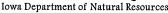


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# Table of Contents

Introduction	1
Wellhead Protection ~ Is It an Issue for Iowa?	
What a Wellhead Protection Program Entails	
Purpose of the Wellhead Protection Model Plan	
Funding and Technical Assistance	
Seven Steps to a Successful Wellhead Protection Plan	
Iowa Aquifers and Recharge Areas	
Surficial Aquifers	4
Bedrock Aquifers	
Team Formation - Step 1	9
Why Form a Team?	9
Who to Recruit	9
How to Recruit	11
Instructions for Completing the Wellhead	
Protection Team Coordinators Form	
Wellhead Protection Team Coordinators Form	13
Delineation of Wellhead Protection Areas - Step 2	15
Importance of Wellhead Protection Area Delineation	15
Defining and Mapping the Wellhead Protection Area	15
Data Requirements	16
Instructions for Completing the Wellhead	
Protection Information Table	
Wellhead Protection Information Table	
Contaminant Inventory - Step 3	23
Identify Activities Within the Wellhead	
Protection Area That Are Potential Sources of Contamination	
In-Depth Review of Potential Sources of Contamination	
Instructions for Completing Contaminant Inventory Table	
Contaminant Inventory Table	
Risk Assessment - Step 4	33
Why Risk Assessment?	
Risk Assessment vs. Risk Screening	33
Completing a Risk Screening	33
Instructions for Completing the Risk Assessment Table	35
Risk Assessment Table	
Instructions for Completing the Risk Consolidation Table	
Risk Consolidation Table	
Contaminant Source Management - Step 5	43
Regulatory Measures to Control Existing	
Sources of Potential Contamination	43

Nonregulatory Measures to Prevent Future	
Sources of Potential Contamination	44
Regulatory Measures to Prevent Future	
Sources of Potential Contamination	45
Zoning Regulations	45
Health Regulations	
Nonregulatory Measures to Prevent Future	
Sources of Potential Contamination	47
Options for Contaminant Source Management	49
Instructions for Completing the Contaminant	= 0
Source Management Log Sheet	53
Contaminant Source Management Log Sheet	
Contingency Plans - Step 6	57
Planning for a Contamination Emergency	57
Instructions for Completing the Water	
Supplier General Information Sheet	60
Water Supplier General Information Sheet	
Instructions for Completing the Contingency Plan Table	
Contingency Plan Table	
Public Participation - Step 7	67
Instructions for Completing the Public	
Participation Log Sheet	
Public Participation Log Sheet	71
Implementation Strategy	75
Planning Wellhead Protection Training	75
Conducting Wellhead Protection Training	
Updating and Administering the Plan	76
Distribution of the Wellhead Protection Plan	
Instructions for Completing the Training Table	
Training Table	
Outcome	83
Glossary of Definitions	85
Appendix One	
Iowa's Bedrock Aquifers	
The Dresbach Aquifer	
The Cambrian-Ordovician Aquifer (Including the Jordan Sandstone)	
Table 1 - Geologic and Hydrogeologic Units in Iowa	92
The Silurian-Devonian Aquifer	94
The Mississippian Aquifer	96
The Dakota Aquifer	
Appendix Two	101
Choosing a Method of Delineation	
Fixed Radius Method	
Analytical Equations Method	

Numerical Flow and Transport Models	104
Other Methods	105
Examples of Delineation	105
STEP 1: Base Map	105
STEP 2: Well Inventory and Screening	105
OPTION A: UNCONFINED AQUIFER	106
STEP 3: Physical Boundaries	106
STEP 4: Hydrologic Boundaries	107
STEP 5: Aquifer Vulnerability Map	108
STEP 6: Water Level Measurements	108
STEP 7: Water Level Surface Map	108
STEP 8: Estimate Aquifer Parameters	119
STEP 9: Estimate Time of Travel	
STEP 10: Delineate the Wellhead Protection Area	111
STEP 11: Recognition of Limitations	112
OPTION B: CONFINED AQUIFER	112
STEP 3: Water Level Measurements	113
STEP 4: Water Level Surface Map	113
STEP 5: Estimate Aquifer Parameters	113
STEP 6: Estimate Time of Travel	114
STEP 7: Delineate the Wellhead Protection Area	115
STEP 8: Recognition of Limitations	115
Summary	116
Appendix Three - Consulting Engineers Council of Iowa	117
Appendix Four	121
Instructions for Completing the Contaminant	
Inventory Site-Specifc Evaluation Table	121
Contaminant Inventory Site-Specific Evaluation Table	
Appendix Five - Toxicity and Mobility Index	125
Appendix Six - Technical Assistance	133
References	135



TERRY E. BRANSTAD, GOVERNOR

# DEPARTMENT OF NATURAL RESOURCES LARRY J. WILSON, DIRECTOR

September 9, 1996

#### To All Model Plan Holders:

During the many years of working with Iowa's drinking water suppliers, we at the Iowa Department of Natural Resources have come to know that Iowa water utilities abide by one common, overriding principle. Though they serve a variety of populations, use different treatment strategies, and are organized in various ways, Iowa's water suppliers aspire to deliver to their consumers a steady supply of safe, quality drinking water. We believe this guiding principle is not diminished in the face of an emergency, but in many instances, becomes more critical. The need to be vigilant becomes very acute when the actual wellhead itself is threatened.

To help water utilities across the state meet their obligations and the expectations of their consumers, we have charged the Des Moines Water Works, working with the Howard R. Green Company, with developing a reference source which will be suitable for assisting water utilities in locating, delineating, and providing protective measures for their respective wellheads.

With the cooperation and funding from the United States Environmental Protection Agency and valuable input from the Iowa Geological Survey Bureau, we have worked with Des Moines Water Works for several months to put together what we feel is an exceptional program. When the projects are completed, it will enable all water utilities to plan to meet challenges that may await them.

We ask that all of you join in our commitment to this project and the heightened reliability it offers to Iowa's drinking water community. We hope further that you will find "Wellhead Protection: A Model Plan for Iowa Water Suppliers" a valuable and useful tool in your community.

Sincerely,

Darrell McAllister

Chief, Water Quality Bureau

Iowa Department of Natural Resources



# Wellhead Protection - Is It an Issue for Iowa?

Across the country, the practice of wellhead protection is becoming a more common operation within a water utility. Simply stated, wellhead protection is a program which protects a community's groundwater supply against contamination - for present and future generations. The program involves education, investigation, land management, documentation, and public participation, all of which are necessary for success. Our society is dependent upon clean water, yet many people don't realize their everyday operations, and day-to-day living, can harm the quality of the drinking water supplies they need.

More than half of this nation's drinking water is provided by groundwater sources. Historically, groundwater was thought to be well-protected from contamination hazards. After all, these water supplies are often located hundreds of feet below the earth's surface. Unfortunately, scientists are now learning this notion is far from true. In fact, groundwater sources are often deemed to be just as vulnerable as surface water supplies, so much so the Environmental Protection Agency's (EPA) Surface Water Treatment Rule has deemed some groundwater sources "under the influence of surface water," requiring them to be treated in much the same manner.

In Iowa, groundwater contamination is a serious issue. Eighty percent of Iowa's drinking water use is provided by groundwater sources, drawn from surficial aquifers and five principal bedrock aquifers. Several public water suppliers are dealing with problems of one or more human-caused contaminants in their supply wells. Most are eventually able to drill new, contaminant-free wells, or connect to a neighboring system. Some have had to provide bottled water, or even shut down one or more of their wells to be able to continue to deliver drinkable water. And, in several towns there are no feasible alternative aquifer sources available to them. In these cases, local governments, residents, and businesses have been severely burdened by expensive cleanup of hazardous contaminations that have affected their water supply, if the contaminations can be cleaned up. All of these situations are costly and disruptive.

Dealing with groundwater contamination cleanup is always more costly than prevention of contamination, which can be provided through a well-designed and implemented wellhead protection plan. Just ask the cities of Decorah or Galva; these communities have experienced contamination and can attest to the burdens that it imposed upon their communities and residents.

# What a Wellhead Protection Program Entails

Wellhead protection is a program designed to manage uses of land so a community's water supply is protected against contamination. When hazardous substances are present in or nearby a community, the well(s) and groundwater source may be at risk of contamination. An effective wellhead protection program will help water utilities determine whether any such hazards exist, and, if they do, what is the likelihood those hazards will deteriorate the safety and quality of their rinking water supply. Knowing this information, water utilities can work with community leaders

the develop plans to manage hazardous situations and minimize, or even avoid, emergencies that could leave the community without an adequate supply of safe drinking water.

Developing a wellhead protection plan will also help your utility be prepared if contamination does occur. Planning alternative water supply options, and knowing how to respond if contamination cannot be avoided, will reassure community residents the drinking water they depend on will be available for generations to come.

As you begin this study of wellhead protection and review this model plan, there are likely to be terms used that may be unfamiliar to you. At the end of the model plan, a *Glossary of Definitions* has been included to assist you.

# Purpose of the Wellhead Protection Model Plan

This model wellhead protection program is designed to teach water suppliers, and the communities they serve, the skills needed to evaluate existing and future risks to their drinking water supplies. When water utilities understand fully the risks posed by certain businesses, operations, and land uses in their community, they can present these issues to the community and together weigh the options for protecting the water supply. The model plan, when completed with information pertinent to your utility, will document characteristics of your water sources, strategies to protect them, and procedures to be followed if a contamination should occur. This model plan meets criteria set out by the EPA for preparing vountary wellhead protection initiatives. While the EPA has not mandated the development of these plans, it is clear from the agency's 1996 Drinking Water Redirection Initiatives Report this type of voluntary program in a partnership-oriented approach with water utilities is desired.

This model plan describes in detail seven steps to be followed to implement wellhead protection planning. For each step, there are one or two fill-in-the-blank forms which need to be completed by water utilities. While many technical aspects of wellhead protection are incorporated into this plan, they are presented in common-sense approaches that are easy to understand and affordable for the smallest communities. This non-traditional strategy will enable Iowa water utilities to use the resources and information they already have available to them to implement wellhead protection plans.

# Funding and Technical Assistance

As you review this model plan, there are two steps which may require in-depth, analytical processes, likely to be provided by engineering consultants or groundwater professionals. For these activities, funding and technical assistance may be needed to allow your utility to proceed with full development of a wellhead protection plan.

Funding for smaller cities may be available, in the form of grants, from sources like the Department of Housing and Urban Development, the Rural Development Administration, and the Clean Water Partnership Program. Technical assistance varies, depending upon your town's proximity to a larger community, and its professional business base. The following organizations may be able to provide technical assistance or resources:

Iowa Department of Natural Resources (IDNR) Water Quality Division
IDNR - Geological Survey Bureau
Extension Services, or Departments of
Geography and Geology of State Universities
U.S. Environmental Protection Agency - Region VII
Regional Planning Council
Iowa Ground Water Association
Iowa Department of Agriculture
National Rural Water Association/Iowa Rural Water Association
Iowa Department of Economic and Community Development

# Seven Steps to a Successful Wellhead Protection Plan

This model plan provides suggestions for wellhead protection program organizing, prioritizing, planning and training. Simple template-style forms included in the seven steps of the model plan require information from your utility or community, and need to be completed as part of your utility's wellhead protection plan. When all forms pertaining to your utility have been completed, this model plan will detail the critical information about your water utility necessary to guard against contamination, prioritize potential hazards, identify appropriate resources, and list measures to keep the plan up to date and useful for your community.

Follow these guidelines to complete the seven steps of the model plan:

- 1. Complete the *Wellhead Protection Team Coordinators* form first. This form will provide basic contact information about each key member of your Wellhead Protection Team. These team members are likely to organize several sub-teams to work on various aspects of the program.
- 2. Complete the *Wellhead Information Table* for each well you use, next. Gathering this information is the first step in identifying your Wellhead Protection Area (WHPA) and will be needed for other steps of the model.
- 3. Complete the *Contaminant Inventory Table* for each well you use, remembering to diagram the locations of possible contaminants on a city street or zoning map, if available. With this information, you will have a "snapshot" of possible risks to your well.
- 4. Complete the *Risk Assessment Table* and *Risk Consolidation Table* to prioritize possible risks. These forms cause you to direct resources to those hazards most likely to impact your water system.
- 5. Complete the *Contaminant Source Management Log Sheet* to record strategies you determine are needed to sufficiently protect your well sites.
- 6. Complete the *Water Supplier General Information Sheet* and the *Contingency Plan Table* to record key contact information and outline measures arranged to assure a continued supply of water is available in the event of a contamination emergency.
  - 7. Complete the Public Participation Log Sheet to record your initiatives to educate and

involve the community in your wellhead protection program.

When completing all forms, it is important to remember to record enough information to allow someone in a back-up capacity to function in a particular team position.

# Iowa Aquifers and Recharge Areas

Many of the towns in Iowa use wells to pump their drinking water from aquifers. Before you can design and put into place an effective wellhead protection program, you need to know what type of aquifer supplies your well, and how your particular aquifer is recharged.

An aquifer is a water-bearing geologic formation that transports and stores groundwater. These formations supply water at a rate large enough to serve as a reliable, long-term source.

The aquifers in Iowa fall into two broad categories: **surficial** and **bedrock**. **Surficial** aquifers are aquifers that have formed within the layers of sand, gravel, and soil which cover most of the state. **Bedrock** aquifers are aquifers that have developed in the deeper geologic, or bedrock, formations beneath the soil.

In addition to being either surficial or bedrock, each aquifer is also either **confined** or **unconfined**. An aquifer is said to be **confined** if it contains layers of material, above and below the aquifer, through which water does not easily flow. **Unconfined** aquifers do not have these layers, so water can flow into them over their entire surface area. Knowing whether an aquifer has a confining layer is important because the way an aquifer is recharged, or replenished, depends not only on the type of aquifer but also whether it is confined or unconfined.

# Surficial Aquifers

Surficial aquifers are aquifers that have formed in the layers of earth above Iowa's bedrock. There are three types of surficial aquifers: alluvial, drift, and buried channel. The alluvial and buried channel deposits yield moderate to large quantities of groundwater. Some of the most productive wells in Iowa draw their water from these deposits. Glacial drift deposits serve as a source of smaller quantities of groundwater. These deposits are significant, however, because they are widespread and they serve as an important source in many rural areas.

Alluvial Aquifers - Alluvial aquifers are large sand and gravel deposits found next to present-day rivers and streams. These aquifers were formed by the rivers and streams when they deposited the sands and gravels in their valleys. Water flows easily through the spaces between the loose particles and, because of their direct connection to the neighboring stream, these aquifers can produce large quantities of water. Within the Missouri River valley a number of wells produce from 1,000 to 1,500 gallons of water per minute. Industrial, irrigation, and municipal wells in the Mississippi River valley regularly pump at the 1,000 to 2,000 gallons per minute (gpm) level. Wells that tap alluvial deposits along Iowa's interior streams commonly yield 200 to 600 gpm. Figure 1 shows the principal alluvial aquifers of Iowa.

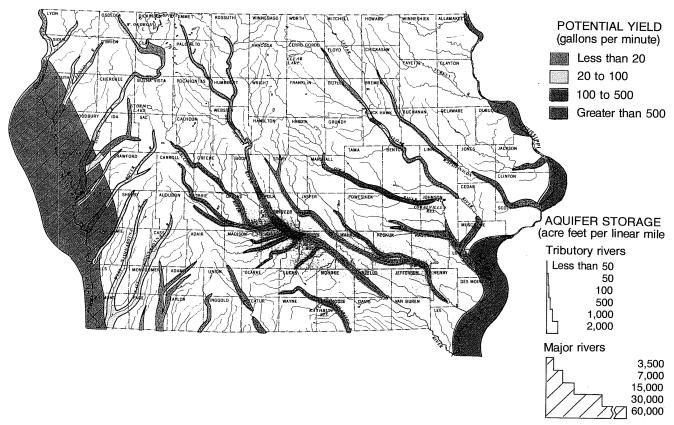


Figure 1: Principal Alluvial Aquifers of Iowa

**Drift Aquifers** - Drift aquifers are localized pockets of sand and gravel distributed within the layers of glacial drift which cover most of the state. The term glacial drift describes any material deposited by glaciers and streams as the glaciers moved into and out of the state. Drift aquifers are generally limited in size and produce only a few gallons of water per minute. Wells in these aquifers are usually shallow, but in some cases exceed 400 feet in depth. Drift aquifers are an important source of water for rural residents in western and southern Iowa, because the bedrock aquifers in that part of the state are deeply buried and often contain poor quality water.

Buried Channel Aquifers - Buried channel aquifers are sand and gravel deposits left by ancient rivers in pre-glacial bedrock valleys. These stream beds were covered when glaciers passed forming buried channels of water-bearing material in various parts of the state. Wells which tap these deposits provide water yields that range from 10 to 100 gpm. The most productive buried channel aquifers are situated in central and eastern Iowa. Figure 2 shows the principal buried channel aquifers of Iowa.

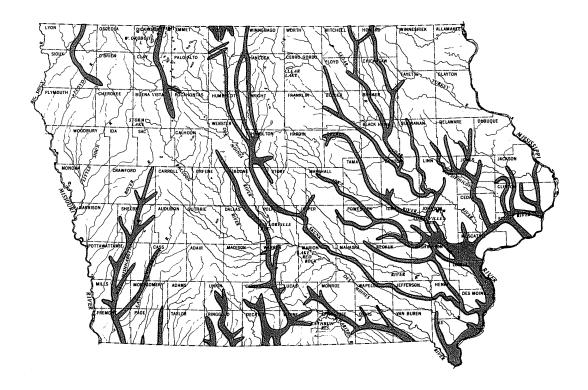


Figure 2: Principal Buried Channel Aquifers of Iowa

Surficial Aquifer Recharge - Surficial aquifers can be recharged or replenished from a number of sources. Many are recharged by precipitation which seeps into the aquifer, or by groundwater which flows in from adjacent areas. Some are also recharged by seepage from underlying bedrock. Alluvial aquifers can be recharged continuously from a nearby stream anytime the water level in the aquifer falls below the water level of the stream.

Some surficial aquifers cannot be recharged directly from the surface because layers of impermeable material separate the aquifer from the surface and groundwater sources. In these cases, the aquifer is said to be confined and the impermeable material is the confining layer. A confining layer is typically made up of clay or other material which limits the movement of water. A confined aquifer is recharged by water which flows in from outside the boundaries of the confining layers, or seeps through the confining beds. Buried channel aquifers are typically confined while alluvial aquifers are typically unconfined.

Surficial Aquifer Water Quality - Water in surficial aquifers is typically hard, but generally less hard than water found in bedrock aquifers. This water often has iron concentrations above the secondary Maximum Contaminant Level (MCL) of 0.3 mg/L. Alluvial aquifers and drift aquifers less than 100 feet deep are susceptible to nitrate and other surface contamination. Surficial aquifers tend to have a lower dissolved solids concentration than water in bedrock aquifers, because the amount of dissolved material in the water is related to the length of time the water has been in contact with the aquifer material. Generally, water in alluvial aquifers and shallow drift aquifers has the lowest dissolved solids concentration, because it has been in the ground the

shortest time. Deep glacial drift aquifers (over 100 feet) and buried channel aquifers generally contain more mineralized water than alluvial aquifers.

# **Bedrock Aquifers**

The bedrock under the state of Iowa was formed over millions of years when the state was repeatedly covered, or partially covered, by shallow seas. With the passage of time, the enormous weight of overlying layers compressed the material deposited on the bottom of these seas to form layers of rock.

Some of these layers of rock hold large quantities of water. The water is stored in sandstones and fractured carbonate rocks. In a sandstone deposit, water is held in the spaces between the grains of sand. In the carbonate rocks, as the sediments harden and undergo structural stresses, cracks develop. Groundwater enters through these openings and dissolves some of the carbonate, thus enlarging the openings, and providing significant water storage. These layers are Iowa's bedrock aquifers, and they fall into two main categories: fractured bedrock aquifers and granular bedrock aquifers.

Fractured Bedrock Aquifers - The two most common types of rock in these formations are limestone, which is primarily calcium carbonate, and dolomite, which consists of both calcium and magnesium carbonates. Limestone and dolomite are both typically very hard and dense with little natural water-holding or transporting capacity. However, once these formations have been fractured by the weight of overlying layers or other forces, water can enter the cracks and slowly dissolve the carbonates forming an interconnected network of channels and caverns. These cracks, channels, and caverns provide the pathways necessary for water movement. The Mississippian aquifer and the Silurian-Devonian aquifer are examples of fractured bedrock aquifers.

Granular Bedrock Aquifers - Sandstone is the rock found in Iowa's granular bedrock aquifers. Sandstone is formed when other rocks are worn away and redeposited by the elements; the resulting material is compressed into rock. Most sandstone is composed of quartz grains which have been cemented together by natural agents. Quartz is common in sandstone because it is very hard and it can survive the weathering process. The flow rate through a granular bedrock aquifer depends on a number of factors, including the amount of cementing material between the grains of sand. Water flows slowly through the spaces between the grains if the spaces are nearly filled with cementing material. Flow tends to increase as the amount of natural cementing material decreases, or is dissolved away. Yield from these formations also tends to increase if the formation is fractured. The Dakota aquifer is an example of a granular bedrock aquifer.

Bedrock Aquifer Recharge - Bedrock aquifers can be recharged through the infiltration of precipitation or surface water, if they are open to the surface. When this is the case, the aquifer is said to be unconfined and the recharge area will be in the immediate vicinity. More commonly, however, this type of recharge is blocked by impermeable layers, such as shale or glacial till, and the aquifer is recharged only in areas where the rock formations are exposed to the surface, or where holes exist in the impermeable layer. When an impermeable layer exists above the aquifer, the aquifer is said to be confined, and the recharge area can be a great distance from the point of use. In Iowa, most bedrock formations generally slope downward from northeast to southwest. The recharge areas for many of the confined bedrock aquifers in Iowa are located in the northeast part of the state and in the southern parts of Minnesota and Wisconsin. In these areas, the rock

formations which make up the aquifers are exposed to the surface, or are shallow enough not to be overlain by an impermeable layer.

Bedrock Aquifer Water Quality - Because of their depth, most bedrock aquifers tend to be less susceptible to contamination by human activities than surficial aquifers. Thick layers of material, including confining layers, slow the movement of contaminants and protect the deep water reserves. As an example, nitrate concentrations in water from the bedrock aquifers tend to be very low. There are, however, some exceptions where bedrock aquifers are close to the surface. These shallow bedrock aquifers can be susceptible to contamination from surface drainage or point sources, such as septic tanks, chemical spills, and refuse dumps. However, even in the case of deep bedrock aquifers, direct pathways, such as improperly abandoned wells, may allow contaminants to enter the aquifer and threaten water quality.

Water quality in bedrock aquifers is also affected by the length of time water has been stored in the aquifer. Over time, water tends to dissolve materials found in the aquifer and hold these materials in solution. Generally, the longer the water is in contact with the aquifer materials, the higher the concentration of dissolved materials will be. In most of Iowa's bedrock aquifers, water tends to move downward from northeast to southwest, allowing higher concentrations of dissolved materials in the southern and western parts of the state. At some point in most of the aquifers the water becomes so highly mineralized as to be a poor-to-objectionable source for most uses. Constituents which tend to increase as time spent in the aquifer increases include: dissolved solids, hardness (calcium and magnesium), iron, manganese, radium, sulfate, and chloride.

The best quality water tends to be found near an aquifer's recharge area, where the water has been in the ground for the shortest amount of time. Unfortunately, these are also the areas which are most susceptible to surface contamination.

For specific information about the bedrock aquifers in Iowa, turn to Appendix One.

# Team Formation - Step 1

# Why Form a Team?

Local involvement or ownership of your wellhead protection plan is vital to its success. One way to ensure ownership is through the building of a Wellhead Protection Team. It's strongly suggested the water utility lead the wellhead protection initiative, however, it will be difficult to implement a comprehensive plan all by yourself. Involving the community early and often builds support for your program. Additionally, if key residents in your community understand and support your efforts, the likelihood of other citizens becoming involved in actively managing the protection area (Step 7) is high. Conversely, if people are left "out of the loop," their acceptance and involvement will be lukewarm at best (hostile at worst), and the probability of a voluntary effort succeeding will be low. Forming a local Wellhead Protection Team is a good way to begin the public involvement process.

# Who to Recruit

Although the size and membership of your Wellhead Protection Team may differ from one community to the next, it is important to make sure your planning team represents all interests in your community. If there are existing groups in your community that have worked together successfully on important local or state issues in the past, it may be useful to include them in a planning team or even build the planning team around them.

Some groups to consider when forming your Wellhead Protection Team are:

- water suppliers
- · elected officials
- local government agencies
  - health
  - planning
  - natural resources
- local well drillers
- businesses
- land developers
- community service organizations
- environmental groups
- public interest groups
- farmers
- interested citizens

Perhaps most important is the selection of a leader who can keep the planning team organized and on track. A local official or community leader who has already gained community support may be a good choice for this position. They can assist with management options and

strategies that may be needed.

Your team will also benefit tremendously from the advice of a hydrogeologist, engineer, or land planner who may teach others in the group or act as the group's Technical, Regulatory, or Planning Coordinator. The local extension service, Natural Resource Conservation Services (NRCS) (formerly known as the Soil Conservation Service), or state Geological Survey Bureau may be able to help you find candidates with these qualifications.

