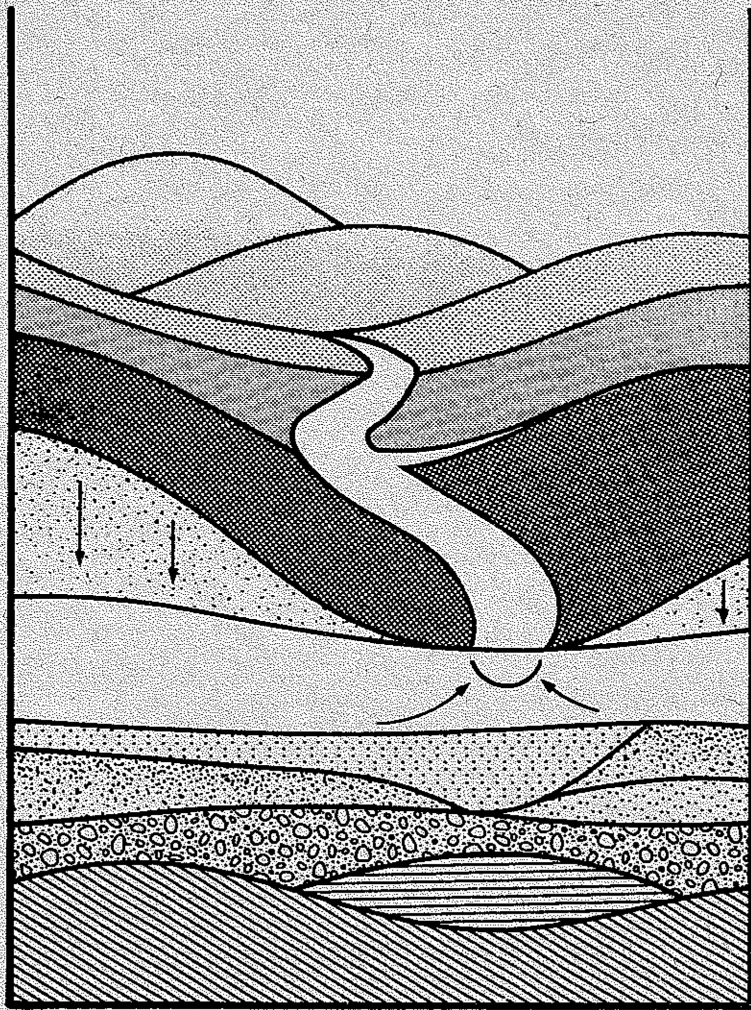

Ground Water Resource Protection

A Handbook for Local Planners and Decision Makers in Washington State

King County
Planning Division

State of Washington
Department of Ecology

Acknowledgements

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The purpose of this handbook is to enable local governments to:

1. discriminate between sensitive and relatively insensitive ground water recharge areas;

2. contract intelligently with qualified ground water professionals; and

3. shape growth within a community in a manner which least impacts ground water supplies.

Because of the variety of land use and ground water issues faced by the state of Washington, strict procedural guidelines would be difficult to apply in many instances. It is the hope of the authors that this handbook will provide sufficient information to allow local decision makers to intelligently address ground water issues within their communities.

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CHAPTER 1

INTRODUCTION TO GROUND WATER PROTECTION

Ground water is one of Washington's most important and fragile natural resources Presently 95% of the state's public water systems, serving over 2,000,000 citizens, depend on ground water supplies Yet this resource is threatened. Landfills, underground storage tanks, agricultural and household use of pesticides and fertilizers, urban runoff, septic systems, industrial practices and the impacts of irrigation and overpumping are affecting our ground water.

In 1984, the Washington State Legislature took a step toward protecting the state's ground water resources by approving House Bill 1138 HB 1138 directs local governments to address the impact of development on ground water. It requires all comprehensive land use plans to provide for protecting the quality and quantity of ground water used for public water supplies.

Since aquifers often span several jurisdictions, protecting ground water will require regional cooperation and planning A second legislative act, SHB 232, complements the provisions of HB 1138 by providing a program to support such cooperative efforts.

Following passage of these two bills, Washington's Department of Ecology awarded King County a grant to prepare this handbook. The handbook is designed to help planners and decision makers in local government understand how to shape growth without damaging ground water resources It is also designed to help them:

1. discriminate between sensitive and relatively insensitive ground water areas,

2. incorporate ground water protection measures into local land use plans, and

3. contract intelligently with ground water consultants.

The handbook provides basic information and tools for guiding local ground water protection efforts. It can also be used as a resource for grasping issues and educating decision makers.

The following chapter, Chapter Two presents general principles of ground water hydrology, including basic terms and concepts used in ground water science. Chapters Three and Four cover the two major threats to ground water: depletion and contamination Each chapter explains how these problems are caused and how they can be detected. Chapter Five describes an array of methods for defining sensitive areas--the places where ground water could easily be contaminated Chapter Six outlines how ground water protection can be incorporated into a comprehensive plan and how land use and development controls can be used to implement the plan. Chapter Seven describes ground water information government agencies and private contractors can provide and special programs or services that are available. Chapter Eight covers the kind of information a consultant can provide, and what time and costs may be involved

The handbook is presented in binder form so that planners may supplement this material with local data, area maps and new information as it becomes available.

HIGHLIGHTS OF CHAPTER 2

BASIC GROUND WATER HYDROLOGY

THE HYDROLOGIC CYCLE

GROUND WATER AND SUBSURFACE WATER

AQUIFERS AND CONFINING BEDS

GROUND WATER RECHARGE AND DISCHARGE

GROUND WATER MOVEMENT

WATER SUPPLY WELLS

GROUND WATER IN WASHINGTON

CHAPTER 2

BASIC GROUND WATER HYDROLOGY

INTRODUCTION

This chapter reviews basic terms and concepts used in ground water science. It also describes where aquifers are found in Washington State.

HYDROLOGIC CYCLE

The **hydrologic cycle** is a constant movement of water above, on, and below the earth's surface. It is a cycle which replenishes ground water supplies. It begins as water vaporizes into the atmosphere from vegetation, soil, lakes, rivers, snowfields and oceans -- a process called **evapotranspiration**.

As the water vapor rises it condenses to form clouds which return water to the land through precipitation: rain, snow, or hail. Precipitation falls on the earth and either percolates into the soil or flows across the ground. Usually it does both. When precipitation percolates into the soil it is called **infiltration**; when it flows across the ground it is called **surface runoff**. The amount of precipitation that infiltrates, versus the amount that flows across the surface, varies depending on factors such as the amount of water already in the soil, soil composition, vegetation cover and degree of slope.

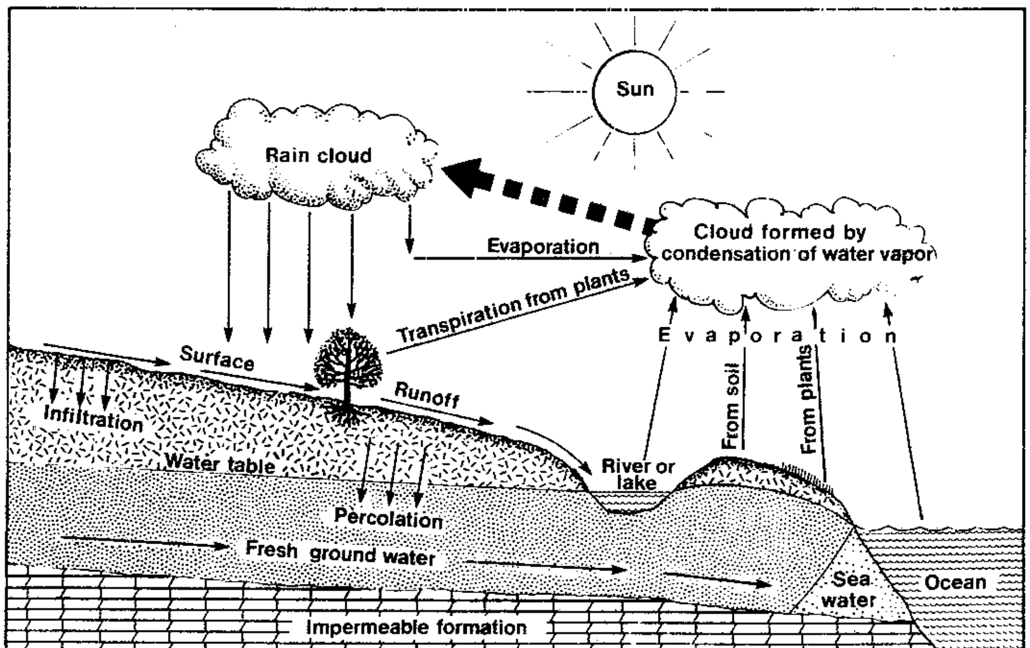

Figure 2.1 The Hydrologic Cycle

Surface runoff eventually reaches a stream or other surface water body where it is again evaporated into the atmosphere. Infiltration, however, moves under the force of gravity through the soil. If soils are dry, water is absorbed by the soil until it is thoroughly wetted. Then excess infiltration begins to move slowly downward to the water table. Once it reaches the water table, it is called **ground water**. Ground water continues to move downward and laterally through the subsurface. Eventually it discharges through hillside springs or seeps into streams, lakes, and the ocean where it is again evaporated to perpetuate the cycle.

GROUND WATER AND SUBSURFACE WATER

Most rock or soil near the earth's surface is composed of solids and voids. The voids are spaces between grains of sand, or cracks in dense rock. All water beneath the land surface occurs within such void spaces and is referred to as underground or **subsurface water**.

Subsurface water occurs in two different zones. One zone, located immediately beneath the land surface in most areas, contains both water and air in the voids. This zone is referred to as the **unsaturated zone**. Other names for the unsaturated zone are zone of aeration and vadose zone.

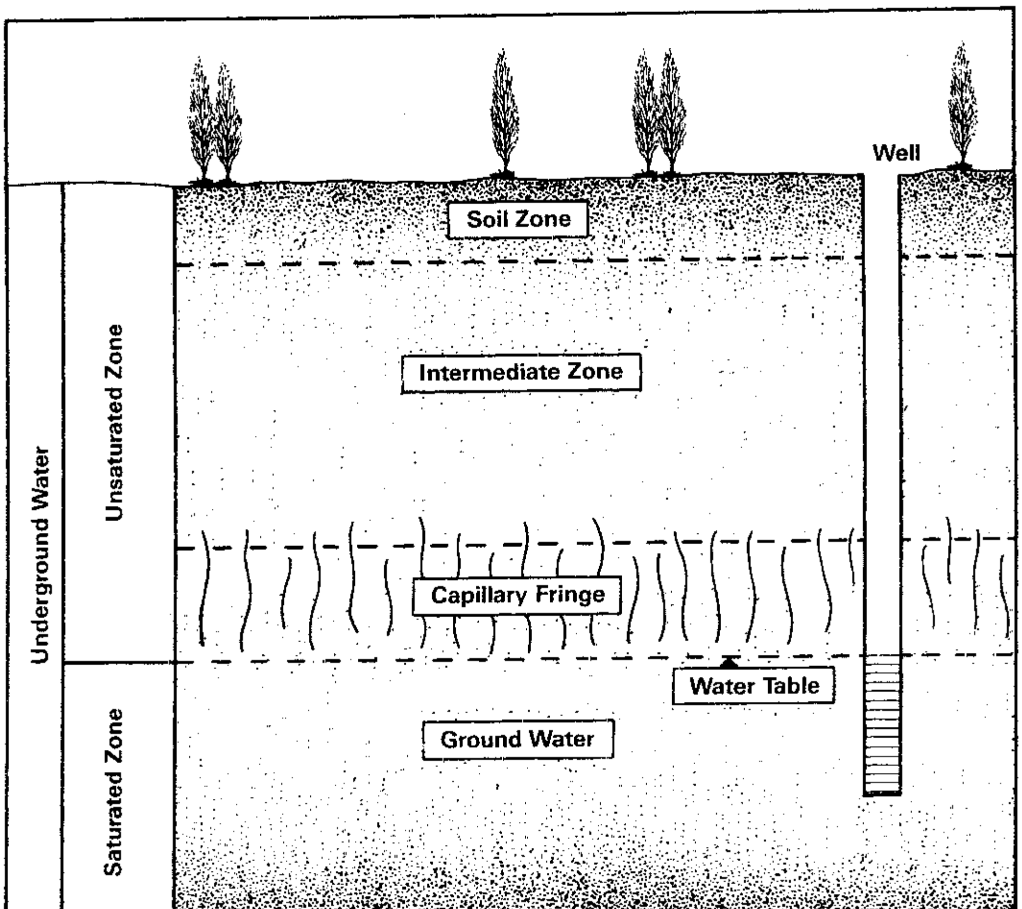

Figure 2.2 Zones of Underground Water

The unsaturated zone is almost always underlain by a second zone in which all voids are full of water. This zone is defined as the **saturated zone**. Water in the saturated zone is referred to as **ground water** and is the only subsurface water available to supply wells and springs.

Water table is often misused as a synonym for ground water. However, the water table is actually the boundary between the unsaturated and saturated zones. It represents the upper surface of the ground water. Technically speaking, it is the level at which the hydraulic pressure is equal to atmospheric pressure. The water level found in unused wells is often the same level as the water table, as shown in Figure 2.2.

AQUIFERS AND CONFINING BEDS

All geologic material beneath the earth's surface is either a potential aquifer or a confining bed. An **aquifer** is a saturated geologic formation that will yield a usable quantity of water to a well or spring. A **confining bed** is a geologic unit which is relatively impermeable and does not yield usable quantities of water. Confining beds, also referred to as aquitards, restrict the movement of ground water into and out of adjacent aquifers.

Ground water occurs in aquifers under two conditions: confined and unconfined. A **confined aquifer** is overlain by a confining bed, such as an impermeable layer of clay or rock. An **unconfined aquifer** has no confining bed above it and is usually open to infiltration from the surface.

Unconfined aquifers are often shallow and frequently overlie one or more confined aquifers. They are recharged through permeable soils and subsurface materials above the aquifer. Because they are usually the uppermost aquifer, unconfined aquifers are also called water table aquifers.

Confined aquifers usually occur at considerable depth and may overlie other confined aquifers. They are often recharged through cracks or openings in impermeable layers above or below them. Confined aquifers in complex geological formations may be exposed at the land surface and can be directly recharged from infiltrating precipitation. Confined aquifers can also receive recharge from an adjacent highland area such as a mountain chain. Water infiltrating fractured rock in the mountains may flow downward and then move laterally into confined aquifers.

Windows are important for transmitting water between aquifers, particularly in glaciated areas such as the Puget Sound region. A window is an area where the confining bed is missing.

The water level in a confined aquifer does not rise and fall freely because it is bounded by the confining bed -- like a lid. Being bounded causes the water to become pressurized. In some cases, the pressure in a confined aquifer is sufficient for a well to spout water several feet above the ground. Such wells are called flowing artesian wells. Confined aquifers are also sometimes called artesian aquifers.

When a well is drilled into an unconfined aquifer, its water level is generally at the same level as the upper surface of the aquifer. This is, in most cases, the water table. By contrast, when a well is drilled into a confined aquifer, its water level will be at some height above the top of the aquifer and perhaps above the surface of the land -- depending on how much the water is pressurized.

If a number of wells are drilled into a confined aquifer, the water level will rise in each well to a certain level. These well levels form an imaginary surface called the **potentiometric surface**. The potentiometric surface is to a confined aquifer what the water table is to an unconfined aquifer. It describes at what level the upper surface of a confined aquifer would occur if the confining bed were removed.

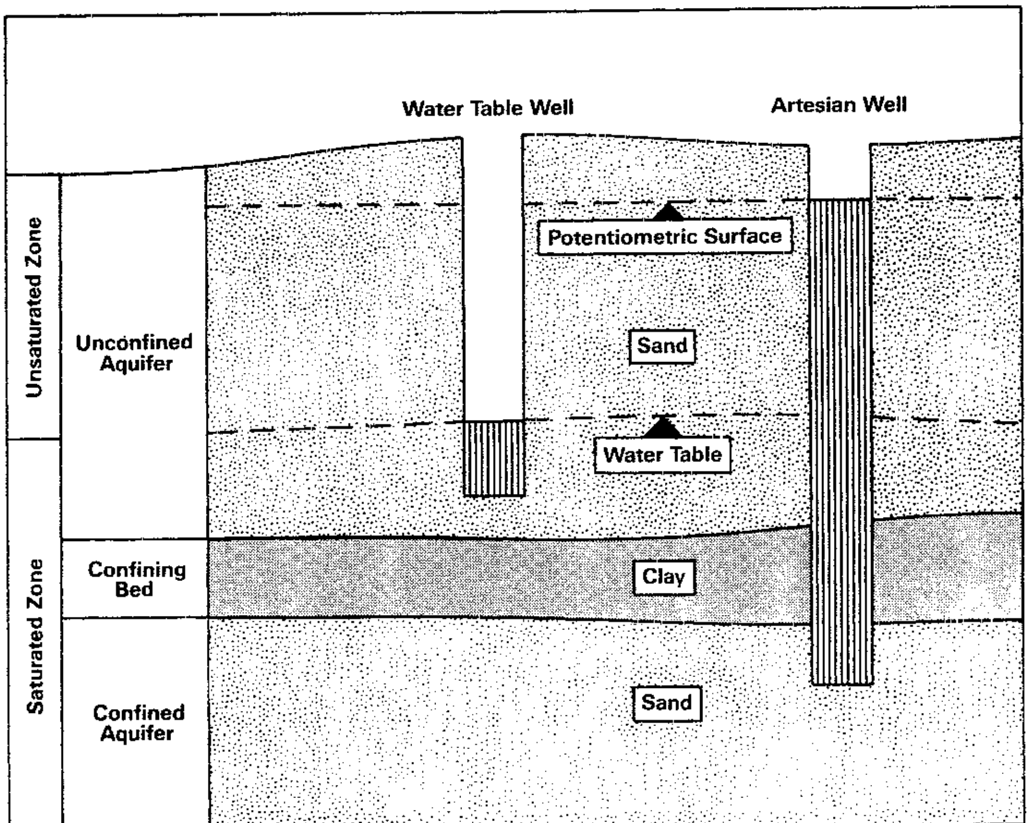

Figure 2.3 Aquifers and Confining Beds

The most productive aquifers, whether confined or unconfined, are generally in sand and gravel deposits. These tend to have large void spaces for holding water. Rocks with large openings such as solution cavities or fractures can also be highly productive aquifers. Generally, the smaller the grain size or the less fracturing, the less water an aquifer will produce. This is because there are fewer void spaces for holding water.

GROUND WATER RECHARGE AND DISCHARGE

Recharge is the process by which ground water is replenished. A **recharge area** is where water from precipitation is transmitted downward to an aquifer.

Most areas, unless composed of solid rock or covered by development, allow a certain percentage of total precipitation to reach the water table. However, in some areas more precipitation will infiltrate than in others. Areas which transmit the most precipitation are often referred to as "high" or "critical" recharge areas.

As described earlier, how much water infiltrates depends on vegetation cover, slope, soil composition, depth to the water table, the presence or absence of confining beds and other factors. Recharge is promoted by natural vegetation cover, flat topography, permeable soils, a deep water table and the absence of confining beds.

Discharge areas are the opposite of recharge areas. They are the locations at which ground water leaves the aquifer and flows to the surface. Ground water discharge occurs where the water table or potentiometric surface intersects the land surface. Where this happens, springs or seeps are found. Springs and seeps may flow into fresh water bodies, such as lakes or streams, or they may flow into saltwater bodies.

Under the force of gravity, ground water generally flows from high areas to low areas. Consequently, high areas--such as hills or plateaus--are typically where aquifers are recharged and low areas--such as river valleys--are where they discharge. However, in many instances aquifers occur beneath river valleys, so river valleys can also be important recharge areas. Typical recharge and discharge areas are depicted in Figure 2.4.

