tank, barnyard, feedlot, or cesspool effluent draining directly into the well. Many contamination and health problems can arise because of poor well construction.

Over time, well casings and seals may also begin to deteriorate in wells. Proper maintenance will help extend the life of your well, but eventually repairs may be needed. A landowner is responsible for the maintenance of wells on his or her property. If well construction problems are discovered that could contribute to the contamination or waste of the groundwater resource, the Oregon Water Resources Department (WRD) can require the landowner repair or eliminate the problem. WRD will look first to the well constructor if the standards were not adhered to, but if the constructor is unwilling or unable to perform the repairs, the landowner must assume the costs.

Unused wells that are not abandoned correctly can cause groundwater contamination, and under certain conditions, waste or loss of artesian pressure. Ultimately, landowners can be held responsible for harm to the groundwater resource of the public resulting from unused wells. Oregon well abandonment standards (OAR 690-220) are designed to protect the resource and the public and to ensure that unused wells are abandoned properly to prevent the problems listed above. The goal in permanently abandoning wells is to restore as closely as possible the geologic conditions which existed before the well was constructed and to prevent any future vertical movement of water in the drillhole.

There are two types of water well abandonment under Oregon rules — temporary and permanent abandonment. A well is considered temporarily abandoned when it is taken out of service due to a recess in use. A temporarily abandoned well must be covered by a watertight cap or seal. This prevents water or any other materials from entering the well from the surface.

A well is considered permanently abandoned when it is completely filled so that movement of water within the well is permanently stopped. The Oregon Water Resources Department requires different abandonment techniques depending upon the type of well construction that was used and the local geology.

1. *Encourage the proper abandonment of any unused wells in your wellhead protection area:*

   - Contact a licensed well constructor or the Oregon Water Resources Department for more information at (503) 378-8455;

   - Obtain "A Consumer's Guide to Water Well Construction, Maintenance, and Abandonment", Oregon Water Resources Department, 1994 for distribution or retain for reference

2. *Encourage special precautions be taken in any storage areas, sheds, and the immediate vicinity of any well to prevent contaminants from entering the well.*

The Oregon Water Resources Department can provide additional technical resources and information on protecting your wells.

Injection Wells / Drywells / Sumps — see Table 3-2 (Section 3.4) for a list of the potential contaminants.

- **Background Information:**

Basically, injection wells are man-made or improved "holes" in the ground, which are deeper than their widest surface dimension and are used to discharge or dispose of fluids underground. When properly sited, constructed, and operated, injections wells can be an effective and environmentally safe means of fluid waste disposal. There are many different types of injection wells, but they are similar in their basic function. Many shallow injection practices occur in Oregon, with differing permit requirements. Those underground injection activities which do not require a permit but are regulated by rule are: (1) storm water runoff; (2) the injection of small quantities of geothermal fluid re-injected into the same aquifer which produced it or into an aquifer of equivalent quality; and (3) cesspools, septic tank/drainfield and seepage pits for domestic sewerage systems with flows of less than 5,000 gallons per day.

1. *Verify the permit status of any injection wells in your wellhead protection area by contacting the Oregon DEQ's Water Quality staff at (503) 229-5279.*

2. *Encourage elimination of the use of any dry wells or sumps in your wellhead protection area.*

Transportation Corridors — see Table 3-2 (Section 3.4) for a list of the potential contaminants).

1. *Ensure that state and local transportation officials know where the wellhead protection area underlies major roadways so precautions can be taken to minimize the applications of herbicides on right-of-ways that may contaminate groundwater. (This includes contacting the local Weed Control District.)*

2. *Review spill response procedures for any hazardous materials that could be spilled on roadways:*

   - Ask transportation officials 'to examine spill/runoff detention capacity to avoid contaminants entering the groundwater after an accident;

   - Ensure that emergency response providers notify your Team (or designated official) in case of accidental spills.

Contact Oregon DEQ with questions about any other potential sources. Wellhead protection staff can be reached at 1-800-452-4011 or 503-229-5413.