Whatever its makeup, your Wellhead Protection Team should include representatives of all groundwater stakeholders in your community. In the following table, the Wellhead Protection Team responsibilities that will need to be carried out are identified. In choosing your team, remember one person can serve more than one role. If you have only a few people interested and available, consider combining responsibilities, as it makes sense for your community. At the same time, recognize to truly do everything needed, you're going to need other people, beyond yourself and the key coordinators shown here, working in each of these areas. Make the most of groups already in existence; see if they will take on a key wellhead protection responsibility within their organization.

Position	Basic Responsibilities
Team Leader	• identify and invite key players and agencies to participate
(suggested people: mayor, city manager, water	• ensure all stakeholders are represented
superintendent/operator)	• delegate, coordinate and integrate all leaders and work groups
	help develop budget
	• serve as focal point for public
·	• perform oversight
	• facilitate public involvement sessions
Financial Coordinator	develop budget with Team Leader
(suggested people: city	identify and solicit funding sources
manager, city clerk, local accountant)	distribute funds and keep appropriate financial records
Technical	work with Team Leader to identify pool of experts
Coordinator (suggested people: water	collect data
superintendent/operator,	• preliminary identification of WHPAs
retiree, civic organization)	determ ine potential contam inants
organization)	assess risks
	• research/evaluation
	• design control/management program
	• interaction with technical experts, as needed
Regulatory	• identify regulatory measures already in place and those needed
Coordinator (suggested people: city	• perform and coordinate monitoring and inspections using appropriate agencies
official, consultant, city	• enforcement
attorney, health depart- ment representative)	
ment representative)	
Planning Coordinator	work with Technical and Regulatory Coordinators to develop source management plan
(suggested people: water	identify consumption patterns
superintendent/operator, city planner, consultant,	develop and plan infrastructure
business leader)	• establish priorities
	identify future threats
Communication	work with Team Leader to coordinate meetings
Coordinator	• report on information gathering
(suggested people: local media employee, retiree,	• act as team recorder/secretary
civic organization, business leader, farmer)	facilitate public outreach program
Water Service	document, administer, and update wellhead protection forms
Coordinator (suggested person: water operator, city clerk)	monitor water service before, during, and after an emergency .
10	

# How to Recruit

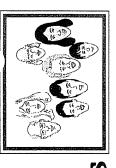
Once the word has been spread that a team is forming, informational packets should be sent to each organization or individual expressing an interest or identified as being a key stakeholder. Those responding should be asked to suggest others whose careers, backgrounds, or hobbies might make them candidates for participation. Remember, a technical background is helpful, but not necessary. The primary criteria for volunteer participation are interest and willingness to serve.

As recommendations for team members are received, be prepared to provide prospective recruits with a full explanation about what wellhead protection is, and be able to "sell" the need for it in your community. Seek help from nearby utility superintendents, your consultant, or the regional IDNR contact to develop your strategy for "selling" the need for wellhead protection. You must be able to convince others of the value of wellhead protection or your effort may not be successful. After a reasonable time has elapsed, an organizational meeting should be held. Invite all interested parties. Use this meeting to answer any questions and appoint the members of your Wellhead Protection Team. Upon appointment, record the contact information for each member on the *Wellhead Protection Team Coordinators* form.

# Instructions for Completing the Wellhead Protection Team Coordinators Form

In the *Name* section, record the appropriate name of the team member beside each team member position assigned. Remember, one person may act in more than one team function.

In the *Work Number, Pager Number, Cellular Number, Fax Number* and *Home Number* sections, write down the applicable numbers for each coordinator position of your Wellhead Protection Team. It is vital to include as many phone numbers as are available, because a contamination emergency can occur during any time of the day of night.



# Wellhead Protection Team Coordinators

Position	Wellhead Prote	Wellhead Protection Team Coordinator Names and Telephone Numbers  me Work Number Pager Number Cellular Number	nator Names and Pager Number	Telephone Number Cellular Number	s Fax Number	Home Number
Team Leader						
Financial Coordinator						
Technical Coordinator						
Regulatory Coordinator						
Planning Coordinator						
Coordinator Coordinator						
Water Service Coordinator						

# Delineation of Wellhead Protection Areas - Step 2

Importance of Wellhead Protection Area Delineation

Having learned something about the aquifers in Iowa, your first step is to identify the aquifer(s) that supplies your well(s). When you've investigated your specific aquifer, you can begin a process to delineate your Wellhead Protection Area (WHPA), or your well's area of influence. Delineate means to determine the area surrounding your well which you need to protect from contamination. Your well's area of influence includes land immediately surrounding the well, and may extend a few feet to a few miles away from the well. The WHPA differs for every well, depending on the aquifer serving the well, its material, and the amount of water being withdrawn. WHPAs are usually odd shaped, rather than being circular areas around the well. Accurately defining the WHPA is important because any contamination occurring in this region could eventually affect your well. If the boundaries established are not correct for your well's usage and the aquifer's groundwater flow characteristics, you may be trying to protect an entirely too large, or too small, area. In this step of the model plan, you will be guided through preliminary data gathering to help you later, in the event a full-scale scientific delineation process is needed.

Beyond the WHPA, you also need to be concerned about the aquifer's recharge area. For some aquifer types, such as alluvial aquifers, the recharge area may be very near the well, and by protecting the land around your well, you can protect at least some part of the recharge area. Many times, however, aquifers recharge some distance from the well. The recharge area is the region most vulnerable to contamination because it is often in direct contact with surface exposures such as spills, runoff, and precipitation. Any contaminant entering the aquifer in this area ends up moving toward the well.

It is important to know where your aquifer's recharge area is because the closer this area is to your well, the faster some contaminants may travel to your well. While you may not be in a position to control or even influence activities that occur in the recharge area, you should at least know whether manufacturing, production, or other facilities are close to the recharge area. This will allow you to be alert to potentially hazardous situations that could affect your utility's water sources, and for you to alert owners/operators of these facilities of the importance of their operations on your community's water supply.

# Defining and Mapping the Wellhead Protection Area

Defining and mapping your wellhead protection area is considered the most critical step in your wellhead protection plan; it is also the most complex. For these reasons, this model plan suggests a two-part approach to defining the WHPA for each well. The first part is to thoroughly study the characteristics of each well used in your drinking water supply system. This can be accomplished by obtaining and reviewing the well log and summary report compiled by the well driller. Additional information is also available from the Geological Survey Bureau and other sources at minimal to no cost, as shown in the following *Data Requirements* table.

DATA SOURCE	POSSIBLE LOCATION	TYPICAL COST
WELL LOG RECORDS: Showing owner, location, depth, name of driller, date of installation, well construction details, geology, intended use, static (prepumping) water level, pumping water level, pumping rate, duration of pumping, chemical analysis	Well log records are available from several sources. First, search the well owner's files for copies of perfinent logs or test results; second, contact the Geological Survey Bureau of the lowa Department of Natural Resources (IDNR-GSB) at(319)335-1575. The driller is required to submit this information; third, contact the driller and request a copy of the records.	If available, this information is usually free, or available for the cost of reproduction and postage.
MAPS: U.S.G.S. 7½-Minute Topographic Map Bedrock Contour Map Geologic Map Aquifer Vulnerability Map Water Level Map (as available)	Maps are available from several sources. Among them are the owner's files, local planning agencies, libraries, university and college Map Libraries or Geology Departments, County Assessor's Offices, IDNR-GSB, and the U.S. Geological Survey at (319)337-4191.	Typically less than \$10 each.
LITERATURE: Regional Water Atlas (IDNR-GSB) Regional Geologic or Hydrogeologic Reports By IDNR-GSB or U.S.G.S. Site-Specific Geologic or Hydrogeologic Reports by Consultants	Published reports on a wide variety of geologic and hydrogeologic topics can be found at the IDNR-GSB or the U.S.G.S.  A summary of pertinent test results are typically provided by the consultant who designed or directed the installation of your well(s).	Cost varies, but typically ranges from a few to tens of dollars, or the cost of reproduction and postage.  This cost can be expensive.
PHOTOGRAPHS: Aerial Photos (1:100,000 and 1:20,000 scales)	Photographs can be obtained from several sources including local planning agencies, the U.S. Dept. of Agriculture -Farm Service Agency (county office), the Natural Resource Conservation Service (formerly Soil Conservation Service) Soil Survey Reports, U.S.G.S., County Auditor, Corps. of Engineers, and commercial aerial photography businesses.	Usually a few to tens of dollars and postage. Delivery may take several weeks.
PERSONAL COMMUNICATIONS:	Typically with the driller, a consultant, or a representative from the IDNR-GSB or U.S.G.S.	Usually free or relatively inexpensive (several dollars per minute).

Using this information you have collected, you need to complete a *Wellhead Protection Information Table* for each well. The *Wellhead Protection Information Table* prompts you to record, in one location, the information about your operations and the well itself that will be needed to calculate exact boundaries of your WHPA, when the time comes for that to occur. It will also cause you to become more familiar with the components of your well, the aquifer, and will enable you to gain a better understanding of how water is actually delivered to your well site.

The following pages provide detailed instructions for completing the *Wellhead Protection Information Table*, along with a blank *Wellhead Protection Information Table* form. A pocket has also been provided for you to keep a copy of the well logs and summary reports for each well for future reference.

Determining and mapping the exact boundaries of your WHPA is the second part of this model's wellhead protection delineation process. Generally, defining a WHPA can be done using one of three methods: 1) simple/fixed radius; 2) moderate/analytical equations; or 3) complex/numerical flow and transport modeling. Each of these methods and a description of their distinct advantages and disadvantages can be found in Appendix Two. At the very least, using the information recorded on the *Wellhead Protection Information Table*, you can determine a fixed radius WHPA for your well. This is a good beginning effort, until you have gone further into Steps 3 and

4 of this model, at which time, you may determine more extensive scientific processes are needed.

To define your WHPA to the fullest extent possible, and to make the delineation viable and accurate, the boundaries must be based on scientific information, rather than "rules of thumb." If a hazard truly does exist within the protection area's boundaries, your utility and community could be faced with some difficult decisions down the road to assure the safety of the water supply. In favorable situations, changes can be negotiated and put in place over agreed upon time periods. In worst-case scenarios, those responsible for the hazard source or property may oppose any measures needed to protect the water supply. If this happens, legal issues may arise, and you want to be in a firm position with sound science backing up the WHPA boundary decisions. Appendix Three contains a list of engineering consultants operating in Iowa with technical expertise to conduct these types of studies.

In the Well No. section, record the specific number of the well this table refers to.

In the Aquifer Name section, enter the name of the aquifer supplying your well.

In the *Aquifer Classification* section, use information from your well driller, this model plan's *Iowa Aquifers and Recharge Areas* section, and data contained in Appendix One to check each box that applies to the aquifer. You will check at least two boxes under either the *Surficial* section or the *Bedrock* section, because every aquifer can be classified as either confined or unconfined.

In the *Well Location Description* section, write a general description of where your well is located that includes, if possible, an address. For example, you may write "One-quarter mile north of Acme Manufacturing at 123 Madison St., between Elm and Maple Streets, directly adjacent to the old feed mill." Also, record the legal description, including section, township, and range, if available. This may be helpful to gather additional information from IDNR-GSB.

In the Well Construction Details section, write down the date your well was constructed, the contractor who built your well, the engineer who designed your well, and the well's depth. Check whether the well is a primary water supply source, or strictly a standby or secondary source. If you have alluvial wells, information about the bore hole will be important. Complete the diameter, length, and gravel-pack areas as appropriate. If your well has a casing, check the appropriate box, and record the type of casing material contained in your well, its diameter, and how many feet of that material your well contains. A well can be made up of more than one type or diameter of casing material, so remember to record all of them. Use a separate blank page if you need more room. If your well is grouted, check the appropriate box for each segment of casing. Mark the appropriate box to indicate if your well has a screen, and record the type of well screen material contained in your well, its length and diameter. Record, in both gallons per minute (gpm) and feet Total Dynamic Head (TDH), your well's pump capacity, how many gallons per minute and hours per day or week your well typically operates, along with the appropriate pump type. If your pump is an "other," make sure you write in the space provided the type of pump used in your well. The ground surface elevation and static and pumping water levels should be recorded next. Finally, it is important to note which aguifer layers the well is open to. In other words, if your well does not have casing or is screened in all or any section of it, what type of aquifer material does it pass through? In this section you need to record at what depth this open area of the well begins, how long the open area is, and the proper name and description of the aquifer formation it is exposed to. For example, at a depth of 500 feet your well's casing material stops and for the next 25 feet there is screen material enclosing your well. At this section, your well is then exposed to the St. Peter sandstone formation.

In the *Well Log Report* section, attach both the well log and any chemical/mineral analysis documentation you have and file them in the pocket page provided in this model plan. If you don't have any or all of this information, call the IDNR-GSB phone number recorded in the *Well Log Report* section; they may be able to provide some missing details.

In the *Diagram Your Well* section, draw a picture of your well that includes the depth, length, diameter and make-up of each casing and screen type. If possible, include a description of the aquifers and other layers running the length of your well. A sample diagram is provided in the

upper left corner of the diagram page.

In the *Well Maintenance History* section, enter descriptions, dates, and names of people who have performed maintenance or repairs on the well, casing(s), pump, etc. Also, record the date when these items should next be checked in a preventive maintenance routine.



# Wellhead Protection Information Table

Well No.

Aquifer Classification (check all that apply): Aquifer Name Surficial: Bedrock: alluvial fractured buried channel granular 🔲 confined  $\square$ drift □ unconfined  $\square$ confined unconfined Well Location Legal Description Description Well Construction Date of construction Details Contractor Engineer Primary 🔲 Depth Standby 🔲 ☐ Bore hole Gravel-Pack: diameter (inches) \_\_\_\_\_\_ length yes 🔲 no 🗖 from feet ☐ Casing Diameter Length Material Grouted: yes 🔲 no 🗆 yes 🔲 no 🗆 yes 🗆 no 🗆 Screened: yes no 🗆 Well screen material, length and diameter \_\_ material length diameter Pump capacity Typically operated at \_\_\_\_\_gpm at \_\_\_\_\_ feet TDH \_\_\_\_\_gpm Pump type: submersible Typically operated line shaft  $\square$ hours/day other 🔲 \_\_\_\_ hours/week Ground surface elevation: \_\_\_\_\_\_ feet, mean sea level Static water level: depth from ground surface feet elevation \_\_\_\_\_\_feet, mean sea level Pumping water level: depth from ground surface elevation \_\_\_\_\_\_feet, mean sea level Parts of well open to aquifer layers (formations) from \_\_\_\_\_ to \_\_\_\_ length \_\_\_\_\_ formation name from \_\_\_\_\_ to \_\_\_\_\_ depth \_\_\_\_\_ length \_\_\_\_\_ formation name from to depth length formation name Please place your well log report and chemical/mineral analysis, if available, in the Well Log Report pocket page provided directly after this section. If you don't have a copy of your well log report, call IDNR-GSB in Iowa City at (319) 335-1575.

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# Contaminant Inventory ~ Step 3

This step of the model plan provides information to help you identify existing and potential sources of groundwater contamination that may impact your well(s). It is also a building block which will outline measures to protect your groundwater supply for Step 5, Contaminant Source Management.

# Identify Activities Within the Wellhead Protection Area That Are Potential Sources of Contamination

Identifying sources of contamination can be an intimidating proposition in many communities. Stories of hazardous cleanups and their enormous costs can frighten a community, particularly smaller ones already operating under rigid financial conditions. No one wants to hear about contaminated water sources, let alone have one. It's perfect reasoning for involving the community in your wellhead protection process. It is vital for all stakeholders to make the commitment up front to work together to alleviate any contamination hazards discovered. If people believe they can be part of the solution, rather than the problem, they will be more willing to help gather the vital information needed.

Choose several key community leaders to help in the contaminant identification process. To keep the activity informal and non-threatening, go to the community rather than having them come to you. Organize meetings at the local Lions or Elks Club building, the fire station, community center, high school library, or other community building. Consider holding one or more sessions where you talk about buildings, land uses, business activities, and other functions that surround each well site, or wellfield, if a number of wells are in close proximity to one another. Remember to include discussion about plans for the future, as well as current operations and past activities. Contamination of the groundwater could have occurred years in the past, the true danger of which could still be undetected.

If you find it difficult to recruit team members and others to assist in this process, you can still work individually to identify contaminant sources affecting the well. While a participative process is desired for all the reasons stated above, it may not be possible for your community. Follow these same processes: start by completing a *Contaminant Inventory Table* for each well or wellfield. Use a community aerial photography map, or street or zoning map if available. (If a map is not available, use the diagramming sheet in this section.) Begin by locating each well, then sketching a circle around the well. Allow the circle to represent a distance of 500 feet from the well. Begin identifying various operations that currently or previously existed inside the circle. After all operations have been identified for the first 500-foot circle, proceed to another circle 500 feet outside of the first. Work outward from the well, establishing target-like rings around the well, and discussing the existence of possible hazards in each. Repeat this process until a minimum 2,500-foot radius from the well has been developed, or until the entire delineated WHPA (if determined) has been covered.

While discussing or thinking about potential hazards that currently or previously existed

within each circle on the diagram or map, use the *Contaminant Inventory Table*, and place a check mark beside each hazard identified. Plot its approximate location on the map or grid form being used. Use the space on the *Contaminant Inventory Table* to the right of each hazard to provide further details. For example, quantity, storage, form (liquid, dry, gas), etc.

In marking contaminant sources, consider past and present storage and disposal sites, some of which might be recognizable as sewage treatment works, dumps, landfills, or underground injection wells. Be careful to also locate small commercial and industrial storage and disposal areas, such as storage tanks, lagoons, agricultural chemical supplies, and drywells. Residential underground septic systems should also be included. The waste materials discharged at these sites can include solid waste, sludge, liquids, solvents, and oils. Investigate whether any of the wastes discharged in your community are hazardous under the Resource Conservation and Recovery Act (RCRA).

When identifying land uses, again consider both present-day and historical uses, such as capped landfills, underground fuel storage tanks, abandoned mines, or the present-day Dairy Sweet that used to be a Clark gas station. Many of these facilities may not be apparent today, but could pose a significant threat to the present water quality of an aquifer. For example, land that was used for agricultural purposes at one stage may contain traces of pesticides that were used, stored, or disposed of on-site.

If you use a zoning map in the identification process, it will show the sections of the community which have been approved for specific land uses, whether it is residential, commercial, or industrial. A zoning map is helpful because it displays concentrations of businesses. If these concentrations are located very near the well or in the recharge zone of the aquifer, they can increase the threat to your water resource. For example, if an industrial area is nearby your well, any spills of chemicals in those operations could reach the aquifer more quickly than a spill from a location at the edge of town, or far from the well. Also, many industries are built along transportation routes that follow river valleys where high-yield aquifers are often located. Looking at a zoning map will identify these areas, and with adequate wellhead protection planning, your community can be sure appropriate zoning is in place to limit high-risk activities.

In addition to contaminants, you need to identify other production pumping and municipal well locations. Plot these on the map, also. While they are not contaminants, they can alter the groundwater flows and speed, and affect the amount of time a potential contaminant can take to reach the well.

# In-Depth Review of Potential Sources of Contamination

The informal sessions and *Contaminant Inventory Table* forms completed in those sessions will identify general information and offer leads to possible hazards. It is then up to the Wellhead Protection Team to determine when additional interviews or field visits are needed. This decision should be made either during or following Step 4 - Risk Assessment.

When you determine more investigation is needed, particularly about past activities, there are many sources of information within your community that can be researched. These include, but are not limited to, interviews with long-time residents of the community; Chamber of Commerce membership lists; the local phone book; local newspapers; the police and fire departments; fisher-

men; the utility companies serving the community; and community boards such as planning, conservation, health, engineering, and public works. Information can also be obtained from state and federal environmental agencies on the transportation and discharge of hazardous materials, groundwater discharge permitting, and discharges to surface waters. Information regarding underground commercial storage tanks is also available from the Iowa Department of Natural Resources.

It is also important that any known contaminated waters be identified at this stage of the process. This identification may involve contacting state water pollution control officials, state drinking water managers, water companies, and waste management agencies. The regional health director can also advise you of known contamination problems. It is likely you will already know of problems of this nature in the vicinities of your well(s), but if you haven't studied the aquifer's recharge area, this is a good time for you to make inquiries to discover possible contaminations in that area.

Along this line, identify the location of any *point source* discharges within the community or in any neighboring communities that may affect your well(s). Point sources discharge waste at a single location and generally consist of pipe outfalls to surface waters. Examples include sewage treatment plant outfalls, water treatment plant outfalls, storm sewers and industries. These discharges are regulated and usually require monitoring. Monitoring logs are an additional source of water quality information and are available from the Iowa Department of Natural Resources ~ Wastewater Section.

**Non-point sources** are widespread sources of contamination that cumulatively present a threat to groundwater. These sources are not regulated by permits and may be more difficult to track down. Examples include roadway and parking lot drainage, landfill runoff, agricultural runoff, and runoff from stockpiles of roadway deicing materials, such as salt.

Field visits are particularly helpful, as you can investigate known sites and also be on the alert for other activities that may present hazards. An example might be unidentified gallons or barrels stored behind a garage or other building. Field visits are another excellent opportunity to get your community involved. Divide the circular areas from your inventory process into smaller sections and enlist local volunteers to canvass specific areas. Community organizations such as 4-H Clubs or FFA groups might be willing to participate in this effort. It is the responsibility of the Wellhead Protection Team to instruct volunteers in how to survey for potential contaminant sources. Once the volunteers confirm an activity that could undermine groundwater quality, they should write a description of the activity, its location, the volume of material or chemical(s) stored and handled, and the name of an individual to contact for additional information. Following the field visits, more exact locations of the hazard sites can be plotted on the circle diagrams for each well. (See Appendix Four for an individual site-specific form to use when recording information from field visits.)

With this process completed, you now have a series of *Contaminant Inventory Tables* and maps showing potential contaminant sites pertinent to each well or wellfield. The maps or diagrams should show land uses, business activities, waste disposal sites, point sources, underground septic systems, underground storage tanks, and other contaminant sites that could threaten your water supply. It should also indicate where groundwater quality has been degraded or where there is a good possibility that it will be. Consider using different symbols on the map or diagram

to distinguish between different sources of contamination.

The following pages provide detailed instructions for completing the *Contaminant Inventory Table* and the diagram of the inventory circles.

# Instructions for Completing Contaminant Inventory Table

In the Well No. section, write the appropriate number of your well or well field.

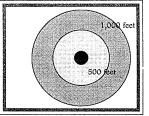
In the *Date of this inventory* section, write the date on which this inventory occurs. If more than one day is needed to complete the survey, write down every date applicable.

In the *Recorded by* section, write down the name of the person who is documenting the brainstorming session or conducting the individual inventory process. (It would also be a good idea to write on a separate piece of paper the names of the people who participate in the brainstorming sessions.)

In the *Potential Sources of Contamination* section, place a check mark beside each hazard that already is, or poses a potential contamination threat to this particular well. In the space provided to the right of each hazard, or in the *Notes* section, record such information as the distance and direction from the well, quantity of each hazard, if there is more than one site where this hazard can be found, and any other pertinent information. For example, in the Herbicide use/storage sites entry, you could record "700' N., 2 gallons of atrazine at the Smith farm."

For plotting potential contaminant sources, it is recommended that an aerial photography city map, or city street or zoning map be used if available. A USGS map showing the town and surrounding area would also work well. If none of these prepared maps is available, use the diagram provided in this section of the model plan. Follow these directions using either the map or diagram: Begin by recording the well location. Then sketch in a circle around the well. Allow the circle to represent a distance of 500 feet from the well. Begin identifying various operations that may exist or previously existed inside the circle. When all information related to the first 500-foot circle has been recorded, proceed to the next 500-foot circle outside of that. Work outward from the well, establishing target-like rings around the well, and recording possible hazards in each. Repeat this process until a minimum 2,500-foot radius from the well has been developed, or until the entire delineated WHPA (if determined) has been covered.

# Contaminant Inventory Table



Well No.