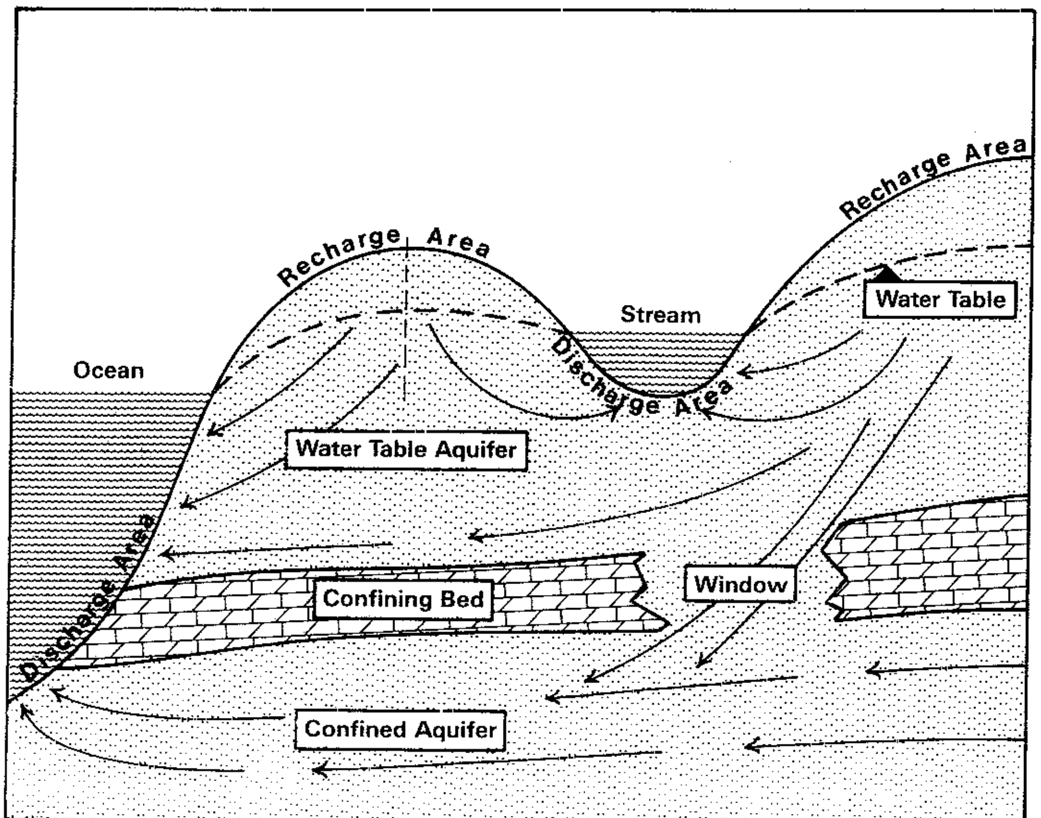

Figure 2.4 Recharge and Discharge Areas

GROUND WATER MOVEMENT

Gravity is the force that moves ground water which generally means it moves downward. However, ground water can also move upwards if the pressure in a deeper aquifer is higher than that of the aquifer above it. This often occurs where pressurized confined aquifers occur beneath unconfined aquifers.

A **ground water divide,** like a surface water divide, indicates distinct ground water flow regions within an aquifer. A divide is defined by a line on either side of which ground water moves in opposite directions. Ground water divides often occur in highland areas, and in some geologic environments coincide with surface water divides. This is common where aquifers are shallow and strongly influenced by surface water flow. Where there are deep aquifers, surface and ground water flows may have little or no relationship.

As ground water flows downwards in an aquifer, its upper surface slopes in the direction of flow. This slope is known as the **hydraulic gradient** and is determined by measuring the water elevation in wells tapping the aquifer. For confined aquifers, the hydraulic gradient is the slope of the potentiometric surface. For unconfined aquifers, it is the slope of the water table.

The velocity at which ground water moves is a function of three main variables:

- hydraulic conductivity (commonly called permeability)
- porosity
- hydraulic gradient

The **hydraulic conductivity** is a measure of the water transmitting capability of an aquifer. High hydraulic conductivity values indicate an aquifer can readily transmit water; low values indicate poor transmitting ability. Because geologic materials vary in their ability to transmit water, hydraulic conductivity values range through 12 orders of magnitude. Some clays, for example, have hydraulic conductivities of .00000001 centimeters per second (cm/sec), whereas gravel hydraulic conductivities can range up to 10,000 cm/sec. Hydraulic conductivity values should not be confused with velocity even though they appear to have similar units. Cm/sec, for example, is not a velocity but is actually a contraction of cubic centimeters per square centimeter per second (cm3/cm2-sec).

In general, course-grained sands and gravels readily transmit water and have high hydraulic conductivities (in the range of 50-1000 m/day). Fine grained silts and clays transmit water poorly and have low hydraulic conductivities (in the range of .001-0.1 m/day).

The **porosity** of an aquifer also has a bearing on its ability to transmit water. Porosity is a measure of the amount of open space in an aquifer. Both clays and gravels typically have high porosities, while silts, sands, and mixtures of different grain sizes tend to have low porosities.

The velocity at which water travels through an aquifer is proportional to the hydraulic conductivity and hydraulic gradient, and inversely proportional to the porosity. Of these three factors, hydraulic conductivity generally has the most effect on velocity. Thus, aquifers with high hydraulic conductivities, such as sand and gravel deposits, will generally transmit water faster than aquifers with lower hydraulic conductivities, such as silt or clay beds.

Ground water velocities are typically very slow, ranging from around a centimeter per day to almost a meter per day. However, some very rapid flow can occur in rock with solution cavities or in fractured rock. Very high flow rates (more than 15 m/day) are associated, for example, with some parts of the Columbia River basalt in eastern Washington.

The volume of ground water flow is controlled by the hydraulic conductivity and gradient, and in addition is controlled by the volume of the aquifer. A large aquifer will have a greater volume of ground water flow than a smaller aquifer with similar hydraulic properties. But if the cross-sectional area--that is, the height and width --are the same for both aquifers, the aquifer with a greater hydraulic conductivity and hydraulic gradient will produce a greater volume of water.

WATER SUPPLY WELLS

How aquifers respond when water is withdrawn from a well is an important topic in ground water hydrology. It explains how a well gets its water, how it can deplete adjacent wells, or how it can induce contamination.

When water is withdrawn from a well, its water level drops. When the water level falls below the water level of the surrounding aquifer, ground water flows into the well. The rate of inflow increases until it equals the rate of withdrawal.

The movement of water from an aquifer into a well alters the surface of the aquifer around the well. It forms what is called a **cone of depression**. A cone of depression is a funnel-shaped drop in the aquifer's surface. The well itself penetrates the bottom of the cone. Within a cone of depression, all ground water flows to the well. The outer limits of the cone define the well's **area of influence**.

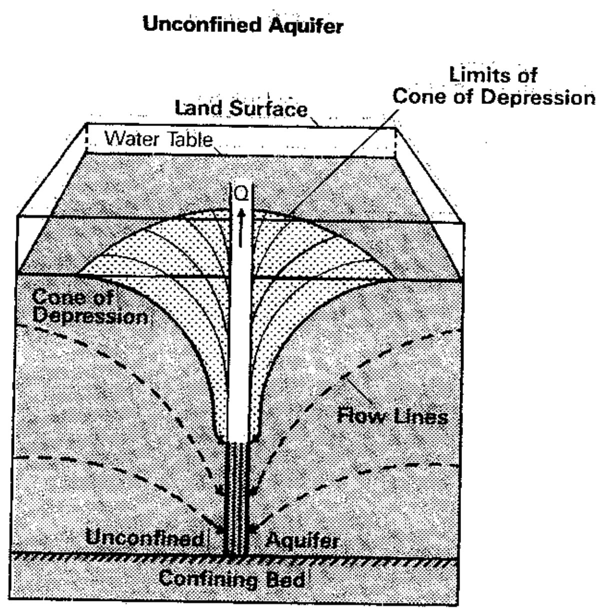

Figure 2.5 Cone of Depression

The size of a cone of depression partly depends on the rate at which water is withdrawn from a well A well from which a high volume of water is withdrawn will generally have a larger cone of depression than a well from which smaller quantities are taken--if both wells tap the same aquifer and are at the same depth. Also, all other factors being equal, pumping from an unconfined aquifer usually results in a larger cone of depression than pumping from a confined aquifer.

Sometimes the cone of depression formed around one well will overlap that of a nearby well. When this happens, the well with the wider and deeper cone of depression could draw water away from the smaller well, eventually causing the water level to drop in the smaller well.

If contaminants are discharged or migrate into a cone of depression, they are likely to be drawn into a well. Contaminants can also be drawn into a well if the cone of depression enlarges to the extent that it intercepts contaminated ground water

GROUND WATER IN WASHINGTON

The main ground water provinces of Washington State are illustrated on Figure 2.6 and described below. These provinces generally follow those outlined in the Washington Department of Ecology Geohydrologic Monograph 5 titled Principal Aquifers and Well Yields in Washington by Molenaar, Grimstad, and Walters, 1980.

1. Puget-Willamette Lowland: The northern portion of the Puget-Willamette lowland is underlain by layers of glacial and non-glacial sediments exceeding 3000 feet in thickness in some areas. Principal aquifers in this region are found in glacial outwash deposits which are composed primarily of sand and gravel. The southern portion of the lowland is underlain by river **alluvium** (sediment deposited by rivers) associated with the Chehalis, Cowlitz, and Columbia Rivers. The principal aquifers in this region occur in sand and gravel deposits within the alluvial sediments.

2. Coastal Areas: The principal aquifers in coastal areas occur in thick beach sand deposits or in terrace sands and gravels River alluvium is also an important water source.

3. Olympic Mountains: The Olympic Mountain province is underlain by dense sedimentary and volcanic bedrock which yields little ground water The most productive aquifers occur in river alluvium.

4. Willapa Hills: The principal aquifers in the Willapa Hills province occur in river alluvium. Areas of higher ground in the region are underlain by volcanic and sedimentary rock yielding little water.

5. Cascade Mountains: The Cascade Mountains and associated foothills constitute a single ground water province despite wide variation in geologic conditions Some of the volcanic rocks underlying the southern Cascade Mountains are highly permeable and are excellent aquifers. However, most aquifers currently used for water supply occur in river alluvium or glacial outwash deposits in valleys

6 Yakima/Horse Heaven Hills: The Yakima/Horse Heaven Hills region includes perimeter rocks associated with the uplift of the Cascade Mountains. The principal aquifers are in folded and faulted basalts or in river alluvium.

7. Central Columbia Basin: The central Columbia Basin is underlain by widespread volcanic basalt flows. These basalt flows, generally referred to as the Columbia River basalt, include a number of waterbearing zones and are the principal aquifers. Unconsolidated sediments between lava flows also yield considerable quantities of ground water.

8. Blue Mountains: The Blue Mountain province is also underlain by Columbia River basalt, but the basalt has been uplifted, folded and faulted. Aquifers occur within the basalt but rugged topography limits their use. Principal aquifers in this region occur in alluvium found along the Snake River and smaller river valleys.

9. Palouse: The Palouse region is covered by thick deposits of loess (wind blown dust) which overlie Columbia River basalt. The principal aquifer in this province occurs in the basalt. Some aquifers are also found in alluvial deposits along stream valleys.

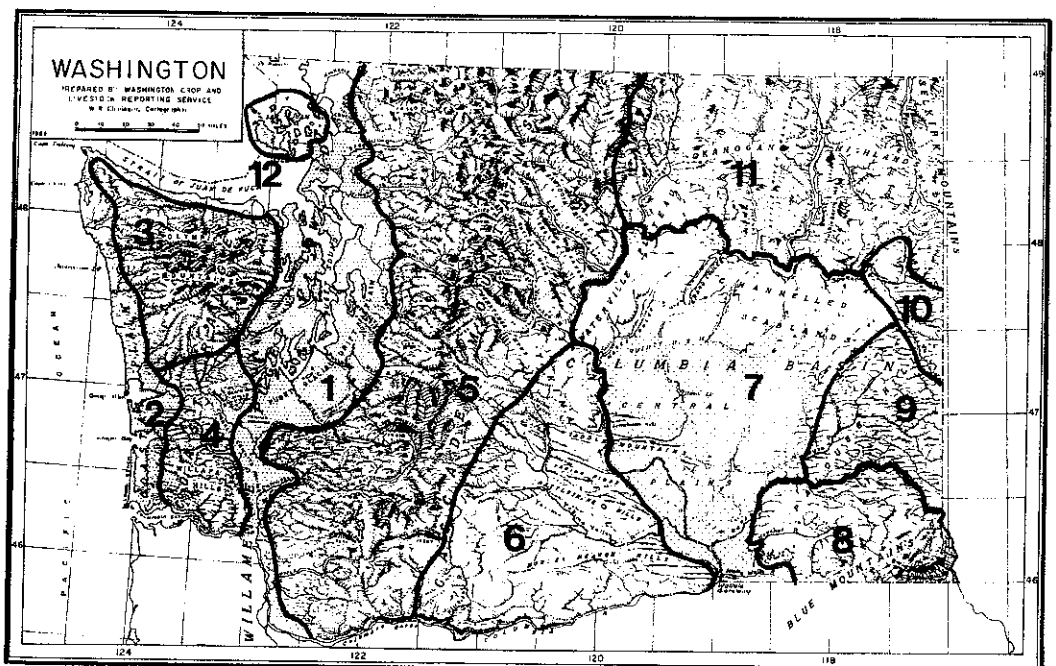

Figure 2.6 Ground Water Provinces in Washington

10. Spokane: The central portion of Spokane County is a unique province containing the Spokane-Rathdrum Aquifer. This aquifer interacts with the Spokane River and is the major source of water supply for the region. It consists of thick alluvial deposits overlying granitic bedrock.

11. Okanogan: The Okanogan region is underlain by granitic and metamorphic bedrock. The principal aquifers are restricted to thick glacial outwash deposits of sand and gravel. These are found in the glacially-formed valleys of the Okanogan, Sanpoil, Colville, and Pend Oreille Rivers and tributary valleys.

12. San Juan Islands: The San Juan Islands are underlain by metamorphic and sedimentary bedrock which yield little water. Principal aquifers are small, scattered deposits of sand and gravel covering the bedrock. These provide limited ground water supplies.

HIGHLIGHTS OF CHAPTER 3

THREATS TO GROUND WATER RESOURCES: GROUND WATER DEPLETION

GROUND WATER DEPLETION IN WASHINGTON

HOW DEVELOPMENT CAUSES GROUND WATER DEPLETION

Development Reduces Aquifer Recharge

Development Reduces Aquifer Storage

Consequences of Ground Water Depletion

HOW TO DETECT GROUND WATER DEPLETION

Observing Water Levels in Wells

Conducting a Water Balance Study

CHAPTER 3

THREATS TO GROUND WATER RESOURCES: GROUND WATER DEPLETION

INTRODUCTION

The problem of diminishing ground water resources has gained nationwide attention over the last decade. Many communities now face major water supply problems. This is forcing planners and government decision makers to review how land use plans and policies affect ground water.

This chapter describes ground water depletion problems that have occurred in Washington. It also explains how development reduces the quantity of ground water available for our use, what the consequences of ground water depletion are and how to detect depletion.

GROUND WATER DEPLETION IN WASHINGTON

In spite of the abundant rainfall in some parts of the State, Washington's ground water supplies are diminishing. At the same time, population growth and expanding industrial and agricultural development are placing greater demands on the state's ground water resources.

In western Washington, residents of island and coastal areas have been the first to see the onset of ground water depletion. The problem is especially serious in areas where there are no alternative sources of drinking water. Over the last ten years, there have been periodic water shortages in San Juan and Island Counties as well as some mainland coastal areas in lower Puget Sound.

In eastern Washington, the residents of many communities depend on ground water for crop irrigation and for drinking water. Agricultural development along the Columbia Plateau has put a serious strain on some ground water supplies. For example, water levels are dropping at a rate of up to 20 feet per year near Moses Lake. However, in some places on the Plateau, irrigation has created an over-abundance of ground water. This raises the water table which can then flood basements, create swamps, cause septic system failures, and buckle pavement. While this problem is not covered in the handbook and is not widespread in Washington, it is important to recognize as another type of ground water problem.

HOW DEVELOPMENT CAUSES GROUND WATER DEPLETION

The quantity of water available for use within a community depends on the flow of water into and out of its aquifers. Under natural conditions, aquifers are in a state of dynamic equilibrium between recharge, leakage to other aquifers, and discharge. Human activities alter this balance.

Development Reduces Aquifer Recharge

In most cases, after an area is developed, less precipitation reaches aquifers than it did before. This is because structures and pavement seal areas which, prior to development, allowed precipitation to filter into the soil and eventually into aquifers. The more an area is developed, the less water will reach any aquifers beneath it. If less water is going into an aquifer but the same amount is being discharged or withdrawn, the water level in the aquifer will start to drop. If nothing is changed, the aquifer is gradually depleted.

Aquifer recharge is also reduced by urban drainage systems. Under natural conditions a certain percentage of surface water runoff will eventually infiltrate the soil. But once intercepted by drainage channels or directed into pipes, surface water is rapidly transported to various outlets (rivers, lakes, the sea) where it is lost as a source of recharge.

Development Reduces Aquifer Storage

When more water is withdrawn or discharged from an aquifer than is recharged (referred to as dewatering the aquifer), the volume of water stored in the aquifer will diminish.

Development reduces aquifer storage primarily as a result of overpumping the aquifer. Overpumping occurs when water is withdrawn at a faster rate than the aquifer is replenished. Unless pumping rates are reduced and remain within the limits of the aquifer's **safe yield,** it will be depleted. Safe yield is a term used to define the volume of water that can be withdrawn from an aquifer before there are negative consequences, such as a permanent decline in water levels.

Aquifer storage can also be reduced in other ways. For example, making deep excavations, such as a gravel pit, often requires continuous pumping to remove ground water that discharges into the excavated area. Over time, a significant volume of water once stored in the aquifer can be removed.

Installing underground pipes can also take water out of an aquifer. Sewer systems or other underground utilities often have faulty pipe connections or cracks allowing ground water to flow into the system and be removed from the aquifers.

Consequences of Ground Water Depletion

As ground water depletion develops, water districts may have to enforce rationing programs because of reductions in well system yields. Shallow wells can go dry requiring costly drilling to develop new, deeper wells or to deepen existing wells. Water withdrawn from deeper aquifers sometimes smells or tastes bad, and costly treatment may be needed. Deeper wells also require larger pumps and higher energy costs.

Ground water depletion can also cause contamination of aquifers. When the volume of water stored in an aquifer is reduced, an inflow of water from surface water bodies or adjacent aquifers can occur. If these sources are contaminated, they will also contaminate the aquifer. In coastal areas, this process can cause seawater to flow into freshwater aquifers.

Ground water depletion can cause water levels in streams, lakes and wetlands to drop. It can even result in the complete loss of surface water flows since ground water is the base flow of many streams and recharges numerous surface water bodies.

In extreme cases ground water depletion causes land subsidence. When this occurs the land surface drops as underlying aquifers lose their water.

HOW TO DETECT GROUND WATER DEPLETION

The previously described consequences of ground water depletion can also be symptoms of depletion. For example, if local water districts begin to enforce rationing programs during dry periods, or if streams that used to run year-round go dry in the summer, ground water depletion may be underway. Any sign of such problems warrants further investigation.

The following section describes three ways to determine if depletion is occurring: 1) by examining water level records 2) by monitoring water levels, and 3) by conducting a water balance study.

Examining water levels would be a good first step to take if there are signs of ground water depletion. If such a survey indicates water levels are dropping, then monitoring water levels could help to verify that information and reveal more about the problem--such as which aquifers are involved and how fast depletion is happening. Conducting a water balance study could provide further information about the capacity of aquifers as well as a means for managing their use.

Examining Water Level Records

Water districts and water companies usually have records of well water levels taken at various times during a year and for a number of years. Such records are also available from the Department of Ecology. By gathering this information, plotting it on a map and comparing the water levels recorded one year with that of other years, a decline in aquifer water levels can be detected.

Well data which show regional declines in water levels may indicate depletion is a serious problem. Smaller scale localized declines are not usually as significant since they may be simply due to short term changes in local weather conditions or seasonal fluctuations.

Monitoring Water Levels

The first step in monitoring water levels is to identify the wells that will be included in the study. Sometimes water levels in surface water bodies are also monitored because they may be recharged by ground water. If there are not enough existing wells from which to make a good assessment, wells may have to be drilled. Once the well network is established, water levels are recorded frequently during a year to distinguish seasonal fluctuations and for enough years to distinguish long-term water level trends. Water level information is plotted on maps and on graphs in order to help identify local or regional ground water level declines.

Conducting A Water Balance Study

Whether or not depletion is occuring or may occur can be predicted by doing a **water balance study**. Water balance studies evaluate the entire flow of water into and out of the aquifer system, enabling experts to calculate depletion magnitude. The resulting data permits a safe yield to be determined for the aquifers involved. Once the safe yield is estimated, it can be used in managing pumping activities.

HIGHLIGHTS OF CHAPTER 4

THREATS TO GROUND WATER RESOURCES: GROUND WATER CONTAMINATION

GROUNDWATER CONTAMINATION IN WASHINGTON

HOW DEVELOPMENT CAUSES GROUND WATER CONTAMINATION

Types of Contaminants

Microbial Contaminants

Organic Chemicals

Inorganic Constituents and Metals

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Sources of Contamination

Discharge of Wastes Onto or Into the Ground for Treatment or Disposal

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Accidental Conduits for Contaminants or Inducing Contamination by Over-pumping

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CHAPTER 4

THREATS TO GROUND WATER: GROUND WATER CONTAMINATION

INTRODUCTION

Ground water contamination is increasingly recognized as a serious environmental problem both nationally and here in Washington. Once contaminated, public water supplies can be unsafe to use for decades. Contaminant identification and cleanup is often difficult and prohibitively expensive, and can require years to complete.

This chapter describes some of the ground water contamination problems that have already occurred in Washington. It also describes what causes contamination and how it can be detected

GROUND WATER CONTAMINATION IN WASHINGTON

Ground water quality in Washington is still very good. But a growing number of contamination problems have occurred throughout the state. Some of the more serious problems have been related to sea water intrusion, industrial development, agriculture, septic systems and sanitary landfills.