Military Installations — see Table 3-2 (Section 3.4) for a list of the potential contaminants)

1. *Contact the state or federal environmental coordinator for any military facilities located within the wellhead protection area and ensure that they are aware of the need for groundwater protection.*

2. *Obtain a copy of any environmental assessments or reports of cleanup activities to be informed of the potential sources on the military base.*

Managed Forests — see Table 3-2 (Section 3.4) for a list of the potential contaminants.

- **Background Information:**

Local governments can impact federal timber harvesting operations including logging methods and erosion control on U.S. Forest Service or Bureau of Land Management lands through local water quality requirements as provided for in Section 313 of PL 92-500. To affect state and private timber operations, local jurisdictions will have to negotiate with the Oregon Department of Forestry regarding forest practices and with the Oregon DEQ regarding the application of water quality standards and possible Total Maximum Daily Load (TMDL) requirements placed on state and private forestry operations.

1. *Review forest practices by federal, state, or private operators within the managed forests in your area:*

   - Contact the Oregon Department of Forestry at (503) 945-7200, the U.S Forest Service at (503) 666-0700, and/or the Bureau of Land Management at (503) 280-7002 for more information on any managed forests;

   - Oregon DEQ's Water Quality staff can be reached at (503) 229-5279 for more information on water quality standards or TMDL issues.

2. *Encourage the application of non-point source control measures in forestry operations:*

   - Obtain "Nonpoint Source Pollution Control GUIDEBOOK for Local Governments", DEQ, 1994 for reference on specific control measures.

3.6 STEP 6

3.6.1 Develop Contingency Plan

Contingency planning is an essential component of the Oregon Wellhead Protection Program that focuses on water purveyor response to the contamination or disruption of the groundwater supply to a public water system. Generally, these plans should focus on:

- The recognition of potential threats to the supply, and
- The development of procedures to be followed should these threats materialize.

The primary responsibility for the development of these plans lies with the individual water purveyor, however, effective development and implementation of the plans may require local, regional and state involvement depending on the structure of emergency response coordination protocols in the area. Where possible, water suppliers should coordinate with existing local emergency response coordinators in developing their contingency plans.

Guidance for the development of a contingency plan is available through USEPA's technical assistance document entitled "Guide to Groundwater Supply Contingency Planning for Local and State Governments", Oregon Health Division Wellhead Protection workshops and this guidance document. The essential elements of a contingency plan under the Oregon Wellhead Protection Program must include the following at a minimum:

1. **An Inventory of All Potential Threats to The Drinking Water Supply**. Each water system must identify all likely contingencies that might impact the flow of water to consumers. Systems may vary depending on the water source, local geology, hydraulic conditions, area land uses, sources of contamination, climatic conditions and water system design and operation. Accordingly, contingency plans must identify and prioritize the most likely threats that could occur.

2. **Prioritization of Water Usage.** Each water system should develop a detailed understanding of its water use and demand in case it becomes necessary to replace the water supply. In order to choose an appropriate replacement, planners need to know what community needs should receive the highest priority as well as minimum and maximum daily consumption levels and peak demands. Usage rates may differ based on whether the water use is for residential, commercial, industrial, agricultural, recreational, fire or health and safety needs.

3. **Protocols for Responding to Potential Incidents**. Scenarios should be developed for the most likely events that may disrupt the water supply and how the water system will respond in each case. Scenarios should include a description of the incident that threatens the water supply, complicating matters that may arise during the episode, and remedial actions that must be taken.

4. **Identification of Key Personnel and Development of A Notification Roster**. In any emergency situation it is necessary to have a chain of command of recognized and qualified individuals who have been specifically chosen for that purpose. A response coordinator should be designated at the water system level to work in conjunction with the established emergency response coordination system of the county. Most counties in Oregon have some program already developed for this purpose. The roster should include local, county, and state contacts as well as local health departments. The Oregon Emergency Management (OEM) staff can help with the development of your contingency plan, can help you locate your county's coordinator, and let you know if your county has an existing approved emergency plan. The OEM can be reached at (503) 378-2911 in Salem.