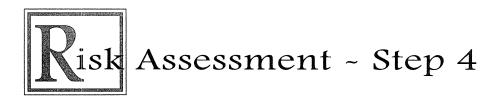
Date	of this inventory	Recorded by
		Potential Sources of Contamination
Place	e a check mark beside each po	otential hazard listed below you have identified might have an impact
	our well.	
	Potential Source	
	Above-ground storage tanks	4)
<u> </u>	Airports (operating/abandon	ed)
	Animal burial sites	1
	Animal feedlots, stables, kenn	.els
	Artificial recharge	
	Asphalt plants Auto repair, service, salvage s	nikoa
	Boatyards	ntes
	Car washes	
	Cemeteries	
	Cesspools	
	Chemical manufacture/stora	ge sites
		Se 01/00
	A	
	Construction sites	
	Drainage wells/ditches/tiles	
	Dry cleaners	
	Dumps	
	Electronics manufacture	
	Electroplaters	
	Fertilizer use/storage sites	
	Foundries/metal fabricators	
	Fuel oil use/storage sites	
	Furniture stripping/refinishing	ng
	Gas stations	
	Golf courses	
	Grain storage bins	
	Hazardous waste landfills	
$\vdash$	Herbicide use/storage sites	
$\vdash$		
	Highways	
	Holding ponds/lagoons	
	Household hazardous produc	nta
	Household lawns	115
	Injection wells	
	Irrigation sites	
	Irrigation wells	
	Wood preserving facilities	
	Jewelry/metal plating establi	shments
	Notes:	

	Percential Company	
✓	Potential Source	
	Landfills	
	Laundromats	
	Machine/metalworking shops	
	Manure spreading sites/pits	
	Medical institutions	
	Mining and mine drainage	
!	Municipal incinerators	
	Municipal landfills	
	Municipal sewer lines	
	Oil/Gas wells	
	Open burning sites	
	Paint manufacture/storage sites	
	Petroleum production/storage sites	
	Photography/printing establishments	
	Pesticide use/storage sites	
	Pipelines	
	Quarries	
	Railroad tracks and yards	
	Recycling/reduction sites	
	Research laboratories	
	Road deicing operations	
	Road maintenance depots	-
	Scrap and junkyards	
	Septage lagoons and sludge	
	Septage overflows	
	Septic systems	***************************************
	Service station disposal wells	***************************************
	Sewer lines	
	Storage tanks	
	Storm water drains/basins	
	Storm sewers	
	Streams (lakes, rivers, creeks)	
	Swimming pools	
	Toxic and hazardous spill sites	-
	Transfer stations	
	Underground storage tanks	
	Wells (operating/abandoned)	
$\Box$	* Residential	
	* Municipal	
$\exists$	* Production	
	1	
$\exists$	Other	
		-
	Notes:	
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# Why Risk Assessment?

The purpose of risk assessment is to prioritize the contaminant sources identified in the prior steps of the model program. Completing this step of the model plan will allow you to determine exactly how vulnerable your well is due to its construction and condition, as well as the degree of risk associated with each contaminant. This information is then combined to identify those contamination sources that present the greatest risk to each well and your water system as a whole.

# Risk Assessment vs. Risk Screening

Traditional risk assessment, as defined by the EPA, has four steps: hazard identification, exposure assessment, dose-response assessment, and risk characterization. It basically identifies who will be exposed, to what contaminants, at what concentration, and for what duration. This information is then combined with a health effects assessment (generally dose-response or epidemiologic data) in order to categorize risk from a given contaminant. This traditional process, like the standard wellhead protection area delineation process, involves a series of numeric calculations and analyses. Again, this exercise may require outside assistance or technical expertise. For the same reasons as stated in the delineation step of this model program, it is recommended a simplified form of risk assessment or "risk screening" be used initially.

# Completing a Risk Screening

Risk screening is something most water utilities can undertake themselves, using the information already gathered in the previous steps of this program, and with the help of several indices published by the EPA. This model uses a relatively simple, two-component screening approach.

The first component evaluates how vulnerable each well or wellfield is. In this portion of the screening, you look at characteristics of the well itself, how it was constructed, and aquifer characteristics to determine if the well is at risk because of any of these conditions, aside from the presence of any contaminant source. Several factors used in this portion of the assessment relate to IDNR's determination of the well as either vulnerable or not vulnerable. Appendix Two's discussion of the fixed radius delineation method also contains specific separation distances used by IDNR when determining your well's vulnerability. This information may be helpful as you complete the *Risk Assessment Table*, in this section of the model plan, for each well or wellfield.

The second component rates each contaminant source in three categories. The first category is its threat to public health. This means how dangerous is the contaminant to people? Will the contaminant cause drinking water to look or smell bad? Will people become sick if exposed to it in their drinking water? Or, could it be life-threatening if consumed? This model uses a one to three rating, based upon toxicity ratings assigned by the EPA for specific land uses and chemicals. Appendix Five contains the adapted indices needed to determine the specific rating for each con-

taminant on your *Risk Assessment Table*. If you know the exact chemical compound, you can locate the rating by name of the chemical. If you do not know the chemical name, but you do know the nature of the land use or business activity, such as agriculture or dry cleaners, the index found in Appendix Five will also allow you to assign a rating based on this broader, general-use category.

The second category rates each contaminant in terms of its ability to move within the water source, called "mobility." Again, this model plan uses a one to three rating, based upon mobility ratings assigned by the EPA for specific land uses and chemicals. These ratings are also found, along with the toxicity ratings, in Appendix Five.

The third category rates each contaminant source's location to the well and/or recharge area. The closer the source is to the well/recharge area, the greater the risk of contamination to the well may be. Again, a one to three rating system is used, based on a contaminant source's distance from the well/recharge area. In this portion of the rating, location is used as a simplified expression of time-of-travel concepts. If advanced WHPA delineation and transport modeling has been completed, more precise risks in this category will be known. In fact, you would likely have 2-, 5-, and 10-year times of travel defined for a particular contaminant source. However, in the absence of this advanced study, distance of the contaminant from the well/recharge area is substituted.

You should complete a *Risk Assessment Table* for each well or wellfield which has significantly different locations, operating or construction methods, or aquifer sources.

The completed *Risk Assessment Table* will show contaminants and sources which require immediate attention, and assist in developing long-term, contaminant management strategies to protect each of your groundwater wells. To know which hazard, from which specific WHPA, offers the highest potential risk, you need to consolidate all the risk assessment data into one sheet. The *Risk Consolidation Table* allows you to do this overall prioritization. Those contaminant sources having the highest risks, when taking into account both the well's vulnerability and the specific contaminants, should be attended to first. If desired, once you have priorities established, you can map the risks (using the same map or diagram used in Step 3) to show areas of highest concern and potential threat to the utility's groundwater supply.

In the *Well No.* section, record the specific number of the well or wellfield this table will refer to.

In the *Vulnerability of Your Well* section, answer questions one through nine with regard to this particular well. If you answer "Yes" for any question, record a check mark in the *Yes* box for that question. If the answer is "No" for any question, record a check mark in the *No* box for that question. If you do not know the answers to these questions, IDNR can help. For assistance with questions one through five, contact your IDNR field office, or the central office in Des Moines. This information may also be found on your operating permit or sanitary survey issued by IDNR. For help with question six, contact IDNR-GSB at (319) 335-1575. Questions seven through nine should be answered with operating knowledge of water utility staff. After answering each question, add the number of check marks in the *Yes* boxes. Write that number in the *Yes Total* square. If you answer "no" to all questions, still record a 1 in the *Yes Total*, to represent the well as being active. The *Yes Total* number may range from a minimum of 1 to a maximum of 9.

In the *Contaminant* section, list by name, being specific as possible, each contaminant source you have identified that could affect this well. Remember to use the Step 3 form to properly record the contaminants you have identified.

In the *Threat to Public Health/Toxicity, Mobility* and *Location to Well* sections, determine the impact each contamination would have on your water utility's individual and commercial users. Using a scale of one to three, with one being a low risk and three being a high risk, assign a number assessing the impact of each factor.

### • Threat to Public Health/Toxicity

Enter the rating number 1 (low), 2 (moderate) or 3 (high) for the specific source category or chemical contaminant from the adapted EPA index sheets in Appendix Five.

## Mobility

Enter the rating number 1, 2 or 3 for the specific source category or chemical contaminant from the adapted EPA index sheets in Appendix Five.

NOTE: If you have a source category or chemical contaminant which cannot be found in Appendix Five, consider this an"unknown" hazard and rate it a 3 until you can consult other resources such as IDNR or EPA to determine more accurate ratings for toxicity and mobility for this contaminant.

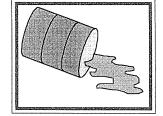
#### Location to Well

If the contaminant source is contained within the first concentric circle (500 feet) around your well, rate it a 3. If the contaminant source is located between 500 and 1,000 feet from your well, rate it a 2. If the contaminant source is greater than 1,000 feet from your well, rate it a 1.

Add together the ratings for *Toxicity, Mobility* and *Location* for each contaminant and enter the sum in column 5 of the form.

You have now determined the vulnerability of the well and from the numbers recorded in column 5, it is easy to see the hazards presenting the greatest risk to this particular well (those hazards with the highest sums). You now need to consolidate this information from each well, so you can determine overall priority among all wells. Use the *Risk Consolidation Table* contained in this section to complete this process.

## Risk Assessment Table



Well No. \_\_\_\_\_

Component 1:

Vulnerability of Your Well		
	Yes	No
1) Has your well ever yielded water with nitrate concentrations higher than		
half the MCL of 10 mg/L (as N)?		
2) Does your well have a history of water quality detects for man-made		
chemicals or contaminants?		
3) Does surface drainage flow toward the well, or has it been determined by		
IDNR to be groundwater under the influence of surface water?		
4) Are there any potential contaminant sources closer to the well than the		
distances set out by IDNR as site separation limits?		
5) Are there any known leaking underground storage tanks, or other		
uncontrolled contaminant sites nearby the well?		
6) Is the well supplied by an unconfined aquifer?		
7) Is this a primary well (rather than used only for standby or secondary		
supply)?		
8) Is the well casing leaking?		
9) Is the well ungrouted, or is the grout seal in poor condition?		
NOTE: If you answered "no" to all questions, give this well a 1 in the Yes Total	Enter the total numb	
just for being an active well.	in the <i>Yes</i> boxes abo	ove:
	Total	

	onent 2:	nking of Contaminar	ıts	Manager de Constantina de la constantina de la Constantina de Cons	
	1. 2. 3. 4. Contaminant Threat to Public Mobility Locati Health/Toxicity (See Appendix Five) (See Appendix Five) (See Appendix Five) 500°-1,c				5. Sum of Columns 2, 3, 4
No.	Chemical name or land use category	L	ow 1 - High 3		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					

**Component 2:** 

Com	oonent 2: Ranl	king of Contaminant	3		
1. Contaminant		2. 3. 4. Threat to Public Mobility Location to Well			5. Sum of Columns 2, 3, 4
No.	Chemical name or land use category	Low	1 - High 3		
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					
31.					
32.					
33.					
34.					

You will need to use all the Risk Assessment Tables to complete the Risk Consolidation Table.

Begin with the *Risk Assessment Table* for your Well No. 1, and follow the next steps until all information for each well's *Risk Assessment Table* has been transferred to the *Risk Consolidation Table*.

In the Well No. section, write the well or wellfield number from the Risk Assessment Table.

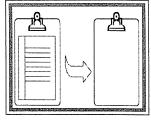
In the *Contaminant No.* section, write the number directly left of the first entry on the *Risk Assessment Table's Chemical Name or Land Use* column. Write in the chemical name or land use on the *Risk Consolidation Table*, also.

Still working with the first chemical/land use item, multiply the figure written in column 5 of the *Risk Assessment Table* by the *Yes Total* from *Component 1* on the top portion of the *Risk Assessment Table*. Enter the product in the *Index Rating* column on the *Risk Consolidation Table*.

Perform these steps for each contaminant entered on the *Risk Assessment Table*. When information regarding all contaminants (chemicals and land uses) from all *Risk Assessment Tables* has been transferred to the *Risk Consolidation Table* as instructed above, you can prioritize all potential contaminants.

On the *Risk Consolidation Table*, prioritize these hazards in ascending numerical order by placing a 1 in the *Ranking* column on the row which has the highest *Index Rating*. This will be your first priority risk. Find the next highest *Index Rating*, and enter a 2 in the appropriate row of the *Ranking* column, and so on until all contaminants entered on the *Risk Consolidation Table* have been assigned a priority.

### Risk Consolidation Table



		IUDIC	<u> </u>	
Well Number	Contamination Number	Chemical Name or Land Use	Index Rating*	Ranking
74 * * * * * * * * * * * * * * * * * * *				
	-			
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<sup>\*</sup> From the previous *Risk Assessment Tables*, multiply the number from column 5 by the number in *Yes Total* and enter the product in the *Index Rating* box.

## Contaminant Source Management ~ Step 5

After the potential contaminants which threaten each of your wells have been prioritized, you can begin to form a management strategy which will help protect your existing water supply from contamination and prevent development of new threats for these and future drinking water wells. You will want to begin by implementing practices which manage the highest ranking contaminants on your list, if possible, realizing it may not be possible to manage every potential source of contamination.

Before proceeding with contaminant management options, it is important at this time to be sure you have accurately defined the boundaries of your WHPA. As mentioned earlier, technical assistance will likely be necessary to establish or delineate these boundaries. Should the need arise, you will want to be in a position to defend your WHPA statistics in order to implement measures that will safeguard the wells and groundwater supply.

There are a number of tools water suppliers can use to manage potential sources of contamination. Most often these tools are divided into two broad categories: regulatory and nonregulatory. As the name implies, regulatory controls involve ordinances or other enforceable measures, while nonregulatory controls are typically voluntary. Many of the tools in both categories are preventive in nature, that is, they are designed to insure potential sources of contamination never have the chance to develop in a location where they could threaten your well. Some, however, can also be used to manage existing sources.

#### Regulatory Measures to Control Existing Sources of Potential Contamination

At this point, you may have identified potential sources of contamination which already exist in your area. Because you will need to manage those sources knowing they will remain in the area, the following paragraphs list a number of tools which can be used to manage existing sources. But, before you begin exploring management options, it would be a good idea to review various ordinances, standards, and permitting requirements already enacted. Determine if these measures will provide the levels of safety and protection you desire. Evaluate terms, procedures, and enforcement provisions for each protection measure. If you find the measures will address the existing contaminant sources, you simply need to make sure sufficient monitoring occurs to serve as a check and balance of the effectiveness of that protection alternative. If the measures seem adequate, but aren't producing the results you desire, consider how terms, procedures, responsibilities or other factors could be changed. And, if you find the measures do not offer adequate protection, evaluate some of the following management strategies.

Chemical Storage Requirements - There are any number of activities which require the use of hazardous materials. Dry cleaners, auto service stations, agricultural chemical suppliers and users, and manufacturing plants, just to name a few. In all of these cases local regulations can limit the quantity of hazardous material stored, specify how the material is stored, and/or outline how the material is collected or disposed of.

*Operating Standards* - Standards can be implemented which govern any number of activities taking place within the WHPA. For example, in certain locations, special use or operating permits may be needed for a particular type of business or land operation. A special use permit may allow a specific function to occur, but only with appropriate protective disposal procedures or containment measures.

Compliance Inspections - Periodic inspections can be required, by ordinance, to insure that rules established to protect your community's water supply are being followed. Chemical storage, handling, and use facilities, sewer systems, drainage systems, and solid waste disposal sites may all require inspection. For some operations, such as waste disposal, the authority to conduct inspections will remain the state's, rather than the city's or the utility's. However, most state agencies are receptive to requests for inspection, particularly if the safety of the water supply may be in question.

**Septic System Regulations** - An ordinance can be adopted which requires periodic inspections, and upgrade if necessary, for septic systems and other sewage disposal systems.

Many of the regulatory approaches to WHPA management require considerable technical expertise and administrative support. In-depth knowledge of each system to be regulated is necessary before an ordinance can be drafted. In addition, those affected by the new regulations may raise political or legal opposition if the new requirements will significantly impact the way they do business. If one of those affected by the proposed regulations is the primary employer in the area, it may not be practical to require operating standards which they are unable to follow.

#### Nonregulatory Measures to Control Existing Sources of Potential Contamination

Nonregulatory controls, although not always as effective, may be more politically acceptable and less likely to result in opposition. These measures may be a good starting point, and they can form the foundation for more comprehensive wellhead protection measures later, if needed.

**Public Education** - Public education is perhaps the most important tool for managing contaminants in a WHPA. It is vital the public understand the connection between land use within the area and drinking water quality. Only after this connection is made will the program receive the support necessary to be successful. Education programs can be as simple as informational fliers included with water bills or displays set up at local gatherings. More intensive education can be provided through seminars involving individuals who will be significantly impacted by the program.

Best Management Practice - A Best Management Practice (BMP) is a proven set of standard operating procedures that can be used in a particular industry or activity to limit the threat to the environment. These practices are common in the agricultural industry. Voluntary Best Management Practices can be an effective tool in controlling contamination if combined with an educational program to promote their use, and many times some financial incentives are included.

**Monitoring** - Groundwater monitoring can be an effective way to insure that contaminants are discovered before they enter the drinking water supply. Monitoring does not, however, prevent a contaminant from entering the supply, and it is expensive to continue on a long-term basis.

**Land Transfer** - In some instances, the property on which the suspect activity is taking place can be purchased by, or donated to, your community. The potential source of contamination can be removed and then the property can be set aside for park land or other public use, or the property can be resold with restrictions on future use.

Conservation Easements - Many times it is not practical or financially feasible to purchase property outright. In these cases it may, however, be feasible to purchase conservation easements which limit the future use of the land. In the case of land which is in agricultural production, it may be possible to purchase an easement which will allow the land to stay in production, but will limit the amount of fertilizer or pesticide used. Easements can be purchased with any number of mutually agreeable conditions or restrictions placed on future use.

These are only a few examples of the types of controls which can be used to help limit the potential for contamination due to existing sources. Many other approaches have been used successfully by communities across the nation. Additional information can be obtained from the Environmental Protection Agency or the Iowa Department of Natural Resources.

It is important to remember that no single control measure will be totally effective in the effort to protect your groundwater supply. Each tool will be most effective when used as part of an integrated wellhead protection program.

#### Regulatory Measures to Prevent Future Sources of Potential Contamination

After existing sources of potential contamination are addressed, preventive control measures can be put in place which will further limit your well's exposure to contamination from new sources. The following paragraphs describe a number of tools which can prevent activity in the wellhead area which is inconsistent with your wellhead protection goals.

#### Zoning Regulations

**Zoning** ~ Zoning regulations are used to separate different land uses into different areas of a community. Although zoning is not an effective means of managing existing sources of contamination, it is a good mechanism for controlling future development. Zoning techniques that can be used in wellhead protection include:

- · overlay water resource protection districts
- · prohibition of various land uses
- · special permitting
- · large lot zoning
- · transfer of development rights

Overlay groundwater protection districts - A groundwater protection district is an area within which more strict regulations will be enforced to protect the groundwater. This area could be the area of influence of a well, the recharge area of an aquifer, etc. Within this area there are more stringent protection regulations, regardless of zoning. These regulations may require a minimum lot size, limit impervious area, or restrict chemical storage and handling. An outline of this area is often drawn on a transparent sheet which is laid over a map of the community. This outline shows the areas which will be affected by the more stringent regulations.

**Prohibition of various land uses** - In most communities, zoning prohibits certain land uses in specific sections of the community. These prohibitions may not be directly related to groundwater protection, but they can serve that function if land uses which involve the use, storage, and disposal of toxic or hazardous materials are not allowed in WHPAs.

**Special permitting** - Special permits can be used to regulate development that could threaten groundwater quality. For example, many communities use the special permitting process to evaluate the risks posed by underground storage tanks within designated WHPAs.

Large lot zoning - The purpose of large lot zoning is to limit the potential for groundwater contamination by reducing the number of buildings and, therefore, septic systems within a WHPA. Large lot zoning has limited effectiveness because zoning law provides protection to land owners whose property may decrease in value if minimum lot sizes are increased. Large lot zoning within WHPAs can still be an effective tool against groundwater contamination considering that septic systems may be one of the most likely causes of groundwater contamination.

Transfer of development rights - In some cases, a town can limit development within a WHPA by allowing a developer who owns property in the area to sell a portion of their development rights to another developer who owns property outside the area. In other words, a developer inside the protection area would agree to develop fewer lots and would sell the rights to the additional lots to a receiving developer outside the protection area. The outside developer would then be allowed to develop more lots on their property than normally allowed by zoning. The town would need to designate areas which are able to "receive" additional development and a perpetual easement or some other development restriction would need be recorded with the deed of the donor parcel.

**Drainage requirements** - Runoff often contributes contaminants to surface waters, which can influence the quality of a groundwater source. To help control this problem, drainage requirements may be established by local planning commissions and boards as part of subdivision review processes. Effective drainage management can minimize the volume of runoff generated, and enhance the natural filtration process.

Site design/landscaping - Land development that incorporates buffer zones, natural land-scaping, specific percent cover standards, and alternative roadway designs can act as a groundwater quality protection measure. In establishing landscaping requirements, communities can encourage xeriscaping techniques. Xeriscaping focuses on the use of native plant materials having lower water and nutrient requirements than standard landscape plantings.

#### Health Regulations

Health regulations are an effective part of a regulatory protection program. The following paragraphs describe two potential sources of groundwater contamination that can be managed with appropriate health regulations.

*Underground storage tanks* - Leaking underground storage tanks are the single largest source of groundwater contamination in the nation. The larger underground gasoline storage tanks associated with automotive service stations have caused numerous groundwater contamination incidents. Regulations can require construction standards for new tanks, leak testing for existing

tanks, or prohibition of all new underground tank installations within the WHPA.

**Septic system regulations** - The maintenance of on-site septic systems is an important consideration in wellhead protection. Both improperly treated sewage and the chemicals used to clean poorly maintained systems can degrade groundwater quality. To minimize the risk of contamination and to ensure proper maintenance of septic systems, many communities have developed a voluntary septic system maintenance program.

#### Nonregulatory Measures to Prevent Future Sources of Potential Contamination

Land acquisitions - Land acquisitions, land donations, and conservation easements are all management techniques that may be more efficiently conducted by nonprofit land conservation organizations than by municipalities. These organizations are tax-exempt, not-for-profit entities. Therefore, donations and bargain sales to the organization are usually considered charitable donations and may have positive federal and state tax consequences for the donors. These organizations can provide expertise in: arranging land transfers; drafting conservation easements; explaining advantages and disadvantages of real estate transfers to both land purchasers and sellers; coordinating with and soliciting aid from various foundations; and, in some cases, providing funds for acquisition or to serve as landowners and stewards.

Conservation easements - Easements can effectively assist a community in protecting land from development by restricting all or a portion of the property to open space or limited development uses. The granting of a conservation easement does not involve the transfer of ownership of the land; instead, it means giving up certain development rights of the property. For example, a conservation easement may restrict the number of houses to be built upon a parcel; restrict the types of development allowed on the parcel; or specify that portions of the parcel remain undeveloped.

Hazardous waste collection - Another nonregulatory protection tool is the collection of household hazardous waste. Although these materials are generated in small amounts, they can represent significant threats to surface and groundwater quality. Motor oil allowed to drain onto the land surface when automobile oil is changed, excess paint discarded in the gutter, and fungicides and herbicides left in a shed that is flooded are possible routes from contaminant container to water. To avoid these scenarios, many communities have implemented hazardous waste collection days several times per year.

**Public education** - The importance of public education to successful implementation of a comprehensive wellhead protection program can not be stressed enough. Public education can be used to build support for regulatory measures or to kick off voluntary programs. It can also be used to assess the political climate prior to enactment. It will be more difficult for individuals and groups to resist your wellhead protection efforts if they understand the relationship between land use and groundwater contamination.

These are just a few of the many options available to utilities for managing contamination possibilities. The table at the end of this section provides a more comprehensive list of options, and points out some legal and administrative considerations of those options, as well. The Environmental Protection Agency has documented numerous alternatives used by utilities across the nation. For copies of the EPA's documents on this subject and related matters, call the Non-Point

Information Exchange at (202) 260-3665, the Office of Water Resource Center at (202) 260-7786, or the Safe Drinking Water Hotline at 800-426-4791. You can also browse the Internet, using "EPA" and "wellhead" to locate numerous other information sources.

Once you have selected the management strategy that best fits your community and the specific contaminants posing risk to your utility's water supply, the *Contaminant Source Management Log Sheet* will help you track efforts to implement your control strategies. This form should be completed as you design ordinances, programs, and other tools. Record when activities begin, when specific targets are attained, and who is responsible for implementation and/or enforcement details. This form should include at least one control strategy for contaminants with the highest priorities listed on the *Risk Consolidation Table*.

### Options for Contaminant Source Management

	A continuation to	I and I Ian	T1	A 1:
	Applicability to Wellhead Protection	Land Use Practice	Legal Considerations	Administrative Considerations
	Weimeau Froiection	rractice	Considerations	Considerations
Regulatory: Zoning				
Overlay GW Protection Districts	Used to map wellhead protection areas (WHPAs). Provides for identification of sensitive areas for protection. Use in conjunction with other tools that follow.	Community identifies WHPAs on practical base/zoning map.	Well-accepted method of identifying sensitive areas. May face legal challenges if WHPA boundaries are based solely on arbitrary delineation.	Requires staff to develop overlay map. Inherent nature of zoning provides "grandfather" protection to pre-existing uses and structures.
Prohibition of Various Land Uses	Used within mapped WHPAs to prohibit groundwater contaminants and uses that generate contaminants.	Community adopts prohibited uses list within their zoning ordinance.	Well-organized function of zoning. Appropriate techniques to protect natural resources from contamination.	Requires amendment to zoning ordinance. Requires enforcement by both visual inspection and on-site investigations.
Special Permitting	Used to restrict uses within WHPAs that may cause groundwater contamination if left unregulated.	Community adopts special permit "thresholds" for various uses and structures within WHPAs. Community grants special permits for "threshold" uses only if groundwater quality will not be compromised.	Well-organized method of segregating land uses within critical resource areas such as WHPAs. Requires case-by-case analysis to ensure equal treatment of applicants.	Requires detailed understanding of WHPA sensitivity by local permit granting authority. Requires enforcement of special permit requirements and on-site investigations.
Large-Lot Zoning	Used to reduce impacts of residential development by limiting numbers of units within WHPAs.	Community "down zones" to increase minimum acreage needed for residential development.	Well-recognized prerogative of local government. Requires rational connection between minimum lot size selected and resource protection goals. Arbitrary large lot zones have been struck down without logical connection to Master Plan or WHPA program.	Requires amendment to zoning ordinance.
Transfer of Development Rights	Used to transfer development from WHPAs to locations outside WHPAs.	Community offers transfer option within zoning ordinance. Community identifies areas where development is to be transferred "from" and "to."	Accepted land use planning tool.	Cumbersome administrative requirements. Not well suited small communities without significant administrative resources.
Cluster/PUD Design	Used to guide residential development outside of WHPAs. Allows for "point source" discharges that are more easily monitored.	Community offers cluster/PUD as development option with zoning ordinance. Community identifies areas where cluster/PUD is allows (i.e., within WHPAs).	Well-accepted option for residential land development.	Slightly more complicated to administer than traditional "grid" subdivision. Enforcement/inspection requirements are similar to "grid" subdivision.
Growth Controls/Timing	Used to time the occurrence of development within WHPAs. Allows communities the opportunity to plan for wellhead delineation and protection.	Community imposes growth controls in the form of building caps, subdivision phasing, or other limitation ties to planning concerns.	Well-accepted option for communities facing development pressures within sensitive resource areas. Growth controls may be challenged if they are imposed without a rational connection to the resource being protected.	Generally complicated administrative process. Requires administrative staff to issue permits and enforce growth control ordinances.

