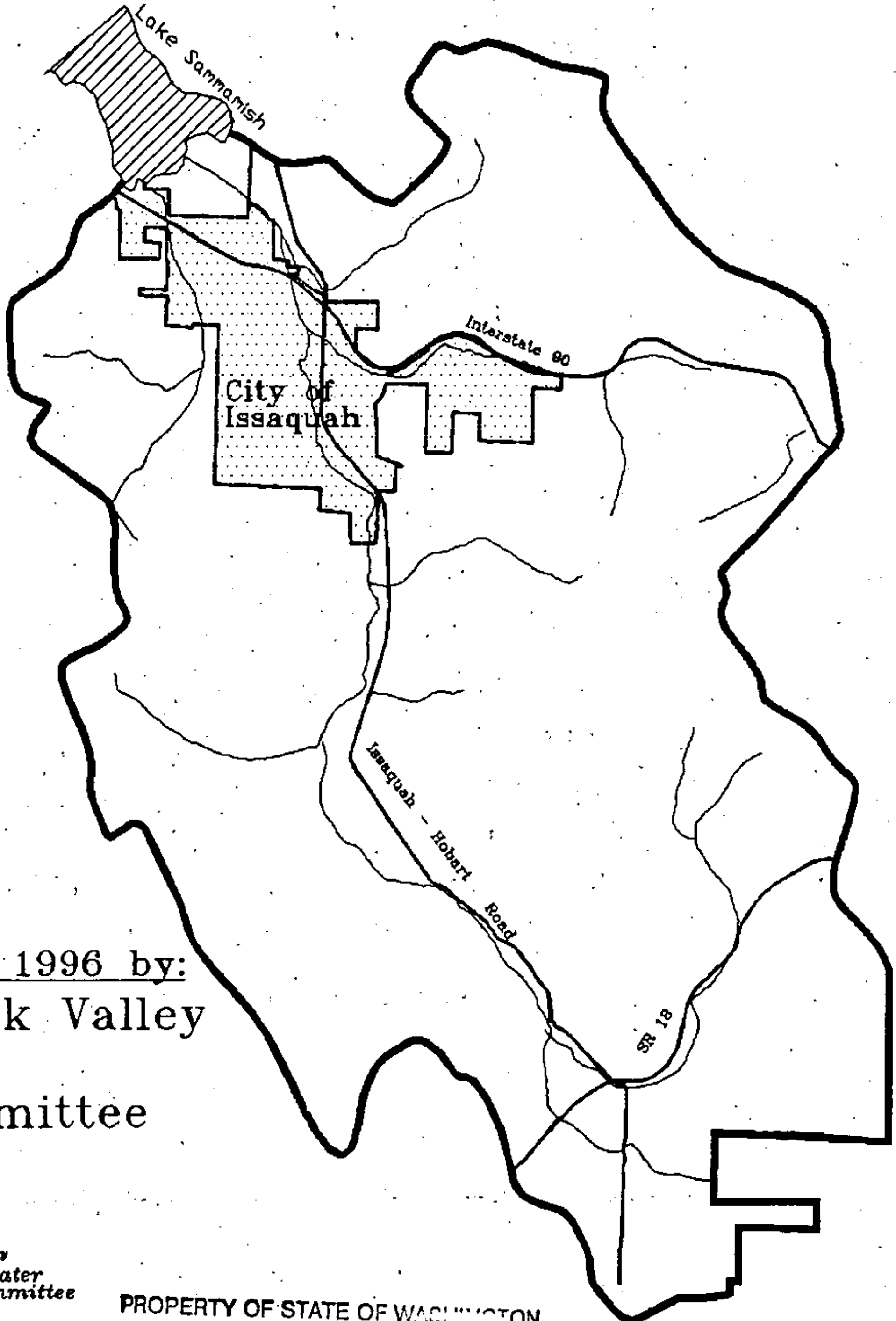
Draft supplement to the Issaquah Creek Valley ground water management plan

# Draft

# Issaquah Creek Valley Ground Water Management Plan

# Supplement




Proposed March, 1996 by:

Issaquah Creek Valley
Ground Water
Advisory Committee

Issaquah Valley
Ground Water
Advisory Committee

98214143

# Draft
# Supplement to the Issaquah Creek Valley Ground Water Management Plan

**March, 1996**

Proposed by:

Redmond-Bear Creek Valley Ground Water Management Committee

King County (Lead Agency)
Surface Water Management Division
Suite 2200
700 Fifth Avenue
Seattle, WA 98104
(206) 296-6519

Seattle-King County Department of Public Health
Environment Health Division
201 Smith Tower
506 Second Avenue
Seattle, WA 98104
(206) 296-0722

Funded in part by the Washington Department of Ecology Centennial Clean Water Fund.

WASHINGTON STATE DEPARTMENT OF ECOLOGY

## Table Of Contents

### Area Characterization

**Management Strategies**



**Management Strategies Bibilography**

**Appendices**:

## TABLES

## TABLES (continued)

## FIGURES

# Area Characterization

**Draft**

**Issaquah Creek Valley**
**Ground Water Management Plan**

**March, 1996**

# AREA CHARACTERIZATION

## 1.0 INTRODUCTION

This report provides an updated characterization of the Issaquah Creek Valley Ground Water Management Area and includes information from the 1993 Lower Issaquah Valley Wellhead Protection Plan. The report also summarizes the results of ground water data collection and analysis activities conducted between 1989 and 1992 as part of the Issaquah Ground Water Management Plan (IGWMP).

This updated area characterization is a compilation of information from previous water investigations conducted in the Issaquah Ground Water Management Area, and data collected as part of this ground water planning process. The physical characteristics of the Issaquah Ground Water Management Area are described and regulatory agencies with authority in the area are discussed. Section 2 presents a detailed description of the boundaries of the Issaquah Ground Water Management Area. Section 3 identifies and describes the various federal, state, and local agencies that have political jurisdiction over the Issaquah Ground Water Management Area.

Section 4 discusses climate, topography and drainage. The plans and policies affecting the ground water resource, and the impacts of present and future land use on ground water quality and quantity are discussed in Section 5. Water applications including sources, services, water rights, population projections and water supply and demand are discussed in Section 6. Section 7 discusses hydrology, geology, hydrogeology, new wells, the wellhead protection plan study by Golder Associates, data collection and analysis, and data needs. Section 8 contains conclusions and recommendations for protecting the ground water resource.

### Data Collection

The data collection and analysis task included ground water quality and quantity data, rainfall data and stream flow data. Data were collected by various entities, including personnel from the City of Issaquah and Sammamish Plateau Water and Sewer District, Seattle-King County Health Department, King County Surface Water Management Division, King County Solid Waste Division, volunteers, and the environmental firms of Carr/Associates, Pacific Ground Water Group, and Parametrix.

The data collection effort was based on recommendations by project consultants Carr & Associates, Pacific Ground Water Group and Parametrix, Inc. as defined in the Data Collection and Analysis Report (February 1990 and 1992). This report was reviewed and approved by Ecology, the Seattle-King County Health Department, the Sammamish Plateau Water and Sewer District, and the Issaquah GWAC. All data collected were handled and saved as instructed by the July 1989 Data Management Plan approved by Ecology and the Issaquah Ground Water Advisory Committee (GWAC).