5. **Identification of Short-Term and Long-Term Replacement of Potable Water Supplies.** Depending on the type of disruption, the water purveyor should evaluate alternative water supplies that will meet the minimum needs of the system during the event. The alternative supply must meet applicable health standards and be in adequate quantity for the community needs. Emergency or short-term options should be evaluated first where the need may be measured in hours or days and then medium and long-term options should be evaluated where a permanent alternative supply must be developed.

6. **Identification of Short-Term and Long-Term Conservation Measures.** Each water system should prioritize their responsibility to their users. Users that purchase surplus

water should be identified and water usages prioritized in case of emergencies. In certain cases some usages must be curtailed to conserve a limited water supply or protect a threatened water source. Conservation measures may include the reduction of use of surplus water, restrictions on agricultural or domestic use of irrigation water or recreation use in favor of usages that effect fire, health and safety. Information on developing a water conservation program can be obtained from the Municipal Water Conservation Specialists at the Oregon Water Resources Department, (503) 378-8455.

7. **Provisions for Plan Testing, Review and Update.** Water systems should develop mock exercises for the high priority scenarios to determine the efficacy of the plans. Water system planners should schedule periodic reviews of contingency plans to reevaluate and revise procedures, protocols, personnel changes and new developments as needed. Summaries should be kept for each scenario and a master schedule maintained identifying parties responsible for plan review, frequency of review and revision up-dates.

8. **Provisions for Personnel Training.** In order to be effective, contingency planning must rely on properly trained individuals, operating within a well organized and effective system with up-to-date information. Water systems should encourage continuing education and training opportunities in all aspects of contingency planning to help key personnel stay abreast of new and ongoing developments. County and state agencies may provide some training opportunities; however, opportunities should be developed by the water system as well.

9. **Provisions for Public Education.** Water systems should develop educational materials to build and maintain public confidence in the Wellhead Protection Plan. Development of newsletters brochures, bill stuffers, public forums and newspaper articles can help water users focus on areas of concern and help nurture support and assistance when contingency plans are put into effect.

10. **Identification of Logistical and Financial Resources.** Essential to the success of implementing contingency plans is the ability to make available key personnel, equipment and technical resources in a well organized and timely manner. The plans should enable local officials to quickly identify and coordinate all pertinent resources to respond to the needs at hand. Equipment and contractor services, chemical and treatment supply services and water transport equipment should be identified and catalogued. An Inventories of materials and material resources should be maintained and revised as needed to be current. Since lack of financial resources is often a limiting factor in responding to emergencies, water purveyors should evaluate their own financial resources as well as federal, state and local funding resources to insure funding is available when the need arises.

To illustrate the contingency planning concepts outlined above, **Appendix I** contains a brief synopsis of a fictitious community water system faced with the disruption of their water supply as a result of a potential contamination episode. In this scenario, it is assumed that the water system has a state certified Wellhead Protection Plan and the contingency plan component is being implemented in response to an emergency situation.

3.7 STEP 7

3.7.1 Planning for Future Public Water System Needs

Water systems may find it necessary, as a result of either existing or projected increased demand, to explore the development of additional groundwater sources for drinking water. Wellhead protection provides a mechanism that can be used to help select the best site and to identify areas that should be protected now in order that they will provide quality drinking water in the future when they are needed. Additionally, it should be realized that the development of a new groundwater source in the vicinity of existing sources may modify the movement of groundwater in the subsurface, perhaps changing the shape and orientation of existing wellhead protection areas (WHPAs). Evaluation of the significance of those changes is necessary in order to ensure that the management strategy that is in place will continue to protect the community's drinking water supply.

In this section the procedures are outlined for systems adding new groundwater sources or modifying existing sources. Water systems are reminded that the development of any new source, or a major modification to an existing source, requires prior approval by the Oregon Health Division, as part of the existing plan review requirements (OAR 333-61-060). The work must also comply with appropriate construction standards as described in OAR 333-61-050.

- ***New Groundwater Source:***

A groundwater source may be a well, wellfield or spring. A new groundwater source is defined as either an additional groundwater source, or an existing groundwater source that has been modified in a manner to increase its capacity or discharge to the system. The guidance in this section applies only to those sources that are owned by the water system.