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	Applicability to Wellhead Protection	Land Use Practice	Legal Considerations	Administrative Considerations		
Regulatory: Zoning (contin	ued)		<u> </u>			
Performance Standards	rformance Standards  Used to regulate development within WHPAs by enforcing predetermined standards for water quality. Allows for aggressive protection of WHPAs by limiting development within WHPAs to an accepted level.		Adoption of specific WHPA performance standards requires sound technical support. Performance standards must be enforced on a case-by-case basis.	Complex administrative requirements to evaluate impacts of land development within WHPAs.		
Regulatory: Subdivision Control						
Drainage Requirements	Used to ensure that subdivision road drainage is directed outside of WHPAs. Used to employ advanced engineering designs of subdivision roads within WHPAs.	Community adopts stringent subdivision rules and regulations to regulate road drainage/runoff in subdivisions within WHPAs.	Well-accepted purpose of subdivision control.	Requires moderate level of inspection and enforcement by administrative staff.		
Regulatory: Health Regulati	ons					
Underground Fuel Storage Systems	Used to prohibit underground fuel storage systems (USTs) within WHPAs. Used to regulate USTs within WHPAs.	Community adopts health/zoning ordinance prohibiting USTs within WHPAs. Community adopts special permit or performance standards for use of USTs within WHPAs.	Well-accepted regulatory option for local government.	Prohibition of USTs requires little administrative support. Regulation USTs requires moderate amounts of administrative support for inspection follow-up and enforcement.		
Privately Owned Wastewater Treatment Plants (Small Sewage Treatment Plants)	Used to prohibit small sewage treatment plants (SSTP) within WHPAs, or to allow an SSTP to avoid numerous individual septic system installations.	Community adopts health/zoning ordinance within WHPAs. Community adopts special permit or performance standards for use of SSTPs within WHPAs.	Well-accepted regulatory option for local government.	Prohibition of SSIPs requires little administrative support. Regulating SSIPs requires moderate amount of administrative support of inspection follow-up and enforcement.		
Septic Cleaner Ban	Used to prohibit the application of certain solvent septic cleaners, a known groundwater contaminant, within WHPAs.	Community adopts health/zoning ordinance prohibiting the use of septic cleaners containing 1, 1, 1-trichlorethane or other solvent compounds within WHPAs.	Well-accepted method of protecting groundwater quality.	Difficult to enforce even with sufficient administrative support.		
Septic System Upgrades	Used to require periodic inspection and upgrading of septic systems.	Community adopts health/zoning ordinance requiring inspection and, if necessary, upgrading of septic systems on a time basis (e.g., every 2 years) or upon title/property transfer.	Well-accepted purview of government to ensure protection of groundwater.	Significant administrative resources required for this option.		
Toxic and Hazardous Materials Handling Regulations	Used to ensure proper handling and disposal of toxic materials/waste.	Community adopts health/zoning ordinance requiring registration and inspection of all businesses with WHPA using toxic/hazardous materials above certain quantities.	Well accepted as within purview of government to ensure protection of groundwater.	Requires administrative support and on-site inspections.		

	Applicability to	Land Use	Legal	Administrative
	Wellhead Protection	Practice	Considerations	Considerations
Regulatory: Health Regulat	tions (continued)			
Private Well Protection	Used to protect private on-site water supply wells.	Community adopts health/zoning ordinance to require permits for new private wells and to ensure appropriate well-to-septic-system setbacks. Also requires pump and water quality testing.	Well accepted as within purview of government to ensure protection of groundwater.	Requires administrative support and review of applications.
Non-Regulatory: Land Tra	nsfer and Voluntary Restricti	ons		
Sale/Donation	Land acquired by a community with WHPAs, either by purchase or donation. Provides broad protection to the groundwater supply.	As non-regulatory technique, communities generally work in partnership with non-profit land conservation organizations.	There are many legal consequences of accepting land for donation or sale from the private sector, mostly involving liability.	There are few administrative requirements involved in accepting donations or sales of land from the private sector. Administrative requirements for maintenance of land accepted or purchased may be substantial, particularly if the community does not have a program for open space management.
Conservation Easements	Can be used to limit development within WHPAs.	Similar to sales/donations, conservation easements are generally obtained with the assistance of non-profit land conservation organization.	Same as above.	Same as above.
Limited Development	As the title implies, this technique limits development to portions of a land parcel outside of WHPAs.	Land developers work with community as part of a cluster/PUD to develop limited portions of a site and restrict other portions, particularly those within WHPAs.	Similar to those noted in cluster/PUD under zoning.	Similar to those noted in cluster/PUD under zoning.
Non-Regulatory: Other				· · · · · · · · · · · · · · · · · · ·
Monitoring	Used to monitor groundwater quality within WHPAs.	Communities establish groundwater monitoring program within WHPA. Communities require developers to monitor groundwater quality downgradient from their development.	Accepted method of ensuring groundwater quality.	Requires moderate administrative staffing to ensure routine sampling and response if sampling indicates contamination.
Contingency Plans	Used to ensure appropriate response in cases of contaminant release or other emergencies within WHPA.	Community prepares a contingency plan involving wide range of municipal/county officials.	None.	Requires significant up- front planning to anticipate and be prepared for emergencies.
Hazardous Waste Collection	Used to reduce accumulation of hazardous materials within WHPAs and the community at large.	Communities, in cooperation with the state, regional planning commission, or other entity, sponsor a "hazardous waste collection day" several times per year.	There are several legal issues raised by the collection, transport, and disposal of hazardous waste.	Hazardous waste collection programs are generally sponsored by government agencies, but administered by a private contractor.

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	Applicability to	Land Use	Legal	Administrative
	Wellhead Protection	Practice	Considerations	Considerations
Non-Regulatory: Other				0.000
Public Education	Used to inform community residents of the connection between land use within WHPAs and drinking water quality.	Communities can employ a variety of public education techniques ranging from brochures detailing their WHPA program, to seminars, to involvement in events such as hazardous waste collection days.	No outstanding legal considerations.	Requires some degree of administrative support for programs such as brochure mailing to more intensive support for seminars and hazardous waste collection days.
Legislative				
Regional WHPA Districts	Used to protect regional aquifer systems by establishing new legislative districts that often transcend existing corporate boundaries.	Requires state legislative action to create a new legislative authority.	Well-accepted method of protection regional groundwater resources.	Administrative requirements will vary depending on the goal of the regional district. Mapping of the regional WHPAs requires moderate administrative support, while creating within the WHPA will require significant administrative personnel and support.
Land Banking	Used to acquire and protect land within WHPAs.	Land banks are usually accomplished with a transfer tax established by state government empowering local government to impose a tax on the transfer of land from one party to another.	Land banks can be subject to legal challenge as an unjust tax, but have been accepted as a legitimate method of raising revenue for resource protection.	Land banks require significant administrative support if they are to function effectively.

In the Well No. section, be sure to record the specific well this table will refer to.

In the *Hazard* section, list each contaminant you have identified as a potential threat to your well. Begin your list with the contaminant(s) you've identified as the highest risk, and given the highest priority to, in Step 4.

In the *Approach for Control* section, write down whether you'll be using regulatory, non-regulatory or both approaches to control the potential contamination; write in specifically the approach to be taken, such as zoning ordinances, monitoring programs, etc.

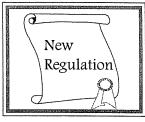
In the *Date Initiated* section, record the date you begin efforts to create each particular control method.

In the *Date Drafted* section, record the date the particular strategy is first released for comment by citizens, interested groups, or those who are potentially affected by the measure.

In the *Date Enacted* section, record the date you successfully put into place each particular control method, such as the date of passage of an ordinance, construction completion date, etc.

In the *Person Responsible* section, write down the name(s) of each person assigned as the responsible party for carrying out or monitoring the approved control strategies. This could be the water utility operator in the case of a monitoring program, or perhaps the planning and zoning commission, in the case or new zoning ordinances or granting of special use permits.

## Contaminant Source Management Log Sheet



Well No. \_\_\_ Approach for Control Hazard Date Date Date Person Responsible Regulatory Non-Regulatory Initiated Drafted Enacted

#### Planning for a Contamination Emergency

As part of your wellhead protection program, you must think about, plan, and prepare strategies for dealing with emergencies that may contaminate your drinking water well(s), and possibly, recharge area(s). Contingency plans are designed to provide water suppliers with a plan to follow if their water source is contaminated or threatened. This involves having a team of people available and trained in preventing the contamination before it occurs, responding to a contamination incident, and restoring your water supply well(s) to safe, reliable operation following a contamination emergency.

Such a team is likely to be made up of people different than your Wellhead Protection Team, although there may be some common individuals on both, for example, the water system superintendent/operator. Basic areas that need to be covered by your emergency response team include:

- overall coordination of the emergency response;
- communication with consumers;
- · management of the specific emergency response operations; and
- assessment of damage including finding out what will be needed to return your well(s) to operation.

It is vital that you be able to contact these people, regardless of time of day, home/office location, etc. Your emergency response plan should include information that tells you how to reach your team 24 hours a day, seven days a week.

You will also need assistance from outside agencies if a drinking water contamination emergency occurs at your utility. It is a good idea to have the same 24-hour, seven-day contact information for these agencies as well. Your emergency plan should provide this information for: health and rescue agencies (such as the police, fire, county and state emergency contacts, etc.), contractors and suppliers of materials that might be needed (plumber, well driller, laboratory services, engineering firms, etc.), and contacts for other utilities (gas, power, telephone, etc.).

All of this information can be easily recorded in the *Water Supplier General Information Sheet*, a form previously developed by Des Moines Water Works in IDNR's "Emergency Preparedness: Preparing for the Unanticipated" emergency planning model. And, if you've already completed that model document, you are one step further in the process to be prepared for a potential contamination of your well(s).

In addition to overall preparedness, special arrangements should be made, far before any contamination emergency, to assure your consumers will be provided with a reliable water supply in the event yours is interrupted or suspended due to such an emergency. You should explore both short- and long-term alternatives, and develop procedures for initiating either strategy should they become necessary. Short-term solutions may include water hauling services, bottled water pur-

chases, additional treatment of the existing supply, and possibly water conservation measures.

In a short-term situation, it may also be important to look into measures that would reduce the quantity of a contaminant released. Long-term options could include back-up sources of supply, stand-by connections to a neighboring community or rural water system, and "in-the-drawer" plans for construction of additional wells. The *Contingency Plan Table* provides a place to document the different options implemented by your utility. For each alternative, record the contact names, telephone numbers (24 hours a day), and a brief description of the service arrangement. If formal contracts, agreements, or procedural documents are involved, copies of those should be included in this section of the wellhead protection model plan. These documents should reflect specific details of how water will be provided and in what quantities. Financial projections for each alternative should also be included.

As part of your effort to be prepared for a contamination emergency, if your wellhead protection area contains buildings, equipment, highways, or other transportation avenues that could introduce hazardous materials into your aquifer, you have some additional work to do. You should become aware of procedures in place with agencies, such as the fire department or a special hazardous materials team (if applicable), who would actually deal with firefighting and hazardous materials, or surface spills and toxic chemical releases. You should know specific contact names, and again, 24-hour contact numbers. Discussing these issues with the other emergency agencies will accomplish two things: 1) you will be aware of their procedures and have the opportunity to identify additional impacts upon your well(s) that may be created in the firefighting/hazardous clean-up process; and 2) you can alert the other agencies to the specific location(s) and possible risk(s) to your well(s). Again, this is information that could be recorded in the *Water Supplier General Information Sheet*.

In preparing your wellhead contamination emergency response plan, you will also need to access various pieces of information learned and recorded earlier in Step 2, when you gathered information about your well(s), and also in Steps 3 and 4, when you determined the hazards most likely to contaminate your water supply. Facts from the *Wellhead Protection Information Table*, such as aquifer type, confining layers, aquifer layers exposed to the well, and casing depths will be very helpful in determining any barriers to the contamination. Also, information gathered in the *Contaminant Inventory Table* and *Risk Assessment Table* will allow you to determine the exact location of the contaminant source in the protection area, and assist in calculating how quickly that contaminant could travel to your well, if this process has not already been completed.

Another very important fact to keep in mind for the contingency planning effort is the velocity, or speed, of the groundwater flow in the aquifer supplying your well. If you have not already sought outside help to determine the time it will take for contaminations to travel to the wellhead site, you should initiate this action at least for the highest priority risks determined in Step 4, particularly if the safety of the public's health is an issue. Remember, typically, groundwater movement is very slow, and in most cases, unless a contamination site is in the immediate vicinity of your well, water utilities will have days and sometimes months to implement the responses needed to protect your water supply.

You should be prepared to initiate your contingency plan if: 1) you have one well and it becomes contaminated and cannot be treated to resolve the problem; or 2) you have multiple wells, but those available and free from contamination won't reliably supply your customers'

average daily demand.

Responding to groundwater contamination will be unlike most other emergencies that pose immediate danger to your water system. However, the fact that less than urgent responses may be possible does not remove the need to address such an important threat to the community. In fact, while this is true scientifically, public perceptions may not be tolerant of such a response. For this reason, short- and long-term alternatives should be pre-arranged, recorded on the *Contingency Plan Table*, and implemented if needed.

#### Instructions for Completing the Water Supplier General Information Sheet

The *Water Supplier General Information Sheet* is to be used to list important information about the water utility, who to contact for direct response and support during an emergency, and to list your utility's critical water users.

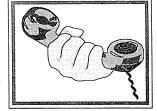
In the *Utility name* section, fill in the appropriate response with regard to your water utility's:

- *Public water supply ID number (PWSID)* ~ the Iowa Department of Natural Resources issues this number.
- Water source check the box that describes your utility's raw water source.
- *Population served* fill in the population number your utility serves.
- Water storage tank capacity enter storage capacity in gallons.
- Average daily pumpage enter the average daily pumpage in gallons per day.

In the *Treatment process* section, check the applicable process types for your water utility.

In the *Emergency telephone notification listing* section, fill in the appropriate responses in as much detail as possible, including daytime and after-hours phone numbers for:

- *Basic Emergency Response Team* list the personnel who are employed by your utility or in the community who would be directly involved in responding to an emergency.
- *Officials outside the utility* list the support agencies and personnel who can be called for direct assistance in responding to recover from an emergency.
- *Contracted services/supplies* list the companies, vendors, lab services, contractors, suppliers frequently used by your utility.
- *Utilities* list the utilities that provide power, gas or general communication services for your water utility.
- *Mutual aid coordination* list the communities that have entered into an agreement with your water utility to provide equipment, water or materials in an emergency.
- *Critical water users* list the users in the service area that require a continuous water supply in an emergency. Also include what the water is used for and the volume that is needed.



## Water Supplier General Information Sheet

Utility name:			T		Date:		
Public water supply	y ID	Water source	Population serv	ed Water sto	rage tank	Average da	ily pumpage
number (PWSID	"			capacity	(gallons)	(gallons	per day)
		Surface					
		☐ Groundwater					
				ent process			
Iron removal			☐ Yes ☐ No	Chlorination			☐ Yes ☐ No
Coagulation, sedimen	tation, fi	ltration	☐ Yes ☐ No	Fluoridation			☐ Yes ☐ No
Softening			☐ Yes ☐ No	Other			☐ Yes ☐ No
		Er	nergency teleph	one notification	listing		
Positions		Name	Work	Pager	Cellular	Fax	Home
	<u> </u>		Emergenc	y Response Team	Limitania		
Emergency				X			
Coordination							
Public							
Communication							
Conditionion							
<u> </u>							
Operations							
Management							
Damage Assessment							
			Officials o	utside the utility			<u> </u>
Fire department						T	
The department							
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Police/Sheriff							
4							
County Emergency							
Coordinator							
State Office of							
Emergency							
Management			515-281-3231				
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Department of Transportation							
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			Contracted	services/supplies			
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Well driller	<b> </b>						
AACH OTHICL			1				
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University Hygienic							
Lab (UHL)			210 225 4500				
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Contracted							
laboratory							
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Positions	Name	Work	Pager	Cellular	Fax	Home
Engineering firm(s)						
Water storage tank manufacturer						STEENING STATE OF STA
Property & casualty insurance						
Materials & equipment						,
Chemicals						
Fuel	· · · · · · · · · · · · · · · · · · ·					
		<u> </u>	Utilities			
Iowa One-Call						
Power company					·	
Gas company						
Telephone						
Radio/Cellular						
		Mutual a	id coordination			
Equipment						
Water						
Materials					1.4.4	
	- Pierre	Critica	l water users			
Health care						
Critical use:					Volume:	
Nursing home					·	
Critical use:					Volume:	
Public shelter						
Critical use:					Volume:	
Other						
Critical use:					Volume:	

Complete both *Short-Term Supply Alternatives* and *Long-Term Supply Alternatives* sections with the following information:

In the *Type of Supply* section, write a brief description of the type of service or arrangement developed. For example, enter bottled water if arrangements have been made to purchase quantities of bottled water from a distributor or local vendor in the event of an emergency. Or, connection to "Town XYZ" to describe a back-up connection to another water supplier.

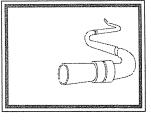
In the *Location* section, record an appropriate street address with city and state, or an approximate description of a physical location where a connection to a standby supply can be found.

In the *Contact Name* section, enter the person's name who you have negotiated arrangements with, or the name of the person to be reached to initiate the particular supply alternative.

In the *Work* section, record the daytime area code and telephone number for the contact person. Likewise, record *Home* telephone numbers, and *Fax* numbers in the appropriate boxes for each contact name.

In the *Documentation Included* section, check either "yes" or "no" to indicate if there is a formal document or procedure that has been inserted in the plan. A pocket folder is included for storage of this document at the end of this section.

## Contingency Plan Table



Type of Supply	Location	hort-Term Supply Alter Contact Name	Work	Home	Fax	Documentation Included
						yes 🗆
						no 🗖
						yes 🗆
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<u></u>	T	ong-Term Supply Alter	motives		L.	no 🗖
Type of Supply	Location	Contact Name	Work	Home	Fax	Documentation
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						no 🗖
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						yes
						yes
						yes
						yes
						yes

Please place copies of mutual aid agreements, contracts for service, or written procedures to initiate a specific alternative in the pocket page provided directly after this section.

## Public Participation ~ Step 7

As mentioned in the *Team Formation* section, grassroots support is essential to the successful implementation and maintenance of a local wellhead protection plan. The Wellhead Protection Team may choose to utilize junior high and high school groups, church groups, senior citizen groups and community groups to help implement the program. These are just a few of the organizations available where you'll find willing and able volunteers. Also, retirees are known to be very effective in all aspects of wellhead protection plan implementation and maintenance.

Whoever you recruit, it cannot be stressed enough that grassroots support is imperative. Although it may seem as if your plan can be implemented using only the Wellhead Protection Team members, once Steps 1 through 6 have been completed, you'll have a much easier time maintaining your protection program with the help of all the people affected by such a plan.

Successful communication is paramount to an effective program. Publicity can be used to both inform and to build support. Take opportunities to meet with people who might be regulated by the program. Be prepared to answer questions and respond to complaints or requests. Talk with people who might participate in monitoring and enforcement. Provide them with clear and concise material on their responsibilities and the rationale for the program. These steps can increase the public's awareness of the program and their likely support for its goals. Involvement of the entire community will ease the burden on the utility.

In certain stages of the program's development, you will want to reach out to the community at large to communicate specific aspects of the program, its purpose, and involvement opportunities for citizens. To carry these messages, consider techniques such as:

- School or library newsletters
- Slide or video presentations
- Speakers
- Brochures
- Statement stuffers
- Signs or posters
- Advertisements
- Fliers
- Community or public meetings
- Press releases
- Press conferences

School or library newsletters are inexpensive ways to reach a large number of people. Usually you can contribute an article, an announcement for an upcoming meeting, or recruit volunteers for either of these publications at no cost to you.

Slide or video presentations are another wonderful method for describing in more detail to groups of all sizes what your protection program has accomplished so far, or what you hope to

accomplish in the future. Presentations of this type can usually be produced for the cost of a camera and film. Enlist the help of the local amateur shutterbug or the high school camera/video club. These presentations can be used to recruit volunteers, explain hazards, and generate overall interest in compliance and enforcement of your new protection plan.

**Speakers** are always a good source of information. Invite one of the experts you may have used to help you develop parts of your plan. A speaker of this caliber can talk in more detail about some aspect of your plan you may be having a hard time explaining to your community. Organize a special coffee or council meeting, depending upon the topic and the number of citizens you'd like to interest.

Brochures are an excellent low-cost method for getting the word out to everyone affected by your wellhead protection program. Brochures can be created and mailed covering, for example, an overview of your program, describing the seven steps in your plan in more detail, and so on. Another popular brochure topic is one sent to landowners in the Wellhead Protection Area covering Best Management Practices.

**Direct mailings**, such as water **statement stuffers**, can be targeted to smaller groups or specific types of recipients, such as gas stations, dry cleaners, or other small businesses likely to engage in activities or handle hazardous substances that are subject to regulation. The detailed inventory form, found in Appendix Four, may be a good tool to include in direct mailings to such groups.

**Signs** posted within a community to identify entrance into a wellhead protection area are a good means of promoting the program, and raising overall awareness of your efforts. They may also cause people to think about their activities.

Advertisements in trade journals to reach certain professions can be useful. Advertisements in local newspapers, while less precisely targeted, may also prove effective, especially when local involvement is needed. Local media may also have public service announcement (PSA) time/space available for you to use at no cost.

Fliers, usually one letter-sized page, may be an effective way to reach a broad section of the population with minimal expense. This would be a good method to remind people that an upcoming event is occurring, such as a hazardous waste cleanup day.

**Community** or **public meetings** can be used to provide information to, and receive input from, members of the community who have a specific interest in groundwater issues. Some suggested topics are:

#### 1. Nature and Magnitude of Risk

Which substances and business activities cause the greatest concern? What level of risk can be accepted by the community? How can you assess site specific risk? Participants will reconsider or reference this topic throughout the process as each potential protection measure is discussed and scientific data becomes available.

#### 2. Wellfield Insurance Program

Could the city establish an effective program that requires a business in a protection area to maintain private wellfield insurance? Monitoring of ongoing business activities might

occur under this scenario because of the private insurance company's desire to protect its assets.

#### 3. Voluntary Programs - Land Use Controls

Provide descriptions and examples of each for discussion. Also, determine what local resources are available to support each approach.

#### 4. Permitting and Licensing - Health Codes

Provide descriptions and examples of each for discussion. Also, determine what local resources are available to support each approach.

#### 5. Wellfield Protection Program Design and Subcommittee Formation

Determine what combination of wellfield protection measures is most appropriate for your town. Participants will consider the impact of each option, both positive and negative, on economic development.

#### 6. Regional Coordination

Discussion and deliberation may result in the formation of a subcommittee.

Questionnaires, mailed to a large number of residents, are useful in getting a message out as well as obtaining feedback on groundwater issues. Although it should be noted that without some additional form of incentive, response to such questionnaire surveys is usually less than ten percent.

**Seminars** may be used to communicate detailed information to a small target group. Although seminars may involve greater effort and expense, this may be a useful way to inform industry of newly developed standards likely to affect their operations.

The Chamber of Commerce may also provide you with a means for reaching local businesses. Local Chambers are usually willing to give you access to their membership lists for mailings, or to their meetings for presentations.

These are some relatively low-cost public communication/participation strategies you may wish to consider. Most can be accomplished using utility staff and local business proprietors. Use the *Public Participation Log Sheet* to record details about each strategy you use.

Because the information to be presented with any of these tools would be very specific to your utility and community effort, it is difficult to provide samples for you to model from. However, should you need to prepare a press release, there are some common pieces of information and methods to follow. A sample press release is included at the end of this section for your reference.