Seawater intrusion is a potential problem in all coastal areas of the state. It is already a particularly serious problem in Island and San Juan counties, where residents depend almost entirely on ground water for public water supplies.

Inadequate disposal of industrial wastes and accidental spills have caused widespread ground water contamination--especially in Washington's urban areas Even spills or releases from small facilities have been a problem. For example, solvent sludges from a small dry cleaning plant south of Tacoma were reportedly disposed of through a septic system. Various organic compounds in the solvent migrated into a major aquifer where they were drawn into two public water supply wells. After contamination was detected both wells were taken out of service. A multimillion dollar treatment system had to be designed to bring the wells back on-line.

Agriculture has been a source of contamination in a number of rural areas. Ground water contamination from the use of agricultural pesticides has occured in the Yakima and Skagit Valley areas. Agricultural fertilizers have been linked to ground water contamination in Benton, Walla Walla and Spokane Counties. Along the Columbia Plateau, farmland irrigation has led to an accumulation of salts in ground water

Septic systems, the most widely used method for disposing of domestic wastes, have caused ground water contamination in nearly all of the counties in Washington.

Ground water contamination has been linked to landfills in King, Clark, Kitsap, Okanagon, Whatcom, Pierce and Spokane counties. For example, volatile organic contaminants from Spokane's Colbert landfill were found in water supply wells one and a half miles away. Poor location and poor construction of the landfill contributed to the problem.

There are more than 450 sanitary landfills in Washington, all of which should be considered potential sources of ground water contamination. Approximately 30% of these sites have documented ground water contamination. However, the full extent of landfill generated contamination has yet to be evaluated statewide.

HOW DEVELOPMENT CAUSES GROUND WATER CONTAMINATION

Ground water contamination usually results from the release of some harmful substance or microbe on or just below the ground surface. Once released, it moves towards the water table. There are several means by which this happens. Some substances dissolve or are carried in suspension to the water table with infiltrating water. Other substances, such as petroleum products, are not readily soluble and migrate to the water table under the force of gravity.

Movement of Contaminants

Because ground water flows in a basically linear fashion, contaminants that dissolve or are carried in suspension will follow ground water flow lines. As a result, they can form distinct plumes as illustrated in figure 4.1.

Plumes of contaminated ground water have been traced from a few feet to several miles from the pollution source. The shape and size of a plume depends on a number of factors including the geologic framework, ground water flow patterns, the type and concentration of contaminants, and the rate of contaminant leaching.

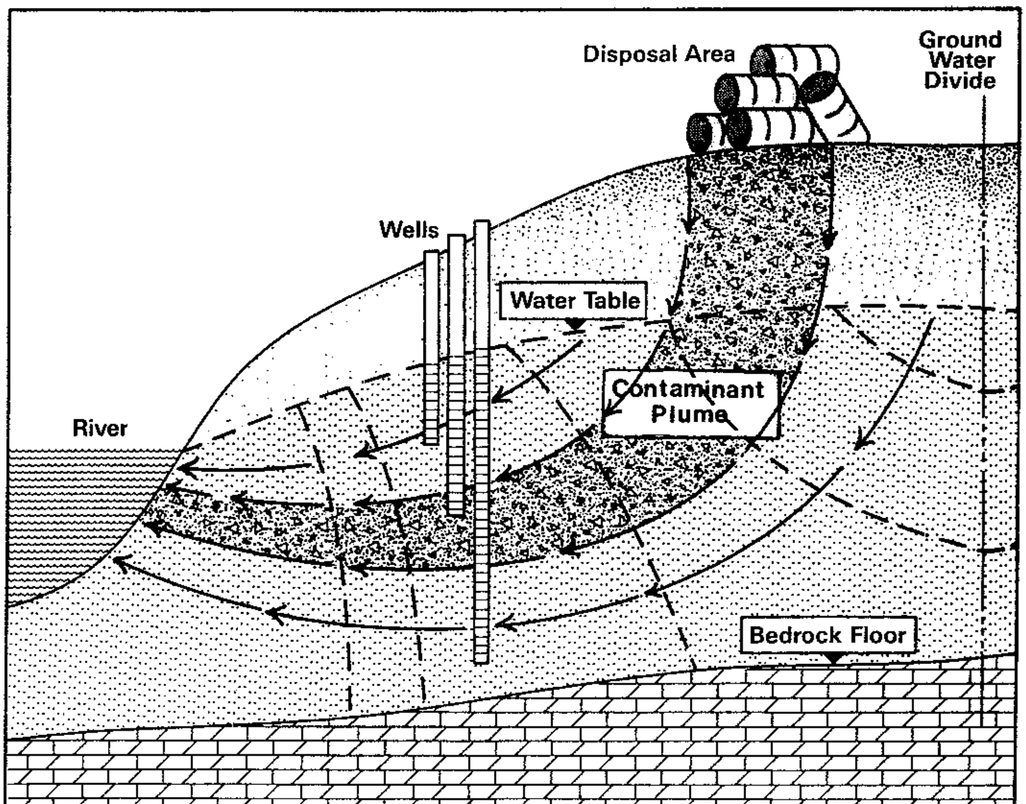

Figure 4-1 Contaminant Plume in a Water Table Aquifer

The mobility of ground water contaminants in a plume is determined by a number of factors including the physical and chemical characteristics of the aquifer, the velocity of the ground water, and the solubility of the contaminant. Some compounds such as nitrates are extremely soluble and, depending on aquifer conditions and ground water movement, can be very mobile. Others, such as PCB's, are very insoluble and not very mobile.

Predicting the movement of contaminants in ground water is difficult. Fortunately, the soil and other subsurface materials act as a treatment system for many ground water contaminants, particularly biological organisms. Contaminants can be immobilized or completely removed while traveling to an aquifer--as a result of biological activity or chemical reactions with the soil. Such processes are said to **attenuate** contaminants.

Types of Contaminants

There are four basic groups of contaminants:

- Microbial pathogens
- Organic chemicals
- Inorganic minerals and metals
- Radionuclides

Microbial Contaminants

Microbial organisms occur naturally in ground water, but usually only in small quantities. This is because they are filtered out by the soil or cannot survive once they reach the water table. However, when microbial contamination does occur, a variety of problems are created for human beings and animals The major microbial categories are bacteria, viruses, and parasites. The most common sources of microbial contaminants are septic systems, leaking sewers, and farm animals.

Table 4.1 lists typical microbial pathogens and indicates their effects on human health

State water quality standards set a maximum contaminant level for total coliform bacteria (Eschericha coli) and public water systems must regularly test for this microbe. The presence of coliforms can mean other microbial pathogens are in the water supply. For this reason, the coliform count is used as an indicator of microbial contamination. Other microbial contaminants aren't monitored except under special circumstances.

TABLE 4.1
Typical Microbial Pathogens

Name	Organism Type	Effect on Humans
1. Entamoeba histolytica	Protozoa	Amoebic dysentery
2. Giardia lamblia	Protozoa	Giardiasic (Diarrhea)
3. Round worms, flat worms	Parasitic worms	Gastrointestinal Disease
4. Campylobacter JeJuni	Bacteria	Gastroenteritis
5. Enteropathogenic Eschericha coli	Bacteria	Gastroenteritis
6. Vibrio cholera	Bacteria	Cholera
7. Salmonella typhosa	Bacteria	Salmonellosis (Diarrhea)
Salmonella typhi	Bacteria	Typhoid
Salmonella para typhi	Bacteria	Para Typhoid
8. Shigella dysenteri	Bacteria	Bacillary dysentery
Shigella sonnei	Bacteria	Bacillery dysentery
9. Yersina enterocolitica	Bacteria	Yersiniosis (high fever, diarrhea)
10. Hepatitis A	Virus	Jaundice, Diarrhea
11. Poliomyelitis	Virus	Paralysis

Organic Chemicals

Some organic chemicals, such as lignins, tanins and some hydrocarbons, occur naturally in ground water. However, a multitude of organic chemicals have been synthesized for home, industrial, business, and agricultural use. There are thousands of chemicals in use today and many more are added each year. Common organic contaminants are listed in Table 4.2. The effects of these contaminants on human health can include mortality, systemic poisoning, and the disruption of normal neurological responses. Some organic chemicals are strong mutagens and carcinogens.

State water quality standards set maximum contaminant levels for some pesticides, but there are no adopted standards for most other organic chemicals. Both the Environmental Protection Agency and State Department of Social and Health Services are working on developing standards for organic chemicals.

TABLE 4.2
Common Organic Contaminants

General Chemical Group	Specific Compounds	Typical Uses
Aliphatic Hydrocarbons	Hexane	gasoline paint thinners
	Pentane	gasoline paint thinners
	Octane	gasoline paint thinners
Aromatic Hydrocarbons	Benzene	solvents, gasoline
	Naphthalene	preservatives, lubricants
	Styrene	plastics, resins
	Benzo(a) Pyrene	coal tar ingredients
Halogenated Hydrocarbons	Chloroform	plastics, refrigerants
	Pentachlorophenol	wood preservatives
	PCB's	heat exchange fluid
	Carbon tetrachloride	solvent
	Methylene chloride	paint stripper
	1,1,2 Trichlorethylene (TCE)	degreasers, drycleaning agent
Pesticides	Chlordane	chlorinated insecticide
	Ethylene Dibromide	chlorinated insecticide
	Lindane	chlorinated insecticide
	DDT	chlorinated insecticide
	2,4D	chlorinated herbicide
	Carbaryl (Sevin)	carbamate insecticide
	Malathion	organophosphate insecticide
Oxygenated Hydrocarbons	Acetone	dyes, solvents
	2,4 dimethylphenol	pharmaceuticals, fungicides
	Tetrahydrofuran	solvents
	Methylethyl ketone (MEK)	solvents

Inorganic Minerals and Metals

Inorganic substances occur naturally in trace to low concentrations in ground water. Common sources of inorganic mineral contamination are septic systems, animal wastes and seawater intrusion. Inorganic metal contamination is often a by-product of industrial activity. The direct health effects of inorganic contaminants are as varied as those of organic contaminants, but fewer inorganic chemicals have been implicated as carcinogens or mutagens.

State water quality standards set maximum concentration levels for many of these substances. Some levels were established for health protection, as is the case with nitrates. Others were established for potability because some constituents adversely affect qualities such as the hardness, odor, turbidity, color or taste of water.

Table 4.3 lists some of the inorganic constituents that occur naturally in ground water. Those listed as principal constituents normally occur in greater amounts than those listed as secondary constituents. The list of secondary constituents includes the heavy metals most often associated with ground water contamination, although other constituents also occur.

TABLE 4.3
Inorganic Ground Water Constituents

Principal Constituents in Natural Water	Secondary Constituents in Natural Water
Calcium	Arsenic
Chloride	Barium
Fluoride	Cadmium
Iron	Chromium
Magnesium	Copper
Manganese	Lead
Nitrate	Nickel
Potassium	Mercury
Silica	Selenium
Sodium	Silver
Sulfate	Zinc

Radionuclides

Radionuclides are the various radioactive forms of elements such as strontium, uranium, tritium or cobalt. Radionuclides occur naturally at low levels in ground water but are most concentrated in wastes from the nuclear industry. Nuclear power facilities, energy laboratories or waste depositories are potential sources of radionuclide contamination. Hospitals and educational institutions that use low level radioactive materials may also be potential sources of contamination. Exposure to radionuclides is known to cause radiation sickness, cancer, and mutations. The state has established maximum concentration levels for radionuclides.

Nuclear waste is a highly specialized ground water problem normally handled by the federal government. Planners should seek state and federal assistance if they encounter radionuclide contamination.

Sources of Contamination

Ground water contamination can result from many human activities Consequently, there are many possible sources of contamination Most potential sources of contamination fall within one of five broad categories:

1. Sources designed to discharge waste onto and into the ground for treatment or disposal.
2. Sources designed to store potential contaminants.
3. Sources designed to transport potential contaminants.
4. Sources that discharge contaminants onto and into the ground as a consequence of some other activity.
5. Sources that provide accidental conduits for contaminants or induce contamination by altering ground water flow patterns.

These contaminant groups are described further on the following pages.

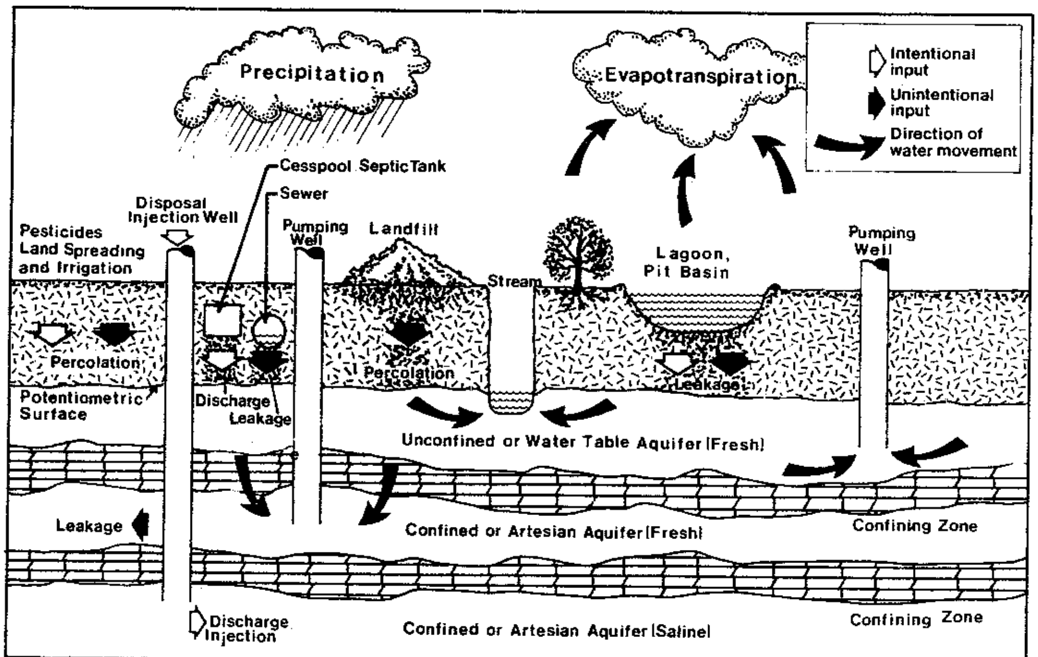

Figure 4.2 How Waste Disposal Practices Contaminate the Groundwater Systems

Group 1 Sources: Discharge of Wastes Onto or Into Ground For Treatment or Disposal

Sources of contamination in this category include:

- o On-site waste disposal
- o Land application of domestic and industrial wastes
- o Wastewater injection wells

Discharging wastes onto or into the ground has been used to treat and dispose of both domestic and industrial wastes. On-site waste disposal methods, primarily septic systems and cesspools, rank highest in the total volume of wastewater discharged directly into the ground. They are also the most frequently cited sources of ground water contamination.

Land application of wastewater is also used as a means of treating wastes. Some municipal sewage authorities spray treated wastewater or spread sludge over land set aside as special treatment areas. The petroleum industry uses "land farming" to dispose of chemical sludges. This method involves spreading sludges on land and cultivating it into the soil.

The treatment of wastes by on-site disposal or land application methods does not necessarily remove all potential contaminants. Some contaminants may reach the water table and build up over time. This is especially true when, for example, septic systems malfunction.

Disposal of industrial wastewater into deep aquifers via injection wells is a common practice in many states but is prohibited in Washington.

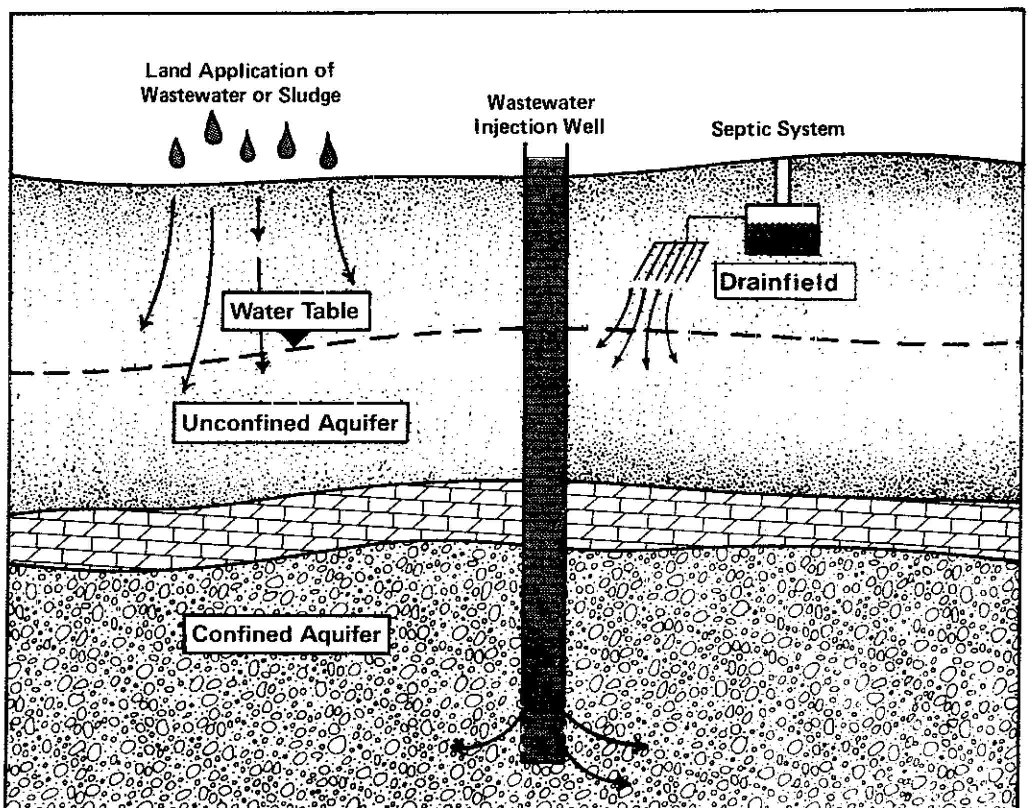

Figure 4.3 Group 1 Sources

Group 2 Sources: Storage or Dumping of Potential Contaminants

Sources of contamination in this category include:

- o Landfills
- o Illegal dumps
- o Surface impoundments (pits, ponds, lagoons)
- o Waste tailings
- o Waste piles
- o Materials stockpiles
- o Above-ground storage tanks
- o Below-ground storage tanks
- o Containers (such as drums)

Waste storage or storage of materials containing contaminants poses a serious threat to ground water. Contaminants can enter ground water by leaching from landfills, illegal dumps, surface impoundments such as sewage lagoons or waste disposal ponds, mining waste tailings, or from any piles of waste or materials that contain contaminants. Contaminants can also leak from storage tanks or other containers.

On a national level, this group of contamination sources has received more attention than any other. Many of the most infamous contamination incidents, such as Love Canal, involved burial or illegal dumping of toxic industrial wastes. Leaking underground storage tanks are currently receiving a large amount of regulatory attention because they represent a widespread and largely unmonitored contaminant source They include, for example, tanks used by gasoline stations to store petroleum products as well as tanks used to store home heating oil.

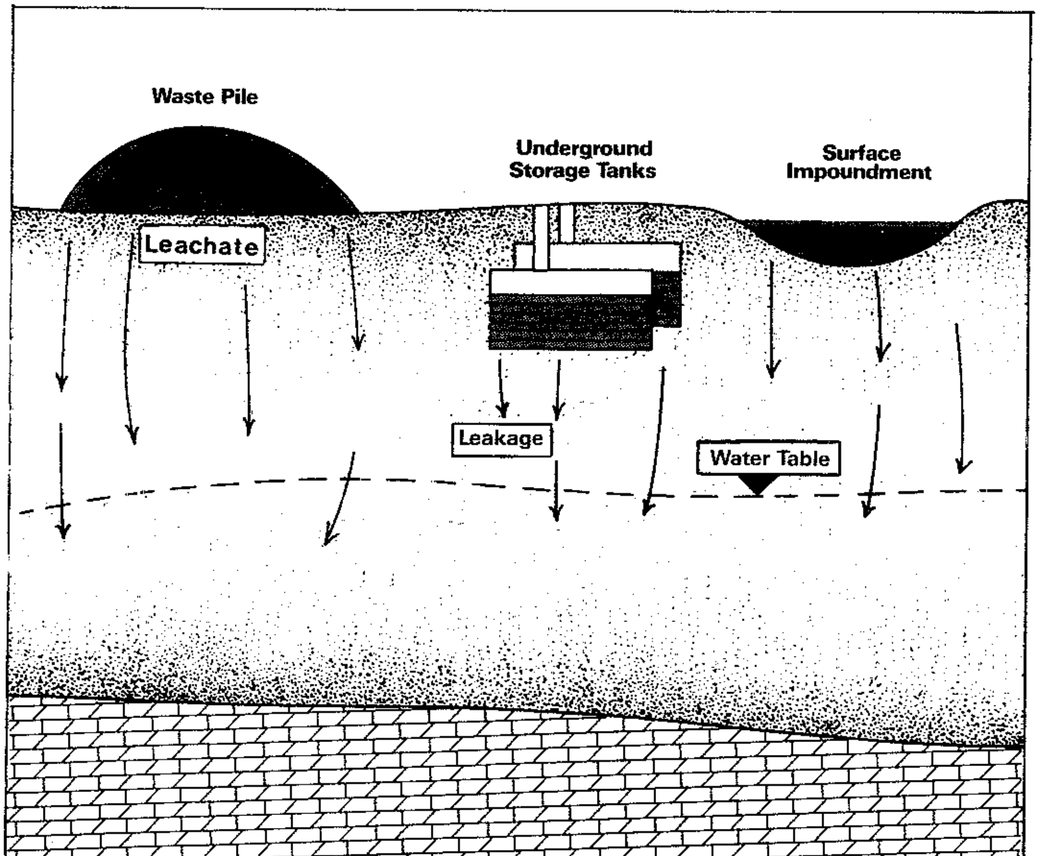

Figure4.4 Group 2 Sources

Group 3 Sources: Transport of Potential Contaminants

This group of contaminant sources includes:

- o Sanitary sewers
- o Hazardous materials pipelines
- o Contaminant transport by truck, or rail

The transport of potential contaminants is a threat to ground water when accidental leaks or spills occur. Sanitary sewers are frequently installed to eliminate the contamination caused by failing septic systems. However, sewers often leak and create localized areas of extreme contamination.