The objective of the data collection and analysis task in the development of the Issaquah Ground Water Management Area plan was to further public understanding of the entire Issaquah Creek Valley water resource (quantity and quality) and to identify data gaps that are needed to determine baseline conditions and facilitate protection of the Issaquah Ground Water Management Area ground water. This was accomplished through the generation and interpretation of historical and new data collected during this study, as described below. The first area characterization reports (July 1990 and December 1991) examined existing information on physical climate, surficial geology, geography, climate, water use and land uses. This report updates the 1990 and 1991 reports and includes a description of new data collected and an analysis of these data, information from new wells drilled, and a summary of the wellhead protection study conducted by Golder Associates for the City of Issaquah and the Sammamish Plateau Water and Sewer District in 1993.

Rainfall data were collected from 1988 to 1990 from eighteen stations by personnel from the King County Surface Water Management Division and the Solid Waste Division of King County Natural Resources, the Washington State Department of Natural Resources, and volunteers living in this area. Stream gauge data were collected from 1988 to 1990 from seventeen sites by personnel from the King County Surface Water Management Division, the Washington State Department of Natural Resources, and the U.S. Geological Survey. Ground water levels were measured from 1989 to 1992 from forty-eight well sites by personnel from the City of Issaquah, Sammamish Plateau Water and Sewer District, and the Seattle-King County Health Department.

Ground water quality samples were collected from nineteen wells by personnel from the City of Issaquah, Sammamish Plateau Water and Sewer District, and the Seattle-King County Health Department. Ground water quality data were also collected at the Cedar Hills Landfill by personnel from the Department of Natural Resources, Solid Waste Division. Ground water quality data were collected in the area surrounding the Cedar Hills Landfill by personnel from the Solid Waste Section of the Environmental Health Division of the Seattle-King County Health Department.

As part of this study, one monitoring well was drilled in the central part of the Issaquah Ground Water Managment Area to collect data to evaluate hydrostratigraphy, ground water flow and water quality. Three wells were later drilled in the lower Issaquah valley as part of the City of Issaquah and the Sammamish Plateau Water and Sewer District's Wellhead Protection study,

## 2.0 ISSAQUAH GROUND WATER MANAGEMENT AREA BOUNDARIES

The Issaquah Creek Valley Ground Water Management Area is a 66-square-mile area consisting of the Issaquah Creek and Tibbetts Creek drainage basins. The Issaquah Ground Water Management Area forms the southern portion of the larger Lake Sammamish watershed. All drainage basins in the Issaquah Ground Water Management Area flow into Lake Sammamish including the Issaquah, North Fork, East Fork, Tibbetts, Mason, Fifteen Mile, Carey, and Holder Creek drainage basins (Carr Associates 1986). Figure 2.1 shows the boundaries for the Issaquah Ground Water Management Area.

These boundaries were primarily defined by the natural divides of the Issaquah Creek and Tibbetts Creek drainage basins. However, 1.5 square miles of the Issaquah Creek basin were excluded from the Issaquah Ground Water Management Area because they fell within the boundaries of the City of Seattle's Cedar River Watershed. The current boundary assumes that ground water contours conform to the surface topography of the Issaquah and Tibbetts Creek drainage basins and that the existing study area demarcates a ground water confluent that eventually flows into Lake Sammamish. Future changes to the current Issaquah Ground Water Management Area boundary may be made if necessary, after additional documentation of the hydrogeologic characteristics of the Issaquah Ground Water Managment Area.

## 3.0 JURISDICTIONS IN THE ISSAQUAH GROUND WATER MANAGEMENT AREA

This section discusses the role of public agencies with jurisdiction in the Issaquah Ground Water Management Area. The ground water-related policies and activities of the agencies in the Issaquah Ground Water Management Area are organized below by federal, state, county and local agencies, respectively.

### 3.1 Federal Agencies

Federal agencies influence ground water management in various ways, both as regulatory bodies and as policy makers. Federal agencies with jurisdiction in the Issaquah Ground Water Management Area are discussed below.

#### 3.1.1 United States Environmental Protection Agency

The U.S. Environmental Protection Agency administers numerous programs that influence ground-water management in the Issaquah Ground Water Management Area, provides technical assistance to state and municipal officials on a variety of ground-water-related issues, and acts as a regulatory agency. As a lead agency, the U.S. Environmental Protection Agency deals with water pollution, underground storage tanks, pesticide and herbicide use, liquid waste, landfills, hazardous waste management (including Comprehensive Environmental Response, Compensation, and Liability Act, Superfund Amendments and Reauthorization Act of 1986 sites and generators), and drinking water management. As a support agency, the U.S. Environmental Protection Agency is involved with regulation of lagoons and holding ponds, sewage waste disposal, sludge application, spill control and prevention, solid waste handling, storm-water runoff, ground water, surface water, wetlands, and wells and water rights. The U.S. Environmental Protection Agency administers the Sole Source Aquifer Program, the Pesticides in Ground Water Survey, and the Agricultural Chemicals in Ground Water Strategy. The U.S.

Environmental Protection Agency also oversees the cleanup investigation and ground water monitoring of the Queen City Farms Superfund site.

### 3.1.2 U.S. Department of Agriculture

The U.S. Department of Agriculture provides technical assistance to landowners and communities concerning municipal sludge applications, livestock, crops, irrigation design, wildlife, and animal-waste ponds. The U.S. Department of Agriculture is a lead agency for pesticide and herbicide programs, and it administers programs such as fish and wildlife conservation programs and watershed projects.

### 3.1.3 The Soil Conservation Service

As part of the U.S. Department of Agriculture, the Soil Conservation Service provides technical assistance in soil erosion control and pesticide and herbicide use. It also plays a support role in agriculture, diking and drainage, forestry, lagoons, surface water, and wetlands.

## 3.2 Washington State Agencies

Some agencies operate at the state level but also influence ground water issues at a local level. The following discussion cites those state agencies that will influence the Issaquah Ground Water Management Area.

### 3.2.1 Washington State Department of Ecology (Ecology)

Ecology is charged with protecting the waters of the state; therefore, Ecology's activities affect ground water management decisions in the Issaquah Ground Water Management Area both directly and indirectly. Funding for the development of the IGWMP comes from the Centennial Clean Water fund, a grant administered by Ecology. Ecology issues discharge permits, performs compliance monitoring and enforces discharge regulations, and responds to pollution incidents. Ecology serves as a lead agency in over 20 environmental categories, including aquifer depletion, seawater intrusion, water resources, well construction and abandonment, and water rights. As a regulatory agency, Ecology is responsible for the cleanup of leaks and spills of hazardous materials, except in navigable waters, oversight of Resource Conservation and Recovery Act facilities and state hazardous waste cleanup sites, and the regulation of underground storage tanks. Ecology is working with the U.S. Environmental Protection Agency on the remediation of the Queen City Farms site.

### 3.2.2 Washington State Department of Health, Office of Environmental Health Programs

The Washington State Department of Health is involved in a variety of programs that influence ground water management. As part of the Northwest Drinking Water Operations Programs, the Washington State Department of Health is responsible for plan approval for Group A public water supplies, including well site inspections and final system certificate of completion review and it administers the wellhead protection program. The Washington State Department of Health conducted an area wide ground water monitoring project in the spring of 1995. This project included a statewide sampling of 1326 wells for pesticides and herbicides including 77 sites in King County. Results of the analysis indicated two wells in King County exceeded U.S. U.S. Environmental Protection Agency's detection limit for pesticides/herbicides. The results of this project has allowed the Washington State Department of Health to grant area wide waivers to purveyors for ongoing monitoring.

Under the heading of On-Site Sewage Program, the Washington State Department of Health is the state agency responsible for enforcing Chapter 248-96 Washington Administrative Code (WAC), the regulations that prescribe design and installation standards for septic systems. These regulations are currently under revision to increase effectiveness in protecting public health and water quality. The Washington State Department of Health is also responsible for guideline development and performance review of alternative sewage disposal systems.