#### Instructions for Completing the Public Participation Log Sheet

In the Well No. section, record the specific number of the well this log sheet refers to.

In the *Assigned Activity* section, record the activity undertaken, such as "hearing on proposed contaminant inventory activities," or "organize field visits in the first 500-foot radius."

In the *Name of Person Assigned to Activity* section, record the name of the person who has volunteered or been appointed to complete or lead each specific activity.

In the *Date Initiated* section, record the date each specific activity is to begin. Use this date to document and keep track of the target dates for assigned activities, and keep your efforts always moving forward.

In the *Date Completed* section, record the date each specific activity is completed.

In the *Evaluation of Activity* section, make a notation as to whether the activity was successful or not, or whether you need to modify the methods used to accomplish the tasks.

# Public Public Meeting 7:00 - Town Hall Friday, Nov. 18 Log Sheet

NOTICE
Public Meeting
7:00 - Town Hall
Friday, Nov. 18

Well No. \_\_\_\_\_

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Assigned Activity	Name of Person Assigned to Activity	Date	Date Completed	Evaluation of
	Assigned to Activity	Initiated	Completed	Activity
	· · · · · · · · · · · · · · · · · · ·			
			**	
- Control of the Cont				



#### Office of Wellhead Protection

## News Release

Date: December 1, 1996

FOR IMMEDIATE RELEASE

Page 1

Contact:

James Smith Affiliation

XXX/XXX-XXXX

#### TITLE OF CORRESPONDENCE

This announcement should be a simple WHO, WHAT, WHEN, WHERE, and WHY correspondence about your activities, people involved, an invitation to a special event, such as a seminar, etc. The news release should be double-spaced with at least a one-inch margin on all four sides.

The date should either read, as above, FOR IMMEDIATE RELEASE, or if you want it run in, for example, consecutive weekly newspapers, indicate what dates you would like these to be.

If your news release is longer than one page, at the bottom of the first page, and every successive page, except the last, put the word ~ MORE ~, centered in the middle of the page. At the end of the news release, be sure to put either the symbol ~ ### ~ or the word ~ END ~.



#### Planning Wellhead Protection Training

By completing the fill-in-the-blank forms contained in the previous sections of this model plan, your utility and community can create its own unique wellhead protection plan. These same forms, particularly the *Risk Assessment Table*, *Risk Consolidation Table*, *Contaminant Source Management Table*, and *Contingency Plan Table* can serve as good indicators of the types of training that may be needed to prepare your Wellhead Protection Team for the responsibilities they must carry out. The *Training Table* has been developed for your use in tracking training activities as they are both planned and completed. The *Training Table* should identify who is to be trained, who will provide training, what types of training techniques are to be used, a schedule for training activities, and how the training will be evaluated to see if objectives were met. With a documented training plan, your utility can incorporate wellhead protection training into regular business processes and budgets as they are developed.

It is important to prioritize training needs to address areas where your utility or community may be most vulnerable. The *Risk Assessment Table* rating will identify the contaminant sources most likely to put your utility at risk. Training needs associated with the highest priority risk should also be of highest priority. In prioritizing training needs, it is also important to consider the roles that each team member will fulfill, and areas where education may be needed. Roles could include routine responsibilities for, say, the Technical Coordinator, and also special responsibilities that person may be assigned in an emergency response to a contamination. If a team member isn't particularly strong in a skill needed for their position on the team, it is important to prepare them with the appropriate training before the need for them to act occurs. This preparation will help to minimize confusion in implementation stages and put forward a solid image to the community regarding the wellhead protection effort.

#### Conducting Wellhead Protection Training

Your utility does not have to spend large amounts of money to prepare Wellhead Protection Team members to fulfill their duties. Remember, utility personnel are often very knowledgeable about their community and the resources available in the utility or community to address an emergency. Use the resources available to begin training efforts, and bring in assistance from outside experts when it is needed.

Training can be provided in many forms. Organizations have used: orientation sessions, discussion groups, reading materials, tabletop exercises, scenarios, walk-through exercises or drills, demonstrations, external seminars, mock emergencies to test contingency plans, etc. Depending on the specific need, one form of training may be more effective than another. To help team members become more familiar with broader wellhead protection principles and to form a common background amongst the team, group question and answer sessions may work well. For specific emergency responses to a contamination, more of a "hands-on" method may be needed,

such as tabletop scenarios or walk-through exercises. These are also extremely valuable tools to discover details not considered when preparing your *Contingency Plan Table*. Choose the tool that best fits the particular training need and the people to be involved in the training.

Once a training session has been conducted, it is important to determine whether it achieved what was intended. Every training activity should be concluded with an evaluation of the training materials and methods to allow for fine-tuning. Additionally, a means of follow-up should be in place to ensure training needs have been satisfied. For example, if the Regulatory Coordinator needed training on researching and writing ordinances, put in place quality checks to be sure the team member can demonstrate the new ability learned from the training.

Training records, in some form, should be maintained for all members of the Wellhead Protection Team. By keeping track of this information, your utility can easily identify someone to serve in a back-up capacity for another team member, or identify how duties can be shifted to others.

#### Updating and Administering the Plan

As with any business that experiences change, water utilities can expect their wellhead protection plans to become outdated. And, without up-to-date information, the plan will become useless as a preventive tool to safeguard the water system. Therefore, it is recommended the plan be reviewed, and potentially modified, at least on an annual basis. The annual process should include:

- Review of the *Risk Assessment Table* and *Risk Consolidation Table* Be sure the priorities from the previous analysis are accurate, and rerank, if necessary due to successful control mechanisms, relocation of business or industry, or other changes. Is the *Contaminant Source Inventory Table* still complete, or should other potential hazards be added to it? If management strategies have been successful in offering the level of protection desired by your utility, these hazards may no longer pose as great a risk. In these situations, make the appropriate adjustments to the *Risk Assessment Table* and the *Risk Consolidation Table* reprioritize hazards. This will allow you to focus on hazards that were formerly not deemed as high a priority, but which will now offer additional protection for the water supply.
- Review the Progress of Contaminant Source Management Efforts Determine if items listed on the *Contaminant Source Management Log Sheet* have been accomplished. Be sure adequate record keeping has occurred for management initiatives that have been accomplished or deemed no longer necessary due to changes in operation or land usage. For incomplete items remaining on the list, evaluate whether the measures are making satisfactory progress according to timelines projected for completion. If sufficient progress is not being achieved, bring your Wellhead Protection Team together to review how the initiatives might be changed to allow them to be implemented, and determine new priorities and schedules for completion. The team may also need to rethink a chosen control strategy and select another option, more appropriate for up-to-date community issues and climates.
- Review *Contingency Plan Table* Consider how changes in team members, facilities, operational procedures, neighboring water suppliers, and community officials may have affected

the information contained in this form. Update the form with appropriate information.

• Review *Training Table* and Individual Training Evaluations - Determine if activities listed on the *Training Table* have been accomplished. Delete items accomplished or no longer necessary due to changes in operation, personnel, or community resources. Consider the results of the training evaluations and determine changes needed in future programs to better meet the needs ofparticipants. For training activities which were not completed, evaluate why those activities were not conducted, make appropriate changes to allow them to be completed, and determine new priorities and schedules for completion based upon the revised *Risk Assessment* and *Risk Consolidation Tables* and *Contaminant Source Management Log Sheet*.

The *Wellhead Protection Team Coordinators* form and *Water Supplier General Information Sheet* should be reviewed monthly for up-to-date names and telephone numbers. Additionally, both Wellhead Protection Team and Emergency Response Team members should be aware of their responsibility to notify the person responsible for maintaining the plan whenever this basic contact information changes. If team members move, obtain new telephone numbers, or are no longer available for after-hours contact, these forms should be updated immediately.

Specific events may also occur which should cause the plan to be updated (and appropriate training to occur) without waiting for the periodic review process. Examples may include: changes in water utility personnel, election of new utility or community officials, new business opportunities for the community, new facilities placed in operation, or significant operational changes.

#### Distribution of the Wellhead Protection Plan

The wellhead protection plan for your utility needs to be communicated in a variety of ways as stated in Step 7- Public Participation. First, it must be written and distributed to the appropriate people in the community. Copies of the plan should be provided to members of the Wellhead Protection Team and the Emergency Response Team, utility officials, community officials, other groundwater stakeholders, and representatives of emergency organizations in the community, such as fire and police departments. As your utility goes through the annual review and updating process, revised copies of the plan or individual pages should be distributed. Also, it is important that Wellhead Protection Team members have copies available not only at their business or day-time locations, but also in their homes.

Beyond circulation of the written plan, it is important to present the plan to your utility staff, community officials, and other community groups. Also mentioned in Step 7 - Public Participation, this educational effort cannot be minimized. The success or failure of your wellhead protection initiatives lies with the degree of acceptance or rejection offered by community residents.

Part of the wellhead protection presentation strategy should include identifying the people who will serve in each of the key team responsibilities. By introducing team members to the community, a first step is made in assuring the public that your utility will be prepared to do what is necessary to provide them with safe drinking water if a contamination emergency does occur. In sharing the plan, special attention should be paid to educating consumers about their roles in the wellhead protection initiatives. Identify how they can be involved.

The *Training Table* should also be presented to the Wellhead Protection Team and utility officials at least annually. This will ensure members and officials understand the priorities placed on training and encourage more support for achieving the training goals.

#### Instructions for Completing the Training Table

In the *Name* section, enter the name of the team member or volunteer who will be attending training.

In the *Training Needed* section, record the specific role, responsibility or function the training will address.

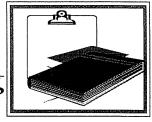
In the *Trainer* section, enter the name of the person conducting the training session.

In the *Training Technique* section, record the type of training being administered, for example, workshop, hands-on demonstration, classroom lecture.

In the Schedule section, record the month and year the training will be administered.

In the *Evaluation Technique* section, identify what method you plan to use to follow-up on the skills attained by the attendee.





Name	Training Needed	Trainer	Training Technique	Schedule	Evaluation Technique
(Staff/Community Member)	(Topic)	(Internal/ External)	(Workshop/Class)	(Month/Year)	(Post-Test/ Observation)
		• TATALON CONTRACTOR C		*****	
				-	
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To meet the expectations of your customers, your utility and staff need to identify potential hazards that could jeopardize the drinking water supply and plan for such occurrences. Wellhead protection begins with selecting the right people to be involved; people who will support justifiable protective measures and remain committed to achieving an adequate level of protection for the drinking water wells and recharge areas, to the extent possible. Follow these steps to begin your wellhead protection program:

Choose the team. Canvass the community, get qualified reliable participants, and complete the *Wellhead Protection Team Coordinators* form to have handy information for contacting these individuals as you approach each step of the model plan.

Prepare to define your wellhead protection area and get help when needed. Collect and review facts about each of your wells; know what characteristics make them vulnerable. Record this information on the *Wellhead Protection Information Table* for each well. Have in mind qualified technical resources to contract with if formal delineation of the wellhead protection area becomes necessary.

Determine potential contaminants. Get input from your community to identify possibly threatening business activities, land uses, or properties -- existing and abandoned. Plot the possible hazards in relationship to the well(s) and record pertinent information on the *Contaminant Inventory Table*.

**Prioritize potential risks.** Evaluate the contaminants identified according to the threats posed to public health, their mobility in groundwater, and their location to the well(s). Record ratings for each contaminant on the *Risk Assessment Table* and complete the *Risk Consolidation Table* to produce a prioritized list of potential threats to the water supply.

Identify management strategies for contaminants. Evaluate regulatory and nonregulatory options for minimizing the risk, or eliminating it altogether, and design measures to assure the water supply will be protected. Record the efforts needed in this process on the *Contaminant Source Management Log Sheet*.

Prepare to respond when contamination emergencies cannot be avoided. Complete the *Contingency Plan Table* with strategies for providing both short- and long-term water sources to your community. Form an Emergency Response Team prepared to deal with contamination emergencies.

**Keep your community educated and involved.** Plan activities that will assure your community is aware and participating in the wellhead protection effort. Record your public participation initiatives on the *Public Participation Log Sheet*.

Remember, wellhead protection is an effort needed today, to be sure the water environment will be safe for tomorrow's children.



## A

**ANALYTICAL EQUATION** - A numeric calculation or formula involving multiple and various components or elements.

**AQUIFER** - A porous, water-bearing geologic formation. Generally restricted to materials capable of yielding an appreciable supply of water.

## B

**BEDROCK** ~ The solid rock encountered below the mantle of loose rock and more or less unconsolidated material which occurs on the surface of the lithosphere.

## C

**CALCIUM CARBONATE** - The principal hardness and scale-causing compound in water; found in nature as calcite and aragonite and in plant ashes, bones, and shells; used in making lime.

**CONE OF DEPRESSION** - The depression, roughly conical in shape, produced in a water table or other piezometric surface by the extraction of water from a well at a given rate. The volume of the cone varies with the rate and duration of withdrawal of water. Also called cone of influence.

**CONFINED AQUIFER** - An aquifer which is surrounded by formations of less permeable or impermeable material.

**CONFINING LAYER** - An impervious stratum or layer directly above or below one bearing water.

**CONSOLIDATED** ~ (1) In geology, any or all the processes whereby loose, soft or liquid earth materials become firm and coherent. (2) In soil mechanics, the adjustment of a saturated soil in response to increased load, involving the removal of water from the pores by increase in pressure and decrease in void ratio.

## D

**DEEP WELL** - A well located and constructed in such a manner that there is a continuous layer of low permeability soil or rock at least five feet thick located at least 25 feet below the normal ground surface and above the aquifer from which water is to be drawn.

**DELINEATE** - To mark the outline of an area.

**DELINEATION** - The act or process of marking the outline of an area.

**DISSOLVED-SOLIDS CONCENTRATION** - Any material that is dissolved in water and can be recovered by evaporating the water after filtering the suspended material.

**DOLOMITE** - An equimolar combination calcium and magnesium carbonates which occurs in nature as a hard rock.

**DOSE-RESPONSE** - The relationship recognized between exposures to harmful substances over time and in varying concentrations (dose) and their subsequent impact upon public health (response).

**DRAWDOWN** ~ (1) The magnitude of the change in surface elevation of a body of water as a result of the withdrawal of water therefrom. (2) The magnitude of the lowering of the water surface in a well, and of the water table or piezometric surface adjacent to the well, resulting from the withdrawal of water from the well by pumping. (3) In a continuous water surface with accelerating flow, the difference in elevation between downstream and upstream points.

## E

**EPIDEMIOLOGIC DATA** - Scientific medical information related to the study of the incidence, distribution, and control of disease in a population.

## F

**FIXED RADIUS METHOD** - An approach used for establishing a wellhead protection area, applying constant distances to delineate a circular area of specific size.

**FRACTURED AQUIFER** - An aquifer in which water is stored and flows through relatively large openings, cracks, or crevasses.

## G

**GEOLOGY** - The science that deals with the origin, history, and structure of the earth, as recorded in the rocks, together with the forces and processes now operating to modify rocks.

## H

**HYDROGEOLOGY** - The branch of hydrology that deals with groundwater, its occurrence and movements, its replenishment and depletion, the properties of rocks that control groundwater movement and storage, and the methods of investigation and use of groundwater. Also called groundwater hydrology.

## 

**IMPERMEABLE** - Not allowing, or allowing only with great difficulty, the movement of water; impervious.

None and Association

K

**LAND USE** - (1) The culture of the land surface, which has a determining effect on the broad social and economic conditions of a region and which determines the amount and character of the runoff and erosion. Three general classes are recognized: crop, pasture or range, and forest. (2) Existing or zoned economic use of land, such as residential, industrial, farm, commercial.

## M

MODELING - Computerized simulation of groundwater flow and pumping conditions.

## N

**NEGATIVE CONFINING BED** - A confining bed that prevents or retards downward movement of groundwater where the overlying water has sufficient head to produce a resultant downward pressure.

## 0

**OPEN CHANNEL** - Any natural or artificial waterway or conduit in which water flows with a free surface.

## P

**PERMEABLE** - Having a texture that permits water to move through perceptibly under the head differences ordinarily found in subsurface water.

Q

R

**RECHARGE** - Addition of water to the zone of saturation from precipitation, infiltration from surface streams, and other sources.

S

**SHALLOW WELL** - A well located and constructed in such a manner that there is not a continuous layer of low permeability soil or rock (or equivalent retarding mechanism acceptable to the IDNR) at least 5 feet thick, the top of which is located at least 25 feet below the normal ground surface and above the aquifer from which water is to be drawn.

**TIME OF TRAVEL (TOT)** - The time required for water to travel from a given point to some other downstream point.

**TOTAL DYNAMIC HEAD (TDH)** - The difference between the elevation corresponding to the pressure at the discharge flange of a pump and the elevation corresponding to the vacuum or pressure at the suction flange of the pump, corrected to the same datum plane, plus the velocity head at the discharge flange of the pump, minus the velocity head at the suction flange of the pump.

## TJ

**UNCONFINED AQUIFER** - An aquifer which is not restricted by formations of less permeable or impermeable material.

## V

VELOCITY - The time rate of linear motion of groundwater in a given direction.

W



**XERISCAPING** - A landscaping practice which uses native plant materials having lower water and nutrient requirements than standard landscape plantings.

Y

Z



## Iowa's Bedrock Aquifers

There are five principal bedrock aquifers used extensively in Iowa: the Dakota, Mississippian, Silurian-Devonian, Cambrian-Ordovician (Jordan) and Dresbach aquifers. These formations, comprised of porous, permeable sandstones and fractured carbonate rocks, are productive wateryielding units. They are usually separated by confining beds that slow the movement of water between the aquifers. At the bottom of the groundwater reservoir are Precambrian rocks in excess of 600 million years old. These rocks lie at a depth of about 5,200 feet in southwestern Iowa, rise to the surface in extreme northwestern Iowa, and to within 800 feet of the surface in northeastern Iowa. The Precambrian rocks are normally impermeable, and do not generally yield groundwater. The water-bearing rock formations are stacked, one on top of the other in layer-cake fashion, above these Precambrian basement rocks. The bottommost aquifer, and the first to be formed, is the Dresbach aquifer, which is estimated to be nearly 600 million years old. The Cambrian-Ordovician, the Silurian-Devonian, the Mississippian aquifers, and intervening units were all laid down in succession over the Dresbach aquifer. At some point, after formation of the Mississippian aquifer, geologic forces warped the bedrock so that these rock units slope downward from northeast to southwest at a rate of about 13 feet per mile. The Dakota aquifer of western Iowa was formed later, and lies relatively flat over approximately 20 percent of the state.

If the layers of overlying glacial materials (sand, gravel, till and soil) could be stripped off and the bedrock layer cake could be sliced from east to west, some interesting features of the bedrock system would be revealed. Figure 1A shows the slope of the bedrock. Because of the slope, bedrock aquifers found at or near the surface in northeast Iowa are buried 2,000 or more feet below the surface in the southwest. Not only are these sloping bedrock layers higher in the northeast, they are also tapered off, becoming thinner and thinner until they become truncated in the eastern portion of the state. Each layer, in turn, becomes the uppermost surface of the bedrock, and it is in these areas, where the aquifers are exposed to the glacial materials which lie above, that the bedrock aquifers are recharged. The Dakota is the only bedrock aquifer which does not exhibit this noticeable slope.

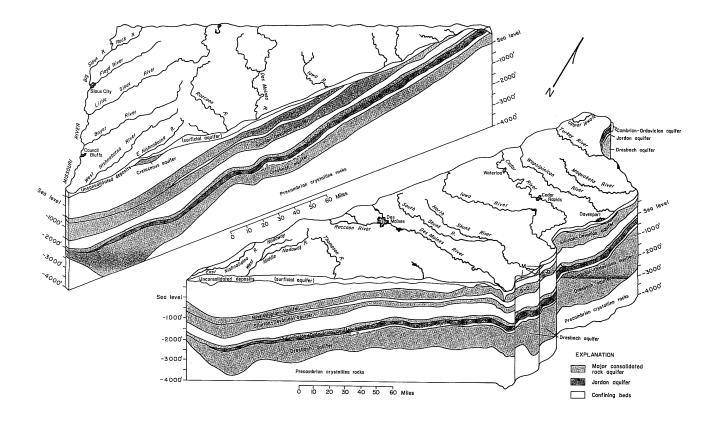


Figure 1A: Slope of Iowa's Bedrock and Aquifer Units

Many factors influence the overall value of each aquifer as a water source. Aquifer depth, thickness, permeability and water quality are just a few of the factors that must be considered. The following paragraphs provide information which can be used to understand differences between the bedrock aquifers in Iowa.

## The Dresbach Aquifer

Physical Characteristics - The Dresbach aquifer, although present, is not really used in most of the state. It is the stratigraphically lowest aquifer in Iowa. The aquifer ranges in depth from less than 100 feet in some eastern counties to well over 3,000 feet in the western half of the state. Information regarding the Dresbach aquifer is limited to a stretch along the Mississippi River, from Allamakee to Clinton Counties. Some records, however, indicate thickness varies from less than 100 to well over 1,000 feet, with significant local variation. The aquifer consists primarily of sandstones in three formations: the Wonewoc Formation (top), Eau Claire Formation (middle), and Mount Simon Sandstone (bottom).

The Dresbach aquifer has generally been used as a water source only in northeastern and east central counties adjacent to the Mississippi River. In this area the aquifer has proven to be productive. Extreme depth, low yield, and poor water quality limit use of the Dresbach aquifer in other parts of the state.

Hydraulics - Water moves through the aquifer away from recharge areas outside the state. Discharge of water into the Mississippi River is likely, based on water levels in the area.

Yields of 500 gpm are common in far eastern counties. Even higher capacity wells have been developed in the aquifer in Dubuque, Clinton, and Maquoketa, where yields of 2,000 gpm are documented. Attempts to develop Dresbach wells in other parts of the state have met with little success. Yields of less than 50 gpm and water which was highly mineralized made successful development unlikely.

Water Quality - Acceptability of water from the Dresbach aquifer most often depends on its dissolved solids concentration. In the far northeastern counties, adjacent to the Mississippi River, water is suitable for most domestic use, with total dissolved solids concentrations of less than 500 milligrams per liter (mg/L). Concentrations increase to the south and west. Radium is also a consideration in some areas of use.

## The Cambrian-Ordovician Aquifer (Including the Jordan Sandstone)

Physical Characteristics - The Cambrian-Ordovician aquifer covers more than 90 percent of the state, with the only exception being the extreme northwestern counties. Figure 1B shows the aquifer's extent in Iowa. A separate aquifer, known simply as the Ordovician aquifer, lies above the Cambrian-Ordovician aquifer and is used by some supplies in northeast Iowa. Its use is not, however, widespread, therefore, detailed information has not been provided about the aquifer. The Cambrian-Ordovician aquifer outcrops in the northeastern tip of the state and lies more than 3,000 feet below the surface in southwest Iowa. Depths range from 1,000 to 1,500 feet in the northern and northeastern counties to 2,500 to 3,000 feet in the central and south-central counties. The average thickness of the aquifer is from 400 to 500 feet. The aquifer consists of three water-bearing zones: the St. Peter Sandstone, the Prairie du Chien Group and the Jordan Sandstone (see Table 1).

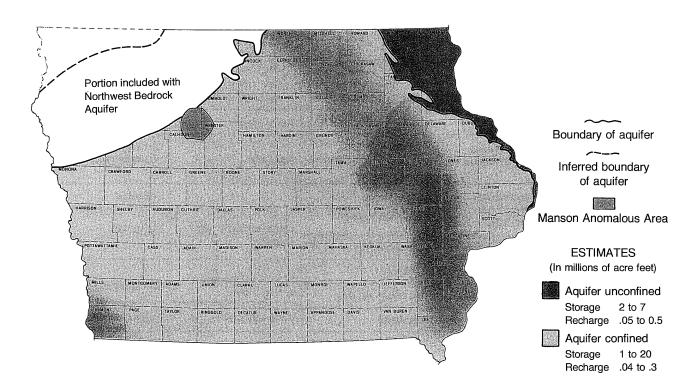


Figure 1B: The Cambrian-Ordovician Aquifer System

Table 1 - Geologic and Hydrogeologic Units in Iowa

	AGE	ROCK UNIT	DESCRIPTION	HYDROGEOLOGIC UNIT	WATER-BEARING
		Alluvium	Sand, gravel, silt and clay	UNII	CHARACTERISTICS Fair to large yields
Cenozoic A	Quarternary	Clacial drift (undifferentiated)	Predominantly till containing scattered irregular bodies of sand and gravel	Surficial aquifer	Low yields
		Buried channel deposits	Sand, gravel, silt and clay		Small to large yields
Mesozoic	Cretaceous	Carlile Formation Granerous Formation	Shale	Aquiclude	Does not yield water
		Dakota Group	Sandstone and shale	Dakota aquifer	High to fair yields
	Jurassic	Fort Dodge Beds	Gypsum, shale	Aquitard	Does not yield water
Mississip	Pennsylvanian	Virgil Series Missouri Series	Shale and limestone	Aquiclude	Low yields only from limestone and sandstone
		Des Moines Series	Shale; sandstones, mostly thin		
		Meramec Series	Limestone, sandy		Fair to low yields
	Mississippian	Osage Series	Limestone and dolomite cherty	Mississippian aquifer	
		Kinderhook Series	Limestone, colitic, and dolomite, cherty		
	Devonian	Maple Mill Shale Sheffield Formation Lime Creek Formation	Shale; limestone in lower part	Devonian aquiclude	Does not yield water
		Cedar Valley Limestone Wapsipinicon Formation	Limestone and dolomite; contains evaporites in southern half of Iowa	Silurian-Devonian aquifer	High to fair yields
	Silurian	Niagaran Series Alexandrian Series	Dolomite, locally cherty	onarian aquito	Tigit to tall yicks
	Ordovician	Maquoketa Formation	Shale and dolomite	Maquoketa aquiclude	Does not yield water, except locally in NE Iowa
		Calena Formation	Limestone and dolomite	Minor aquifer	Low yields
		Decorah Formation Platteville Formation	Limestone and thin shales; includes sandstone in SE Iowa	Aquiclude	Cenerally does not yield water; fair yields locally in SE lowa
		St. Peter Sandstone	Sandstone		Fair yields
		Prairie du Chien Formation	Dolomite, sandy and cherty	Cambrian-Ordovician	High yields
	Cambrian	Jordan Sandstone	Sandstone	aquifer	
		St. Lawrence Formation	Dolomite	Aquiclude (wedges out in NW Iowa)	Does not yield water
		Franconia Sandstone	Sandstone and shale		
		Dresbach Group	Sandstone	Dresbach aquifer	High to low yields
Precambrian		Sioux Quartzite	Quartzite	Base of groundwater reservoir	Not known to yield water except at center of Manson impact area
		Undifferentiated	Coarse sandstones; crystalline rocks		

The sandstones of the St. Peter Formation are very poorly cemented and tend to cave in, filling portions of the well with sand. For this reason, the St. Peter Formation is often cased-off or not used, and not allowed to contribute water to Cambrian-Ordovician wells.