Pipelines carry a wide variety of hazardous materials, such as petroleum products and manufacturing chemicals. Like sewers, pipelines can leak or break resulting in localized but serious contamination.

Numerous spills have also occurred during the transport of contaminants by truck or rail, resulting in localized ground water contamination.

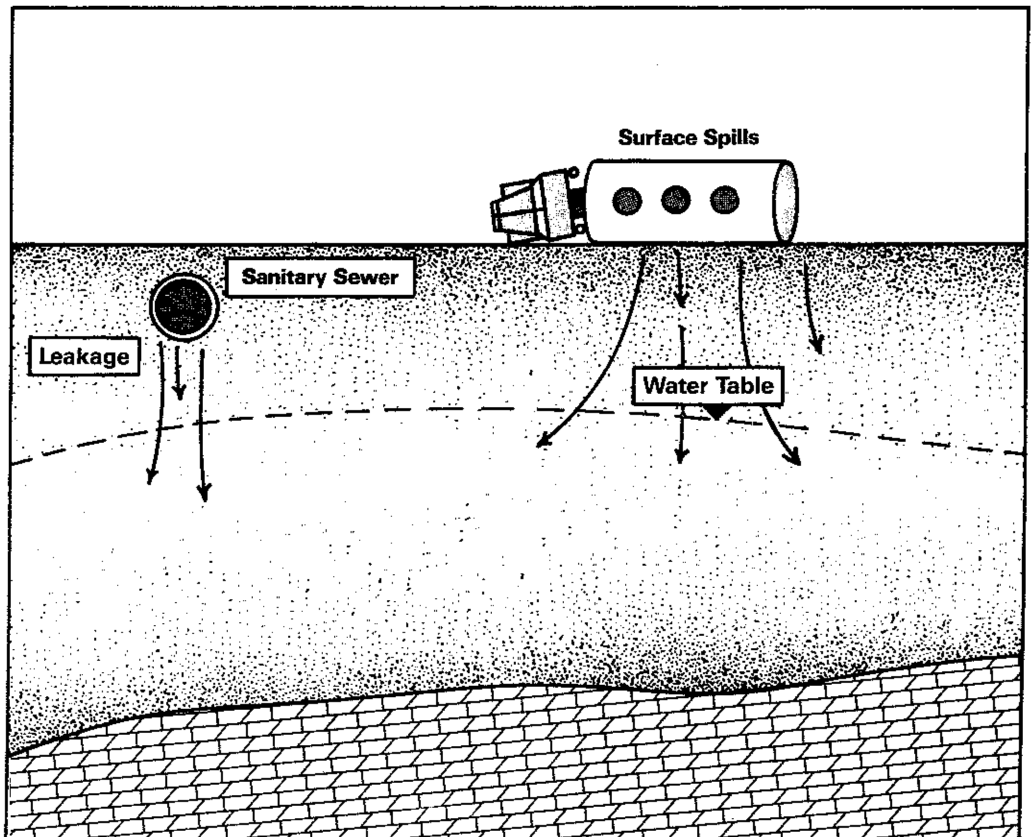

Figure 4.5 Group 3 Sources

Group 4 Sources: Incidental Contaminant Discharge As A Result of Other Activities

This group includes several disparate sources of contamination:

- o Agricultural chemical use
- o Irrigation practices
- o Animal feeding operations
- o Urban runoff
- o Mining and mine drainage

Agricultural chemicals, in the form of fertilizers and pesticides, tend to migrate with infiltration to the water table. Irrigation accelerates this process and can also leach mineral salts and metals from the soil.

Applying fertilizers and pesticides with irrigation water, a practice called chemigation, can contaminate ground water unless safety devices are installed to prevent water from being siphoned back into the well.

Animal feed lots accumulate high concentrations of animal waste that can cause nitrate and bacterial contamination.

Urban runoff is widely recognized as a significant source of pollution. Runoff picks up contaminants from streets, roofs, construction sites, industrial and commercial areas and domestic gardens. Toxic substances that have leaked or spilled may also be picked up. As a result, urban runoff can contain organic contaminants such as petroleum hydrocarbons or pesticides, inorganic contaminants such as nitrates or metals, and microbial pathogens. Urban runoff can contaminate ground water where it accumulates in natural basins or is collected in retention basins that allow runoff to infiltrate to the water table. It can also contaminate ground water when discharged to "dry wells"--a method used extensively in Washington to dispose of runoff.

Mining often contaminates surface water with acids and heavy metals, which can infiltrate to the water table.

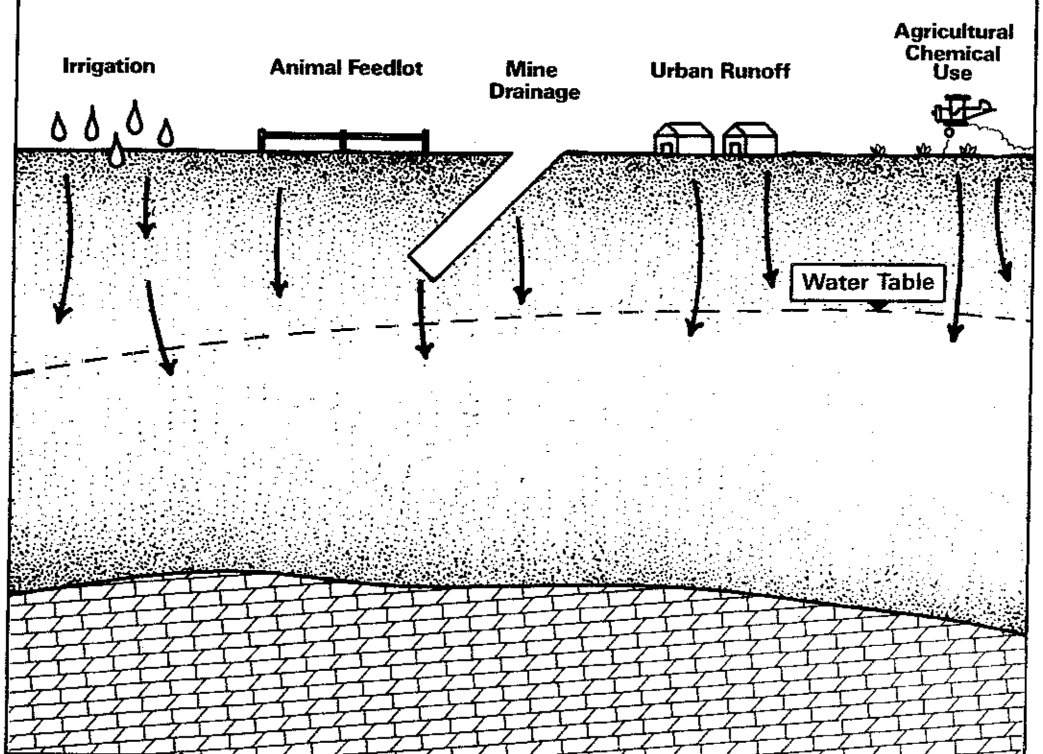

Figure4-6 Group 4 Sources

Group 5 Sources: Accidental Conduits for Contaminants or Inducing Contamination by Overpumping

- Oil, gas, or geothermal wells (deep production wells)
- Ground water monitoring or water supply wells
- Excavations
- Overpumping

Any well or vertical borehole represents a possible conduit for ground water contamination. Consequently, improper well construction can allow contaminated water to migrate from the surface, or from contaminated aquifers, to aquifers used for water supplies. A common source of bacteria contamination in rural areas is improper sealing of abandoned wells. Improper sealing can allow contaminated surface water to enter the well and leak into adjacent aquifers.

Deep excavations in the ground, such as gravel pits, can also provide a conduit for contaminated surface water to reach the water table

Overpumping, withdrawing water in excess of an aquifer's safe yield, can create contamination by inducing flow from brackish aquifers or saltwater bodies.

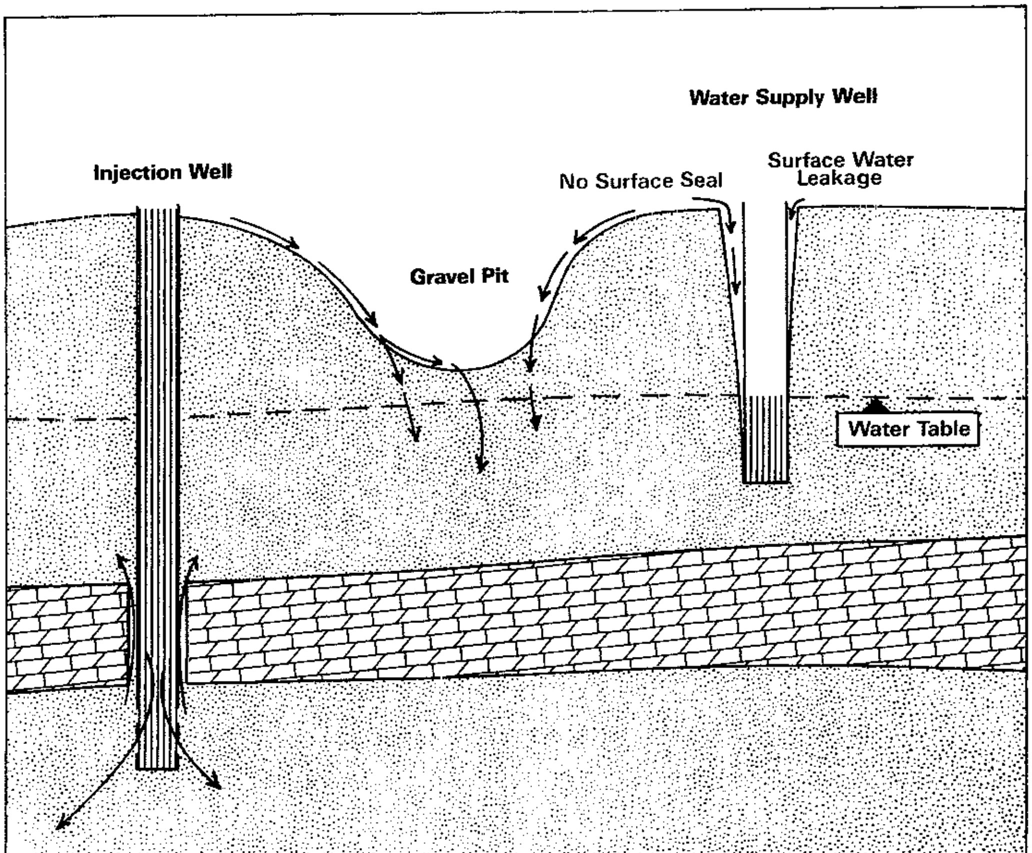

Figure 4.7 Group 5 Sources

Potential Contaminants by Land Use Category

The following table classifies land uses by categories that planners work with in developing comprehensive plans. These categories represent uses that often have different impacts on ground water. The table lists common sources and types of contaminants associated with each use. It also indicates whether a contaminant source is likely to have a localized versus a more regional impact on aquifers.

TABLE 4.4
Land Use Impacts on Ground Water Quality

Land Use Category	Contaminant Source	Typical Contaminants	Contamination Potential Local	Contamination Potential Regional
Agriculture	Agricultural chemical use	Pesticides, herbicides, fertilizers	High	High
	Irrigation	Same as above	High	High
	Above ground storage tanks	Petroleum products	High	Low
	Materials stockpiles	Pesticides, fertilizers	Moderate	Low
Animal Husbandry	Animal feeding operations	Biological, nitrates	Moderate	Low
Mining	Mining and mine drainage	Acidity, heavy metals, cyanide	High	Moderate
	Excavation	Biological, organic and inorganic chemicals	Moderate	Moderate
Low density residential with septic systems (less than 1 home per 15 acres)	On-site waste disposal	Biological, nitrates	Low	Low
		Household hazardous wastes, Synthetic chemicals	Moderate	Low
Medium density residential with septic systems (1 home per 15 acres up to 1 home per 3.5 acres)	On-site waste disposal	Biological and nitrate	Moderate	Moderate
	Below ground storage tanks	Heating oil	High	Moderate
	Urban runoff	Wide variety of potential contaminants	Moderate	Low
High density residential with sewers (greater than 3.5 homes per acre)	Sanitary sewers	Biological nitrates	High	Moderate
	Below ground storage tanks	Heating oil	High	Low
	Urban runoff	Wide variety of potetial	High	High
Commercial	Sanitary sewers	Biologicals nitrates	High	Moderate
	Below ground storage tanks	Organic chemicals	High	Low
	Urban runoff	Organic and inorganic chemicals	High	High

Land Use Category	Contaminant Source	Typical Contaminants	Contamination Potential Local	Contamination Potential Regional
Industrial	On-site waste disposal	Biological. nitrates Organic and inorganic chemicals	High High	Low Mod-high
	Sanitary sewers	Same as above	High	Low-mod
	Land application of wastewater	Biological, nitrates, heavy metals, organic chemicals	High	Low
	Land application of hazardous wastes	Petroleum products	High	Low-high
	Wastewater injection wells	Organic chemicals	High	Mod-high
	Illegal dumps	Wide variety of organic & inorganic chemicals	High	Low-mod
	Surface impoundments	Organic chemicals, inorganic chemicals	High	Low-mod
	Waste piles	Same as above	High	Low-mod
	Materials stockpiles	Same as above	High	Low-mod
	Above ground storage tanks	Same as above	High	Low-mod
	Below ground storage tanks	Organic and inorganic chemicals	High	Low-mod
	Containers	Same as above	High	Low
	Hazardous materials pipelines	Same as above	High	Low
	Contaminant transport	Same as above	High	Low
	Urban runoff	Same as above	High	Low-mod
Landfills	Landfills	Biologicals, organic & inorganic chemicals. methane	High	High
Sources not associated with specific land uses	Illegal dumps	Organic chemicals. metals inorganic chemicals	High	
	Hazardous materials pipelines	Petroleum	High	Low
	Contaminant transport via trucking, railroad or shipping	Organic and inorganic chemicals	High	Low
	Oil, gas or geothermal wells	Brines	High	High
	Ground water monitoring or supply wells	Surface water or contaminated groundwater	High	Moderate
	Excavations	Surface water runoff	High	Moderate

HOW TO DETECT GROUND WATER CONTAMINATION

Ground water contamination may occur anywhere in a community--but it is more likely to be found where there are potential sources of contamination. Any effort to identify problem areas should begin with finding out where the potential sources of contamination, such as those described in this chapter, are located. Industrial districts, agricultural areas, high density residential areas where septic systems are used, landfill sites, or coastal areas should all be outlined on a map and examined more closely for signs of ground water contamination.

The following describes two ways to detect ground water contamination: 1) by evaluating existing water quality records and 2) by monitoring water quality.

Evaluating Existing Water Quality Data

Good water quality data is crucial to determining if contamination is occurring. Generally, water quality data is most useful if it is compared over a period of time. Comparing data over time indicates whether water quality is stable, improving or deteriorating. This helps to identify aquifers or portions of aquifers that may be at risk.

A number of federal, state and local agencies are involved in monitoring and collecting water quality information. The primary sources of this information are the State Department of Social and Health Services (DSHS), local health departments and local water providers.

Water purveyors are required by the state to monitor for certain contaminants. Their records are filed with local health departments and DSHS. If these records are available and cover a significant period of time, they can be used to evaluate water quality trends

The severity of contamination can be evaluated by comparing water quality data with water quality standards. State drinking water quality standards are shown on Table 4.5. As noted earlier, the state is working to expand the number of contaminants included in the standards. Water samples showing one or more contaminants near or exceeding these maximum levels could indicate a serious water quality problem. Depending on the contaminant involved, human health or potability may be threatened.

Other standards that can be used to gauge how serious contamination may be are available through the U.S. Environmental Protection Agency (EPA). EPA issues publications listing the reommended maximum contaminant levels for many contaminants not included in the state s standards.

The degree of aquifer contamination can be determined by comparing water quality from a network of wells located in the aquifer. If a number of wells show elevated concentrations of one or more contaminants, it may indicate contamination is spreading through the aquifer. By plotting this information on maps, areas of contaminated ground water can be outlined.

Monitoring Water Quality

If existing information is inadequate, a special study to monitor water quality may be necessary. Or, if existing information indicates water quality is deteriorating, monitoring can be used to find out more about the problem--such as the area contaminated, the rate of contamination, the direction contaminants are moving and the sources of contamination. Water quality studies are also conducted to detect contaminants not normally monitored by state and local agencies.

Water quality studies involve identifying a network of wells to be monitored. Existing wells are used unless there are not enough to complete the network. Then wells may have to be drilled. Water samples are taken regularly from the wells and tested. This is usually done for a number of years in order to determine long-term water quality trends.

Table 4.5
WASHINGTON STATE DRINKING WATER STANDARDS[1]

Primary Inorganic Chemicals & Physical Contaminants	Maximum Level	Secondary Inorganic Chemicals and Physical Contaminants	Maximum Level
Arsenic	0.05 mg/L	Chloride	250 mg/L
Barium	1 mg/L	Color	15 units
Cadmium	0.010 mg/L	Copper	1.0 mg/L
Chromium	0.05 mg/L	Iron	0.3 mg/L
Lead	0.05 mg/L	Manganese	0.05 mg/L
Mercury	0.002 mg/L	Specific Conductivity	700 umhos/cm
Nitrate (as N)	10 mg/L	Sulfate	250 mg/L
Selenium	0.01 mg/L	Total Dissolved Solids	500 mg/L
Silver	0.05 mg/L	Zinc	5.0 mg/L
Fluoride	2.0 mg/L		
Sodium[2]	-		
Turbidity	1 TU		

Primary Organic Chemical Contaminants	Maximum Level
Chlorinated hydrocarbons:	
Endrin	0.0002 mg/L
Lindane	0.004 mg/L
Methoxyether	0.1 mg/L
Toxaphene	0.005 mg/L
Chlorophenoxys:	
2,4-D	0.1 mg/L
2,4,5-TP Silvex	0.01 mg/L
Total Trihalomethanes	0.10 mg/L

Note:

1 From Rules and Regulations of the State Board of Health, Chapter 248-54. Table does not include standards for bacteriology, radioactivity, or corrosivity.

2 There is no maximum contaminant level established for sodium, however, monitoring is required.

HIGHLIGHTS OF CHAPTER 5

IDENTIFYING SENSITIVE AREAS

DEFINING SENSITIVE AREAS

SENSITIVE AREA CLASSIFICATION SYSTEMS

Systems that Focus on Protecting Aquifers

Drastic System

Chambers/Clover Creek System

Systems that Focus on Protecting Wells or Springs

Dade County System

Systems That Identify Groundwater Impacts of a Specific Contamination Source

LeGrand System

Hazard Ranking System

SENSITIVE AREA CLASSIFICATION SYSTEMS AND THEIR USE IN PLANNING

CHAPTER 5

IDENTIFYING SENSITIVE AREAS

INTRODUCTION

It is important to focus local ground water protection efforts on the areas which are in greatest need of protection. Identifying sensitive areas is one way of doing this. This chapter outlines how sensitive areas are defined and describes some of the sensitive area classification systems now being used.

A number of sensitive area methods are being tested across the country. They vary in definitions and methods of identifying sensitive areas. Ground water protection planning is a relatively new field, so sensitive area methods are not yet well established. Methods are usually tailored to fit a particular community's ground water problems and geohydrologic conditions. Because communities differ, so do sensitive area methods.

This chapter describes the similarities and differences among sensitive area classification systems and outlines how they are used in protecting ground water.

DEFINING SENSITIVE AREAS

Sensitive areas are geographic areas where ground water could easily be contaminated. Human activities are usually the source of ground water contamination, but natural conditions make some areas more vulnerable to contamination than others. Such areas can be described as being hydrogeologically sensitive. The following are some of the conditions which determine hydrogeologic sensitivity.