A. New Groundwater Sources Outside an Existing WHPA Boundary:

If the water system is planning on developing a previously unexploited groundwater resource that occurs outside the boundary(ies) of already delineated sources, there are several steps that should be followed. If more than one potential site is available, the system should conduct a provisional delineation and preliminary potential contaminant source inventory for each site being considered. By provisional delineation it is meant the application of the existing model for already delineated wells to the considered sites. Depending on the size of the system, the following procedures are recommended:

1. Systems using wells and serving a population of 500 or less.

   a. A circle of the same radius as the largest producing well already delineated should be centered on each of the potential well sites. A system may choose to use the formula for the calculated fixed radius (see Section 3-3 of this manual) to calculate the radius based on the projected pumping rate of the new well.

   b. A preliminary inventory of potential contaminant sources should be conducted (see Section 3-4 of this manual) within each provisional delineation.

   c. An evaluation of the potential threat to the groundwater at each site should be completed. This may be accomplished by using a qualitative comparison of the numbers of high-, moderate- and low-risk facilities (see Section 3-4 of this manual) in each area. In those cases where the potential threats are similar, the system may choose to conduct a susceptibility analysis (see Section 3-3 of this manual) in order to estimate the potential of a contaminant released at the surface migrating to the aquifer.

   d. The proposed site possessing the lowest perceived threat of contamination should be chosen as the site for the new well.

   e. After the chosen site has been developed, the WHPA for the site should be delineated in accordance to procedures described in Section 3-3 of this document.

   f. The potential influence of the new WHPA on the geometry and orientation of existing WHPAs should be evaluated. Modifications to existing WHPAs should be accomplished if necessary.

2. Systems serving greater than 500 population and using wells as a drinking water source.

   a. Systems in this size range will have developed conceptual models to assist in defining aquifer characteristics and the hydrogeologic setting. In the simplest case, the proposed sites will be in an area where the conceptual model indicates that the assumptions used and the constraints applied to the original delineation are applicable at each proposed site. In this case, the provisional delineation may be nothing more than overlaying the original delineation onto each of the proposed site areas (assuming the proposed and existing well will have similar pumping rates). Note that orientation of the provisional WHPA will have to be consistent with the gradient direction.

   At the other end of the spectrum are the situations where the proposed sites are either outside the area originally evaluated in the development of the conceptual model or the conceptual model indicates that the assumptions used in the original delineation do not apply at the proposed site. The system may choose to obtain sufficient information from existing data sources or from field measurements to perform a provisional delineation using either the analytical or numerical methods. At the minimum, the water system should follow the Pre-Delineation Assessment procedures described in Section 3-1 of this document in order to determine an area in which to identify potential contaminant sources.

b. See 1b.

c. See 1c.

d. See 1d.

e. See 1e.

f. See 1f.

3. Systems deriving their groundwater from springs.

a. The delineation of the recharge area for springs is accomplished through hydrogeologic mapping (see Section 3-3 in this document). Although there are exceptions, most springs originate through recharge at elevations that are greater than that where the springs occur. For the purpose of evaluating new spring sites, it is recommended that the system identify the potential contaminant sources that occur within an area upslope that fall within a arc having a 1,000 foot radius, with the distance measured in the horizontal.

b. See 1b.

c. See 1c

d. See 1d.

e. The chosen spring site should be delineated using hydrogeologic mapping as described in Section 3-3 of this document.

B. The Development of New Sources Within a System's Existing WHPA.

If more than one potential site is available for the new source, the system should proceed in its evaluation of those sites according to the discussions above. If a system develops a new well, or increases the capacity of an existing well that is within an already delineated WHPA, it is likely that the new or modified source will have a significant impact on the existing WHPA (see Section 3-3 in this document). In all cases, the affect of the new well on the already existing WHPA geometry and orientation should be evaluated.

1. **Calculated Fixed Radius Method.** The impact of proximal wells on the individual WHPAs is accounted for in the delineation process by determining the "capture zone" associated with a hypothetical single well having the combined pumpage of the other wells and located according to the individual pumping rates (see Section 3-3 and Appendix A).