### 3.2.3 Washington State Department of Natural Resources

The management of state lands for coal and timber production in the Issaquah Ground Water Management Area is the responsibility of the Washington State Department of Natural Resources. The Washington State Department of Natural Resources also collects hydrologic data as part of its timber management program.

### 3.2.4 Washington State Department of Transportation

The Washington State Department of Transportation is involved in highway planning and in the Issaquah Basin carries out shoulder and ditch maintenance as well as roadside spraying for plant control. Interstate 90 and State Routes 900 and 18 are the only roads maintained by the Washinton State Department of Transportation in the study area.

### 3.2.5 Washington State Department of Trade and Economic Development

The Washington State Department of Trade and Economic Development provides guidelines for implementing the Growth Management Act.

### 3.2.6 King Conservation District

The King Conservation District works with the urban and agricultural community to implement animal management and land use practices that increase productivity while minimizing soil erosion and water pollution. The King Conservation District is neither a branch of county government nor an enforcement agency, but rather a political subdivision of state government authorized by Chapter 89.08 RCW. The King Conservation District is dedicated to the conservation and best uses of the natural resources of King County.

## 3.3 King County Agencies

King County agencies which operate in the Issaquah Ground Water Management Area conduct activities that either directly or indirectly affect ground water management in the area.

### 3.3.1 The Metropolitan King County Council

The Metropolitan King County Council has legislative authority to enact ordinances and regulations governing protection of ground water resources, including land use provisions. In the past, the Metropolitan King County Council administered water resource, land use, and wetlands programs in addition to assisting in community plan reviews. The Metropolitan King County Council has adopted the King County Comprehensive Plan, and the community plans for Tahoma/Raven Heights, East Sammamish, Newcastle, and Snoqualmie. (See Figure 3.1)

### 3.3.2 King County Office of Strategic Planning

The Office of Strategic Planning is primarily involved in developing the King County Comprehensive Plan, subarea land use plans, affordable housing, and economic development. Additionally, this Office is involved in coordinating King County's review of comprehensive plans for all water and sewer systems operating in unincorporated King County.

### 3.3.3 King County Department of Development and Environmental Services

The King County Department of Development and Environmental Services regulates and enforces land development and zoning in the Issaquah Ground Water Management Area. Its specific duties include development control, commercial and residential permitting, sensitive area monitoring, and environmental review. The Department of Development and Environmental Services also implements the community plans for Tahoma/Raven

Heights, East Sammamish, Newcastle, and Snoqualmie by issuing building permits and by administering rezones and plats.

### 3.3.4 Seattle-King County Health Department, Environmental Health Division

The Seattle-King County Health Department is an advisory and regulatory body involved in a wide variety of related topics, including regulation of Group B public water systems. The Seattle-King County Health Department was the lead agency for the IGWMP through December of 1995. The Seattle-King County Health Department coordinated the activities necessary for ground water management plan development. Additionally, the Seattle-King County Health Department collected ground water quality and quantity data, managed the ground water database, drafted technical issue papers, and prepared the budget for development of the IGWMP. On January 1, 1996, the King County Department of Natural Resources, Surface Water Management Division replaced the Seattle-King County Health Department as lead agency for completion and implementation of the Issaquah Creek Valley Ground Water Management Plan.

The Seattle-King County Health Department is responsible for evaluating soil quality preparatory to permitting for on-site wastewater disposal systems. The Seattle-King County Health Department issues permits for proposed on-site sewage systems; responds to complaints about, and regulates the repair of, failing systems; reviews all subdivision proposals for which on-site sewage disposal is proposed; and educates homeowners in the proper maintenance of their systems. The Solid Waste Section of the Seattle-King County Health Department is responsible for permitting landfills, overseeing and permitting sludge applications, and sampling ground water in areas around the Cedar Hills Landfill.

The Local Hazardous Waste Management Program in King County helps businesses and households in identifying hazardous wastes, reducing the amount of hazardous waste and in managing these wastes properly. This Program is a joint effort by the Seattle-King County Health Department, King County Department of Metropolitan Services, King County Department of Natural Resources Solid Waste Division, the Seattle Solid Waste Utility, and 32 cities in King County. The goal of the program is to divert the maximum amount of household hazardous waste and small quantity generator waste from disposal in the municipal waste stream and from the environment.

The Local Hazardous Waste Management Program in King County covers these areas: household hazardous waste education and collection; small quantity generator education/technical assistance; collection; compliance; and program evaluation. The household hazardous waste education coordinator is housed at the Seattle-King County Health Department, and staff in the other agencies collaborate on the household hazardous waste education activities. Household hazardous waste collection and waste handling is coordinated by both the King County Department of Natural Resources Solid Waste Division and the Seattle Solid Waste Utility. There are two fixed collection sites and one mobile collection facility. Small quantity generator education and technical assistance consists of a telephone information line, printed material, seminars and workshops, an industrial materials exchanges (IMEX), and on-site consultation. The coordinator for this section is at Metro. Small quantity generator collection activities include providing waste collection facilities, operated by private firms under contract to local government, and encouraging licensed private sector hazardous waste handlers to take small quantity generator waste. These collection activities are coordinated by Solid Waste. The compliance coordinator is housed at Metro. Compliance activities include the Interagency Regulatory Advisory Committee, which review proposed regulations, the field teams perform on-site audits and other advisory visits and respond to complaints about businesses. Evaluation of the program is accomplished by implementation of the evaluation strategy developed by Seattle-King County Health Department. The actual data analysis is carried out by consultants, overseen by Seattle-King County Health Department. (*Local Hazardous Waste Management Plan*, November, 1990, Final Plan and EIS and *Local Hazardous Waste Management Plan Annual Report*, Calendar Year 1994, June 1995.)

### 3.3.5 King County Department of Natural Resources

The following divisions of the Department of Natural Resources conduct the activities described below in the Issaquah Ground Water Management Area.

**Solid Waste Division**

The Solid Waste Division operates and maintains the Cedar Hills Landfill. The Solid Waste Division responsibilities include on-site ground and surface water quality monitoring.

**Surface Water Management Division**

On January 1, 1996, the Surface Water Management Division became a part of the new King County Department of Natural Resources and assumed the lead agency role for the ground water program. Given the continuity between surface water and ground water in much of King County, the Surface Water Management Division management of surface water has a direct influence on the quantity and quality of water infiltrating to ground water.

The King County Surface Water Management Division is responsible for a variety of programs that address surface water quality and quantity in the Issaquah Ground Water Management Area. The programs include basin planning, non-point source pollution control, wetlands, and the construction and maintenance of drainage and water quality facilities

**Water Pollution Control Division**

The Water Pollution Control Division oversees most of the sewage collection and treatment for sewered areas in the Issaquah Ground Water Management Area, and is the designated regional water quality planning agency under the 1972 Clean Water Act. The Water Pollution Control Division provides sewage treatment services to the City of Issaquah and the Sammamish Plateau Water and Sewer District. The Water Pollution Control Division will be combined with the Surface Water Management Division to form the King County Department of Natural Resources, Water Resources Division in 1997.

**Natural Resources Division**

The Natural Resources Division includes the Office of Open Space and the Agricultural and Resources Lands Section. This Division provides resource planning services, administers County open space acquisition programs, public benefit rating system and other agriculturally related programs. The Resource Planning Section, Environmental Division was the lead agency for compilation of the natural environment chapter of the King County Comprehensive Plan. The Resource Planning Section also studies the interaction of wetlands and surface runoff and is involved in drainage basin planning.