There are a number of units in the Prairie du Chien Group. The two which contibute water to wells which tap the Cambrian-Ordovician aquifer are the Oneota Dolomite and Root Valley (New Richmond) Sandstone members. The Oneota is a drab-gray- to buff-colored dolomite that is locally cavernous and highly fractured. Its maximum thickness is about 235 feet. The Root Valley (New Richmond) consists of white- to buff-colored, fine- to medium-grained, quartz sandstone. It is loosely cemented in northern Iowa, becoming more tightly cemented to the south. It is as thick as 110 feet.

The Jordan Sandstone is the principal water-producing unit in the aquifer. It is a white- to buff-colored, fine- to coarse-grained, quartz sandstone that is loosely to moderately cemented. The thickness of the formation ranges from a maximum of about 145 feet in northeastern Iowa to about 30 feet in central and southwestern Iowa.

The Cambrian-Ordovician aquifer is used extensively as a water source by municipalities and industries in eastern Iowa. Many communities in central and southern Iowa also obtain their water supplies from the Cambrian-Ordovician aquifer, because in that region of the state the aquifers lying above the Cambrian-Ordovician either have low water yields or produce poor quality water.

Hydraulics - Water enters the Cambrian-Ordovician aquifer primarily through vertical leakage from overlying rocks in northwest, central and eastern Iowa. Water also enters through infiltration in areas where the aquifer is the uppermost bedrock unit. Water passes only through soil before it enters the aquifer in the northern most part of the recharge area but must pass through layers of sandstones, shales, and carbonate rocks in the rest of the recharge area. From the recharge area, the water moves by subsurface flow toward Illinois and Missouri. Water actually discharges from the aquifer into the Mississippi River and parts of the Illinois Basin.

Jordan wells are one of the most dependable groundwater sources for large capacity wells in Iowa. Generally, yields from these wells range from several hundred to 1,000 gpm, and occasionally 2,000 gpm in the southeastern part of the state. To some extent the variation in yield depends on the amount of cementation of the sandstones and the presence or absence of fractures in the dolomites.

Proper well construction and development are important in obtaining maximum yields from wells tapping the Jordan aquifer. The most successful wells usually have a bottom hole diameter of at least eight inches, and are cased from the surface into the upper part of the Prairie du Chien Group, with the full length of pipe grouted.

Water Quality - The best quality water in the Cambrian-Ordovician aquifer occurs in northeast Iowa, near the recharge area, where the concentration of dissolved solids is less than 500 mg/L. The mineral content of the water increases significantly southwest of a line running from Winnebago to Clinton Counties. Water that is classified as good-to-fair quality, with dissolved-solids concentrations of 500 to 1500 mg/L, is found in a broad belt through the central and southeastern parts of the state. In addition to high dissolved solids, the sodium and chloride concentrations increase significantly as the water approaches the southern and southeastern borders

93

of the state. West and southwest of this central belt, the water generally is so highly mineralized as to be a poor-to-objectionable source for most uses.

Iron concentrations in water from Jordan wells vary considerably from 0.0 to 5.6 mg/L, with a mean value of 1.08 mg/L. Manganese concentrations range from 0.0 to 0.36 mg/L, with a mean value of 0.02 mg/L. Hydrogen sulfide exists in objectionable quantities in some areas, and the concentration of radium has an important bearing on the general acceptance of Jordan water supplies. Lower radium values generally occur in northeast Iowa, while higher values are found in central and western Iowa.

Nitrate concentrations in water from the Jordan wells throughout the state are very low. The concentrations range from 0.0 to 5.5 mg/L, with a mean value of 1.4 mg/L. Higher concentrations may occur in northeastern Iowa where the Jordan aquifer is close to the surface, thus subject to contamination from surface sources. The Allamakee, Clayton, and Winneshiek County areas, where the aquifer is the shallowest, are susceptible not only to nitrate contamination, but also to bacterial pollution from surface water infiltration.

Only a few Jordan supplies are not treated in some way. The majority of the Jordan well water supplies used for municipal purposes require treatment for iron removal. A typical treatment system consists of aeration, filtration, and disinfection, in that order. Seventy-five to 80 percent of all municipal Jordan wells are treated in this fashion. A relatively small number of supplies are also softened as a part of their treatment process. Most of the softened supplies are located in the southeast quarter of the state. Fluoridation is included in several treatment systems in the northern part of the state, where the natural fluoride concentration of the Jordan water is less than 1.0 mg/L. About 25 percent of the Jordan municipal supplies add polyphosphate or alkali chemicals to the water for stabilization, to adjust the pH, for corrosion control, and to hold iron in solution. A few communities aerate the water to remove hydrogen sulfide odor.

## The Silurian-Devonian Aquifer

*Physical Characteristics* - The Silurian-Devonian aquifer underlies approximately 90 percent of the state, except for the northeast and northwest corners. Figure 1C shows the boundaries of the Silurian-Devonian aquifer in Iowa. The depth to the top of the aquifer ranges from 0 to 400 feet in the outcrop area, where it is the uppermost rock unit, but it is usually between 50 and 250 feet deep. In the subcrop area, where the aquifer underlies other rock units, several hundred feet of drilling may be required before the aquifer is reached.

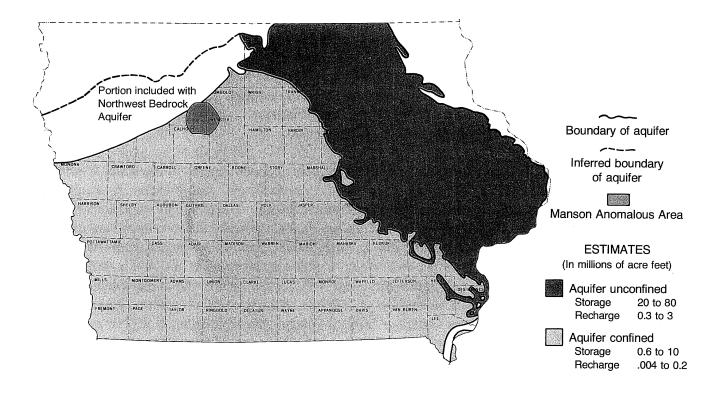


Figure 1C: The Silurian-Devonian Aquifer System

The aquifer is thickest in the southwest quarter of the state where it is generally 500 to 600 feet thick, reaching a maximum of 700 feet. Over most of eastern and northern Iowa, the Silurian-Devonian aquifer averages between 200 and 400 feet in thickness. However, because of surface erosion, the thickness of the aquifer in the outcrop area often is less than the average.

The Silurian-Devonian aquifer consists of a succession of thick carbonate rocks of Devonian and Silurian age. Dense limestones and dolomites, with significant secondary porosity (fractures, joints, bedding planes, and solution cavities), are the principal rock types. Locally, shales and clays fill large cavities in Silurian carbonates. Table 1 shows where these rock layers lie in relation to the other bedrock aquifers.

More than 15 percent of the municipal and rural populations of the state are supplied by wells tapping the Silurian-Devonian aquifer. The aquifer is used as a water source primarily in northeast and eastern Iowa where it lies beneath glacial drift only. The aquifer is also used to some extent in northwestern Iowa, where it is overlain by Cretaceous strata. In central and southern Iowa, the aquifer is highly mineralized. For this reason, the Silurian-Devonian aquifer is not used a great deal in central and southern Iowa. In western and southwestern Iowa, the aquifer is deeply buried beneath younger rocks and is not often utilized.

Hydraulics - Recharge to the Silurian-Devonian aquifer is directly in the outcrop area in the northeastern part of the state. Recharge is rapid in this area because the soil and glacial drift is less than 25 to 50 feet thick in many places, and highly porous. In the subcrop area of the aquifer, recharge occurs at a much slower rate.

The Silurian-Devonian aquifer is most productive in the outcrop area in northeastern Iowa, because the rocks near the surface have more fractures and solution-bearing cavities. The highest-capacity wells are usually found in or near river valleys, because the limestone and dolomite have dissolved to a greater extent in these areas, giving the aquifer greater water transmissivity and storage capacity. A number of municipal and industrial wells in northeastern and eastern Iowa obtain between 150 to 400 gpm from the Silurian-Devonian aquifer. A narrow strip along the Cedar River valley from Charles City to Waterloo is very cavernous. Yields in excess of 4,000 gpm have been recorded from wells at Cedar Falls and Waterloo.

Water Quality - Iron commonly occurs in troublesome concentrations in the water from the Silurian-Devonian aquifer. In fact, in most places it is practically mandatory to install equipment for iron removal or to stabilize the water to hold iron in solution. The iron concentrations range from 0.0 to 31.0 mg/L, with a mean value of 1.54 mg/L. Manganese concentrations range from 0.0 to 2.5 mg/L with a mean value of 0.9 mg/L. Nitrate concentrations in water from the Silurian-Devonian aquifer range from 0.0 to 300 mg/L with a mean value of 6.6 mg/L. Wells less than 50 feet deep show the most contamination, but wells located where the overburden is thin will show high nitrate concentrations as deep as 150 feet. If high nitrates are found in deeper wells it may imply that water from shallower levels is entering the well because of poor construction or corroded casing. Chloride concentrations in water from the Silurian-Devonian aquifer range from about 0.5 to 100 mg/L in the northern half of the state and from about 100 to 1000 + mg/L in the southern half. The dividing lines run roughly from Louisa to Polk to Pottawattamie Counties.

In central and southern Iowa, the aquifer contains a high concentration of sulfate ions. For this reason the Silurian-Devonian aquifer is not used a great deal in those regions. Total dissolved solids range between 2,000 and 5,000 mg/L in the subcrop area of the Silurian-Devonian aquifer, which is poor quality for most domestic purposes. Fluoride concentrations in the Silurian-Devonian aquifer range from 0.1 to 5.0 mg/L. The higher concentrations occur in most of the southwestern, southern and southeastern parts of the state. Water hardness levels in the Silurian-Devonian aquifer run from 200 mg/L to more than 2,000 mg/L, with values between 300 and 400mg/L common in the outcrop area in north-central, northeastern and east-central Iowa.

Where unconsolidated materials, less than 25 to 50 feet thick, overly the Silurian-Devonian (and all northeast Iowa aquifers), and where concentrations of sinkholes occur, groundwater may be severely polluted by nitrate. The upper bedrock in these areas is highly susceptible to pollution from farmland infiltration, or infiltration from point sources of pollution such as manure piles, barnyards, septic tanks, and refuse dumps.

The most frequently used methods of treatment for supplies developed from the Silurian-Devonian aquifer are disinfection by gas chlorination or hypo-chlorination, and iron and manganese removal by aeration and filtration. In addition, a few supplies are softened, however, the aquifer is not used extensively in areas where hardness exceeds 500 mg/L.

## The Mississippian Aquifer

*Physical Characteristics* - The Mississippian aquifer underlies about 60 percent of the state, but it serves as a major drinking water supply in only about 15 percent of its total area. Figure 1D shows the limits of the Mississippian aquifer in Iowa.

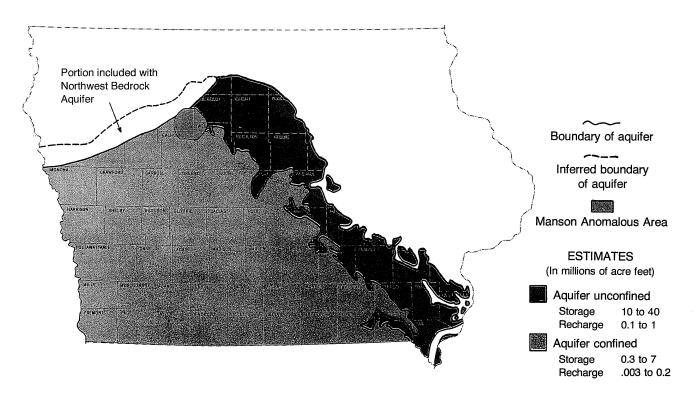


Figure 1D: The Mississippian Aquifer System

The depth of the Mississippian aquifer varies from 50 to 100 feet in north central regions of the state, to more than 500 feet in the southwestern quarter of the state. The maximum thickness of the aquifer is about 600 feet; however, in the outcrop area, the thickness generally ranges from less than 100 feet up to about 300 feet.

The Mississippian aquifer, consists principally of limestone and dolomite strata that are grouped into three mappable units: the Kinderhookian, Osagean, and Meramecian Series. The Kinderhookian strata are chiefly limestone and cherty dolomite, with some siltstone. In north-central Iowa, the series is characterized by carbonate beds which become more shallow to the south and southeast. The Osagean strata are chiefly dolomite and limestone with an abundance of chert; however, the only shale (Warsaw Shale) as an important aquiclide in Mississippian rocks occurs in this unit in southeastern Iowa. The Meramecian rocks are mainly sandy limestone and sandstone with some dense dolomite beds near the base, and shale locally near the top. This unit in south-central Iowa contains beds of gypsum and anhydrite at its base.

The principal area of development of the Mississippian aquifer is located in central and southeastern Iowa. This area comprises all or parts of 10 counties in the north-central part of the Mississippian outcrop belt, where the aquifer yields moderate to large supplies of good- to excellent-quality water. In this area, the aquifer is overlain by glacial deposits.

Hydraulics - Recharge to the aquifer is in the outcrop area and by seepage of water from the northwest. The water moves through the aquifer, which is confined by overlying and underlying confining beds, in a southerly and southeasterly direction. Some water moves into Missouri as underflow, but the Des Moines River is the principal discharge area for the aquifer. Other important discharge areas are the valleys of the Skunk, North Skunk, and South Skunk Rivers.

Water is stored principally in secondary openings in the predominantly carbonate-type rocks of the Mississippian aquifer. These openings occur randomly and vary in size and extent. Water is also stored in rock units that have primary porosity, such as the St. Louis Sandstone in the Meramecian Series. The storage and transmission characteristics of the Mississippian aquifer are variable from place to place.

Artesian conditions predominate in the Mississippian aquifer, even in the outcrop area where the aquifer is confined by glacial till. However, in many localities in the outcrop area, the artesian pressure is quickly depleted in the vicinity of pumping wells. Under these conditions, the aquifer is being dewatered.

In the subcrop area, specific capacities generally are much less than one gpm per foot of drawdown. However, because more room for drawdown generally is available in the deeper wells penetrating the aquifer in the subcrop area, yields of as much as 50 gpm may be obtained. Water yields from the aquifer are variable and range from more than 500 gpm in Wright, Hardin, and Story Counties to only a few gallons per minute in southeastern Iowa.

Water Quality ~ Chloride content generally is less than 20 mg/L in the outcrop area of the aquifer and, generally, less than 80 mg/L elsewhere. Higher concentrations occur locally in southern Iowa. These high concentrations are always associated with very high sodium concentrations, but not all water with high sodium content has a high chloride content. Nitrate content generally is less than 5 mg/L. Water with an unusually high concentration of nitrate is a good indication that the well is polluted. Iron and manganese concentrations vary considerably. Both constituents, however, are readily removed by treatment.

Water from the aquifer, with few exceptions, is extremely hard. The exceptions occur in a small area through central Iowa. High concentrations of fluoride are usually associated with the low-hardness water.

## The Dakota Aquifer

*Physical Characteristics* - The Dakota aquifer of northwestern Iowa covers approximately 20 percent of the state. It is the chief bedrock aquifer in northwestern Iowa, and is occasionally used in western and southwestern Iowa, as well. Figure 1E shows the area of the Dakota aquifer. Depth to the top of the aquifer varies considerably, because its surface was weathered before the overlying materials were deposited. In the northwestern counties, the top of the aquifer can be as deep as 600 feet, while in other areas it may only be necessary to drill between 50 and 200 feet to reach the aquifer. The thickness of the aquifer varies from less than 50 feet to more than 200 feet, with an average thickness of about 75 feet.

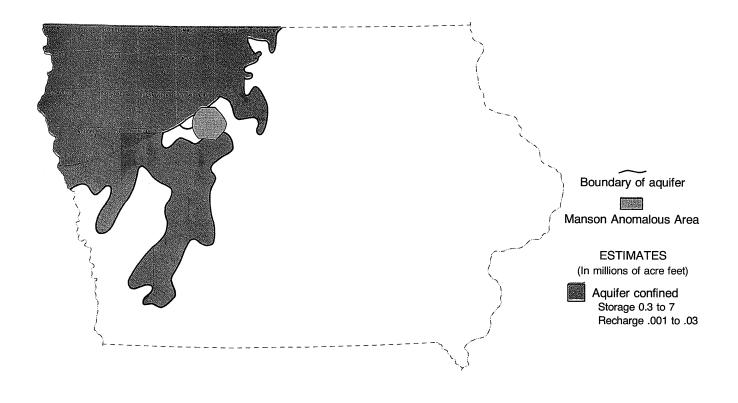


Figure 1E: The Dakota Aquifer System (Northwest Bedrock Aquifer System)

The aquifer is made up of many layers, most of which are Dakota sandstones. The sandstone which forms the Dakota aquifer is generally fine-grained and poorly cemented. These characteristics can result in problems if proper well construction and aquifer development techniques are not used.

Hydraulics - The Dakota, a confined aquifer, is recharged primarily in southwestern Minnesota and northwestern Iowa. Water tends to move from the northwest and north-central part of the aquifer to the southwest, south, and east. Water discharges from the aquifer into the Big Sioux and the Missouri Rivers, interior rivers and streams, and other geologic units.

The Dakota aquifer provides water for rural and municipal needs in northwestern Iowa. In Sioux City, yields of more than 1,500 gallons per minute have been obtained. Some municipal wells in the Dakota aquifer in O'Brien and Cherokee Counties have been shown to produce from 350 to 750 gpm. Even where the aquifer is only moderately thick, many wells have been developed that yield 50 to 100 gallons of water per minute.

Water Quality - The quality of water in the Dakota aquifer varies somewhat depending on location. Dissolved-solids concentrations vary from less than 500 to more than 2,000 mg/L. Sulfate concentrations, which are less than 250 mg/L over much of the area, exceed 1,000 mg/L in some areas. Concentrations of dissolved solids and sulfate both seem to be elevated in areas where the aquifer is recharged.



## Choosing a Method of Delineation

Several methods for delineation of wellhead protection areas (WHPAs) are commonly used. Again, the intent is to choose the method which offers each community the degree of accuracy desired in determining the area which must be monitored for potential threats to the water supply. The most common methods can be grouped into three general categories including the fixed radius method, the analytical equations method, and numerical flow and transport modeling. A brief description of each is included in this appendix.

When going beyond a simple fixed radius approach, selection of a delineation method is based on factors such as radius of influence around a well, depth of drawdown by a well at a given point, the time of travel of contaminants in various hydrologic conditions, and distance from the well. EPA has established these factors as "criteria" because they can represent the conceptual standards that form the technical basis for WHPA delineation. Four common types of criteria are identified: distance, drawdown, time of travel, and flow boundaries. In using these criteria for WHPA delineation, a threshold value or set of values must be selected to represent the limits above or below which a given criterion will cease to provide the desired degree of protection. These values are referred to as "criteria thresholds." In general, EPA has indicated protection from chemical threats is usually covered over the following criteria threshold ranges:

Distance:

less than 500 feet to more than 2 miles

Drawdown:

0.1 to 1.0 foot

Time of travel:

Tens of days to years (typically years)

Flow boundaries:

Physical and hydrologic

The selection of a method and criterion, or combination of criteria, will likely depend upon a blending of technical and non-technical (administrative, policy, etc.) considerations. The method used will also depend on budget, availability of data, required precision, and time available for implementation. Ultimately, the approach which satisfies your community's overall protection goal for the WHPA should be chosen.

## Fixed Radius Method

The fixed radius method is used to delineate a circular area of specific size for use as a WHPA (See Figure 2A). The size can be based on arbitrary guidelines or generalized hydrogeologic conditions.

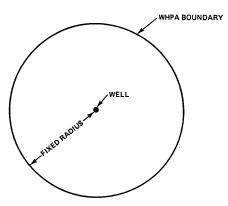


Figure 2A: Wellhead Protection Area Delineation Using the Fixed Radius Method

Arbitrary or non-hydrogeologic guidelines such as regulatory statute are often used in the fixed radius method. This is currently the case in Iowa, where the Iowa Administrative Code requires that all public wells have a minimum lifetime protected zone extending 200 feet from the well. This requirement is meant to restrict activities and potential sources of pollution in the vicinity of the well. In addition, the Code addresses groundwater vulnerability as a function of distance to potential contamination sources, and provides minimum lateral setback distances from selected sources of contamination (e.g., landfills, lagoons, etc.), as shown below. Though partially effective in some cases, it is important to understand that an arbitrary selection of a distance can be inaccurate and, unless very large, can fail to protect recharge areas.

	Shallow Wells as Defined in	Deep Wells as Defined in
Sources of Contamination	56740.2(455B)	56740.2(455B)
Wellhouse floor drains (point discharges)	5 ft.	5 ft.
Water treatment plant wastes (point discharges)	50 ft.	50 ft.
Sanitary and industrial point discharges	400 ft.	400 ft.
Wellhouse floor drains to surface	5, 10, 25 or 75 ft. depending	5, 10, 25 or 75 ft. depending
	on pipe materials	on pipe materials
Wellhouse floor drains to sewers	25, 75 or 200 ft. depending on	25, 75 or 200 ft. depending
	pipe materials	on pipe materials
Water plant wastes	25, 75 or 200 ft. depending on	25, 75 or 200 ft. depending
	pipe materials	on pipe materials
Sanitary and storm sewers, drains	25, 75 or 200 ft. depending on	25, 75 or 200 ft. depending
	pipe materials	on pipe materials
Sewer force mains	75 or 400 ft. depending on	75 or 400 ft. depending on
	pipe materials	pipe materials
Land application of solid wastes	200 ft.	100 ft.
Irrigation of wastewater	200 ft.	100 ft.
Concrete vaults and septic tanks	200 ft.	100 ft.
Mechanical wastewater treatment plants	400 ft.	200 ft.
Cesspools and earth pit privies	400 ft.	200 ft.
Soil absorption fields	400 ft.	200 ft.
Chemical application to ground surface	200 ft.	100 ft.
Lagoons	1,000 ft.	400 ft.
Chemical and mineral storage (above ground)	200 ft.	100 ft.
Chemical and mineral storage including	400 ft.	200 ft.
underground storage tanks on or below ground		*
Animal pasturage	50 ft.	50 ft.
Animal enclosure	200 ft.	100 ft.
Animal wastes - land application of solids	200 ft.	100 ft.
Animal wastes - land application of liquid/slurry	200 ft.	100 ft.
Animal wastes - storage tank	200 ft.	100 ft.
Animal wastes - solids stockpile	400 ft.	200 ft.
Animal wastes - storage basin or lagoon	1,000 ft.	400 ft.
Earthen silage trench or pit	200 ft.	100 ft.
Basements, pits, sumps	10 ft.	10 ft.
Flowing streams/other surface water bodies	50 ft.	50 ft.
Cisterns	100 ft.	50 ft.
Cem eteries	200 ft.	200 ft.
Private wells	400 ft.	200 ft.
Solid waste disposal site	1,000 ft.	1,000 ft.