Composition and Thickness of the Unsaturated Zone. The material in the unsaturated zone is a critical factor determining how fast contaminants will reach the water table and the degree to which contaminants will be attenuated. Finer grained materials protect underlying aquifers more effectively than coarser grained materials. Water moves more slowly through fine grained materials so there is more time for pollutants to be attenuated before reaching the water table. If rock is present, the degree of fracturing is important: highly fractured rock permits ready passage of pollutants; unfractured rock restricts passage

The thickness of the unsaturated zone is important because it determines the distance pollutants must travel before reaching the water table. The greater the distance, the greater the opportunity for pollutant attenuation.

Whether Aquifers are Confined or Unconfined. Unconfined aquifers are usually much more vulnerable to contamination and more quickly contaminated than confined aquifers A confined aquifer is protected by one or more overlying impervious layers which inhibit the flow of contaminants that might be transportated from the surface. In most cases, an unconfined aquifer has no such protective layer and is therefore more vulnerable to contaminants.

Geologic Nature of the Aquifer. The geologic nature of the aquifer is a factor in determining how far and fast a contaminant will travel once it has reached an aquifer and the extent to which contaminants will be attenuated. In general, the attenuation capacity of fine-grained aquifers is better than coarse-grained aquifers.

Volume of Recharge. The volume of recharge water transmitted to an aquifer can vary from one location to the next. Often, but not always, high recharge areas occur where precipition is high, the topography is flat, the soil and geologic material between the land surface and the aquifer are very permeable and the water table is deep. Because high recharge areas do transmit large volumes of water to an aquifer, they also transport more contaminants from the land surface. Also, contaminants tend to be less attenuated in high recharge areas because of the greater speed with which infiltration reaches the water table. Locating a potential source of contamination in a high recharge area could have far greater water quality impacts than it would in an area with less recharge potential.

Proximity of Salt Water Bodies or Contaminated Water Bodies Aquifers near a body of salt water are at risk of being contaminated by seawater intrusion. Overpumping of the aquifer can induce seawater to flow into the aquifer. Aquifers are also at risk if they are close to a contaminated water body.

SENSITIVE AREA CLASSIFICATION SYSTEMS

As noted earlier, a variety of methods are being used to identify sensitive areas. Some are extremely complex, require expensive ground water studies and the help of technical experts. Others are relatively simple, don't necessarily require special studies or even much technical expertise.

Generally, there have been two levels of effort in protecting ground water. One has been to focus on protecting entire aquifers; the other has been to focus on protecting the portions of aquifers that supply public drinking water The sensitive areas defined in each case are different.

Another group of sensitive area methods are designed to protect ground water at a particular location from a specific source of potential contamination--such as a landfill. In this case, the portions of an aquifer that would be most affected if contamination did occur are identified as sensitive areas.

Some of the sensitive area classification systems described below are actually a combination of these methods.

Systems that Focus on Protecting Aquifers

The sensitive area classification methods in this category involve identifying areas where human activities could contaminate an aquifer.

Some of these methods, such as the DRASTIC System described below, focus on the hydrogeologic conditions between the surface and the water table to identify sensitive areas. Sensitive areas are defined as the areas that could easily transmit contaminants to the water table.

Other methods involve deeper and more complex hydrogeologic investigations. In addition to evaluating hydrogeologic conditions above the water table, these methods examine the aquifer or aquifers that could be contaminated. Sensitive areas may be defined by their potential for damaging a number of aquifers or an especially important aquifer.

For example, if aquifers have been classified, areas that would transmit contaminants to a high ranked aquifer would be more sensitive than areas transmitting to lower ranking aquifers.

Classifying aquifers is a means of establishing which resources need to be protected most Usually, aquifers are classified by how much they are used. An aquifer may also be classified based on its capacity, its quality or its vulnerability to contamination or depletion. For example, the EPA proposed, in its Draft Ground Water Strategy, to classify aquifers as follows:

Class I	Special aquifers: those highly vulnerable to contamination or irreplaceable as a water supply.
Class II	All other aquifers that are current or potential drinking water sources.
Class III	Brackish or contaminated aquifers not usable as drinking water sources.

Washington's Department of Ecology is developing an aquifer classification system as part of the state ground water protection strategy. Aquifers will be classified based on their existing or potential beneficial use.

The following are two examples of sensitive area classification systems that focus on aquifer protection.

DRASTIC System

The DRASTIC system uses commonly available information to evaluate and rank ground water pollution potential. It involves first identifying key hydrogeologic parameters. These include:

- D = Depth to water table
- R = Recharge (net)
- A = Aquifer media
- S = Soil media
- T = Topography
- I = Impact of the unsaturated zone
- C = Conductivity (permeability) of the aquifer

A ranking system is then used to assign a number to each parameter The relative pollution potential is determined by adding these numbers. This information can then be used to develop maps showing areas that are most vulnerable to contamination

The DRASTIC system is recommended as one of the more easily implemented methods of identifying areas sensitive to contamination. It was developed for use by a wide range of people--including those with limited technical knowledge. DRASTIC is intended to be used for evaluating areas larger than 100 acres.

Copies of a report describing the DRASTIC method can be obtained from the Washington State Department of Ecology, the Environmental Protection Agency or the National Water Well Association.

Clover/Chambers Creek System

A recently completed study of the Clover/Chambers Creek area in Pierce County (Brown & Caldwell, 1985), uses another hydrogeologic rating system.

The Clover/Chambers Creek area is underlain by a thick sequence of complexly inter-bedded glacial and non-glacial sediments Within this sequence, four aquifers or potential aquifers and three confining beds were identified. The study defined seven degrees of surface sensitivity based on the presence or absence of the various confining beds. The least sensitive category includes areas capped with confining beds of glacial till, while the most sensitive category encompasses areas where all three confining beds are absent. In the former case, aquifers are protected from contamination by the glacial till. In the latter, aquifers are open to vertical contamination from the surface.

This system was developed based on a detailed knowledge of local geologic and hydrologic conditions. As a consequence, it is not generally applicable to other areas unless geologic conditions are similar.

Systems that Focus on Protecting Wells or Springs

This type of sensitive area classification identifies geographic areas within which development or other activities could impact a particular water supply source. These methods are usually applied to wells but can also apply to springs. The geographic area defined is called a well-head protection area. A well-field protection area is similar but covers more than one well. Once a well-head or well-field protection area has been identified it can be used as a basis for regulating land use and development within its borders.

A well-head protection area can be established without an indepth examination of hydrogeologic conditions. Such protection areas are often defined as a circular control zone around a well--for example, an area extending one mile in radius around a well. This area would be given a higher sensitivity rating than areas beyond the one mile radius. If the general direction of ground water flow is known, then an asymmetrical protection area may be outlined. In this case, there would be a larger area upgradient (where water is flowing towards the well) than downgradient of the well.

Conducting a hydrologic study to identify a well-head protection area generally involves identifying a well's area of influence. The area of influence is defined by the outer limits of the cone of depression formed by the well, and encompasses the areas of an aquifer that are drawn to the well.

Regional flow within the aquifer may also be taken into consideration in identifying well-head protection areas. This involves outlining the areas where ground water is flowing towards the well and will be intercepted by its cone of depression. By accounting for regional flow, the well-head protection area will encompass land beyond its immediate area of influence.

Figure 5.1 illustrates an area of influence in plan view and cross section. Note that leachate from hypothetical waste dumps may or may not reach the pumping well, depending on their location with respect to the ground water flow pattern.

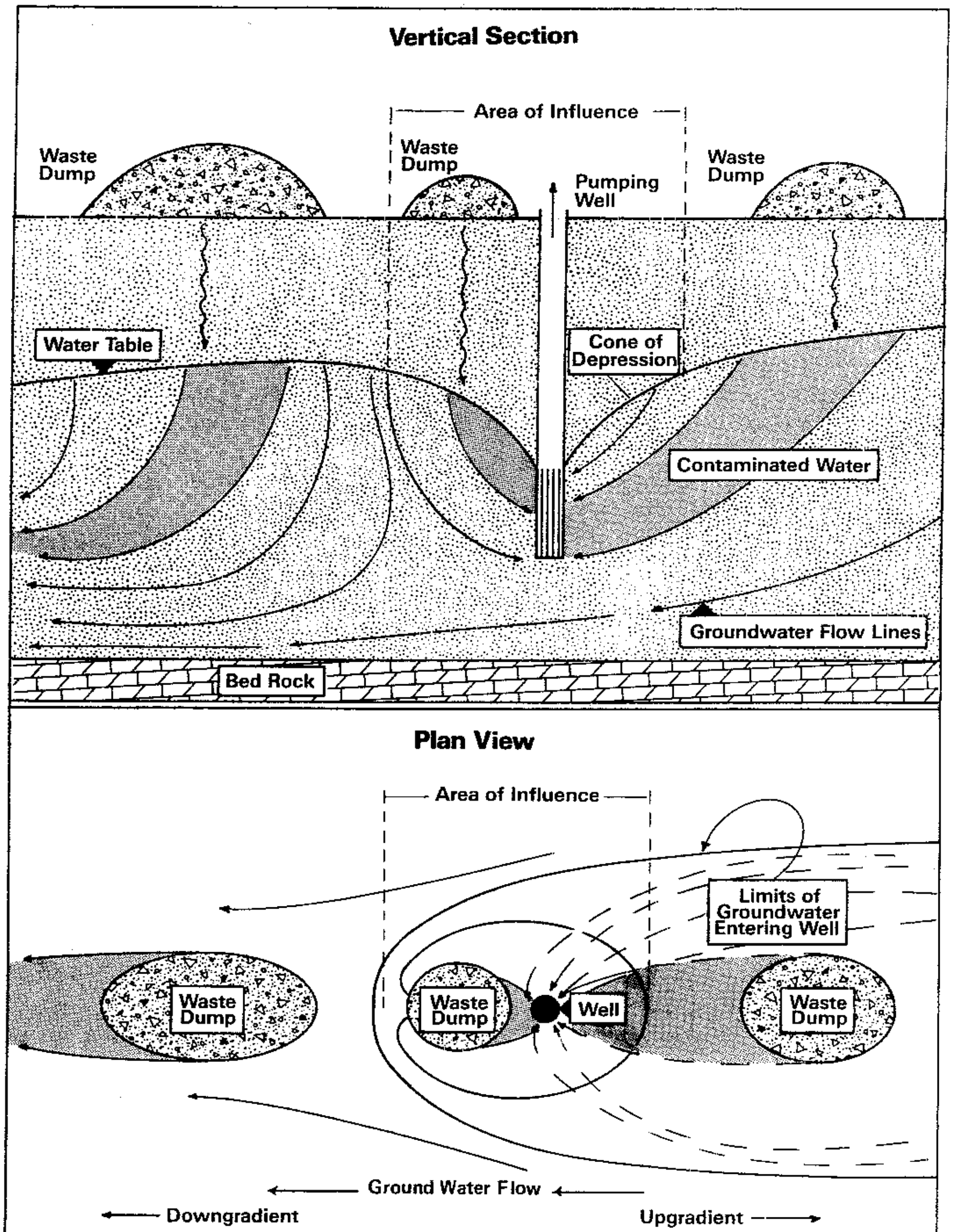

Figure 5.1 Area of Influence

Dade County System

Dade County, Florida has chosen to use a travel-time system to establish areas of influence and regulate land uses around a well. Under this system (DiNova & Jaffe, 1984), zones are outlined based on the time involved for ground water to reach a particular well. The zones are arranged concentrically around each well outlining areas from which ground water arrives within different time intervals. This system assumes that with longer travel times contaminants will be more attenuated.

The following table shows how septic systems are regulated based on these zones.

TABLE 5.1
Dade County Travel-Time System

Zone	Maximum Septic System Loading (gallons/day/acre)
10 day travel	140
30 day travel	350
100 day travel	600
210 day travel	800
> 210 day travel	1,500

Systems that Identify Ground Water Impacts of a Specific Contamination Source

These sensitive area classification systems are used to indicate what aquifers, portions of an aquifer or wells could be contaminated by a high-risk use such as a land fill. They are also used to compare the impacts of locating a high-risk use at one site versus another.

Such methods evaluate hydrogeologic factors, but may also reflect the value of aquifers and wells threatened by the contamination source or the relative level of health risk.

The two systems described below were developed to identify the impacts of hazardous waste facilities on ground water. They can also be used to evaluate the impact of other high-risk uses.

LeGrand System

The LeGrand System assigns numerical values to factors intended to reflect the hydrogeologic vulnerability of areas to ground water contamination. It also assigns values to parameters intended to represent resource value and degree of threat. Factors included in the LeGrand system are:

- o Distance between contamination source and water supply
- o Depth to water table
- o Hydraulic gradient (slope)
- o Permeability

- o Degree of confidence in values
- o Degree of seriousness, including contaminant toxicity, importance of aquifer, and general aquifer sensitivity

A report describing the LeGrand system is available from the National Water Well Association.

Hazard Ranking System (HRS)

The EPA Hazardous Waste Site Ranking Model or Hazard Ranking System (HRS) also assigns numbers to factors intended to represent resource value and degree of threat.

HRS factors are ranked and added to provide an overall risk rating. The factors include:

- o Measured level or evidence of contaminants
- o Depth to aquifer
- o Net precipitation
- o Permeability of unsaturated zone
- o Method of waste management
- o Physical state of wastes
- o Contaminant persistence in the environment
- o Contaminant toxicity/infectiousness
- o Total waste quantity
- o Ground water use
- o Distance to nearest downgradient well
- o Population served by ground water within a 3-mile radius

Information on the HRS system can be obtained from the Seattle Regional Office of the U.S. Environmental Protection Agency.

SENSITIVE AREA CLASSIFICATION SYSTEMS AND THEIR USE IN PLANNING

Sensitive area classification systems that focus on protecting aquifers, such as the DRASTIC and Chambers/Clover Creek sysems, involve regional ground water assessments. As a result, they can be used as a comprehensive land use planning tool. They can help in evaluating the ground water impacts of development and in making comprehensive land use and zoning decisions that will protect ground water.

Sensitive area classification systems that focus on protecting water supply sources. such as the Dade County System, involve a more limited geographic assessment of ground water. They can be useful, on a smaller scale, in making land use and zoning decisions. More often, however, these systems are used as a basis for restricting development or regulating activities within well-head protection areas.

Sensitive area classification systems that identify the ground water impacts of a contamination source, such as the LeGrand or Hazard Ranking System, also involve limited geographic assessments of ground water. These methods are most often used to select the best location for specific high-risk uses. They can also be used as a basis for developing special design and operating standards to mitigate the impacts of such uses

HIGHLIGHTS OF CHAPTER 6

PROTECTING GROUND WATER THROUGH LAND USE AND DEVELOPMENT CONTROLS

HOW TO INCORPORATE GROUND WATER PROTECTION INTO THE COMPREHENSIVE PLAN

- **Identifying Ground Water Protection Goals**
- **Mapping Ground Water Protection Areas in the Plan**
- **Selecting Appropriate Land Use and Development Controls**

LAND USE AND DEVELOPMENT CONTROLS THAT CAN BE USED TO PROTECT GROUND WATER

- **Using Zoning and Subdivision Controls to Protect Ground Water**
  - Changing Zoning Designations
  - Creating Zoning Overlays
  - Amending Subdivision Regulations and Related Ordinances
- **Using Other Regulatory Methods to Protect Ground Water**
  - Building Permits
  - On-site Waste Disposal Permits
  - Well Site Approvals
  - Other Permits
- **Using Non-regulatory Methods to Protect Ground Water**
  - Water Conservation Programs
  - Land Acquisition
  - Transfer of Development Rights (TDR)

CHAPTER 6

PROTECTING GROUND WATER THROUGH LAND USE AND DEVELOPMENT CONTROLS

INTRODUCTION

Chapter 6 describes how ground water protection can be incorporated into a comprehensive land use plan and what to consider when formulating local ground water protection goals and priorities. It describes how land use and development controls, such as zoning or subdivision regulation, can be used to protect ground water and what to consider before choosing a course of action.

HOW TO INCORPORATE GROUND WATER PROTECTION INTO THE COMPREHENSIVE PLAN

One of the primary roles of local government is to manage growth and development. The regulatory authority to do so is provided under several state planning laws--the Planning Commission Act, Optional Municipal Code, and the Planning Enabling Act. These laws require local government to prepare comprehensive land use plans as a foundation for its regulatory actions. A comprehensive plan must estimate population growth, indicate the location of land uses and recommend development density.

With passage of House Bill 1138 in 1984, (see Appendix I) comprehensive plans must also provide for protecting the quality and quantity of ground water used for public water supplies. The bill, in effect, directs local government to use development controls to protect ground water.

The most widely applied development controls in Washington State are zoning and subdivision regulation. As a result, the following discussion emphasizes protecting ground water by these methods. However, as will also be discussed in this chapter, there are other regulatory and non-regulatory measures that can be used to protect ground water.

At least three major elements can be included in a comprehensive plan to protect ground water:

1. A set of ground water protection goals
2. A map or other means of identifying which ground water resources are to be protected
3. A set of recommended measures, in the form of objectives or policies, to be implemented by local government to achieve its goals

The following outlines what to consider in developing these elements.

Identifying Ground Water Protection Goals

Ground water protection goals may vary substantially from one local government to the next. This is to be expected, especially in a state as geographically diverse as Washington. Ground water resources, ground water problems, and ground water protection needs vary from community to community. Nevertheless once ground water resources are identified, each community will have to decide both what to protect and how that protection will be provided. This should be made evident in its ground water protection goals.

Both aquifers and water supply sources (wells or springs) can be considered ground water resources. Nationally, the resource protection efforts of local governments have fallen into three categories: those that focus on protecting aquifers, those that focus on protecting the portions of aquifers that supply public water sources, and those that do both.

Whether a community chooses to protect aquifers, public water supply sources or both, addressing the following issues can be helpful in deciding what ground water resources need more protection than others. These issues reflect two basic concerns: the relative value of the resource, and the extent to which the resource is threatened.

1. Resource capacity:
   - o How much water is the aquifer capable of providing on a sustained basis?

2. Resource quality:
   - o How free of natural or man-introduced contaminants, (i.e., how suitable for drinking?) is the aquifer or water source?

3. Existing or potential use of the resource:
   - o Is the aquifer or water source being used now and if so, for what uses?
   - o Is it needed for future use and if so what are the potential uses?

4. Local water supply options:
   - o Is the aquifer the only source of water available to the community or are alternative sources available?

5. Existing ground water depletion problems:
   - o Are aquifers or water sources showing signs of depletion?
   - o How severe is the problem?
   - o Can the problem be halted or corrected?

6. Potential ground water depletion problems:
   - o Which aquifers or water sources are vulnerable to depletion due to existing or proposed land uses?
   - o Which are vulnerable due to future demand for water exceeding resource capacity?

7. Existing ground water quality problems:
   - o Are aquifers or water sources showing signs of ground water contamination?
   - o How severe is the problem--is there a health risk?
   - o Can the problem be halted or corrected?

8. Potential ground water quality problems:
   - o Which aquifers or water sources are most vulnerable to future contamination due to hydrogeologic sensitivity?
   - o Which are vulnerable to contamination due to existing or proposed land uses or development activities?

Not every local government will have the financial resources to conduct the ground water research necessary to address all of these questions. Regardless of financial resources, however, local governments should be able to develop a list of basic ground water protection goals and priorities by considering these kinds of issues.

A good example of ground water protection goals and policies are those developed by the Tacoma Planning Department, which are included in Appendix III.

Mapping Ground Water Protection Areas in the Plan

Once a community has identified what ground water resources need to be protected, sensitive areas should be identified and outlined as ground water protection zones. Sensitive areas, or ground water protection zones, should be shown on a map in the comprehensive plan document or in a document appending the comprehensive plan. The precision or accuracy of the map or maps prepared will vary depending on the level of resource information each agency has been able to gather.

Selecting Appropriate Land Use and Development Controls

Just as ground water protection goals and priorities will vary from one local government to the next, so will the means by which those goals are implemented. At a minimum, local government should examine how its land use plan conforms with its ground water protection goals and how zoning can be used to implement those goals. Some communities may want to consider a broader range of possible controls. Regardless of the scope, the following should be considered:

1. <u>The type of protection needed</u>

   The development controls that will protect ground water in one setting may not work in another. For example, controlling land use and density through zoning may protect ground water in relatively undeveloped areas that have no ground water problems. However, zoning alone would probably not be enough to protect ground water in more developed areas, especially if ground water problems already exist. In this case it would be better to use controls that would alter existing development practices--particularly those associated with ground water problems. Controls might include, for example, new standards for disposal of domestic or industrial wastes.

2. <u>The role of local government versus state government in protecting ground water resources</u>

   Some ground water problems may already be addressed or may be more appropriately addressed by state agencies. Table 6.1 indicates when state agencies have primary responsibility for regulating a potential contamination source and when local governments are responsible. Note that for several sources, such as septic systems, as many as three agencies are listed. This indicates that regulatory responsibility is shared. The first agency listed is generally responsible for issuing the most permits. The second and third listed may issue permits to larger operations or may be responsible for enforcement actions.