### 3.3.6 Department of Transportation

The Department of Transportation consists of the former Department of Metropolitan Services (formerly Metro) and the former King County Department of Natural Resources, Roads Division.

**Road Services Division**

In addition to construction and maintenance of roads and associated drainage, the Department of Transportation, Road Services Division is responsible for vegetation control along the roadside.

## 3.4 Local Agencies

### 3.4.1 City of Issaquah

The City of Issaquah Planning Department, Environmental Community Services (SEPA), Parks Department and Natural Resources are the agencies primarily responsible for all issues related to ground water management within city limits. The Planning Department and Environmental Community Services are responsible for policy development and the permitting and review of new development(s) in the city. The City of Issaquah Public Works has responsibility for water and sewer system planning and administration, road maintenance, plant control on city property, and local water quality monitoring and protection.

### 3.4.2 Sammamish Plateau Water and Sewer District

The service area of the Sammamish Plateau Water and Sewer District is limited to households and commercial services in the northernmost portion of the Issaquah Ground Water Management Area. Its role is to provide water and sewer service within a specific area as well as to advise on matters relating to ground water quality and quantity. Sammamish Plateau Water and Sewer District's legal mandate was provided under state statutes, Chapters 56 and 57 RCW (Little 1989).

## 4. PHYSICAL GEOGRAPHY

This section describes the Issaquah Ground Water Management Area geographic setting, topography, and climate.

### 4.1 Geographic Setting

The Issaquah Ground Water Management Area is located in King County, Washington, east of the urbanized Seattle-Bellevue areas. The study area lies generally southeast of Lake Sammamish. The boundaries of the approximately 66-square-mile (171 $km^2$) Issaquah Ground Water Management Area are largely defined by the natural drainage divides of the Tibbetts Creek and Issaquah Creek watersheds. About 1.5 square miles (3.9 $km^2$) of the Issaquah Creek watershed southeast of State Route 18 (which lies within the boundary of the city of Seattle's Cedar River Watershed) is excluded from the Issaquah Ground Water Management Area (see Figure 4.1).

### 4.2 Topography

Over 90 percent of the Issaquah Ground Water Management Area lies above 400 feet (122 m) elevation and can be described as hilly, uneven uplands or mountainous. Rugged, steeply sloped hillsides and a group of peaks locally known as the Issaquah Alps dominate the landscape.

To simplify later descriptions and establish geographic references, local terrain is subdivided into three physiographic units: mountains, uplands and valleys. The mountains and uplands are forested or partially cleared. Lower valleys are partially or completely cleared as pasture or residential/commercial areas. Figure 4.2 depicts Issaquah Ground Water Management Area physiographic units.

Mountain areas include all or portions of Grand Ridge, Cougar Mountain, Squak Mountain, West Tiger Mountain, Tiger Mountain, South Tiger Mountain, and Taylor Mountain. Peak elevations are between 1,400 and 3,000 feet (427 to 914 m). Tiger Mountain is the tallest peak at 3,004 feet (916 m). The various Tiger Mountain peaks and Taylor mountain area will hereafter be collectively referred to as the Tiger Mountain peak complex. Numerous peaks, pinnacle-like hilltops, steeply sloped ridges, cliffs, and sharply cut canyons typify the relief.

The uplands are generally situated between 400 to 700 feet (122 to 213 m) elevation and include several residential areas. The upland surface is shaped by small hills, gently sloping areas, and depressions. Drainage is not well-defined. Significant upland features include portions of the East Sammamish Plateau, the lower western slope of Grand Ridge, Tradition Lake Terrace, Cedar Hills, and Hobart Plateau. Five small lakes are situated on the uplands; these being Yellow Lake, Tradition Lake, Lake MacDonald, Francis Lake, and Webster Lake.

The valleys are bordered by the steep slopes and bluffs of the uplands and mountains. Valley areas are generally situated below 400 feet (122 m) elevation. The Lake Sammamish shoreline defines the lowest elevation at 25 feet (8 m) above mean sea level. Surface relief varies and includes features such as short canyon-like cuts, irregular hills, depressions, ponds, terraces, alluvial fans, and narrow to broad floodplains. Drainage in the valleys is dominated by the major streams described below.

Tibbetts Creek and various unnamed streams and ditches drain about 6 square miles (16 $km^2$) in the northwest part of the Issaquah Ground Water Management Area, beneath Cougar and Squak Mountains. The lower reach of Tibbetts Creek joins a channelized drainage system that empties into Lake Sammamish.

Issaquah Creek and its tributaries drain approximately 60 square miles (155 $km^2$) or about 90 percent of the Issaquah Ground Water Management Area. Six major streams feed Issaquah Creek. Fifteen-mile Creek, Mason (sometimes called MacDonald) Creek, Holder Creek, and Carey Creek join Issaquah Creek and drain the entire southern half of the Issaquah Ground Water Management Area. Issaquah Creek flows northward through a narrow gap between Squak Mountain and West Tiger Mountain to the City of Issaquah, where it is joined by its two remaining tributaries, the East Fork and the North Fork.

Below 400 feet (122 m) elevation, Issaquah Creek and certain stretches of its tributaries flow through somewhat broadened valleys, bordered by sharply rising slopes. During the rainy season and storm events, numerous unnamed, intermittent streams and springs rush down these slopes and contribute substantial flows to perennial streams.
The valley widens to form a flat plain from the City's downtown to the shore of Lake Sammamish. Issaquah Creek and Tibbetts Creek flow across opposite sides of this valley and empty into the south end of Lake Sammamish.

### 4.3 Climate

Maritime air masses from the Pacific Ocean influence the climate year round and result in moderate temperatures. Short periods of hot, dry weather are caused by continental air masses brought by easterly winds. Likewise, short periods of cold winter temperatures are usually caused by frigid continental air masses.

Temperature data for the closest weather station at Landsburg (located south of the Issaquah Ground Water Management Area) are indicative of the cool, moderate climatic conditions associated with the region. July and August are typically the warmest months of the year, with an average temperature of 62° Fahrenheit (16.7° C). Warm season temperatures from June through September average 60° (15.6° C). The colder months are November through March with temperatures averaging 40° (4.4° C). January is the coldest month, averaging 37° (2.8° C). The average annual temperature is 49° (9.6° C) with the extreme temperatures ranging from -27° to 100°F. For elevations above Landsburg's 535 feet (163 m), average temperatures are expected to be cooler.

During the fall and winter months, prevailing winds from the southwest bring in moist air about the same temperature as the ocean's surface. Precipitation is typically of light to moderate intensity and long duration. About 75 percent of the annual precipitation occurs from October through March. Winter precipitation occasionally falls as snow at the higher elevations. Refer to Figure 4.3.

In the spring and summer prevailing winds are from the northwest. The summer can be described as the dry season. Typically, less than 5 percent of the annual rainfall occurs in July and August. Although infrequent, thunderstorms are more likely to occur during the summer months.

## 5.0 LAND USE IMPACTS ON GROUND WATER

The following discusses land use plans and policies, and the impacts of various land use activities on the ground water resource in the Issaquah Ground Water Management Area.

### 5.1 Existing and Proposed Land Use

This section discusses plans and policies relating specifically to ground water management for each agency in the Issaquah Ground Water Management Area and the impacts to ground water from the various land use activities.