Generalized hydrogeologic information can be used to improve upon the accuracy of an arbitrary fixed radius. This information can be used to approximate the cone of depression or time of travel distance for a specific well. A cone of depression is the depression of water level elevation around a pumping well caused by withdrawal of water, as shown in Figure 2B. The time of travel distance is the distance which water moves through the aquifer in a given amount of time, say five years. Because water typically moves slowly to a well, the area of influence of a well can be expressed in terms of time. Calculating this time of travel zone is often the basis for defining a WHPA. Extrapolated hydrogeologic data can be used to estimate the diameter of the cone of depression or the distance water will travel in a given amount of time. Either of these estimates can then be used to establish a somewhat more accurate fixed radius. This radius then would be applied to all wells in the area, without further consideration of site-specific conditions. This is termed the calculated fixed radius. Because hydrogeologic conditions may vary drastically over short distances (e.g., aquifer thickness, hydraulic conductivity, flow boundaries), this method also is not very accurate, though it is slightly better than an arbitrary fixed radius.

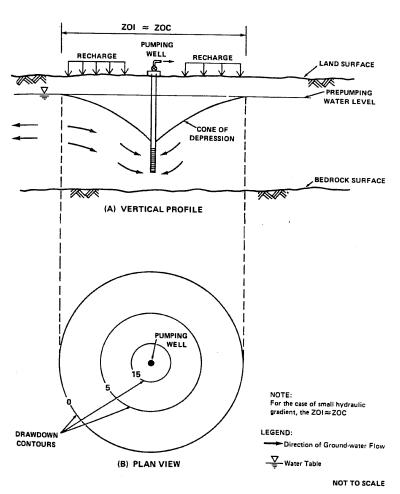


Figure 2B: Schematic of an Unconfined Aquifer Showing Drawdown (Cone of Depression) and an Evenly Distributed Recharge Area

The advantages of the fixed radius techniques are that they are relatively easy and inexpensive to apply. Fixed radius can be effective if large distances (say greater than two miles) are selected, thereby overcoming the lack of hydrogeologic precision. The primary disadvantages are that the methods may over- or under-protect recharge areas, and there is a high degree of uncertainty making fixed radius delineation difficult to defend.

## Analytical Equations Method

Analytical equations are used to delineate groundwater flow patterns near a pumping well. Based on the flow patterns, an appropriate WHPA can be established. The size and shape of the WHPA is dependent upon the pumping rate, the location of aquifer boundaries, and the characteristics of the aquifer itself.

The equations are used to define the cone of depression around a specific pumping well. As noted above, a cone of depression occurs when water levels in the vicinity of the well are lowered, causing water to move toward the well. The drop in water level, relative to its original position, is called drawdown. The distance from the well at which no drawdown occurs is equal to the radius of the cone of depression and may be used as an approximate lateral boundary for the WHPA (Figure 2B). The upgradient extent of the WHPA can then be calculated based on an appropriate time of travel or local flow boundary condition. This method provides a conservative estimate of the WHPA boundary since it assumes that contaminants will move at the same rate as the groundwater, and thus does not account for natural processes that may reduce the concentration of the contaminant as it moves through the subsurface.

The advantages of this method are that it is easily understood by persons familiar with basic hydrogeology concepts and the equations take into account site-specific hydrogeologic and operating conditions. When combined with time of travel, distance, and flow boundary considerations, the analytical equations method is the most cost-efficient and accurate method available to address site-specific needs. It is also the most widely applied method in establishing WHPAs. The main disadvantage is that the equations are based on simplifying assumptions that may or may not adequately represent complex site-specific conditions.

## Numerical Flow and Transport Models

Numerical models are used to simulate groundwater flow and contaminant transport or movement. The results are then used to establish the WHPA. The models can accurately simulate flow and contaminant transport in highly complex hydrogeologic conditions. One model commonly used is the EPA semi-analytical groundwater flow model, referred to as WHPA, which is designed to assist in the delineation process.

Groundwater flow models can be developed to simulate drawdown, flow boundaries, recharge areas, and time of travel using input data such as hydraulic conductivity, porosity, specific yield, aquifer thickness, recharge rates, aquifer geometry, and hydrologic boundary conditions. Once the flow model is developed and calibrated, a contaminant transport model using contaminant-specific characteristics can be developed.

The advantages of numerical models are that they can be used to represent complex site-specific hydrogeologic conditions. In addition to predicting groundwater flow and contaminant transport, they can also be used to predict recharge rates and the impact of additional pumping wells. The disadvantage is that the models are expensive to develop due to the large amount of site-specific data needed and the time-consuming field calibration which is required.

#### Other Methods

The fixed radius, analytical equations, and numerical models are the most frequently applied methods in determining WHPAs. There are several other methods which are less frequently applied, but still appropriate, for use in defining a WHPA. They include the hydrogeologic mapping method, water budget approach, and variable shapes method. Any one of these may be a suitable application at a given site and each offers advantages and disadvantages. Often, one of these methods may be combined with the fixed radius or analytical equations methods to provide a better definition of the WHPA.

## Examples of Delineation

Two delineation examples are presented below, one for each unconfined and confined aquifers. Two examples are provided because of the significant differences between recharge of confined verses unconfined aquifers. These examples provide steps to guide you through the delineation process using the calculated fixed radius method in conjunction with the time of travel and flow boundary criteria mentioned at the beginning of this appendix. Certain steps are straightforward, requiring minimal to no expertise; while other steps are more technical, possibly requiring outside assistance or experience-based professional judgment.

The basis of the calculated fixed radius method, using the time of travel criterion, is to determine the direction in which groundwater is moving through the aquifer and the rate at which it is moving. With this information, the distance groundwater will travel in a specified period of time can be estimated. These time of travel (TOT) distances can then be used to approximate a WHPA.

Other than an arbitrary fixed radius, this is the least complex of the delineation methods. The end product of this method is an area that can be considered the minimum workable WHPA.

The first two steps are common to both Options. Complete Steps 1 and 2 and then proceed with the delineation process by selecting Option A if your aquifer is unconfined, or Option B if your aquifer is confined.

## STEP 1: Base Map

The best way to show the important aspects from the data collection phase is to generate a base map showing pertinent information such as well locations, physical boundaries, and hydrogeologic boundaries. For the base map, use a city map showing streets and major features or some other small-scale map. You may also want to use a 7½-minute USGS quadrangle map as a regional base map.

## STEP 2: Well Inventory and Screening

Note which aquifer supplies your well or well field and whether it is unconfined or confined. Examine the available well records for all wells in the area and determine which wells penetrate this aquifer. If you have wells in different aquifers, you will have to assess each aquifer independently.

Compile a data record for each well penetrating the aquifer(s). Include the exact location, water level information, well construction details, water quality information, a notation as to the quality of the drillers log, etc. This survey can be conducted by municipal workers, service clubs, senior citizens, etc.

Very likely, all of this data will not be readily available and a search will be required. The search should include municipal files, contacts with contractors, consultants, and local well drillers, as well as a phone call or visit to the IDNR-GSB at (319) 335-1575 or USGS at (319) 337-4191, both located in Iowa City.

On the small scale city map, plot and label all identified wells which penetrate the aquifer, including all municipal and industrial wells and, as many domestic wells as possible. If you are addressing two or more aquifers, make a base map for each. Also plot the locations of all test borings which were drilled into your aquifer prior to installation of the municipal wells. For convenience, use a variety of symbols to show the information for each well (e.g., circles around water levels, boxes around pumping rates, etc.).

Plot the major wells (municipal, high pumpage industrial, irrigation, or other public wells) on the  $7\frac{1}{2}$ -minute quadrangle map. This will give you a regional perspective with respect to well locations and physical (topography) and hydrologic boundaries (rivers, lakes, etc.). It is important to recognize that high pumpage wells may alter flow paths of the water.

Proceed to Option A if your aquifer is unconfined, or Option B if the aquifer is confined.

## OPTION A: UNCONFINED AQUIFER

The recharge area of an unconfined surficial or shallow bedrock aquifer is usually located relatively close to the well or well field. Unconfined aquifers are sensitive to surface contamination because there is no confining layer to protect the aquifer. In unconfined aquifers, surface water tends to move relatively freely down to the water table throughout the recharge area (see Figure 2B). The recharge area is often the surface watershed basin, or the area from which precipitation runs toward the well.

In the unconfined aquifer case, a good starting point is to identify the area which drains towards the well. This watershed basin will be a rough approximation of the local groundwater flow divides. The time of travel criterion can then be used to refine the WHPA, as appropriate.

## STEP 3: Physical Boundaries

Sketch the surface watershed boundary, as shown in Figure 2C, on the quadrangle base map. Use the topographic information as your guide. These boundaries will tend to follow ridges and waterways.

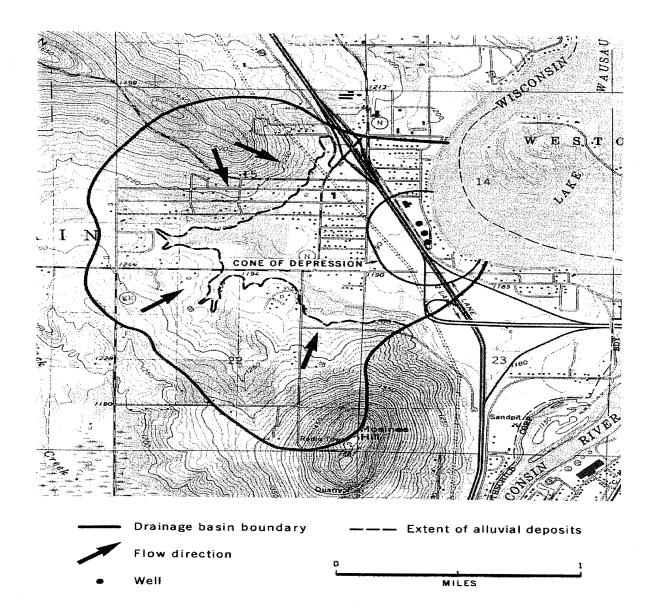


Figure 2C: Map illustrating drainage basin showing flow directions and cone of depression of a well field.

## STEP 4: Hydrologic Boundaries

Make a note of the hydrologic boundaries on the base map. Hydrologic boundaries are features or conditions that form groundwater flow divides. In the same way that surface water flow does not cross a river or a topographic high point, groundwater flow does not cross a hydrologic boundary. Hydrologic boundaries often coincide with surface features such as rivers, major streams, lakes, or topographic ridges (since a groundwater divide will often be a subdued reflection of surface topography, the divide may generally correspond to the trend of an overlying topographic ridge). A hydrologic boundary may also be an area known to have lower than normal (or expected) production rates. This may be known through knowledge of a "poor" producing well.

## STEP 5: Aquifer Vulnerability Map

The purpose of the vulnerability map is to assess how much natural protection an aquifer has, where it is or isn't protected, and its hydrologic properties. This map is generally useful when evaluating the unconfined surficial and shallow bedrock aquifers. Construct an aquifer sensitivity map. First, use the Iowa Groundwater Vulnerability Map (IDNR-GSB, 1991) as an overlay on the quadrangle map (or sketch it in since the two maps are different scales). This will provide a general idea of the hydrogeologic characteristics affecting the relative susceptibility of aquifers to contamination in your area. Note that the Iowa Groundwater Vulnerability Map is plotted at a scale suited for regional analysis and is not intended to address site-specific issues. However, it may be used as a general guide during site evaluations.

Site-specific detail can be added to the susceptibility map by incorporating information from the drillers' logs. This should be done with caution because the terminology used to describe drill cuttings are not always used in the same way by drillers. For example, a driller may use the term blue clay to describe glacial till. This implies the material has little water transmitting capability. In reality, the material may have significant sand content and transmit water readily. Another example is a driller may use the term "sandy clay," which in reality may be a fine sand with minor amounts of silt and clay. Again, the water transmitting capability is much greater than implied by "sandy clay."

#### STEP 6: Water Level Measurements

Measure the water levels in all the wells you have identified that are completed in your aquifer. Obtain the measurements, as depth to water from the ground surface, while the well is pumping, if possible. Convert the depth to elevation above mean sea level by subtracting the depth measurement from the ground elevation at the well. If the ground elevation is not available, estimate the elevation using the topographic contours on the quadrangle base map. Note the elevations on the small-scale base map near the well. Again, if you are dealing with two or more aquifers, collect readings from the wells that penetrate each aquifer and generate a map for each.

## STEP 7: Water Level Surface Map

Using the elevations obtained in Step 6, draw lines of equal water level on the small-scale base map for each aquifer. To do this, pick an elevation which is even to the nearest 10 feet, say 660 feet. This contour line will pass outside points with a water elevation of less than 660 and inside all points with a water elevation of greater than 660. Draw additional contours for other elevations. Contours for lower elevations will lie inside contours for higher elevations in areas where there is a depression in the water surface. After the base map has been contoured, draw in some flow lines. These are drawn from relative high elevations toward lower elevations (i.e., point downgradient) and indicate the direction of groundwater flow (see Figure 2D). In the area of the pumping well, the flow lines will converge on the well. Flow lines always cross the water level contours at a right angle.

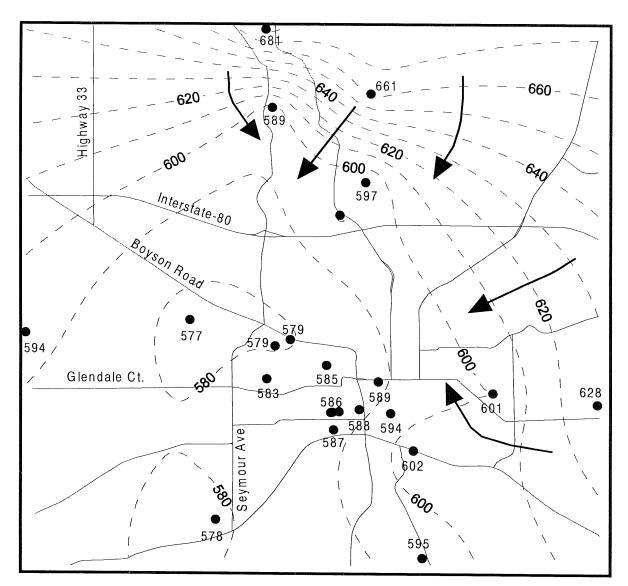


Figure 2D: Water Level Surface Map. Dashed lines follow points of equal water level elevation. The arrows represent groundwater flow paths which always cross the water level contours at a right angle.

## STEP 8: Estimate Aquifer Parameters

Aquifer parameters describe how the aquifer functions. Some pertinent parameters are hydraulic head, hydraulic gradient, effective porosity, hydraulic conductivity, and average groundwater flow velocity. Estimate each of these parameters at your most important or representative well. Each parameter is described briefly below.

#### Hydraulic head, h

The hydraulic head (h) is equal to the water level elevation collected in Step 6.

#### Hydraulic gradient, i

Hydraulic gradient (i) is the slope on the water surface. It is equal to the change in water level elevation between two points, divided by the distance (d) between the two points. Using the water level surface map, draw a line at right angles to the contours. Measure the distance between two points on the line, in feet. Calculate the difference in water level elevation between the two points. Calculate the slope at a number of points and use the steepest result as this will be most conservative and provide the greatest degree of protection. The slope will be greatest where the contours are closest together.

The equation for hydraulic gradient is: i = (h1-h2) / d

#### Effective porosity, n

Effective porosity is a measure of how interconnected the pores in an aquifer are. Groundwater flows through pores that are interconnected, and thus, it is the effective porosity that is important. Effective porosity can be estimated from the values provided below based on the well log descriptions, or through personal communication with the IDNR-GSB, the USGS, or local consultant.

Representative values of effective porosity are as follows:

Soil	0.40
Clay	0.02
Sand	0.22
Gravel	0.19
Limestone	0.18
Dolomite	0.18
Sandstone	0.06

#### Hydraulic conductivity, K

Hydraulic conductivity is a measure of how fast water can move through an aquifer. Hydraulic conductivity can be estimated from the values provided below based on the well log descriptions, or through personal communication with the IDNR-GSB, the USGS, or local consultant.

Representative values of hydraulic conductivity in units of gallons per day per square foot (GPD/sq ft):

Coarse sand	1500
Medium sand	1000
Mixed sand	500
Silty sand, fine sand	15
Sandy gravel	2000
Clean gravel	4000
Limestone	2000
Dolomite	2000

Average Groundwater Flow Velocity, v

Groundwater flows at rates typically ranging from a few feet per year to several feet per day. The average groundwater flow velocity (v) is calculated as follows:

 $v = Ki / 7.48\eta$ 

where: v = average groundwater flow velocity (ft/day)

K = hydraulic conductivity (GPD/sq ft)

i = hydraulic gradient (unitless)

 $\eta$  = effective porosity (decimal fraction, unitless)

## STEP 9: Estimate Time of Travel

Once average groundwater velocity has been calculated you can estimate how far groundwater will move toward a pumping well in a given amount of time. Calculate the distance groundwater will travel in 2 years, 5 years, and 10 years by multiplying the velocity in feet per day times the number of years times 365 days per year. These distances are referred to as time of travel (TOT) threshold values. Assuming that contaminants in the groundwater will move at the same rate as the groundwater, these distances will represent the boundary along which it is estimated that groundwater (and thus contaminants) will take about 2, 5, and 10 years to reach the pumping well(s) or well field.

The TOT threshold values suggested above are chosen to allow remedial measures and contingency plans to be implemented if a contaminant is released into the aquifer within the protected area. The TOT threshold values usually vary between 2 to 20 years, with the 2-5- and 10-year or 5-, 10-, and 20-year threshold values typically selected. Selection of an appropriate TOT threshold value(s) depends upon site-specific hydrogeologic conditions, monitoring frequency, and administrative response or policy implementation time needed to initiate remedial action or contingency plans.

## STEP 10: Delineate the Wellhead Protection Area

The calculated fixed radius can now be defined in terms of TOT and, if applicable, ground-water flow boundaries. First, establish the upgradient direction from the well or well field. Upgradient is the direction from which the groundwater is flowing toward the well.

Next, establish initial WHPA boundaries by using the hydrologic and physical boundaries noted earlier, where possible. This may include the entire surface watershed basin, perhaps bounded by a river along one portion and uplands everywhere else. It is reasonable to assume these boundaries generally coincide with groundwater flow divides and, as such, may represent an approximate WHPA.

Draw circles (to scale) around each municipal well with radii equal to the 2-, 5-, and 10-year TOT distances (or be conservative and use 5-, 10-, and 20-year values).

Compare the TOT boundaries with the watershed boundary. If the watershed boundary approximation is smaller than the 5- or 10-year TOT boundary, use the watershed boundary as your WHPA. If the watershed boundary is much greater than the 10-year TOT boundary, or if it is too large to practically manage, establish the WHPA based on TOT alone. Perhaps a combination

of the watershed boundary (along the downgradient and sidegradient portions) and TOT along the upgradient portion would form the best WHPA.

For example, create three management zones, where Zone 1 might be the 200-foot radius required by state regulation, or the 2-year TOT threshold boundary. Select whichever is the greater distance. This zone is typically subject to the highest contaminant threat, and therefore, the land use restrictions are the most severe. Zone 2 might be defined by the 5- or 10-year TOT threshold boundary. This zone would also be subject to strict, though slightly less restrictive, land use controls than Zone 1; and to a high degree of management effort (monitoring, potential source identification, etc.). Zone 3 might be defined as the 10-15- or 20- year threshold boundary, or the remainder of the upgradient recharge (susceptible) portion of the watershed basin, as determined from the drillers' logs and guidance from the aquifer sensitivity map created in Step 5. This may provide the time required for the contaminant concentrations to be naturally reduced in the aquifer before reaching the well, thereby reducing remedial costs and the need for very rapid response. Land use control here would be the least restrictive, though monitoring and exercise of some control is definitely warranted.

Be accurate and conservative in your delineations. It is better to slightly overprotect the aquifer than invest in wellhead protection planning and find out there is a problem that was overlooked or underestimated.

## STEP 11: Recognition of Limitations

Other than an arbitrary selection of distance, the calculated fixed radius method is the simplest method used to determine WHPA. This method, used in conjunction with the time of travel and/or flow boundary criteria, incorporates a very limited amount of site-specific data to determine a WHPA. The delineation is specific to a given well, though the results are typically then applied to all wells in the area, without further consideration of site-specific hydrogeologic or operating conditions. This method may leave the aquifer unprotected in vital recharge zones and must be applied with caution.

## OPTION B: CONFINED AQUIFER

It may be that the recharge area of an confined buried channel or, in particular, deep bedrock aquifer is located some distance from the well or well field. In this case, surface features generally do not provide acceptable WHPA boundaries and the susceptibility of the aquifer to contamination cannot be assessed by using the Iowa Groundwater Vulnerability Map.

Confined aquifers are, by definition, overlain by low-permeability confining units. They are typically less likely to be impacted by surface contamination than are unconfined surficial or shallow bedrock aquifers. However, no confining unit is totally impervious and all are subject to eventual downward leakage of contaminants, either by slow leakage, rapid movement through fractures, or introduction along man-made pathways such as existing wells. This is another reason it is important to identify all wells that penetrate the confined aquifer, as they potentially represent a pathway for contaminant migration into the aquifer. Thus a slightly different concept is used in defining the WHPA for confined aquifers. For confined aquifers, only the time of travel approach is recommended.

#### STEP 3: Water Level Measurements

Measure the water levels in all the wells you have identified that are completed in your aquifer. Obtain the measurements, as depth to water from the ground surface, while the well is pumping, if possible. Convert the depth to elevation above mean sea level by subtracting the depth to water measurement from the ground elevation at the well. If the ground elevation is not available, estimate the elevation using the topographic contours on the quadrangle base map. Note the elevations on the small-scale base map near the well. Again, if you are dealing with two or more aquifers, collect readings from the wells that penetrate each aquifer and generate a map for each.

## STEP 4: Water Level Surface Map

Using the elevations obtained in Step 3, draw lines of equal water level on the small scale base map for each aquifer. After the base map has been contoured draw in some flow lines. These are drawn from relative high elevations toward lower elevations (i.e., point downgradient) and indicate the direction of groundwater flow. The flow lines will converge on the pumping wells. Flow lines always cross the water level contours at a right angle. (See figure 2D on page 109.)

## STEP 5: Estimate Aquifer Parameters

Aquifer parameters describe how the aquifer functions. Some pertinent parameters are hydraulic head, hydraulic gradient, effective porosity, hydraulic conductivity, and average groundwater flow velocity. Estimate each of these parameters at your most important or representative well. Each parameter is described briefly below.

#### Hydraulic head, h

The hydraulic head (h) is equal to the water level elevation collected in Step 6.

#### Hydraulic gradient, i

Hydraulic gradient (i) is the slope on the water surface. It is equal to the change in water level elevation between two points, divided by the distance (d) between the two points. Using the water level surface map, draw a line at right angles to the contours. Measure the distance between two points on the line, in feet. Calculate the difference in water level elevation between the two points. Calculate the slope at a number of points and use the steepest result as this will be most conservative and provide the greatest degree of protection. The slope will be greatest where the contours are closest together.

The equation for hydraulic gradient is: i = (h1-h2) / d

#### Effective porosity, n

Effective porosity is a measure of how interconnected the pores in an aquifer are. Groundwater flows through pores that are interconnected, and thus, it is the effective porosity that is important. Effective porosity can be estimated from the values provided below based on the well log

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Representative values of effective porosity are as follows:

Soil	0.40
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Sand	0.22
Gravel	0.19
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Sandstone	0.06

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Hydraulic conductivity is a measure of how fast water can move through an aquifer. Hy-draulic conductivity can be estimated from the values provided below based on the well log descriptions, or through personal communication with the IDNR-GSB, the USGS, or local consultant.

Representative values of hydraulic conductivity in units of gallons per day per square foot (GPD/sq ft):

Coarse sand	1500
Medium sand	1000
Mixed sand	500
Silty sand, fine sand	15
Sandy gravel	2000
Clean gravel	4000
Limestone	2000
Dolomite	2000

#### Average Groundwater Flow Velocity, v

Groundwater flows at rates typically ranging from a few feet per year to several feet per day. The average groundwater flow velocity (v) is calculated as follows:

$$v = Ki / 7.48\eta$$

where: v = average groundwater flow velocity (ft/day)

K = hydraulic conductivity (GPD/sq ft)

i = hydraulic gradient (unitless)

 $\eta$  = effective porosity (decimal fraction, unitless)

## STEP 6: Estimate Time of Travel

Once average groundwater velocity has been calculated you can estimate how far groundwater will move toward a pumping well in a given amount of time. Calculate the distance groundwater will travel in 2 years, 5 years, and 10 years by multiplying the velocity in feet per day times 114

the number of years times 365 days per year. These distances are referred to as time of travel (TOT) threshold values. Assuming that contaminants in the groundwater will move at the same rate as the groundwater, these distances will represent the boundary along which it is estimated that groundwater (and thus contaminants) will take about 2, 5, and 10 years to reach the pumping well(s) or well field.

The TOT threshold values suggested above are chosen to allow remedial measures and contingency plans to be implemented if a contaminant is released into the aquifer within the protected area. The TOT threshold values usually vary between 2 to 20 years, with the 2-5- and 10-year or 5-, 10-, and 20-year threshold values typically selected. Selection of an appropriate TOT threshold value(s) depends upon site-specific hydrogeologic conditions, monitoring frequency, and administrative response or policy implementation time needed to initiate remedial action or contingency plans.

## STEP 7: Delineate the Wellhead Protection Area

The calculated fixed radius can now be defined in terms of TOT. Draw circles (to scale) around each municipal well with radii equal to the 2-, 5-, and 10-year TOT distances (or be conservative and use the 5-, 10-, and 20-year values).