2. **Analytical and Numerical Methods.** In these methods, the impact of proximal wells can be accounted for within the models themselves, provided the location and pump rate of these wells are known. The models calculate capture zones based on the input provided. If such a model has been used to previously delineate the WHPA of a system's well(s), the model can be rerun and new or adjusted WHPAs identified by modifying the input to the model. The system may wish to contact the consultant who performed the original delineations for this task.

The adjusted WHPA boundaries should be compared to the existing WHPA boundaries. If significant differences are observed, the system should consider modifying the existing wellhead protection plan to encompass the new delineation.

C. Future Sources:

Systems may recognize that as a result of growth, diminishing sources or both, there will be a need for additional groundwater supplies, beyond their current capacity, in the future. These systems may choose to identify the area(s) where this future supply will be obtained for protection purposes. These areas may be identified through a regional hydrogeologic study designed to assess the availability of groundwater resources. This study will involve the development of a conceptual model similar to that required by the delineation step. Existing wells and perhaps test wells will be utilized to evaluate water quantity issues.

Once an area or site for future groundwater development been identified, it will be in the best interest of the system to develop a protection strategy to apply in the area in order to ensure that the groundwater will be usable for drinking water when the future need arises. Provisional delineations may be utilized in order to recognize the more critical areas needing protection. With this information in hand, future development can be directed in a manner that will allow for growth but will provide a layer of protection for the system's future drinking water needs.

3.8 STEP 8

3.8.1 Submit Plan to DEQ for Certification

The last step in the wellhead protection process is to submit a report to DEQ which provides a description of how your local community developed and has chosen to implement its Wellhead Protection Plan. Preparing a written report and submitting it to DEQ will enable certification of the Plan if it meets requirements specified in OAR 340-40-170. A certified Wellhead Protection Plan will also be recognized as meeting the wellhead protection requirements under the Federal Safe Drinking Water Act of 1986, Section 1428 (42 USC 300F to 300J - 26).

- ***Suggested Outline of Wellhead Protection Plan Report:***

The following outline is provided as guidance for preparing your Plan report. Although the report format can vary according to your preference, the contents should correspond to the required elements of your Plan. DEQ suggests the following format for your Wellhead Protection Plan report:

- **Section 1 — Introduction:**

  Discuss how wellhead protection was initiated in your community. Provide a brief description of the local area, such as the geographic, economic, and resource factors. Identify all the "Responsible Management Authorities" (RMAs) — any government entity with management, rule, or ordinance making authority within the Wellhead Protection Area. The jurisdictional boundaries of each RMA can be shown on a map. Remember that RMAs can include cities, counties, special districts, Indian tribes, state/federal governmental entities and Public Water Systems. For each RMA identified, the responsibilities and the duties they will perform during implementation of the Plan should be identified in this section. Describe the procedure used to notify and attempt to involve the RMAs within your wellhead area.

- **Section 2 — Delineation of Wellhead Protection Area:**

  Describe the delineation of the Wellhead Protection Area as specified under Health Division's (OHD) rules under OAR 333-61-057(1). Include the delineation report submitted to OHD in this section if preferred. Attach the letter of certification from OHD for your delineation.

- **Section 3 — Inventory of Potential Contaminant Sources:**

  Describe how the inventory was accomplished within your Wellhead Protection Area. For an adequate inventory, your effort should have been designed to identify past practices which may have resulted in a potential threat to the groundwater, those potential sources of contamination presently existing, and those potential sources which may exist in the future.

- **Section 4 — Management of Potential Sources of Contamination:**

  Describe the management action(s) to be employed to reduce the risk of contamination to the groundwater from the source(s) identified in your inventory. Provide justification for your proposed management actions and an level of protection to be provided by these management actions.

  This section should also identify the process to be used to address potential sources of contamination that may locate within the Wellhead Protection Area in the future. Discuss how the source will be evaluated for acceptability within the area, and how the management actions identified in this Plan for reducing the risk of contamination will be implemented.

- **Section 5 — Contingency Plan:**

  Describe the contingency plans for Wellhead Protection Areas developed in accordance with OHD rules under OAR 333-61-057 (3).