#### 5.1.1 Plans and Policies Affecting Land Use

An understanding of existing land use activities and development trends in the Issaquah Ground Water Management Area requires a discussion of local and state land use policies influencing these factors. A summary of the King County Comprehensive Plan, Community Plans; City of Issaquah comprehensive plan, subarea plan, and ground water ordinance is included in this section. The Sammamish Plateau Water and Sewer District's authority does not permit it to adopt or enforce ground water policies or regulations (Little, 1989).

**King County Comprehensive Plan.** The King County Comprehensive Plan establishes countywide policies and goals as well as a framework for policy making at the local level. The King County Comprehensive Plan is concerned with land use in the county and directs decisions affecting growth and land development. The King County Comprehensive Plan has been revised to comply with the Growth Management Act and the King County Countywide Planning Policies. The King County Comprehensive Plan was adopted on November 18, 1994.

The King County Comprehensive Plan establishes policy priorities for ground water management for all of King County, including the Issaquah Creek Basin. The Comprehensive Plan calls for the implementation of these policies through land use plans and development reviews. Ground water policies should also be used to guide the County's review of the plans prepared for water and sewer purveyors and other government projects.

The King County Comprehensive Plan establishes countywide policies and goals as well as a framework for policy making at the local level. The King County Comprehensive Plan is concerned with land use in the county and directs decisions affecting growth and land development. The King County Comprehensive Plan includes the following policies revised to comply with the Growth Management Act and the King County Countywide Planning Policies.

NE 332 In unincorporated King County, areas identified as sole source aquifers or as areas with high susceptibility for ground water contamination where aquifers are used for potable water are designated as Critical Aquifer Recharge Areas as shown on the map, entitled Areas Highly Susceptible to Ground Water Contamination. Since this map focuses primarily on water quality issues, the county shall work in conjunction with cities and ground water purveyors to designate and map recharge areas which address ground water quantity concerns as a new information from ground water and wellhead protection studies adopted by county or state agencies becomes available. Updating and refining the map shall be an ongoing process.

NE-333 King County should protect the quality and quantity of ground water countywide by:

a. Placing a priority on implementation of adopted Ground Water Management Plans;
b. Developing a process by which King County will review, and implement, as appropriate, adopted Wellhead Protection Programs in conjunction with cities and groundwater purveyors;
c. Developing, with affected jurisdictions, best management practices for new development and for forestry, agriculture, and mining operation recommended in adopted Ground Water Management Plans and Wellhead Protection Programs as appropriate. The goals of these practices should be to promote aquifer recharge quality and to strive for no net reduction of recharge to ground water quantity; and,
d. Refining regulations as appropriate to protect critical aquifer recharge areas when information is evaluated and adopted by King County.

NE-334 King County should protect ground water recharge quantity in the Urban Growth Area by promoting methods that infiltrate runoff where site conditions permit, except where potential ground water contamination cannot be prevented by pollution source controls and stormwater pretreatment.

NE-335 In making future zoning and land use decisions which are subject to environmental review, King County shall evaluate and monitor ground water policies, their implementation costs, and the impacts upon the quantity and quality of ground water. The depletion or degradation of aquifers needed for potable water supplies should be avoided or mitigated, and the need to plan and develop feasible and equivalent replacement sources to compensate for the potential loss of water supplies should be considered.

NE-336 King County should protect ground water in the Rural Area by:

a. Preferring land uses that retain a high ratio of permeable to impermeable surface area, maintain or augment the infiltration capacity of the natural soils and;
b. Requiring standards for seasonal and maximum vegetation clearing limits, impervious surface limit, and, where appropriate, infiltration of surface water. These standards should be designed to provide appropriate exceptions consistent with Policy R-216.

**King County Community Plans.** Community plans represent another legally binding policy document with jurisdiction in the Issaquah Ground Water Management Area. King County is divided into community planning areas allowing citizens and planning officials to develop local area goals, plans, and policies. Once adopted by the Metropolitan King County Council, a community plan becomes an official document affecting development and municipal expenditures in the community.

The King County Comprehensive Plan adopted by the Metropolitan King County Council requires within one year of adoption of the Plan that the County Executive should report to the Council with a work program to revise, replace, or repeal existing community plans within three years. The Council adopted the following King County Comprehensive Plan policies:

- I-301 Existing community plans shall remain in effect and continue as official County policy until reviewed and revised to be consistent with the 1994 Comprehensive Plan and adopted as elements of the Comprehensive Plan, or until repealed or replaced. In the case of conflict or inconsistency between applicable policies in existing community plans and the 1994 Comprehensive Plan, the Comprehensive Plan shall govern.

- I-302 The King County Executive will report to the Council by December 31, 1995 or by the time the first amendments to the Comprehensive Plan are adopted, whichever is sooner, with a work program to review and revised existing community plans to make them consistent with the Comprehensive plan, or to replace or repeal them, within three years of adoption of this Plan. Any such review shall include extensive citizen participation and the participation of adjacent or affected cities.

King County Community Planning Areas in the Issaquah Ground Water Management Area are Tahoma/Raven Heights, East Sammamish, Newcastle, and Snoqualmie. Policies are developed for each community and, if adopted by the Metropolitan King County Council, they are included in the community plan.

Since the majority of the study area falls within the boundaries of the Tahoma/Raven Heights Community, land use policies for this community have a greater influence on land use in the Issaquah Ground Water Management Area than do policies for other communities. The Tahoma/Raven Heights Plan (King County Planning 1984) lists four general elements that describe the most important land use priorities in the area:

- The rural character should be preserved and balanced with new development;
- The compatibility of adjacent land uses should be maintained, especially with regard to new development and rural uses;
- Public services should meet existing demand before expanding to serve new development;
- Sensitive areas should be permanently protected, and development should be redirected whenever it poses a threat to sensitive areas.

The East Sammamish Community Plan was updated and adopted by the Metropolitan King County Council on May 25, 1993. The East Sammamish Community Plan includes Grand Ridge which is located in the northeast area of the Issaquah Ground Water Management Area. The majority of Grand Ridge was designated rural with some quarry mining designations. The natural environment chapter of the East Sammamish Community Plan includes policies to implement the IGWMP (see Appendix B).

Ground water plans and policies specific to the Issaquah Creek Basin are developed in each of the four King County Community Plans with jurisdiction in the area. The key features of these plans relating to ground water include:

- The demand for water in Tahoma/Raven Heights should not exceed the area's ability to provide clean, plentiful ground water.
- As in the King County Comprehensive Plan, the Tahoma/Raven Heights Plan maintains that ground water recharge areas and watersheds should be identified and protected from potentially harmful land uses.
- The Snoqualmie Plan specifies that underground storage tanks holding potential water pollutants should have special containment and leak detection systems.
- The East Sammamish Plan includes the following key features related to ground water:

NE-8 Upon adoption, the recommendations of the Issaquah Creek, Redmond-Bear Creek and East King County Ground Water Management Program(s) should be implemented through zoning and other mechanisms to protect ground water resources.

GM-16 The eastern portion of Grand Ridge should retain its Rural designation and is not included within the UGA. Zoning for this eastern portion shall require rural clustering. The western portion of Grand Ridge that is less environmentally constrained shall also keep a Rural designation and is not within the UGA. Residential development within the western portion of Grand Ridge should require rural clustering. The western portion is substantially less constrained than the balance of Grand Ridge, and redesignation to Urban may be considered through a plan amendment study, once the Issaquah Wellhead Protection Study is complete. Such plan amendment study also must comply with the Ground Water Management Plan when approved by the Department of Ecology. Land use decisions should be compatible with the findings of the Wellhead Protection Study and the adopted Ground Water Management Plan.