Create three management zones, where Zone 1 might be the 200 foot radius required by state regulation, or the 2-year TOT boundary. Select whichever is the greater distance. This zone is typically subject to the highest contaminant threat, and therefore, the land use restrictions are the most severe. Zone 2 might be a 5-year TOT threshold. This zone would also be subject to strict, though slightly less restrictive, land use controls than Zone 1; and to a high degree of management effort (monitoring, potential source identification, etc.). Zone 3 might be defined as the 10-15- or 20- year threshold limits. This may provide the time required for the contaminants to decay or disperse in the aquifer before reaching the well, thereby reducing remedial costs and the need for very rapid response. Land use control here would be the least restrictive, though monitoring and exercise of some control is definitely warranted.

For confined aquifers where there is an impermeable layer greater than 50 feet thick, a Zone 1-type delineation may provide adequate wellhead protection. However, this is only true if a complete inventory of nearby wells served by the same aquifer has been conducted, and the wells are found to be in sound operating condition. Additionally, the Zone 1 delineation would be adequate only with assurance that all inactive wells were properly abandoned.

Again, be accurate and conservative in your delineations. It is better to slightly overprotect the aquifer than invest in wellhead protection planning and find out there is a problem that was overlooked or underestimated.

## STEP 8: Recognition of Limitations

Other than an arbitrary selection of distance, the calculated fixed radius method is the simplest method used to determine WHPA. This method, used in conjunction with the time of travel criterion, incorporates a very limited amount of site-specific data to determine a WHPA. The

delineation is specific to a given well, though the results are typically then applied to all wells in the area, without further consideration of site-specific hydrogeologic or operating conditions. This method may leave the aquifer unprotected in vital recharge zones and must be applied with caution.

The delineation of a WHPA is a crucial step in providing substantial protection to one of your greatest resources - groundwater. In concept, it is not difficult to understand that the preservation of chemical quality of an aquifer is related to land use practices within the recharge area for that aquifer. Practically though, it can be difficult to visualize or determine exactly where and how the aquifer is being recharged, making it difficult to inventory and manage potential contamination sources.

Thus, a systematic and science-based evaluation of site-specific hydrogeologic and operating conditions is essential to completing an accurate and defensible delineation. The steps outlined above (fixed radius delineation using time of travel/flow boundary criteria) provide guidance for conducting the initial step in meeting this goal. They represent the minimum recommended delineation approach. It is important to recognize that the successful completion of the steps will likely not result in an entirely effective wellhead protection area, but rather provide a minimum approximation of something that resembles a wellhead protection area.

To establish a wellhead protection area with greater certainty and completeness, it is recommended that the analytical equations method be used in combination with several delineation criteria (distance, drawdown, time of travel, hydrogeologic boundaries) at each well, and then integrated to accurately delineate a comprehensive wellhead protection area. In particular, the recognition of the site-specific hydrogeologic conditions for each well is critical to selecting the appropriate delineation criteria, as they likely vary from one well to the next. For more complex conditions, numerical modeling may be an economical alternative to the analytical equations method. Whatever the circumstance, when applying the analytical equations or numerical modeling methods, outside guidance or assistance from experienced personnel specializing in hydrogeology and planning is recommended.

# Appendix Three - Consulting Engineers Council of Iowa

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WILBUR SMITH ASSOCIATES, INC. Joel A. Dermid, Jr., P.E. 904 Walnut St., Suite 310 Des Moines, IA 50309 (515) 280-5310



### Instructions for Completing the *Contaminant Inventory*Site-Specific Evaluation Table

In the *No.* section, write the appropriate number of this inventory. Your inventories should be chronologically numbered using any system you deem satisfactory.

In the *Date of this inventory section*, write the date on which this inventory occurs. If more than one day is needed to complete the survey, write down every date applicable.

In the *Date of last inventory* section, note the date on which any previous inventory was taken. This will help you gauge the time between inventories, and decide how often surveys need to be taken.

In the *Name of person taking inventory* section, write down the name of the Wellhead Protection Team member of volunteer who is conducting the survey.

In the *Name of person being interviewed* section, record the name of the person who is answering the questions on the survey. If more than one person participates, write down every name applicable.

In the Proper name of facility section, recordthe name of the business situated on this land.

In the *Landowner's name* section, record the name of the property owner. Often businesses are owned by one person, but the land on which the business is situated is owned by another. If contaminations are discovered, it is necessary to determine who is liable for the clean-up costs.

In the *Operator's name* section, write down the name of the manager of the business who is likely to be there on a daily basis.

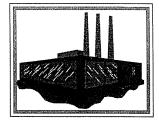
In the *Property address* section, record the business address of the facility.

In the *Diagram of hazard locations* section, draw a sketch of the physical property situated on the land, then indicate the location of each hazard identified.

In the *Nature of Property* section, place a check mark in the box that most closely relfects what type of activity or business is situated on this property.

In the *Potential Sources of Contamination* section, place a check mark beside each hazard that already is, or poses a potential contamination threat to this particular well. In the space provided to the right of each hazard, in the *Quantity* section, record the quantity of each hazard found. In the *Notes* section, write information such as if there is more than one site at this location where this hazard can be found, and any other pertinent information.

# Contaminant Inventory Site-Specific Evaluation Table



No. \_\_\_\_\_

Dat	e of this	invent	ory						Da	Date of last inventory							
Nar	ne of per	rson ta	king in	ventor	у				Na	me of p	erson l	peing in	ntervie	wed			
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	Photography/printing establishments	
	Pesticide use/storage sites	
	Pipelines	
Construction sites	Quarries	
Drainage wells/ditches/tiles	Railroad tracks and yards	
Dry cleaners	Recycling/reduction sites	
Dumps	Research laboratories	
Electronics manufacture	Road deicing operations	
Electroplaters	Road maintenance depots	
Fertilizer use/storage sites	Scrap and junkyards	
	Septage lagoons and sludge	
Foundries/metal fabricators	Septage overflows	
Fuel oil use/storage sites	Septic systems	
Furniture stripping/refinishing	Service station disposal wells	
Gas stations	Sewer lines	
Golf courses	Storage tanks	
Grain storage bins	Storm water drains/basins	
Hazardous waste landfills	Storm sewers	
Herbicide use/storage sites	Streams (lakes, rivers, creeks)	
	Swimming pools	
	Toxic and hazardous spill sites	
Highways	Transfer stations	
Holding ponds/lagoons	Underground storage tanks	
Household hazardous products	Wells (operating/abandoned)	
Household lawns	* Residential	
Injection wells	* Municipal	
Irrigation sites	* Production	
Irrigation wells	Troduction	
Wood preserving facilities		
Jewelry/metal plating establishments	Other	
Jewen y/ metar planning establishments	Other	
tes:		

## Appendix Five - Toxicity and Mobility Index

	ICITY AND MOBILITY SCORES ANT/MIXTURE AND SOURCE CATE	GORY	
SOURCE CATEGORY: AGRICHEMICAL APPLICATION	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
Corn Crop - Pesticides, Fertilizers	Composite - dicamba, other	2	3
Soybean Crop - Pesticides, Fertilizers	pesticides, nitrate-nitrogen Composite - trifluralin, other pesticides, nitrate-nitrogen	2	3
Cotton Crop - Pesticides, Fertilizers	Composite - aldicarb, nitrate- nitrogen	2	3
Wheat Crop - Pesticides, Fertilizers	Composite - aldicarb, nitrate- nitrogen	2	3
Other Crops - Pesticides	Composite - aldicarb, nitrate- nitrogen	2	3
SOURCE CATEGORY: LANDFILLS	CONTAMINANT ·	TOXICITY SCORE	MOBILITY SCORE
Hazardous Waste ("Subtitle C" Sites) and Municipal Waste ("Subtitle D" Sites) pre-1976	Composite - arsenic, benzene, chromium	3	3
Municipal Waste ("Subtitle D" Sites) post-1976	Composite - arsenic, organics mix <sup>1</sup> , iron	3	3
NOTE:  vinyl chloride and dichloromethane			
SOURCE CATEGORY: PIPELINES	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
Sewer Other (Includes Petroleum)	Composite - chloroform, benzene, bis(2 ethylhexyl) phthalate, chromium benzene	2	3
SOURCE CATEGORY: SEPTIC TANK SYSTEMS	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
Septic Tank Systems	nitrates	2	3
SOURCE CATEGORY: SURFACE IMPOUNDMENTS	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
Hazardous Waste ("Subtitle C")	Composite - arsenic, benzene, chromium, metals mix <sup>1</sup>	3	3
Industrial Waste ("Subtitle D")	Composite - chloroform, organics mix <sup>2</sup> , nitrobenzene	3	3
Municipal Waste Treatment Ponds("Subtitle D")	Composite - chloroform, benzene, chromium	3	2
Urban Stormwater Retention Ponds	Composite - arsesnic, chromium, metals mix <sup>4</sup>	3	3
ANIMAL FEEDLOTS Dirt Lot Runoff and Paved Lot Runoff	nitrate	2	3
MINE TAILING PONDS Copper Sector	Composite - arsenic, manganese, metals mix <sup>3</sup>	3	3
Lead Sector	Composite - arsenic, metals	3	3
Zinc/Zinc Oxide	mix <sup>3</sup> Composite - arsenic, metals mix <sup>3</sup>	3	3
Aluminum Sector	arsenic	3	3

#### NOTES:

1 cyanide, cadmium and lead

<sup>2</sup> benzene, and 2,4,6 trichlorophenol

<sup>3</sup> cadmium and lead

<sup>4</sup> zinc, lead, cadmium and nickel

TOXICITY AND MOBILITY SCORES
BY CONTAMINANT/MIXTURE AND SOURCE CATEGORY

	ANT/WINTOKE AND SOURCE CATE		
SOURCE CATEGORY: CONTAINER STORAGE AND MATERIAL TRANSFER AND TRANSPORT	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
HAZARDOUS WASTE/ACCUMULATION D001: Ignitable Wastes	Composite - benzene, methanol, organics mix <sup>1</sup>	3	2
D002: Corrosive Wastes	Composite - methanol, toluene	2	2
F001: Spent, Halogenated Solvents Used for Degreasing	Composite - chloroform, carbon tetrachloride, organics mix <sup>2</sup>	3	2
F003: Spent, Non-Halogenated Solvents	Composite - benzene, methyl ethyl ketone	3	2
RCRA PERMITTED STORAGE D001: Ignitable Wastes	Composite - benzene, methanol organics mix <sup>1</sup>	3	2
F003: Spent, Non-Halogenated Solvents	Composite - benzene, methyl ethyl ketone	3	2
X500: Ignitable Waste Mixtures	Composite - benzene, organics mix <sup>1</sup>	3	2
X501: Corrosive Waste Mixtures	Composite - chromium mix <sup>3</sup> , lead	2	2
X504: Toxic Waste Mixtures	Composite - chloroform, carbon tetrachloride, organics mix4	3	2
HAZARDOUS MATERIAL/PRODUCTS Petroleum (gasoline, diesel)	benzene	3	2
Chemical/Cleaning Liquids (corrosive)	acetic acid	1	3
Sulfuric Acid	sulfuric acid	1	3
Paint Dryer (flammable)	Composite - benzene, organics mix 1 <sup>5</sup> , organics mix 2 <sup>6</sup>	3	2

#### NOTES:

<sup>1</sup> acetone and methylethyl ketone <sup>2</sup> 1,2-dichlorobenzene <sup>3</sup> chromium and methanol

<sup>4</sup> 1, 1, 1-trichloroethane <sup>5</sup> methyl ethyl ketone, cresol and acetone <sup>6</sup> xylene, napthalene, toluene and 1,1,1-trichloroethane

SOURCE CATEGORY: INJECTION WELLS/DEEP WELLS (Classes I, II, and III)	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
Class I: Wastewater Disposal	Composite - benzene, chromium mix 1, cyanide	3	2
Class II: Oil and Gas Activity	Composite - arsenic, benzene, boron	3	3
Class III: Mineral Extraction - Metals Mining	Composite - arsenic, metals mix 1 <sup>2</sup> , metals mix 2 <sup>3</sup>	3	3

#### NOTES:

1 chromium and sulfuric acid 2 chromium, manganese and barium 3 nickel, vanadium, mercury, iron, cadmium, zinc, berylium, silver and lead

SOURCE CATEGORY: INJECTION WELLS/SHALLOW WELLS (Class V)	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
AGRICULTURAL DRAINAGE WELLS			
Corn Crop	Composite - dicamba, other pesticides, nitrate-nitrogen	2	3
Soybean Crop	Composite - trifluralin, other pesticides, nitrate-nitrogen	2	3
Other Crops	Composité - aldicarb, nitrate- nitrogen	2	3
AUTOMOBILE SERVICE STATION DISPOSAL			
WELLS			
Service and Repair	Composite - arsenic, chromium, metals mix <sup>1</sup>	3	3
Body Shops	Composite - chromium, metals mix <sup>1</sup>	2	3
Car Washing	Composite - arsenic, chromium, metals mix1	3	3

#### TOXICITY AND MOBILITY SCORES BY CONTAMINANT/MIXTURE AND SOURCE CATEGORY

	I		
SOURCE CATEGORY: INJECTION WELLS/SHALLOW WELLS (Class V) (continued)	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
INDUSTRIAL PROCESS WATER DISPOSAL WELLS			
Low Throughput (less than 2.6 million gallons/year)	Composite - methanol, cyanide mix <sup>2</sup> , metals mix <sup>3</sup>	2	2
Medium Throughput (between 2.6 and 31.2 million gallons/year) Inorganic Chemical Manufacture	Composite - chromium, cyanide, metals mix <sup>4</sup>	2	3
Laundry and Cleaning Services	tetrachloroethylene	2	2
High Throughput (more than 31.2 million gallons/year) Electroplating	Composite - chromium, cyanide, metals mix <sup>5</sup>	2	3
Cooling waters	chromium	2	3

#### NOTES:

<sup>5</sup> nickel, zinc, iron, silver, cadmium and lead

SOURCE CATEGORY: LAND TREATMENT	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
Petroleum Refining	Composite - arsenic, benzene,	3	3
Inorganic Chemicals	metals mix 1 <sup>1</sup> , metals mix 2 <sup>2</sup> Composite - chromium (total),	2	2
inorganie enemiean	metals mix 3	4	3
Organic Chemicals	Composite - chromium (total),	2	3
	metals mix 4		

NOTES: 1 chromium and barium

<sup>4</sup> lead zinc and cadmiun

<sup>2</sup> lead, vanadium, nickel and zinc	4 lead, zinc and cadmium		
SOURCE CATEGORY: STORAGE PILES	CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE
HEAP LEACHING PILES	Composite - arsenic, metals mix 1 <sup>1</sup> , metals mix 2 <sup>2</sup>	3	3
NON-HEAP LEACHING PILES/ HAZARDOUS WASTE PILES			
D002 & D006: Corrosive Materials Waste & Cadmium	Composite - arsenic, sulfuric acid, metals mix <sup>3</sup>	3	3
D008: Lead Waste	lead	2	2
F001: Spent Halogenated Solvents Used in Degreasing	Composite - dichloroethane, 1,1,1-trichloroethane	3	3
F006: Wastewater Treatment Sludges from Electroplating, Except Aluminum, Tin or Zinc	Composite - metals mix 14, cyanide, metals mix 25	2	3
F019: Waste fromthe Chemical Conversion Coating of Aluminum	Composite - metals mix 1 <sup>4</sup> , cyanide, metals mix 2 <sup>5</sup>	2	3
K048, K049, K050, K051: Sludges from the Petroleum Refining Industry	Composite - arsenic, benzene, metals mix 14, metals mix 27	3	3
K061: Emission Control Dust/Sludges from Steel Production	Composite - arsenic, chrominum (VI), metals mix <sup>5</sup>	3	3
NONHAZARDOUS WASTE PILES	Composite - chromium, metals mix 8	2	3
MATERIAL STOCK PILES	Composite - arsenic, metals mix 19, metals mix 210	3	3
MINE WASTE PILES Copper Sector	Composite - arsenic, metals mix <sup>11</sup>	3	3
Lead Sector	Composite - arsesnic, metals mix <sup>11</sup>	3	3
Zinc/Zinc Oxide	Composite - arsenic, manganese, metals mix <sup>11</sup>	3	3
Aluminum Sector	arsenic	2	2

<sup>&</sup>lt;sup>1</sup> cadmium and lead

<sup>&</sup>lt;sup>2</sup> cyanide, phenol and acetone <sup>3</sup> iron, boron and silver

<sup>4</sup> nickel, mercury, zinc and lead

<sup>&</sup>lt;sup>2</sup> lead, vanadium, nickel and zinc

<sup>&</sup>lt;sup>3</sup> chromium, zinc and nickel

<sup>&</sup>lt;sup>1</sup> chromium, manganese and barium

<sup>&</sup>lt;sup>2</sup> nickel, vanadium, mercury, iron, cadmium, zinc, berylium, silver and lead

<sup>&</sup>lt;sup>3</sup> tin and lead

<sup>&</sup>lt;sup>4</sup> chromium and barium

<sup>&</sup>lt;sup>5</sup> nickel, lead, zinc and cadmium

<sup>6</sup> nickel and zinc

<sup>&</sup>lt;sup>7</sup> cyanide, vanadium, lead and zinc

<sup>8</sup> chromium, nickel, cadmium, zinc and lead9 chromium and manganese

<sup>10</sup> lead, nickel, berylium, cadmium, iron and mercury

<sup>11</sup> cadmium and lead

#### TOXICITY AND MOBILITY SCORES BY CONTAMINANT/MIXTURE AND SOURCE CATEGORY SOURCE CATEGORY: TANKS CONTAMINANT TOXICITY MOBILITY SCORE SCORE HAZARDOUS WASTE TREATMENT/ DISTILLATION D001: Ignitable Wastes Composite - benzene, methanol, 3 2 organics mix1 Composite - benzene, methyl FOO3: Spent, Halogenated Solvents 3 2 ethyl ketone, organics mix<sup>2</sup> X907: Chlorinated Pesticide Production Wastes Composite - chloroform, 3 2 hexachlorobenzene, hexachloro-cyclopentadiene OXIDATION/REDUCTION PRECIPITATION D007: Chromium Waste chromium 3 2 F006: Wastewater Treatment Sludges from 2 chromium 3 Electroplating K048: Dissolved Air Flotation Waste From the Composite - metals mix3, 2 3 Petroleum Refining Industry chromium, lead HAZARDOUS WASTE STORAGE/ ACCUMULATION D001: Ignitable Wastes Composite - benzene, methanol, 3 2 organics mix1 D002: Corrosive Wastes Composite - methanol, toluene 2 2 F001: Spent, Halogenated Solvents Used for Composite - chloroform, carbon 3 2 Degreasing tetrachloride, organics mix4 F003: Spent, Non-Halogenated Solvents: Composite - benzene, methyl 2 3 ethyl ketone RCRA PERMITTED STORAGE D001: Ignitable Wastes Composite - benzene, methanol, 3 2 organics mix1 F003: Spent, Non-Halogenated Solvents Composite - benzene, methyyl 3 2 ethyl ketone X500: Ignitable Waste Mixtures Composite - benzene, organics 3 2 mix1 X501: Corrosive Waste Mixtures Composite - chromium mix6, 2 2 lead X504: Toxic Waste Mixtures Composite - chloroform, carbon 3 2 tetrachloride, organics mix<sup>6</sup> SMALL QUANTITY GENERATORS -ABOVE GROUND TANKS Stream 1: Halogenated Spent Solvents and Composite - chloroform, carbon 3 2 Ignitable Wastes tetrachloride, 1.1.1-trichloroethane Stream 2: Non-Halogenated Spent Solvents and Composite - benzene, organics 3 2 Ignitable Wastes mix1 Stream 3: Strong Acid or Alkaline Waste lead 2 2 SMALL QUANTITY GENERATORS -BELOW GROUND TANKS Stream 1: Halogenated Spent Solvents and Composite - chloroform, carbon 3 2 Ignitable Wastes tetrachloride. 1,1,1-trichloroethane Stream 2: Non-Halogenated Spent Solvents and Composite - benzene, organics 3 2

mix1

lead

2

2

Ignitable Wastes

Stream 3: Strong Acid or Alkaline Waste

#### TOXICITY AND MOBILITY SCORES BY CONTAMINANT/MIXTURE AND SOURCE CATEGORY TOXICITY MOBILITY SOURCE CATEGORY: CONTAMINANT SCORE SCORE TANKS (continued) PRODUCT STORAGE 2 Petroleum (gasoline, diesel) benzene 3 Chemical/Cleaning Liquids (corrosive) acetic acid 1 3 sulfuric acid 3 Sulfuric Acid 1 Composite - benzene, organics 3 2 Paint Dryer (flammable) mix 17, organics mix 28 MUNICIPAL ("SUBTITLE D") WASTEWATERS Composite - chloroform, 3 2 benzene, bis(2-ethylhexyl)phtalate, chromium

### NOTES:

- <sup>1</sup> acetone and methyl ethyl ketone
- <sup>2</sup> xylene and toluene
- <sup>3</sup> cadmium, lead and nickel
- 4 1,2-dichlorobenzene
- <sup>5</sup> chromium and methanol
- <sup>6</sup> 1,1,1-trichloroethane
- <sup>7</sup> methyl ethyl ketone, cresol and acetone
- 8 xylene, napthalene, toluene and 1,1,1-trichloroethane

TOXICITY AND MOBILITY SCORES BY CONTAMINANT					
CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE			
1,1,1-Trichloroethane	1	2			
1,1,2,2-Tetrachloroethane	3	2			
1,2-Dichlorobenzene	1	2			
1,2-Trans-Dichloroethylene	2	3			
2,4, 5-TP Silvex	3	2			
2,4,6-Trichlorophenol	3	2			
2,4-D	2	2			
Acetic Acid	1	3			
Acetone	1	3			
Alachlor	2	2			
Aldicarb	2	3			
Antimony	3	1			
Arsenic	3	3			
Atrazine	2	2			
Barium	1	3			
Bentazon	2	2			
Benzene	3	2			
Beryllium	2	2			
Bis(2-ethylhexyl)phthalate	2	1			
Boron	1	2			
Butylate	1	2			
Cadmium	2	2			
Carbon Tetrachloride	3	2			
Chloride	1	3			
Chloroform	2	3			
Chromium	2	3			
Cresol	2	1			
Cyanazine	2	2			
Cyanide	2	3			
Dicamba	2	2			
Dichloroethane	3	3			
Dichloromethane	2	3			
Dinitro-butyl phthalate	1	2			
Endrin	3	1			
EPTC+	2	2			
Ethylbenzene	2	2			
Hexachlorobenzene	3	2			
Hexachlorobutadiene	3	1			
Hexachlorocyclopentadiene	2	2			
Iron	1	2			
Lead	2	2			
Lindane	3	2			

TOXICITY AND MOBILITY SCORES BY CONTAMINANT					
CONTAMINANT	TOXICITY SCORE	MOBILITY SCORE			
Manganese	1	3			
Mercury	3	2			
Methanol	1	3			
Methyl ethylketone	2	3			
Methoxychlor	3	1			
Metolachor	2	2			
Metribuzin	2	2			
M-xylene	1	2			
Naphthalene	1	2			
Nickel	2	2			
Nitrate-Nitrogen	2	3			
Nitrobenzene	3	3			
Phenol	1	3			
Selenium	2	3			
Silver	2	2			
Sulfuric Acid	1	3			
Tetrachloroethylene	2	2			
Trichlorethylene	2	2			
Tin	1	2			
Toluene	2	2			
Trifluralin	2	1			
Vandium	2	2			
Vinyl chloride	3	3			
Xylene	2	2			
Zinc	1	2			

# Appendix Six ~ Technical Assistance

### Iowa Department of Natural Resources

Region	Address & Phone	Name
Field Office 1	817 W. Fayette St. Manchester, IA 52057 (319) 927-2640	Shelli Grapp Mike Wade
Field Office 2	2300 15th St., S.W. P.O. Box 1443 Mason City, IA 50401 (515) 424-4073	Jeff Vansteenburg
Field Office 3	1900 N. Grand Ave. Spencer, IA 51301 (712) 262-4177	Bryon Whiting Gregory Olson Julie Sievers
Field Office 4	706 Sunnyside Atlantic, IA 50022 (712) 243-1934	Mike Spetman Shellie Ferguson Jerry Jordison
Field Office 5	607 E. Second St. River Hills Business Park Des Moines, IA 50309 (515)281-9069	Jim Stricker Randy Lane Janet Gastineau Steve Grgurich Bob Schuelzky
Field Office 6	1004 W. Madison Washington, IA 52353 (319) 653-2135	Dan Stipe
Central Office	900 E. Grand Ave. Des Moines, IA 50319 (515) 281-8998 (515) 281-6599 (515) 281-8945 (515) 281-7814 (515) 281-3989 (515) 281-5130 (515) 281-6853 (515) 281-6845 (515) 281-8863 (515) 281-8998 (515) 281-8743 (515) 281-8914	Dennis Alt Mike Anderson Roy Ney Brent Parker Mike Wiemann Jennifer Simmons Brian Haugstad Hal Frank Diane Moles Anne Lynam Joe Zerfas Charlotte Henderson
Geological Survey Bureau	109 Trowbridge Hall Iowa City, IA 52242-1319 (319) 335-1575	



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