- **Section 6 — Procedure for Future Public Water System Needs:**

  Describe the procedure for planning for and siting new public water system wells or springs in accordance with OHD rules under OAR 333-61-057 (2).

- **Section 7 — Public Participation:**

  This section should include a description of the public participation efforts used in the preparation of the Plan and those efforts to be used during implementation of the Plan. Include a description of how property owners and residents within the Wellhead Protection Area were notified of the development of a Wellhead Protection Plan, such as a copy of any articles or adds from the local newspaper(s).

Discuss the formation of your local Team that assisted in the development of the Plan. Provide a brief description of the steps taken to provide opportunity for various interests within the affected area to participate in the develop of the Plan. Include documentation that all local public hearing procedures, if necessary, were (or will be) followed in developing and implementing the Plan.

- ***Certification of Your Plan:***

Your Wellhead Protection Plans should be submitted to DEQ's Water Quality Division at the following address:

Oregon Department of
Environmental Quality
Water Quality Division
Wellhead Protection Coordinator
811 SW 6th Avenue
Portland, Oregon 97204

DEQ shall act as the contact point for approval or certification of all Wellhead Protection Plans. DEQ will coordinate with other agencies to ensure that your Plan is consistent with the requirements and guidelines of OHD, the Department of Land Conservation and Development, Department of Agriculture, Water Resources Department, and any other entities before DEQ certifies your Plan. DEQ will consult with the Department of Agriculture on agricultural issues, the Department of Land Conservation and Development on land use issues, OHD on issues concerning delineation, new wells and contingency. DEQ is responsible for giving the overall certification for each local Wellhead Protection Plan if each element is found to be adequately addressed.

Within 60 days of the submittal of your Plan to DEQ for certification, DEQ will send a written acknowledgment of receipt of the request and an estimated date for review and certification of the plan. DEQ will reduce the response time for certification as much as possible. When approved, DEQ will provide a written certification to all signatories to the Plan.

- ***Update Procedure:***

Each Wellhead Protection Plan must be recertified every five years from the date of prior DEQ certification. A new Plan report does not generally need to be prepared. A letter request should be sent to DEQ providing information on any changes to the original Plan. By rule, the "Recertification" of the present Plan can take place only if all the following conditions apply:

- No conditions that could potentially modify the boundaries of the Wellhead Protection Area have occurred;
- An updated inventory is completed and submitted which shows that no new (or changes in the types of) potential sources of contamination are in the wellhead protection area which were not addressed in the previous Plan;
- The management practices outlined in the existing Plan are still appropriate and being implemented;
- The existing contingency elements in the Plan are still relevant; and
- All signatories to the existing Plan agree to recertify the Plan by signing the recertification request letter.

If a certified Plan cannot meet the conditions above, then a revised Wellhead Protection Plan must be resubmitted for certification. The revised Plan should address all elements specified in OAR 340-40-190 (3).

- ***Decertification Procedure:***

There are several ways that a previously certified Plan can become "decertified". A Plan can be automatically decertified if the signatories to a Wellhead Protection Plan do not submit for recertification within six months of the recertification date for that Plan.

A plan can also be decertified by DEQ if it comes to DEQ's attention that a signatory to a Plan is not or has not adhered to and implemented the certified Plan, although this is not an automatic decertification. Any Responsible Management Authority (RMA) that is a signatory to a certified Plan has the ability to withdraw from participation in a Wellhead Protection Plan and the certification process at any time. DEQ will review the Plan to determine if it is still certifiable without the participation of the withdrawing or non-participating RMA. Every effort will be made to avoid a decertification in this circumstance unless DEQ determines that without that RMA, the Plan cannot accomplish the goal of providing a reduction in the risk of contamination of the public water supply.

To decertify a Wellhead Protection Plan, DEQ will send a U. S. Postal

Service-certified letter to all signatories to the Plan detailing the reason(s) why DEQ believes the certified Plan is or was not being followed or is no longer valid and DEQ's intent to decertify the Plan. The signatories to the Plan will have 30 days to respond as to why their Plan should not be decertified. DEQ will review the signatories' response and make a determination as to whether the Plan is still certifiable. DEQ will then send a copy of its decision to all signatories of the Plan.