GM-16 has been superseded by the 1994 King County Comprehensive Plan. Policy I-301 of the Plan states that existing community plans shall remain in effect and continue as official county policy until reviewed and revised to be consistent with the 1994 Plan and adopted as elements of the King County Comprehensive Plan or until repealed or replaced. In the case of conflict or inconsistency between applicable policies in existing community plans and the 1994 King County Comprehensive Plan, the Comprehensive Plan shall govern.

Policy U-510 of the Comprehensive Plan, designates the Grand Ridge site as an Urban Planned Development. The Grand Ridge area includes an Urban Planned Development, public open space and rural areas. The exact uses and development standards for the urban and rural areas will be determined upon agreement to an Urban Planned Development conditions by the Metropolitan King County Council.

NE-6 Public sewers are the preferred method for wastewater treatment in Urban Areas, including Urban Reserve Areas. Within Rural Areas, and Urban Areas where sewers are not yet available, proper siting and maintenance of septic systems should continue to receive special attention for new and existing land development to reserve the valuable ecological functions and beneficial public uses of water resources.

NE-11 All golf course proposals shall be carefully evaluated for their impact on surface and ground water quality and quantity, sensitive areas, and fish and wildlife resources and habitat.

NE-12 Water used for irrigating golf courses should come from non-potable water sources whenever possible. Use of natural surface water sources, such as streams, should be avoided due to impacts on fish and other wildlife habitat. A water conservation plan must be submitted with golf course applications and should address measures such as the use of drought-tolerant plant species.

The Issaquah Creek Basin and Nonpoint Action Plan is one of a series of basin plans being completed within the Issaquah Ground Water Management Area. The plan focuses on drainage and flooding, water pollution, and programs with fish and wildlife habitat in the 61-square mile Issaquah Creek basin. The plan recommends a set of regulatory, programmatic, and capital improvement actions to address these problems. While the plan focuses on surface water issues, the maintenance of ground water quality and recharge was considered in the development of the recommendations. The plan was adopted by the Metropolitan King County Council on July 10, 1995 and the Issaquah City Council has incorporated sections of this plan into the Issaquah Comprehensive Plan.

**City of Issaquah**

**Issaquah Comprehensive Plan**. As it is with King County, the Issaquah Comprehensive Plan is one of the guiding policy documents for the City of Issaquah. In accordance with the guidelines mandated by the Washington State Growth Management Act (GMA), Issaquah adopted its Comprehensive Plan April 17, 1995. Additional documents related to the Issaquah Comprehensive Plan include: Environmental Impact Statement for the Comprehensive Plan, release to the public in February 1995; an updated Critical Areas Ordinance, adopted July 17, 1995; and an updated Shorelines Master Program, expected adoption March 1996. The GMA requires the protection of Critical Aquifer Recharge Areas as well as many other critical areas. (Lewine, J. 1995)

**Sub-Area Plans**. Subarea Plans adopted prior to 1995 are being examined by the Planning Department for consistency with the Issaquah Comprehensive Plan. The 1983 I-90 Subarea Plan and the 1985 Newport Subarea Plan have been repealed. The existing 1989 Tibbetts-East Cougar Subarea Plan is not repealed; however, it is to be used for policy direction and for the community input that it contains, and not as a GMA consistent plan.

Natural systems, including surface water and ground water, are examined in all of the above plans. It will continue to be a major component in Issaquah's new and updated Subarea Plans. (Lewine, J. 1995)

**Ground Water Ordinance.** The City of Issaquah has a non-degradation ordinance for ground water quality protection at its wellheads.

**State Policy Documents**

The Shoreline Management Act, adopted by the legislature in 1971, protects shoreline resources according to the environmental designation of the shoreline. Each environmental designation represents a particular land use emphasis and approach to development. Policies and recommendations within each designation encourage land uses that enhance the natural character of the shoreline. In the study area, the Act applies only to Lake Sammamish and Issaquah Creek.

Ecology enforces the water quality standards for ground water of the State of Washington (Chapter 73-200 WAC. See Appendix C). Under these standards, the Ecology antidegradation policy ensures the purity of the state's ground water and protects the natural environment. Existing and future beneficial uses must be maintained and protected, and degradation of ground water quality that would interfere with or become injurious to beneficial uses is not allowed.

### 5.1.2 Existing Land Use and Development Trends

The City of Issaquah and the I-90 corridor represent the primary centers of development in the study area. The majority of the area, however, is rural in character.

**Existing Land Use.** Residential development is concentrated in the City of Issaquah, the Mirrormont area, and in the area northeast of Lake Sammamish State Park. In the City of Issaquah, the highest density of single-family and duplex residences is east of Front Street, whereas multi-family residences are found near Hobart Road and Wildwood Boulevard. Most of the western half of the City is zoned for single-family medium-density housing. In the Issaquah Ground Water Management Area there are approximately 6,295 single-family residences and 2,387 multi-family units (King County LDIS October 1993). Figure 5.1A shows existing land use in the Issaquah Creek Valley Ground Water Managment Area.

The primary commercial and industrial zones in the Issaquah Ground Water Management Area are located within Issaquah's city limits. Industrial activities include a milk processing plant, a state-owned fish hatchery, and various manufacturing activities in industrial parks located along the I-90 corridor. Issaquah also supports a variety of technical, retail, and professional services.

Industrial land use in unincorporated sections of the Issaquah Ground Water Management Area is limited to resource extraction and a regional landfill. Sand and gravel pits are located north of I-90 along the North Fork of Issaquah Creek and in the southwestern part of the study area near Cedar Grove Road. In addition, the Cedar Hills Regional Landfill is located in the study area on a 920-acre site north of Cedar Grove Road.

Issaquah Creek Valley's undeveloped portions include forest and agricultural lands. Logging operations take place in timber parcels to the northwest and east of Mirrormont. Agriculture in the Issaquah Ground Water Management Area is primarily pastoral with small farms each keeping 10 to 15 head of livestock scattered along the Issaquah-Hobart Road and in the Hobart area. Small-scale horticulture exists in individual plots throughout the study area, while a limited amount of row crops, orchards, and nurseries are located on the Hobart Plateau (Scheer 1988).

**Residential Development Trends**. Housing development in the Issaquah Creek Basin has increased in proportion to growth experienced in the rest of King County in the 1980s. Residential trends are reflected in Table 5.1 for the Issaquah Ground Water Management Area and in Table 5.2 for the City of Issaquah. In the City of Issaquah there were 29 single-family applications in 1991, 41 in 1992 and 81 in 1993. Household population forecasts are also discussed in Section 6.5 and in Table 6.5.

**Commercial and Industrial Development Trends.** With the exception of scattered markets and service stations, commercial development in the Issaquah Ground Water Management Area is contained within Issaquah city boundaries. Included in these plans are added retail facilities and office complexes (Issaquah/DDR 1989). Industrial development in Issaquah is limited to light assembly manufacturing and retail.

Growth of commercial and industrial services in the Issaquah Ground Water Management Area will increase the potential for ground water contamination. In addition, placement of these facilities over ground water recharge areas may reduce the quantity of ground water available for future use.

**Agricultural Trends**. Small-scale grazing and horticulture may drop off slightly in rural areas in the Issaquah Ground Water Management Area due to the increase in single-family housing development. The Tahoma/Raven Heights Communities Plan and the King County Comprehensive Plan designate the Hobart Plateau as rural. This designation may slow, or stop, the transition from agricultural uses to residential development.

**Areas of Concern and Future Information Needs.** Additional information is needed to enable accurate commercial, and industrial development projections for the Issaquah Creek Basin. Figure 5.1B shows projections for future land use in the Issaquah Ground Water Management Area. Figure 5.1C shows proposed future land use specifically for the City of Issaquah. Information on the specific type and location of existing activities and new development occurring in the Issaquah Ground Water Management Area would also help to indicate where ground water contamination is likely to occur and to what extent the demand for ground water is likely to increase in the future.