TABLE 6.1

GROUND WATER PROTECTION RESPONSIBILITIES

SOURCE	AGENCY
Landfills	Local, Ecology
Impoundments	Ecology
Septic systems	Local, DSHS, Ecology
Lagoons	Ecology
Storage tanks	Local, Ecology
Spills	Ecology
Radioactive waste	Ecology
Hazardous waste	Ecology
Agricultural runoff	WDA, Ecology
Seawater intrusion	Ecology, DSHS
Disposal wells	Ecology
Abandoned wells	Ecology
Oil/gas wells	DNR, Ecology
Stormwater runoff	Ecology, Local
Aquifer recharge	Ecology, Local
Mining	DNR
Mining wastes	Ecology
Sludge disposal	Ecology
Land activities	Local
Public drinking water	DSHS

Ecology - Department of Ecology
DSHS - Department of Social and Health Services
DNR - Department of Natural Resources
WDA - Washington Department of Agriculture

LAND USE AND DEVELOPMENT CONTROLS THAT CAN BE USED TO PROTECT GROUND WATER

The following section describes a variety of land use and development controls local governments can use to protect ground water resources.

Using Zoning and Subdivision Controls to Protect Ground Water

Zoning is one of the principal means by which the land use element of a comprehensive plan is implemented. It can also be an effective tool for protecting ground water. Zoning can be used to prohibit land uses that cause ground water problems, or to enforce special conditions designed to mitigate potential problems. It can also be used to limit development density and control population growth--all of which can help protect ground water.

Zoning has been used to protect ground water in primarily two ways. One involves simply rearranging or changing zoning designations. The other involves creating special overlay zones.

Changing Zoning Designations

If there is evidence that ground water may be adversely affected by the uses, density or overall population growth allowed under existing zoning patterns, zoning designations can be changed. This does not necessarily require developing new zoning categories.

For example, if existing zoning would allow heavy industrial development in what has been identified as a ground water protection area, it may be appropriate to change the zoning to a less intensive and less hazardous use--such as a low density residential use.

Zoning can also be used to prevent water resources from being over-taxed. For example, if existing zoning would allow high density development where water supplies are limited, the zoning can be changed (down zoned) to designations that would allow less development.

Application: Changing zoning designations is most effective for protecting ground water resources when applied to areas that are relatively undeveloped or where ground water problems have not yet occurred. It is the simpler of the two zoning approaches cited because it does not involve creating a new zoning classification.

It is unlikely, however, to remove all potential hazards to ground water. For instance, although a low density residential use would be a better choice than industrial development in the example cited above, there might also be hazards to ground water associated with residential use--contamination from septic systems for example. Unless special conditions are attached or written into the zoning classification itself, this type of problem would have to be addressed by other means.

Example: This approach has been used in King County to help protect the ground water resources of Vashon Island. A study of the Island's ground water resources concluded the island cannot support a great number of people (an estimated maximum of about 13,000) and that septic systems pose a serious threat to ground water quality. Based on the study, extensive areas of the island have been down zoned from as high as three homes per acre to as low as one home per ten acres. Down zoning is intended both to limit population growth within the estimated capacity of the resource and to protect ground water from contamination.

Creating Zoning Overlays

Overlay zoning can be used in combination with a conventional zoning system to create special regulatory districts designed to protect ground water.

An overlay zone adds development regulations to those already enforced by local government. It is generally applied to areas that have been singled out for special protection. Additional regulations enforced through an overlay zone can cover the full range of activities that are normally regulated by local governments

Application: Creating an overlay zone is one way to protect ground water from potentially hazardous uses or activities that would not be adequately dealt with through existing zoning controls or other regulations It would generally be a more effective approach, compared to simply changing designations, in developed areas and areas that already have ground water problems. It offers the opportunity not only to prevent ground water problems but to halt or modify practices that may be contributing to groundwater problems

Overlay zoning can be more difficult to implement than simply changing zoning designations. This is because creating an overlay zone requires delineating the area within which special controls and standards will be enforced--as well as defining what those controls and standards will be. It will generally require a higher level of information about the resource in order to adequately map protection areas. It may also require a more sophisticated understanding of how development affects ground water resources and the means by which those impacts can be mitigated.

Examples: Many communities in Washington already use this approach to protect other sensitive areas such as wetlands, steep slopes or flood hazard areas A few are using it to protect ground water.

Spokane County has developed overlay zoning to restrict development in what have been identified as aquifer sensitive areas. The zoning ordinance requires that all new development in aquifer sensitive areas be connected to existing sewer facilities If the area is unsewered, then a five acre minimum lot size is required. However, property owners are required to connect to public sewer lines whenever they become available.

Overlay zoning is also being proposed in Tacoma to prevent further contamination of an aquifer which provides up to 40% of the city's water supply. An overlay zone would be applied to regulate development above the aquifer The area involved is primarily developed and includes a number of small commercial and industrial uses which were found to be the major source of contamination. Special regulations would be imposed on users and handlers of toxic and hazardous materials within the overlay zone. Some land uses would be prohibited outright. There would be new permit requirements for hazardous material storage or handling facilities, new engineering standards for construction of such facilities, and additional on-site monitoring and inspection requirements The overlay zone would also impose restrictions on the amount of impervious surface coverage allowed for residential, commercial and industrial uses.

Amending Subdivision Regulations and Related Ordinances

Subdivision regulations complement the zoning powers of local government and, like zoning, can be modified to protect ground water

Subdivision regulation is used to control how vacant land is converted into lots and actually developed Proposed subdivisions are reviewed by local government and approved if they meet local development standards. These standards are usually outlined in a subdivision ordinance or in a series of development-related ordinances that apply to subdivisions. In many cases, the standards applied could have an impact on ground water resources. Typically, they address the adequacy of water supply and waste disposal systems, clearing and grading procedures, drainage control systems, erosion control methods, landscaping and open space preservation.

In most cases, such standards can be revised to offer better ground water protection. For example, water supply systems might be required to meet new water conservation standards. Waste disposal standards could require the use of superior waste disposal methods. Grading and drainage standards could require features, such as swales or retention basins, that would promote ground water recharge. Landscaping standards could be used to encourage water conservation by requiring drought tolerant plant species, or limiting areas that need heavy watering. Open space standards could be used to discourage development over sensitive ground water areas within a proposed subdivison.

Application: Although not useful for protecting ground water in areas that are already developed, amending subdivision and other development-related regulations offers a way to mitigate some of the ground water impacts that occur with new development. Amendments can be made to apply to all new development in a community or, through an overlay zone, to new development within designated ground water protection areas.

Using Other Regulatory Methods

Local governments regulate a variety of other development activities that can affect ground water, based on building, health and sanitary codes. For example, they issue building permits, septic system permits, well site approvals, underground storage tank permits and permits for solid waste disposal facilities.

For the most part, local governments are responsible for enforcing minimum standards established by the state. However, local regulations may exceed state standards if necessary to protect ground water resources.

Communities wishing to take a more comprehensive approach to protecting ground water should examine the entire range of activities undertaken by local government to identify how existing regulations or standards may be changed. The following suggests how, through some of these activities, this can be achieved.

Building Permits

Building permits are issued by local building departments subject to regulations governing the design and installation of structures. Local building codes can be amended to protect ground water resources through water conservation. This can be done by requiring water conserving design features in all new development or development in specified ground water resource protection areas.

Application: Encouraging water conservation through local building codes may be particularly useful in areas where ground water supplies are limited.

Examples: This approach has been used in California, where building codes have been amended to require water-conserving plumbing fixtures or plumbing fixtures that recycle water.

On-Site Waste Disposal Permits

Permits for septic systems or other on-site waste disposal systems are primarily issued by local health departments, although some are issued by state agencies (Ecology and DSHS). Permits are issued subject to state regulations governing the design, installation and maintenance of these systems. Although state standards for on-site waste disposal systems are intended to protect ground water resources from contamination, certain communities may find they do not go far enough. If this is the case, additional standards or conditions may be applied by amending local on-site waste disposal regulations.

Application: This approach may be useful in areas where ground water contamination from septic systems is an existing or potential problem.

Examples: On Vashon Island, where ground water contamination from septic systems is a potential threat, citizens recommended that King County require regular pumping of septic systems as a condition of permit approval. Some counties in Wisconsin require septic systems to be pumped every three years

Another approach, used in California and Ohio, involves setting up septic system maintenance districts. These are special purpose units of government that set and enforce septic system design and maintenance standards. Routine pumping and replacement of failing systems is undertaken by the district using revenues from special assessments

Well Site Approvals

In Washington, local health departments approve the siting of wells based on state standards which require water purveyors to establish well-head protection areas. Land within a specified circumference of the source (200 feet for dug wells or springs, 100 feet for drilled wells) is to be kept free of potential contamination sources, such as septic systems. State regulations allow local health departments to require even larger protection areas if it appears more protection is needed. Where contamination of public water supplies is a concern, local health departments can be encouraged to use this authority more aggressively.

Application: Establishing larger well-head protection areas, through well site approvals, can help prevent the contamination of wells -- especially in problem areas. The major difficulty in doing this is deciding how large a protection area should be. Although not necessary in all cases, this is sometimes done based on special hydrologic studies--as outlined in Chapter 5.

Other Permits

Other permits issued by local governments which can affect ground water include permits for solid waste disposal and underground storage facilities. Generally, health departments issue permits for solid waste disposal facilities and fire departments issue permits for underground storage facilities. As in the previous examples, these facilities are subject to minimum state standards governing siting, design, construction or maintenance which local governments can add to if necessary.

Using Non-Regulatory Methods to Protect Ground Water

Water Conservation Programs

Water conservation can be an effective means of protecting ground water by reducing its consumption. Water conservation programs have been able to decrease water use by as much as 50%. Conservation can be achieved through measures such as installing watersaving plumbing fixtures, recycling water, repairing leaky pipes or instituting a progressive rate fee for water use. In the case of the latter, water users are charged at a higher rate for water consumed beyond a certain level.

Application: Water conservation can be implemented through a variety of means including permit requirements, water use penalty fees, or voluntary efforts encouraged by government sponsored educational programs. It is a useful approach wherever ground water supplies are limited.

Land Acquisition

One of the most effective means of protecting sensitive areas from adverse development impacts is public land acquisition. This can include outright acquisition or acquisition of conservation easements.

Land acquisition is commonly used to acquire watersheds or areas of influence associated with a public water supply source. In such cases, most other uses of the property are prohibited. However, government land acquisition programs for parks or other public uses can also be used to protect ground water. For example, in acquiring land for public parks, local governments can buy parcels which both meet recreation needs and protect a sensitive ground water area from development.

Application: Most communities will be unable to afford extensive land acquisition programs. Therefore land acquisition should be used where it will do the most good--in highly sensitive ground water resource areas where other means of protection may be insufficient

Transfer of Development Rights (TDR)

A transfer of development rights (TDR) program can also be used to protect sensitive areas from development. TDR is based on the notion that land ownership consists of rights that can be separated and sold individually These rights include being able to build at the densities alllowed by zoning.

Under a TDR system, the right to develop at a certain density for a particular use may be sold and conferred to another piece of property The property from which development rights have been sold may lose some or even most of its development potential, while the property to which those rights have been transfered will be allowed to develop at a higher density In this way, development can be restricted in one area and expanded in another without actually changing zoning designations Property owners who lose development potential are compensated for the loss. At the same time, those who gain from the transfer must pay.

To implement a TDR program, areas in which development is to be restricted are delineated in a comprehensive plan or on a zoning map These are the areas from which development rights may be sold. Similarly, areas in which development is to be encouraged are delineated. These are the areas to which purchased development rights may be added.

Application: TDR can be used to protect ground water resources in highly sensitive areas where it may be appropriate to discourage almost all development. It can also offer a less costly alternative to outright acquisition of land. However, a development rights transfer program may require more administrative expertise than some of the traditional regulatory techniques discussed earlier in this chapter, and examples of successful TDR programs are rare.

HIGHLIGHTS OF CHAPTER 7

SOURCES OF INFORMATION AND ASSISTANCE FOR GROUND WATER PROTECTION

FEDERAL AGENCIES

United States Geological Survey (USGS)
- Hydrologic Information
- Geologic Information
- Land Use and Topographic Information
- Special Programs
- Libraries
- Addresses

Environmental Protection Agency (EPA)
- Hydrologic Information
- Library
- Addresses

Soil Conservation Service (SCS)
- Soil Information

National Climatic Data Center (NCDC)
- Climatic Data
- Addresses

STATE AGENCIES

Washington State Department of Ecology
- Water Quantity Information
- Water Quality Information
- State Ground Water Quality Management Strategy
- Special Programs
- Addresses

Department of Social and Health Services (DSHS)
- Water Quality Information
- Special Program
- Addresses

Department of Natural Resources (DNR)
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Washington Department of Agriculture (WDA)
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OTHER SOURCES OF INFORMATION

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Public and Private Water Suppliers

Well Drillers and Septic System Installers

Universities and Colleges

Planning Advisory Service

INFORMATION SOURCES SUMMARY

CHAPTER 7

SOURCES OF INFORMATION AND ASSISTANCE FOR GROUND WATER PROTECTION

INTRODUCTION

This chapter describes which federal, state and local agencies, and private contractors may have information that could be useful in identifying local ground water resources and ground water problems. Special programs or services offered by agencies that could be used to help local ground water protection efforts are also described.

FEDERAL AGENCIES

United States Geological Survey (USGS)

The USGS provides much of the nation's geologic, topographic and hydrologic information. This information includes maps, data bases, descriptions and analyses of ground water resources. The USGS has no regulatory authority, but the information it provides supports the regulatory activities of other federal, state and local agencies.

There are two central offices of the USGS in Washington State: the Water Resources Division in Tacoma and the Geologic Division in Spokane.

Hydrologic Information

Providing and interpreting hydrologic data are the primary functions of the USGS Water Resources Division. Through studies conducted by the division, often in cooperation with state and local agencies, a variety of hydrologic maps and reports have been produced

To date, a general aquifer map has been prepared covering the entire state of Washington. More detailed aquifer maps have been developed for special study areas such as Island County, Bainbridge Island, the San Juan Islands and the Columbia Basin Plateau. The agency also has a substantial amount of computerized information on state ground water quality and water supply capacity. Other information available from the Water Resources Division includes: ground water flow maps, maps indicating depth to ground water, maps indicating the permeability of rocks, instream water quality information, and ground water models

To find out about hydrologic maps or publications that cover a particular area of the state, contact the Information Officer at the Water Resources Division of the USGS in Tacoma. USGS will mail a printout indicating the published information available for that area and where to order copies.

Geologic Information

The Geologic Division of the USGS provides and interprets geologic data. Like the Water Resources Division, it produces a variety of maps and publications. These include maps and descriptions of surface and subsurface materials.

For information about geologic maps or publications for the state, contact the Information Officer at the Geologic Division of the USGS in Spokane.

Land Use and Topographic Information

The USGS National Cartographic Information Center distributes maps and data produced under the National Mapping Program Aerial photographs, topographic maps, land use and land cover maps are available for Washington State. National Mapping Program Map Data Catalog describes this information and explains how to order. The catalogue is for sale at the U.S. Government Printing Office.

Special Programs

Under the USGS Federal-State Cooperative Program, the Water Resources Division conducts special hydrologic studies or projects of state and local concern. These are generally funded up to 50% by USGS and 50% by state and local government. **For more information about the Federal-State Cooperative Program, contact the Washington Chief of the USGS Water Resources Division.**

Libraries

Both the Tacoma and Spokane offices of the USGS have excellent libraries which are open to the public; however, materials are not available for loan.

Addresses

- USGS Water Resources Division
  1201 Pacific Avenue, Suite 600
  Tacoma, WA 98402
  Phone: (206) 593-6510

- Water Resources Division Information Officer
  (same address and phone number as above)

- Washington Chief, USGS
  (same address and phone number as above)

- USGS Geologic Survey
  656 U.S. Courthouse
  Spokane, WA 99201
  Phone: (509) 456-4677

- Geologic Division Information Officer
  (same address as above)
  Phone: (509) 456-2524

- USGS National Cartographic Information Center
  345 Middlefield Road
  Menlo Park, CA 94025
  Phone: (415) 323-8111, Ext. 2427

Environmental Protection Agency (EPA)

EPA developed a national strategy for ground water protection following a comprehensive evaluation of federal, state and local ground water protection programs. A major part of the agency's strategy is to provide financial and technical support to state and local governments in their efforts to develop ground water protection programs. EPA also provides financial support to state agencies in carrying out the provisions of federal ground water-related legislation (the Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act and Comprehensive Environmental Response Compensation and Liability Act) and technical support in developing health advisories and drinking water standards.

EPA's regional offices are located in Seattle. Ground water related programs are carried out by the Water Division, Air and Toxics Division, Hazardous Waste Division, and the Environmental Services Division.

Hydrologic Information

While EPA's monitoring efforts have not been as extensive as those of other agencies, it does have water quality information for some locations. EPA has monitored ground water quality in connection with Superfund sites, hazardous waste sites and special problems, such as pesticides contamination. EPA is developing a computerized data system that will compile all of the ground water quality information EPA has collected in Washington State. Except where data are enforcement sensitive, EPA data is also turned over to the State Department of Ecology or Department of Social and Health Services. **For more information about EPA involvement in ground water, contact the Water Division's Office of Ground Water.**

EPA also publishes educational information on ground water protection for public distribution. A list of current publications can be obtained from the EPA Publications Clerk.

Library

EPA has a library where most EPA technical publications as well as additional materials on ground water resources can be reviewed. Only EPA publications are available for loan.

o EPA Office of Ground Water, Region 10
1200 - 6th Avenue
Seattle, WA 98101
Phone: (206) 442-1086

o EPA Publications Clerk - Mailstop 541
(same address as above)
Phone: (206) 442-1259

o EPA Library
(same address as above)
Phone: (206) 442-1289

Soil Conservation Service (SCS)

The Soil Conservation Service is a branch of the United States Department of Agriculture. One of the primary purposes of the SCS is to provide and interpret soil information.

The head offices of the SCS are located in Spokane. Additional administrative offices are located in Olympia, Yakima and Ephrata. Field offices are located in most counties.

Soil Information

The SCS produces a series of maps which locate and classify soils based on their physical properties. Soil survey maps are available for most of Washington State. The maps are accompanied by text describing soil characteristics. Some interpretation is provided of the suitability of soils for such uses as septic tank filter fields, sanitary landfills, building foundations or agriculture.

The SCS is also available to provide some technical assistance in interpreting soils information. For example, based on its soils data, the SCS may be able to identify potential threats to ground water posed by a specific land use or development proposal.

For information about soil survey maps or technical assistance from SCS staff, contact the SCS field office in your county. Field offices are listed under the United States Department of Agricuture in the telephone book.

National Climatic Data Center (NCDC)

The National Climatic Data Center (NCDC) is a branch of the National Oceanic and Atmospheric Administration (NOAA). The purpose of the agency is to record and store weather data from weather stations throughout the country. The NCDC is located in North Carolina -- there are no branch offices in Washington.

Climatic Data

NCDC collects and publishes monthly and annual weather data summaries for the state It issues separate summaries for climatological data, hourly precipitation, storm data and comparative climatic data The climatological summaries include precipitation and related data used in ground water resource investigations. Monthly or annual data summaries are available for all of the years official weather stations have operated in the state. **For copies of weather data summaries, contact the NCDC in North Carolina.**

The National Oceanic and Atmospheric Administration (NOAA) recommends contacting the State Climatologist for additional weather data. According to NOAA, the State Climatologist may have more current data, as well as historical data, not available through the NCDC. The State Climatologist is located at Western Washington University Office hours are Monday, Wednesday and Friday until noon.

Addresses

o National Climatic Data Center
Printing and Publication Distribution Center
Asheville, NC 28801
Phone: (704) 259-0682

o State Climatologist
Western Washington University
Department of Geography
Arentzen Hall 20B
Bellingham, WA 98225
Phone: (206) 676-3116

STATE AGENCIES

Washington State Department of Ecology

The Department of Ecology has the most comprehensive role in protecting and managing Washington State's ground water resources. The agency is responsible for enforcing a number of federal and state ground water protection laws and is concerned with both ground water depletion and quality issues.

Ecology's main offices are located in Olympia and Lacey. Regional offices are located in Yakima, Spokane, Redmond and Tumwater.

Water Quantity Information:

Ecology's Water Resources program oversees the allocation and use of all ground waters within the state The agency has broad powers to prevent ground water depletion -- including the authority to close an aquifer to further use.

Ecology has started mapping some aquifers in the state to identify water supply availability. Ecology and USGS are also conducting an ambient ground water level monitoring program to detect aquifer depletion. Aquifer mapping projects have focussed primarily on water resource problem areas in eastern Washington including Adams, Grant, Lincoln and Okanogan counties. **For information on aquifer maps, on known or potential areas of ground water depletion, or on ground water use, contact the Ecology Water Resources Program.**

The Water Resources program is also charged with keeping a record of all water well reports, also referred to as well logs, filed under WAC 173-160-050. The primary purpose of a well log is to record information on water resources. A well log must be filed for any well drilled in the state and should describe the well location, static water level, well capacity and the depth to various materials drilled through. Well logs can be used to map well locations, identify ground water levels, and subsurface geology. However, well logs must be used with caution because information is not always accurately recorded. **Well log information for a particular area of the state can be obtained by contacting the Water Resources division, or one of the four regional Ecology offices.**

Water Quality Information:

Several divisions of Ecology are involved in regulating potential ground water contamination sources. As part of this activity, they also compile water quality data Potential contamination sources regulated by each division are summarized below:

- Operations and Enforcement: Impoundments, lagoons, spills, saltwater intrusion, disposal wells, mining wastes, sludge disposal. Shares responsibility with local government for storage tanks and septic tanks.