## 5.2 <u>On-Site Septic Systems</u>

On-site septic systems can be found throughout the Issaquah Ground Water Management Area. They occur, to a limited extent, in those areas served by the City of Issaquah and Sammamish Plateau Water and Sewer District sanitary sewer collection systems. All on-site septic systems in the study area are regulated by the Seattle-King County Health Department. New on-site septic systems in the Issaquah Ground Water Management Area must conform to location and design guidelines established by the King County Board of Health Regulations, Title 13.

On-site septic systems, if properly designed, installed, and maintained, may be the preferred alternative to sewers because of lower water use and reinfiltration of wastewater to the ground.

The costs of installation and repair of on-site septic systems are minor when compared to the environmental and economic costs of installing and maintaining sewer systems. Depending on lot sizes and soil types these repairs may or may not conform to current regulations.

### 5.2.1 Soils and Sewage Effluent

According to the Issaquah Creek Basin Current/Future Conditions and Source Identification Report: King County Surface Water Management Division (October 1991), some soils, such as those in the Kitsap series, are more suitable for treating and absorbing sewage effluent than others. Clays and clay loams filter and attenuate contaminants well, but they do not absorb effluent adequately. Soils with a coarse texture, such as those in the Everett series, absorb effluent well, but do not remove contaminants because of their high permeability.

Soil depth is also important when determining the proper function of a sewage system. At least 3 feet of unsaturated soil is required to protect potable ground water aquifers. If a design reviewed by the Seattle-King County Health Department indicates that the soil depth and soil type on a proposed site are not appropriate for a conventional subsurface soil absorption system, an alternative type of system, such as a mound system or sand filter may be needed.

### 5.2.2 Areas of Concern and Future Information Needs

In 1990, the Seattle-King County Health Department reviewed on-site septic system records, past field surveys, and a field survey of 192 septic systems in the Issaquah Creek Basin. The file review of 1,432 systems provided an estimated on-site septic system failure rate of 5.5 percent; that is, 78 of the 1,432 systems are either currently failing or have failed in the past (Anderberg, 1991). The field survey indicated an overall 9 percent failure rate. Roughly 32 percent of the systems reviewed were installed before 1970, when the focus was on design for disposal, not treatment of wastewater. "Lack of septic system maintenance (pumping) may contribute to an increase in the number of failures in the future as only 10 percent of all systems have records of being pumped in the last 20 years" (Issaquah Creek Basin Current/Future Conditions and Source Identification Report: King County Surface Water Management Division (October 1991)).

These systems may be a source of nonpoint pollution to ground water if they are located in extremely permeable soils or within high recharge areas above ground water. The Issaquah Ground Water Management Area has limited areas of extremely permeable (Everett) soils and large areas of shallow (Alderwood) soils. Figure 5.2 shows where failing on-site septic systems are concentrated in relation to existing soil types. Many of the failure areas are located in Alderwood soils.

Another research priority should be locating all on-site septic systems, especially those with a history of failure and those located in potential ground water recharge zones. Septic drainage fields are a potential contributor of phosphates, nitrates, and synthetic organic chemicals to surface and ground water. More research is needed on the actual threat to ground water posed by drainage fields in the study area.

## 5.3 Sewers

The City of Issaquah and the Sammamish Plateau Water and Sewer District are the only sanitary sewer providers in the Issaquah Ground Water Management Area. The boundaries of these sewer service areas are shown in Figure 5.3. All other development in the study area operates on on-site septic systems.

### 5.3.1 City of Issaquah

The City of Issaquah provides sanitary sewer service to most developed areas of the city. Older homes constructed before the installation of the sanitary sewer are not required to connect to the sewer system if their septic systems meet the Seattle-King County Health Department standards. The City of Issaquah has planned to extend sanitary sewers to the southern part of the city and has evaluated the impacts of extending service to Grand Ridge and part(s) of Cougar Mountain as part of the Sewer Comprehensive Plan update. The City of Issaquah is not planning to extend the sanitary sewer to Mirrormont (Lynne 1994).

Leaks have been detected in some of Issaquah's older sewer lines which were installed more than 30 years ago. Leaks in the Issaquah system are located by using cameras; leaks are repaired by grouting.

Since the shutdown of a small sewage treatment facility on Issaquah Creek in 1962, the City of Issaquah has routed all sewage to Metro's treatment facility in Renton via a trunk line.

### 5.3.2 Sammamish Plateau Water and Sewer District

Sammamish Plateau Water and Sewer District began to construct a sanitary sewer system in 1970. The portion of the Sammamish Plateau Water and Sewer District sewer system that falls into Issaquah Ground Water Management Area boundaries serves residences and also businesses north of the City of Issaquah limits. Future connections will be made to all new buildings constructed in this area and to those homes found to have inadequate septic systems by the Seattle-King County Health Department (Phillips 1989).

As with the City of Issaquah's sewer system, all sewage from the Sammamish Plateau Water and Sewer District sewer system is sent through a trunk line to Metro's treatment facility in Renton.

### 5.3.3 Areas of Concern and Future Information Needs

For both of the referenced sanitary sewer collection systems, additional information is needed on existing and projected sewer quantities, as well as a detailed account of future service options and system expansion plans. This information, together with data on sewer line leaks, would provide a more complete picture of Issaquah Ground Water Management Area sewer service in relation to sensitive ground water areas.

## 5.4 Stormwater

### 5.4.1 Existing Systems

Storm water is important to ground water management for two reasons. First, storm water has the potential to carry contaminants, such as oil and grease found along roadways and other impervious surfaces, to ground water recharge zones. In addition, stormwater management can affect ground water quantity if stormwater is directed to ground water recharge areas.

There are several major roads in the Issaquah Ground Water Management Area: Interstate 90, State Routes 900 and 18, the Issaquah-Hobart Road, Vaughn Hill Road and SE 56th Street. Common contaminants found in stormwater runoff from roads include petroleum products, heavy metals, and soot. In areas where existing roads cross streams, untreated road runoff may be discharged directly to local streams in the Issaquah Ground Water Management Area. For example, untreated roadway runoff is discharged into the North Fork of Issaquah Creek at river mile 0.2 and 1.2 (Issaquah Creek Basin Current/Future Conditions and Source Identification Report, King County Surface Water Management Division, October, 1991).

The only stormwater systems in the Issaquah Ground Water Management Area are operated by the City of Issaquah and the King County Division of Surface Water Management. Storm sewers for the City of Issaquah conform to the same boundaries as its sanitary sewer system. Some portions of the storm system include oil and water separators and these are required in all parking area drainage systems. The city has recently established a Stormwater Management Utility to direct the improvement of stormwater systems in Issaquah (Rothnie 1989). Stormwater sewer services, provided by the King County Surface Water Management Division, are located in a limited number of areas in the remainder of the Issaquah Ground Water Management Area, including the Mirrormont area (Eckel 1989). Single line storm drains are also located throughout the study area, especially along most roadways, and empty into local surface water bodies.

Ecology has developed stormwater management guidelines, under the 1989 Puget Sound Water Quality Management Plan. The guidelines which became effective in mid-1994, are directly relevant to I-90, State Route 18, and State Route 900 in the Issaquah Creek Basin. The guidelines will be implemented by local jurisdictions and the State Department of Transportation (King County Surface Water Management Division 1991). In addition, King County and the City of Issaquah, with partial funding from Ecology have prepared a basin plan for the Issaquah Creek watershed. This plan, which includes recommendations for the management of stormwater quality and quantity, will be submitted to the City of Issaquah and the Metropolitan King County Council for adoption in February 1995.