- Water Quality: Oversees all water quality program activities; develops UIC program; provides technical guidance and policy oversite for ground water management; cooperates with Washington Department of Agriculture and Soil Conservation Districts to control pesticide contamination and develop best management practices; cooperates with Washington Department of Social and Health Services to protect public water supplies.

- Water Resources: Abandoned wells, monitoring wells and aquifer recharge.

- o Program of Solid and Hazardous Waste: Shares responsibility with local government for landfills; develops policy, regulations and programs for hazardous and solid waste handling and disposal.

At present, Ecology's water quality data is not centralized. **Each Ecology division must be contacted for water quality information with respect to the contamination source it regulates.** Also, where regulatory authority is shared with another agency, the other agency should also be contacted for information.

Ecology's Water Quality program has developed a set of large presentation maps that show existing and potential ground water quality problem areas in the state. The maps are based on existing land use and aquifer information and are intended for educational use. Smaller maps (11"x17") have also been prepared. Ecology staff are available to present and explain the maps to local jurisdictions. **For more information about the ground water quality maps of Washington contact the Water Quality Program.**

State Ground Water Quality Management Strategy

Ecology's Water Quality Program is charged with defining the agency's ground water policy. The division has also been charged with developing a ground water quality management strategy for the state. The strategy will guide the efforts of the state ground water management program initiated by passage of SHB 232 described below. **The state ground water quality management strategy is outlined in a report available from the Water Quality Program.**

Special Programs

A bill passed in 1985 by the Washington State legislature, SHB 232 (codified as RCW 90.44.400), created a program of assistance to local government for protecting and improving ground water resources. In the 232 program, local governments initiate a process that will, with guidance and technical assistance from the Department of Ecology, result in the development of comprehensive ground water management plans and programs. Basic funding support from the state can be up to 50 percent (75 percent for Conservation Districts). Eligible applicants are ranked for priority in receiving funds, with highest priority going to areas where ground water quality is "imminently threatened." A publication entitled Guidelines for Development of Ground Water Management Areas and Programs describes the 232 program and application process in detail. It is available at no cost from the Department of Ecology's Office of Water Quality.

For more information on the "232" process program and other programs or sources of funding available for ground water protection planning, contact Ecology's Water Quality Program.

Addresses

- o Washington State Department of Ecology
  Operations and Enforcement
  Abbott Raphael Hall
  Mailstop PV-11
  Olympia, WA 98504
  Phone: (206) 459-6000

- o Water Quality Program
  (same address and phone number as above)

- o Water Resources Program
  Baran Hall
  Mailstop PV-11
  Olympia, WA 98504
  Phone: (206) 459-6770

- o Program of Solid and Hazardous Waste
  4224 - 6th Ave. S.E., Bldg. 4
  Lacey, WA 98503
  Phone: (206) 459-6322

Department of Social and Health Services (DSHS)

Water Quality Information

The Washington State Department of Social and Health Services (DSHS) and local health departments share responsibility for enforcing federal and state drinking water standards. As part of this effort, suppliers of public and private drinking water systems are required to test water samples for contaminants at least every three years. These data are submitted to DSHS, which maintains Washington State's largest water quality data base. **For information on water quality data, first contact the nearest DSHS regional office. Additional information may be available from the Water Supply and Waste Section in Olympia. For computerized data contact the Water Facility Inventory in Olympia.**

DSHS shares review and approval of on-site sewage disposal systems with Ecology and local health departments. Although local health departments review most septic system permits, some larger systems are reviewed by DSHS. **For information on the location of septic systems approved by DSHS, as well as information about septic system failures or potential ground water contamination from septic systems, contact the nearest regional office. Additional information may be available from the Water Supply and Wastewater Section in Olympia.**

Special Programs

DSHS administers the Public Water System Coordination Act (Chapter 248.56 WAC). Under this act, areas identified as having inadequate public water supplies, because of poor water quality, unreliable service or lack of coordinated planning, can be declared critical water supply service areas. The declaration is issued by DSHS or by the local government. Then DSHS works with the local government to develop long range planning and management programs. This involves coordinating water service providers and developing mutual design standards among systems.

State support is available for accomplishing the studies conducted under the Public Water System Coordination Act. The Public Water System Coordination Act has been or is being used in Clark, Grant, Island, Jefferson, King, Pacific, Pierce, San Juan, Skagit, Spokane, Thurston and Walla Walla counties. **For information on the Public Water Systems Coordination Act, contact the DSHS Water Supply and Wastewater Section, Planning Program.**

Addresses

- o Department of Social and Health Services
  Water Supply and Wastewater Section
  Olympia, WA 98504
  (206) 753-3466

- o Water Facility Inventory
  (206) 753-3520

- o Planning Program
  (206) 753-5986

- o DSHS Northwest Regional Office
  217 Pine Street - Room 220
  Seattle, WA 98101
  Phone: (206) 464-7670

- o DSHS East Regional Office
  West 924 Sinto
  Spokane, WA 99201
  Phone: (509) 456-3115

- o DSHS Southwest Regional Office
  Mailstop LD-11
  Olympia, WA 98504
  Phone: (206) 753-3466

Department of Natural Resources (DNR)

The Department of Natural Resources through the Geology and Earth Resources Division, is responsible for the efficient use and development of the state's natural resources. This includes locating and characterizing its oil, gas and geothermal resources. The agency is also responsible for enforcing three state laws which protect ground water: the Surface Mined Land Reclamation Act, the Oil and Gas Conservation Act, and the Geothermal Resources Act

Geologic Information

DNR publishes a series of maps, open file reports, bulletins, information circulars, and reports of investigation which contain valuable information about local geologic conditions. Generally, this information will be more useful to a ground water consultant than to a planner, but may still be a source worth pursuing. **A geologic publications list is available and can be obtained by contacting DNR division offices in Lacey.**

Library

The Geology and Earth Resources Division maintains a comprehensive library on the hydrology, geology, geochemistry and mineral resources of Washington State. The library is located at the division's offices in Lacey and is open to the public.

Address

- o Department of Natural Resources
  Division of Geology and Earth Resources
  4224 - 6th Avenue S.E.
  Building 1, Rowe Six
  Lacey, Washington 98503
  Phone: (206) 459-6372

Washington Department of Agriculture (WDA)

The Washington Department of Agriculture is responsible for enforcing federal regulations and state controls on the use of pesticides. Together with DSHS, the agency investigates pesticide-related human health incidents. WDA also investigates contamination of ground water from pesticide use. **For information on existing or potential pesticides contamination contact WDA offices in Olympia.**

Address

- o Washington Department of Agriculture
  406 General Administration Building
  Olympia, Washington 98504
  Phone: (206) 753-5062

OTHER SOURCES OF INFORMATION

Local Health Departments

Review and approval of on-site wastewater disposal systems is primarily the responsibility of local health departments, which regulate over 90 percent of the systems installed in the state. Local health departments can be a good source of information on existing or potential ground water contamination problems resulting from on-site waste disposal.

Typically, local health departments are responsible for regulating the siting, design and operation of sanitary landfills. They can provide information on the location of landfills and may have information on existing or potential landfill-related ground water contamination.

Local health departments are also involved in monitoring drinking water quality, reviewing and approving smaller water supply systems, and in investigating ground water contamination where human health is at risk. Local health departments may be able to provide water quality information not available from DSHS.

Public and Private Water Suppliers

Public and private water suppliers can provide information on the location of public water supply sources, the quality and output of those sources, the location of watersheds, water use statistics and general information about ground water resource conditions. Some water suppliers also conduct special, independent ground water investigations which could provide useful resource information.

Well Drillers and Septic System Installers

Private contractors such as well drillers or septic system installers can provide general information on local ground water conditions. For example well drillers may be aware of areas in which well water levels have dropped over a period of years--possibly indicating ground water depletion. Drillers can also be a source of information on aquifers and aquifer boundaries. Similarly, septic system installers may be familiar with areas experiencing a high rate of septic system failures--or areas where ground water contamination from septic systems may be a problem.

Universities and Colleges

Universities and colleges can be sources of additional information and assistance in ground water protection planning. However, only one of the numerous universities and colleges in Washington State has a ground water hydrology program. The University of Washington has a small but growing program in the College of Engineering staffed by Dr Wen-Sen Chu, Dr. Steven J. Burges, and Dr. Dennis P. Lettenmaier. A number of ground water investigations have been conducted by staff and graduate students at the college. Dr. Chu indicates graduate students may be interested in providing research or other assistance to planners. For more information, contact Dr. Chu, Burges or Lettenmaier

<u>Address</u>

o University of Washington
  College of Engineering
  Department of Civil Engineering FX-10
  Seattle WA 98195
  Phone: (206) 543-2390 or 543-2547

Planning Advisory Service

The Planning Advisory Service (PAS) is a research service offered by the American Planning Association. PAS collects and produces information on a variety of planning related subjects--including ground water protection planning. Among the more useful kinds of information available through the service are examples of special studies, plans, and ordinances prepared by planning offices throughout the country. Examples of ground water studies, comprehensive plans that address ground water, or ground water protection ordinances may be available through PAS. You can get this information by either calling or writing the PAS Research Division. However, you or the agency you work for must be a PAS subscriber to receive the service.

<u>Address</u>

o Planning Advisory Service
  Research Division
  1313 East 60th Street
  Chicago IL 60637
  Phone: (312) 955-9100

INFORMATION SOURCES SUMMARY

Table 7.1 summarizes what information is available from the sources described in the preceding sections

TABLE 7.1: INFORMATION SOURCES SUMMARY

	FEDERAL			STATE					OTHER			
	USGS	EPA	SCS	NCDC	Ecology	DSHS	DNR	WDA	Local Health Depts.	Public & Private Water Suppliers	Well Drillers	Universities and Colleges
1. BASIC RESOURCE INFORMATION												
A. Aquifer Locations and Characteristics	X	X			X		X				X	
B. Ground Water Movement	X	X			X							
C. Ground Water Recharge and Discharge	X	X			X							
D. Ground Water Capacity	X				X					X	X	
E. Ground Water Quality	X	X			X	X			X	X		
F. Water Use						X			X	X		
G. Land Use	X											
2. FACTORS AFFECTING SENSITIVITY TO CONTAMINATION												
A. Topography	X						X					
B. Composition and Thickness of the Unsaturated Zone	X		X		X		X					
C. Volume of Recharge	X		X	X	X							
D. Geologic Nature of the Aquifer	X	X			X		X				X	
E. Proximity to Salt-water Bodies					X							
3. OTHER INFORMATION												
A. Special Ground Water-Related Programs or Funding Sources	X USGS Federal-State cooperative Program				X State Ground Water Mgmt. Program (HB 232)	X Public Water Systems Coordination (HB 155)						

HIGHLIGHTS OF CHAPTER 8

GROUND WATER CONSULTANTS

WHAT TO CONSIDER BEFORE HIRING A CONSULTANT

TIME AND COSTS OF PREPARING GROUND WATER STUDIES

Time Factors

Cost Factors

Estimated Project Costs

Five Project Examples

HIRING A CONSULTANT

CHAPTER 8

GROUND WATER CONSULTANTS

INTRODUCTION

This chapter discusses how to decide when to hire a ground water consultant, what kind of information a consultant can provide, what time and costs may be involved in conducting a ground water study, and how to go about hiring a consultant.

WHAT TO CONSIDER BEFORE HIRING A CONSULTANT

There are no hard and fast rules about when to hire a consultant. The decision will depend on local circumstances: the complexity of the hydrologic setting, the severity of existing ground water problems, a jurisdiction's financial resources, planning staff's skill in ground water protection planning and the level of technical support available within the jurisdiction or from other agencies. Some planning agencies may be able to develop a comprehensive plan that incorporates ground water protection with in-house expertise or help from other agencies. Others will want to consider hiring a consultant to support ground water protection efforts.

Consultants are available with expertise in virtually every aspect of ground water protection planning. They can direct the planning process, gather ground water resource information, identify ground water problems, define sensitive areas and develop the comprehensive plan.

In working with a consultant, it is important to remember that consultants are most efficient and offer the most cost-effective service when they are asked to solve a specific problem or when the scope of work is well defined. It is far less effective to hire consultants prior to carefully specifying the scope of work. Some jurisdictions may want to consider hiring a consultant to help define what a project will cover.

It is also important to know what type of consultants are appropriate for the kind of work that needs to be done. Some firms specialize in engineering, geological, or planning services, while other firms may combine these services. Consulting firms with capabilities in ground water and planning are generally listed in the yellow pages under one of the following categories.

- Geologists: These firms are versed in resource evaluation and ground water data acquisition and evaluation
- Environmental Engineers: These firms usually have a range of capabilities including planning, resource evaluation, and engineering application.
- Foundation or Geotechnical Engineers: These firms often maintain geologists or hydrogeologists on staff.
- Civil Engineers: These firms specialize in land development and environmental planning, and often have specific expertise in projects involving hydrologic design.

TIME AND COSTS OF PREPARING GROUND WATER STUDIES

The time and costs involved in undertaking a ground water study are clearly a function of the complexity and scope of the project. This section lists some factors that can help in evaluating how long and how expensive a ground water study might be.

Time Factors

- Will the project involve collecting and reviewing of existing information or will new data need to be generated?
  New data generally requires a longer period of time to collect.

- If new data is to be collected, will it be collected over several seasons or in a single year?
  Ground water studies which involve water sampling or monitoring typically extend over several seasons so that seasonal effects can be evaluated.

- How will project completion be determined? Will it require approval from a number of people? Will public input be required?
  The more people involved in the review or approval of the project, the longer the project will take to complete. Although an obvious factor, the time involved is usually underestimated.

- How extensive is the study?
  The proposed study's size and complexity are the major determinants of the time required to complete it.

Cost Factors

- Will the project involve collecting new subsurface information?
  If exploratory borings are necessary, costs are usually high.

- Will chemical analyses be required?
  Conventional water analyses are not too expensive, but analysis for exotic organic chemicals can be quite costly.

- Is the project scope well defined or will it be refined as the project progresses?
  Although often necessary to a successful project, scope refinement is generally more costly.

- How extensive is the study?
  Project scope ultimately determines cost.

- Will project completion require approval from a number of people? Will public input be required?
  Expanding the number of people involved expands costs primarily because more meetings and more report revisions are required.

- Are there any unusual conditions influencing the project's completion?
  Unusual conditions could include weather, the requirement for field work changes in elected or appointed officials, requirements for regulatory agency approval, or logistical difficulties related to dealing with large military installations.

Estimated Project Costs

As noted, project time and costs depend on the project's scope and complexity. Each project will have a unique set of circumstances and conditions which influence these costs. Although no summary can accurately reflect exact costs for a specific project, some examples, based on 1986/87 prices, are offered below. These include three of the major costs involved in conducting ground water studies: personnel costs, drilling costs and chemical analysis costs.

Personnel Costs

Most consultants charge on an hourly basis within either an estimated or "not-to-exceed" budget amount. Hourly rates commonly range as follows:

Clerical personnel	\$20 - \$30 per hour
Project personnel	\$30 - \$50 per hour
Senior personnel	\$50 - \$75 per hour

Generally, the majority of the work is performed by "project personnel". Therefore, the average hourly rate for most projects will be between \$30 and \$50 per hour. Based on this rate and assuming 40 hours at an average rate of \$38 per hour, the average weekly cost would be around \$1,500

Drilling Costs

Drilling costs for installing ground water monitoring wells will vary according to drilling conditions. For example, soft drilling conditions in alluvium will result in a lower footage charge than drilling in basalt. Also, the type of drill rig used influences the costs.

In most cases, drillers charge on a per foot basis, plus material expenses and well development time. Well development is normally charged on an hourly basis. Footage rates generally range between \$10 and \$50 per foot, depending on the conditions. In some cases, for example, where hazardous materials are expected, drillers charge on an hourly basis. These rates typically range from \$85 to \$125 per hour.

Chemical Analysis Costs

Costs for chemical analyses also vary with the type of test. Typical charge rates are given in Table 8.1

TABLE 8.1

CHEMICAL ANALYSIS COST EXAMPLES

TEST	COST
Total Coliform	\$10 - \$15 each
Metals	\$5 - \$12 each
Inorganics (nitrate, sulfate, chloride, etc.)	\$5 - \$15 each
Indicator tests (pH, hardness, total organic carbon)	\$10 - \$50 each
Organic compounds	Wide range. Usually analyzed for groups of compounds rather than individual compounds. Example: EPA priority pollutant volatile organics are \$200 - \$300 each; polycyclic aromatic hydrocarbons are \$150 - \$250 each.

Five Project Examples

The time and costs of five ground water studies recently conducted in Washington are shown on Table 8.2. The table reflects the consultant's involvement in each project. The time and costs involved in agency management of the project are not included.

TABLE 8.2
TYPICAL PROJECT COSTS

Project	Time	Approx. cost
Clover/Chambers Creek Geohydrologic Study. Tacoma-Pierce County Health Department – 1985 Comprehensive assessment of geohydrology, water quality, and land use, and development of framework for ground water protection plan including public education. Project included 25-well monitoring program		$450,000
Phase 1: Study area characterization	9 months	
Phase 2: Data Collection	14 months	
Phase 3: Evaluation and Report	6 months	
Groundwater Availability Study. Washington State Reformatory Monroe – 1984 Research available information, evaluate ground water occurrence, recommend well location and design.	2 weeks	$ 2,000
Spokane Aquifer Cause and Effect Study. Spokane County – 1978	1 year	
Well installation		$ 20,000
Chemical analyses		75,000
U.S.G.S. computer modelling		80,000
Data review and evaluation*		55,000
		$230,000
Ground Water Supply Study. City of Auburn – 1982 Define geology and hydrology in area and potential for ground water development. Included water level monitoring, and installation of seven test wells. Formulate long-range water supply plans	1 year	$329,000
Ground Water Resource Evaluation Study. Kitsap Public Utility District Number 1 – 1985 Research available information, compile well inventory, identify principal aquifers, evaluate aquifer yield, recommend new well siting and general design	8 weeks	$ 7,000

*Note: Data review was performed by a consultant who was paid as an employee of Spokane County. If normal consultant rates were used, costs would have more than doubled for data review.

HIRING A CONSULTANT

Once the jurisdiction has determined the scope of the project and the type of consultant needed, a consultant invitation should be prepared. The invitation can take the form of a request for qualifications (RFQ) or a request for proposals (RFP). An RFQ is simply a request for a statement from the consulting firm regarding its qualifications and expertise. An RFP, on the other hand, is a request for a detailed response to a specific project in which the firm is asked to describe how it will complete the scope of work, staff qualifications to do the work, and an estimate of what the job will cost.

The most efficient way to proceed is to begin the process with an RFQ. This permits the jurisdiction to screen potential consultants and select those appearing to be the most qualified. Proposals are then requested from the "short list" of those consultants most qualified to meet the jurisdiction's needs.

An effective Request for Proposals should provide:

- project title
- principal project goals
- project background and previous efforts
- scope of the project (sufficiently detailed to outline required work and sufficiently general to require the responding consultant to show an understanding of the project)
- general level of effort expected of the consultant
- criteria for selecting the consultant
- deadline and conditions for submission, including the number of copies to be submitted

The RFP should request the consultant to provide a:

- work plan (methodology, analytic method, required data) for completing the work outlined in the scope of work
- budget providing a breakdown of estimated costs for completing the work
- schedule of work indicating deadlines for completing each element of the scope of work

Generally, the jurisdiction will need to form a selection committee to rate proposals and interview the top 3-5 firms. Rating criteria should include the following:

- overall firm experience
- specific experience in similar projects
- professional qualifications of staff, especially those who will be assigned to the project

- firm's policies and approach to project management, including organization and communication

- approach to project, including understanding of the work to be done, and the thoroughness, responsiveness and appropriateness of the presentation

- availability of staff, facilities and equipment necessary for the project

- costs: considered on a per task basis (some costs may appear low because less work is being proposed than is offered by others)

- firm's reputation and references from previous clients

Once the consultant is hired, a lead staff member should be assigned to work with the consultant, to monitor progress and to coordinate communication between the consultant and the jurisdiction. Periodic progress reports or meetings should be incorporated into the contract to assure that the expectations of both parties are being met.

ANNOTATED BIBLIOGRAPHY

The following annotated bibliography highlights important national, regional and local publications on subjects related to ground water protection planning. Organized by topic, section headings include:

- Legal and Regulatory Framework
- Ground Water and Land Use Planning
- Ground Water Science
- Water Supply Systems and Their Development
- Ground Water Contamination and Remediation
- Ground Water Studies and Maps Covering Washington State
- Ground Water Studies and Maps Covering Counties in Washington State

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Washington State Department of Ecology, Chapter 173-100 WAC. Ground Water Management Areas and Programs. Adopted: December 18, 1985.

This establishes guidelines, criteria, and procedures for designating ground water management areas, subareas or zones. It also sets forth the process for developing ground water management programs.

Washington State Legislature, Chapter 90.44, RCW. Regulation of Public Ground Waters.

The State Ground Water Code specifies conditions of issuance of water right permits for ground water withdrawals, limitations on granting permits, priorities between appropriators, etc.

Washington State Legislature, Chapter 90.54, RCW. Water Resources Act of 1971.

This act sets forth the policy fundamentals for the use and management of waters within Washington State, including ground water. The Act designates responsibility to the Washington Department of Ecology to develop and implement the state's water resources program, seek involvement of other persons and entities, and make reports to the legislature.

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This bill adds new sections to Chapter 90.54 RCW (see above). It requires all local government comprehensive plans to include elements protecting the quality and quantity of public ground water supplies.

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GLOSSARY OF TERMS USED IN THE TEXT

Alluvium: River sediment such as clay, silt, sand, gravel, or other similar material deposited by running water.

Area of Influence: The area within a cone of depression (depression in the water table -- see below) as projected to the land surface.

Attenuation: The general process of reducing the amount and concentration of contaminants in water. Includes physical, chemical and biological processes as well as dilution.

Capillary Fringe: The zone above the water table in which water is drawn up and held by surface tension.

Clean Water Act: Basic federal legislation regulating surface water quality.

Cone of Depression: The depression in the water table or potentiometric surface (see below) around a pumping well caused by water withdrawal.

Confined Aquifer: An aquifer overlain by a confining bed in which the water level in a well drilled into the aquifer stands above the base of the confining bed.

Confining Bed: A geologic unit with low permeability (hydraulic conductivity) which restricts movement of water into or out of the aquifer.

Contaminant: An undesirable or injurious substance added to the water.

Discharge Area: The location at which ground water moves from an aquifer to the land surface or to a surface water body.

Drillers Log: A record of the geologic and aquifer conditions encountered by a driller during drilling of a water supply well. The State of Washington requires that a log be completed for each well.

Flow Rate: The volume of flow per time (e.g., gallons per minute).

Flowing Artesian Wells: Wells which tap confined aquifers which flow at ground surface without the necessity of pumping.

Geologic Map: A map showing the aerial distribution of geologic units and the attitude or structure of those units.

Geothermal: Relating to elevated temperatures in the subsurface which typically includes heated ground water.

Ground Water Divide: A line separating two regions of diverging flow.

Hazardous Wastes: Wastes containing compounds injurious to the environment or which pose a health risk.

Hydraulic Conductivity Value: The capacity of a rock or soil to transmit water. It is a factor which relates volume of flow to the difference in hydraulic head between two points.

Hydraulic Gradient: Change in head between two points divided by the distance between the points (i.e., slope).

Hydrologic Cycle: The cyclical movement of water from the oceans to the land and back to the oceans.

Indicator Tests: Non-specific chemical tests designed to monitor group characteristics or properties as an indicator of general water quality.

Intermediate Zone: The portion of the unsaturated zone (see below) between the soil zone and the capillary fringe (see above).

Ionic Form: In a form having a plus or minus charge.

Land Farming: Spreading chemical sludges on land and cultivating them into the soil for degradation.

Leaching: To remove soluble constituents from a soil or waste by infiltrating water

Microbial Pathogens: Micro-organisms which can cause disease.

Organic Chemicals: Generally compounds containing hydrogen and carbon, i.e., hydrocarbons.

Plume: A contaminated portion of an aquifer extending from the original contaminant source.

Potability: Ability to be used as drinking water.

Potentiometric Surface: An imaginary surface representing the total head of a confined aquifer. The total head consists of the elevation head and pressure head.

Production Zone: The depth interval in a water supply well from which water is being obtained.

Radionuclides: The radioactive forms of various elements.

Recharge Area: An area which primarily serves to recharge a given aquifer. Ground water flow in this area is predominantly downward from the water table.

Seawater Intrusion: The entry of seawater into a fresh water aquifer.

Saturated Zone: The zone beneath the land surface in which water fills all pores at a pressure greater than or equal to atmospheric pressure.

Soil Zone: The zone which generally supports plant growth.

Solution Cavities: Cavities created in limestones by water dissolution.

Unconfined (Water Table) Aquifer: An aquifer which is only partially filled with water and in which the water table, or a surface in equilibrium with atmospheric pressure, forms the upper boundary.

Unsaturated Zone: The subsurface zone containing both water and air. The lower part of the unsaturated zone (capillary fringe) does not actually contain air, but is saturated with water held by suction at less than atmospheric pressure.

Wastewater Injection Wells: Wells designed to inject wastewaters into deep aquifers for disposal purposes.

Water Table: The level of underground water at which the hydraulic pressure equals atmospheric pressure.

APPENDIX I

CHAPTER 253

[House Bill No. 1138]

GROUND WATER

AN ACT Relating to the protection of water resources; amending section 35.63.090, chapter 7, Laws of 1965 as amended by section 5, chapter 170, Laws of 1979 ex. sess. and RCW 35.63.090; amending section 35A.63.061, chapter 119, Laws of 1967 ex. sess. and RCW 35A.63.061; amending section 36.70.330, chapter 4, Laws of 1963 and RCW 36.70.330; and adding new sections to chapter 90.54 RCW

Be it enacted by the Legislature of the State of Washington:

Sec. 1. Section 35.63.090, chapter 7, Laws of 1965 as amended by section 5, chapter 170, Laws of 1979 ex. sess. and RCW 35.63.090 are each amended to read as follows:

All regulations shall be worked out as parts of a comprehensive plan which each commission shall prepare for the physical and other generally advantageous development of the municipality and shall be designed, among other things, to encourage the most appropriate use of land throughout the municipality; to lessen traffic congestion and accidents; to secure safety from fire; to provide adequate light and air; to prevent overcrowding of land; to avoid undue concentration of population; to promote a coordinated development of the unbuilt areas; to encourage the formation of neighborhood or community units; to secure an appropriate allotment of land area in new developments for all the requirements of community life; to conserve and restore natural beauty and other natural resources; to encourage and protect access to direct sunlight for solar energy systems; and to facilitate the adequate provision of transportation, water, sewerage and other public uses and requirements, including protection of the quality and quantity of ground water used for public water supplies.

Sec. 2. Section 35A.63.061, chapter 119, Laws of 1967 ex. sess. and RCW 35A.63.061 are each amended to read as follows:

The comprehensive plan shall be in such form and of such scope as the code city's ordinance or charter may require. It may consist of a map or maps, diagrams, charts, reports and descriptive and explanatory text or other devices and materials to express, explain, or depict the elements of the plan; and it shall include a recommended plan, scheme, or design for each of the following elements:

(1) A land-use element that designates the proposed general distribution, general location, and extent of the uses of land. These uses may include, but are not limited to, agricultural, residential, commercial, industrial, recreational, educational, public, and other categories of public and private uses of land. The land-use element shall also include estimates of future population growth in, and statements of recommended standards of population density and building intensity for, the area covered by the comprehensive plan. The land use element shall also provide for protection of the quality and quantity of ground water used for public water supplies.

(2) A circulation element consisting of the general location, alignment, and extent of existing and proposed major thoroughfares, major transportation routes, and major terminal facilities, all of which shall be correlated with the land-use element of the comprehensive plan.

Sec. 3. Section 36.70.330, chapter 4, Laws of 1963 and RCW 36.70-.330 are each amended to read as follows:

The comprehensive plan shall consist of a map or maps, and descriptive text covering objectives, principles and standards used to develop it, and shall include each of the following elements:

(1) A land use element which designates the proposed general distribution and general location and extent of the uses of land for agriculture, housing, commerce, industry, recreation, education, public buildings and lands, and other categories of public and private use of land, including a statement of the standards of population density and building intensity recommended for the various areas in the jurisdiction and estimates of future population growth in the area covered by the comprehensive plan, all correlated with the land use element of the comprehensive plan. The land use element shall also provide for protection of the quality and quantity of ground water used for public water supplies;

(2) A circulation element consisting of the general location, alignment and extent of major thoroughfares, major transportation routes, trunk utility lines, and major terminal facilities, all of which shall be correlated with the land use element of the comprehensive plan;

(3) Any supporting maps, diagrams, charts, descriptive material and reports necessary to explain and supplement the above elements.

NEW SECTION. Sec. 4. There is added to chapter 90.54 RCW a new section to read as follows:

The department of ecology may recommend land use management policy modifications it finds appropriate for the further protection of ground and surface water resources in this state. Such advisory recommendations may be made to other state regulatory agencies, local governments, water systems, and other appropriate bodies.

NEW SECTION. Sec. 5. There is added to chapter 90.54 RCW a new section to read as follows:

The legislature hereby declares that the protection of groundwater aquifers which are the sole drinking water source for a given jurisdiction shall be of the uppermost priority of the state department of ecology, department of social and health services, and all local government agencies with jurisdiction over such areas. In administration of programs related to the disposal of wastes and other practices which may impact such water quality, the department of ecology, department of social and health services, and such affected local agencies shall explore all possible measures for the protection of the aquifer, including any appropriate incentives, penalties, or other measures designed to bring about practices which provide for the least impact on the quality of the groundwater.

Passed the House March 2, 1984.
Passed the Senate February 24, 1984.
Approved by the Governor March 28, 1984.
Filed in Office of Secretary of State March 28, 1984.

APPENDIX II

CHAPTER 453

[Substitute House Bill No. 232]
GROUND WATER MANAGEMENT

AN ACT Relating to ground water management; adding new sections to chapter 90.44 RCW; and declaring an emergency.

Be it enacted by the Legislature of the State of Washington:

<u>NEW SECTION.</u> Sec. 1 (1) This legislation is enacted for the purpose of identifying ground water management procedures that are consistent with both local needs and state water resource policies and management objectives; including the protection of water quality, assurance of quantity, and efficient management of water resources to meet future needs.

In recognition of existing water rights and the need to manage ground water aquifers for future use, the department of ecology shall, by rule, establish standards, criteria, and a process for the designation of specific ground water areas or sub-areas, or separate depth zones within such area or sub-area, and provide for either the department of ecology, local governments, or ground water users of the area to initiate development of a ground water management program for each area or sub-area, consistent with state and local government objectives, policies, and authorities. The department shall develop and adopt these rules by January 1, 1986.

(2) The department of ecology, in cooperation with other state agencies, local government, and user groups, shall identify probable ground water management areas or sub-areas. The department shall also prepare a general schedule for the development of ground water management programs that recognizes the available local or state agency staff and financial resources to carry out the intent of sections 1 through 3 of this act. The department shall also provide the option for locally initiated studies and for local government to assume the lead agency role in developing the ground water management program and in implementing the provisions of sections 1 through 3 of this act. The criteria to guide identification of the ground water areas or sub-areas shall include but not be limited to, the following:

(a) Aquifer systems that are declining due to restricted recharge or over-utilization;

(b) Aquifer systems in which over-appropriation may have occurred and adjudication of water rights has not yet been completed;

(c) Aquifer systems currently being considered for water supply reservation under chapter 90.54 RCW for future beneficial uses;

(d) Aquifers identified as the primary source of supply for public water supply systems;

(e) Aquifers designated as a sole source aquifer by the federal environmental protection agency; and

(f) Geographical areas where land use may result in contamination or degradation of the ground water quality.

(3) In developing the ground water management programs, priority shall be given to areas or sub-areas where water quality is imminently threatened.

NEW SECTION. Sec. 2. (1) To assist in the development of ground water management programs, a ground water management advisory committee, with representation from major user and public interest groups, and state and local governments shall be appointed by the department for each area or sub-area. The procedure for advisory committee appointment, terms of appointment, and committee responsibilities shall be addressed in the rules prepared under section 1 of this act.

(2) The ground water area or sub-area management programs shall include:

(a) A description of the specific ground water area or sub-areas, or separate depth zones within any such area or sub-area, and the relationship of this zone or area to the land use management responsibilities of county government;

(b) A management program based on long-term monitoring and resource management objectives for the area or sub-area;

(c) Identification of water resources and the allocation of the resources to meet state and local needs;

(d) Projection of water supply needs for existing and future identified user groups and beneficial uses;

(e) Identification of water resource management policies and/or practices that may impact the recharge of the designated area or policies that may affect the safe yield and quantity of water available for future appropriation;

(f) Identification of land use and other activities that may impact the quality and efficient use of the ground water, including domestic, industrial, solid, and other waste disposal, underground storage facilities, or storm water management practices;

(g) The design of the program necessary to manage the resource to assure long term benefits to the citizens of the state;

(h) Identification of water quality objectives for the aquifer system which recognize existing and future uses of the aquifer and that are in accordance with department of ecology and department of social and health services drinking and surface water quality standards;

(i) Long-term policies and construction practices necessary to protect existing water rights and subsequent facilities installed in accordance with the ground water area or sub-area management programs and/or other water right procedures;

(j) Annual withdrawal rates and safe yield guidelines which are directed by the long-term management programs that recognize annual variations in aquifer recharge;

(k) A description of conditions and potential conflicts and identification of a program to resolve conflicts with existing water rights;

(l) Alternative management programs to meet future needs and existing conditions including water conservation plans; and

(m) A process for the periodic review of the ground water management program and monitoring of the implementation of the program

(3) The ground water area or sub-area management programs shall be submitted for review in accordance with the state environmental policy act

NEW SECTION. Sec 3 The department of ecology shall consider the ground water area or sub-area management plan for adoption in accordance with this chapter and chapter 90 54 RCW

Upon completion of the ground water area or sub-area management program, the department of ecology shall hold a public hearing within the designated ground water management area for the purpose of taking public testimony on the proposed program Following the public hearing, the department of ecology and affected local governments shall (1) prepare findings which either provide for the subsequent adoption of the program as proposed or identify the revisions necessary to ensure that the program is consistent with the intent of this chapter, and (2) adopt regulations, ordinances, and/or programs for implementing those provisions of the ground water management program which are within their respective jurisdictional authorities

NEW SECTION. Sec 4 The department of ecology, the department of social and health services, and affected local governments shall be guided by the adopted program when reviewing and considering approval of all studies, plans, and facilities that may utilize or impact the implementation of the program.

NEW SECTION. Sec. 5. Sections 1 through 4 of this act shall not affect any water rights existing as of the effective date of this act.

NEW SECTION. Sec. 6. This act is necessary for the immediate preservation of the public peace, health, and safety, the support of the state government and its existing public institutions, and shall take effect immediately.

NEW SECTION. Sec 7 Sections 1 through 5 of this act are each added to chapter 90 44 RCW.

Passed the House March 13, 1985
Passed the Senate April 18, 1985.
Approved by the Governor May 21, 1985
Filed in Office of Secretary of State May 21, 1985

APPENDIX III

KEY STATE LAWS AND REGULATIONS - BY POLLUTANT SOURCE

POLLUTANT SOURCE	STATE LAW	STATE REGULATION
Landfills and Dumps	RCW 70.95 Solid Waste Managment RCW 70.105 Hazardous Waste Management RCW 90.48 Water Pollution Control RCW 90.52 Pollution Disclosure	WAC 173-301 Minimum Functional Standards WAC 173-303 Dangerous Waste Regulations WAC 173-216 State Waste Discharge Permits WAC 173-220 NPDES Permits
Surface Impoundments	RCW 90.48 Water Pollution Control RCW 90.52 Pollution Disclosure	WAC 173-216 State Waste Discharge Permits WAC 173-220 NPDES Permits
Subsurface Sewage Disposal and Lakes Application	RCW 90.48 Water Pollution Control RCW 43.20 State Board of Health RCW 70.05, 70.08, 70.46 Local Boards of Health	WAC 173-240 Submission of Plans and Reports for Construction of Wastewater Facilities WAC 248-96 Rules and Regulations of the State Board of Health - On Site Sewage Disposal Systems WAC 372-36 Columbia Basin Irrigation Area - Sewage and Waste
Underground Storage Tanks	RCW 90.48 Water Pollution Control RCW 70.105 Hazardous Waste Management	WAC 173-303 Dangerous Waste Regulations
Accidental Spills	RCW 90.48 Water Pollution Control	
Radioactive Waste	RCW 70.98 Nuclear Energy RCW 70.121 Mill Tailing - Lisc and Perpetual Care	Title 402 WACs
Agricultural Wastes	RCW 90.48 Water Pollution Control	WAC 173-220 NPDES Permits WAC 173-216 State Waste Discharge Permits WAC 173-240 Submission of Plans & Reports for Construction of Wastewater Facilities
Salt Water Intrusion	RCW 90.44 Regulation of Public Groundwaters RCW 90.54 Water Resources Act RCW 70.116 Public Water System Coord. Act	WAC 173-590 Reaeration of Water WAC 173-500 Water Resources Management Program WAC 248-56 Water System Coordination Act - Procedural Regulations
Petroleum Exploration/ Development	RCW 78.52 Oil and Gas Conservation	
Injection Wells	RCW 90.48 Water Pollution Control RCW 43.21A Department of Ecology	WAC 173-218 Underground Injection Control Protram
Abandoned Wells, Monitoring Wells, Water Supply Wells	RCW 18.104 Water Well Construction	WAC 173-160 Minimum Standards for Construction and Maintenance
Highway Deicing	RCW 90.48 Water Pollution Control	
Artificial Recharge	RCW 90.48 Water Pollution Control	
Mining Wastes		
Sludge Application	RCW 70.95 Solid Waste Management	WAC 173-301 Minimum Functional Standards

APPENDIX IV

STATE OF WASHINGTON

GROUND WATER QUALITY MANAGEMENT STRATEGY

Summary

For three years the State of Washington has worked on a Ground Water Quality Management Strategy to protect ground water resources. The state Legislature has supported the effort by enacting recent laws directing local governments to include ground water protection measures in their comprehensive plans. In 1984 a Citizens Ground Water Task Force began to define the strategy's goals and to develop recommended actions.

Goal of Ground Water Management Strategy

Based on the Task Force conclusions, public comment, and study by the Department of Ecology, the State of Washington has defined the goal of Ground water Quality Management: To maintain high quality for all waters of the state, allowing no reduction in water quality, except in overriding consideration of public interest. No reduction would be allowed to affect adversely the ability to use that water for its intended beneficial uses.

Ground Water in Washington State

Three quarters of the state's population relies on ground water for drinking. Washington residents use ground water for agriculture, fish propagation, hydropower, industry, and to replenish surface water. In many areas of the state, almost all the surface water is already being used, so ground water will become an increasingly important resource.

Extent of Ground Water Contamination

The general quality of Washington's ground water is good; however there are increasing instances of localized contamination:

- In 30 of 39 counties, there has been documented contamination of public water supplies with chlorides and nitrates.
- In 27 of 39 counties, there has been documented contamination of ground water with heavy metals, petroleum products, and synthetic organic chemicals.

There are currently 638 known or suspected hazardous waste sites in Washington. Ground water contamination has been documented at 12 percent of those sites, with drinking water contamination observed at nearly 5 percent. There is a potential for contamination of drinking water supplies at nearly one-fourth of the remaining sites.

Federal and State Laws

While there are many federal and state laws on water quality and ground water, there is no comprehensive approach. The strategy gives a listing of laws relating to ground water. It points out the most recent Washington State laws which focus on local governments action and responsibility.

Current Ground Water Quality Management Activities In Washington

The strategy lists many planning and study efforts in the state, including geohydrologic studies, computerized data management systems, a management plan for the Spokane Valley Aquifer and other comprehensive plans by local governments.

Current monitoring efforts include USGS observation wells, the DSHS drinking water program, and compliance monitoring of waste facilities.

Other activities include data management, control of pollution sources, technical asistance and training, and financial assistance.

RECOMMENDED ACTIONS

DEVELOP AND ADOPT STATEWIDE STANDARDS FOR GROUND WATER QUALITY AND A MEANS OF MEASURING COMPLIANCE

The Department of Ecology should develop and adopt statewide standards for ground water quality based on current and future beneficial uses and on variable levels of protection. Geology, recharge, and other ground water characteristics should be considered. The initial efforts should focus on drinking water aquifers and drinking water criteria.

DEVELOP STATEWIDE TECHNOLOGY BASED STANDARDS

The state should establish known, available, and reasonable methods of treatment for activities which have a potential to pollute the waters of the state.

THE STATE SHOULD ESTABLISH ENFORCEABLE CONTROL MECHANISMS TO ACHIEVE WATER QUALITY GOALS

The Department of Ecology should establish rigorous and enforceable waste discharge permit requirements. The state should strengthen enforcement against noncomplying dischargers. Regulatory agencies should provide more thorough and responsive review of plans and reports. Local government should place greater emphasis on ground water quality planning, management, and protection -- including innovative approaches.

DEVELOP NECESSARY PROGRAM SUPPORT AND EVALUATION

Ecology, in cooperation with USGS, should continue--and strengthen--planning efforts in conducting basic ground water studies. State and local governments need to evaluate and revise existing programs to achieve water quality goals.

The state--with Ecology as lead--should develop a comprehensive water quality monitoring and data management program.

Ecology and other state and local agencies should identify and develop funding sources for the ground water program. Ecology should establish appropriate program coordination.

PROVIDE TECHNICAL ASSISTANCE AND TRAINING

Increased technical training should be provided for staff at Ecology, DSHS, and local government--public health, planning, and public works.