### 5.4.2 Areas of Concern and Future Information Needs

One problem associated with urban runoff is the complexity of the contaminants. Typical pollutants associated with forested areas are sediments and nutrients, whereas urban runoff carries more complex and variable pollutant types. The most common land use changes in the Issaquah Creek Basin are forest land to residential development and non-forested lowland to commercial development. The result is that more complex and variable contaminants may be seeping towards the ground water.

A research priority in this area should be to determine the extent to which storm water runoff represents a threat to ground water quality. This research would also locate those areas where a significant amount of vehicular oils and greases are channeled by storm water systems into sensitive ground water recharge zones.

## 5.5 <u>Landfills and Industrial Waste Sites</u>

Improperly managed landfills and industrial waste sites can represent a significant potential threat to ground water quality in the study area. Both the Cedar Hills Landfill and the Queen City Farms industrial waste site are located in the study area; however, there are no buried or abandoned landfills.

There have been numerous cases of the illegal dumping of non-hazardous wastes throughout the Issaquah Ground Water Management Area, consisting of household trash, furniture, appliances and car parts. The Seattle-King County Health Department has investigated these incidents and contacted the applicable agency, such as King County Roads, to remediate the site (for example, collect household garbage). In other instances, such as the dumping of oil and antifreeze near a creek on High Point Road, the case has been referred to the appropriate agency, in this instance, King County Surface Water Management (Slagle, K. October 1995).

Table 5.3 lists businesses in the Issaquah Ground Water Management Area where Ecology is investigating or monitoring the cleanup of toxic material spills. In most instances, ground water contamination is either suspected or confirmed.

### 5.5.1 Cedar Hills Landfill

Cedar Hills Landfill covers 920 acres in the western portion of the study area, between the May Valley and Cedar Grove Roads. This regional landfill is closed to self-haulers, but accepts waste from the seven County-operated transfer stations located outside the Issaquah Ground Water Managment Area and commercial collection companies. In 1992, 909,833 tons of solid waste were disposed, an average of approximately 2,500 tons per day (King County Solid Waste Division Tonnage Report, December, 1992). The expected life capacity of Cedar Hills is projected to be approximately 27 years (1992 Comprehensive Solid Waste Management Plan and EIS, Solid Waste Division, August 1993).

The wastes accepted at Cedar Hills are strictly in accordance with all applicable federal, state, and local regulations. The waste is municipal solid waste, except for the special wastes which are cleared through the Seattle-King County Health Department's waste clearance process. The Solid Waste Division also has a program to screen wastes coming into the system to minimize acceptance of unwanted materials.

The Cedar Hills Draft Site Development Plan was completed in 1987 (King County Solid Waste Division, 1987); its purpose was to ensure that the landfill: (1) meets the disposal needs of King County; (2) meets all applicable federal, state, and local laws and regulations; and (3) provides a method of waste disposal that protects the human health and safety and minimizes environmental impacts.

Under the guidance of the Site Development Plan, the Solid Waste Division had made significant engineering and operational changes to Cedar Hills to reduce environmental impacts and to meet new federal, state, and local regulations. Major improvements included: (1) construction of a storm water control system; (2) installation of an active gas collection and flare system; (3) installation of a leachate collection, pretreatment, and transmission system; (4) interim and final closure of all past refuse disposal areas; (5) installation of a composite clay and synthetic liner system under all new refuse disposal areas; and (6) expansion of the ground water and landfill gas monitoring programs.

Ground water quality at Cedar Hills has most recently been documented in the Evaluation of Ground Water Quality Data (EMCON April 1991) and the 1994 Annual Ground Water Data Evaluation Report (King County Solid Waste Division, February, 1996). These annual reports evaluate data collected from monitoring wells completed in two separate ground water systems at Cedar Hills, including a shallow local system encompassing Vashon age deposits and a deeper regional system encompassing pre-Vashon deposits.

The local ground water system consists of discontinuous perched saturated lenses within five distinct stratigraphic units including the alluvium, recessional outwash, glacial till, stratified drift, and advance outwash deposits. Ground water impacts have been identified in perched lenses within the stratified drift on the east side of the landfill. These impacts have consisted primarily of the detection of vinyl chloride with sporadic detection of other compounds. A series of ground water extraction wells have since been installed to remediate the impacts and follow-up monitoring in the area is ongoing. Ground water impacts have also been observed in the stratified drift to the south of the landfill. Although concentrations of typical leachate indicator parameters have been dramatically reduced, there have most recently been detection of vinyl chloride. A consultant is presently under contract to evaluate possible remedial measures for this southern area, if they are determined to be necessary (Komorita 1994).

The deeper regional system below Cedar Hills consists of an aquifer of limited extent (Aquifer 2) and one of regional extent (Aquifer 3). There have been no landfill impacts identified in the regional system; however, as will be discussed in the following section, ground water impacts have been confirmed in the regional system at the Queen City Farms site located immediately to the south of Cedar Hills. The general ground water flow direction below Cedar Hills is to the north (Komorita 1994).

The hydrogeologic conditions at Cedar Hills have been extensively studied and most recently documented in the Expanded Aquifer Monitoring Project Phase I Report (EMCON November 1992). The Phase I Report summarizes all available hydrogeologic information about the landfill and the surrounding areas, and it identified data gaps which were completed as part of the Phase II portion of the project. The Phase II Report focused on characterization of the uppermost aquifer below the site (Komorita 1994).

The direction of ground water flow below Cedar Hills in this deep regional aquifer (Aquifer 3) has been documented to be in an northerly to north easterly direction. (South Cedar Hills Remedial Investigation, Sweet-Edwards/EMCON, January 1991, Evaluation of Ground Water Quality Data, Sweet Edwards/EMCON, April, 1991; 1992 Annual Ground Water Data Evaluation Report, Solid Waste Division, July 1993; and Expanded Aquifer Monitoring Phase I Report, EMCON Northwest, February, 1994). Rural residential areas exist to the west, north, and east of Cedar Hills with Queen City Farms to the south. The residences immediately to the east have potable wells which are on the Solid Waste Division's quarterly ground water monitoring program (Komorita 1994).

The Seattle-King County Health Department, Solid Waste Division samples four wells biannually, around the Cedar Hills Landfill, for priority pollutants. None of these off-site monitoring wells, to date, has exhibited levels above primary drinking water standards for the constituents analyzed (Hickok 1994).

### 5.5.2 Queen City Farms Industrial Waste Site

Queen City Farms is located immediately south of the Cedar Hills Landfill and north of Cedar Grove Road. If improperly managed, industrial waste sites can represent a significant threat to ground water quality. Before Queen City Farms was closed, the Boeing Company was a primary user of the farm as an industrial waste site in the 1950s and 1960s. Industrial liquid waste and drums were deposited at the site in three ponds (numbers 1-3) and in a trench. An additional three ponds (numbers 4-6) were used to contain unacceptable pig feed from the farm itself (Wall 1989).

After the designation of Queen City Farms as an U.S. Environmental Protection Agency Superfund site, ten ground water monitoring wells were drilled and contamination was found in water drawn from wells located near ponds 1-3. To mitigate the threat to ground water, Boeing and Queen City Farms have undertaken three cleanup measures: (1) the ponds have been backfilled with clean soil; (2) each pond has been capped with a liner; and (3) efforts have been made to intercept contaminants before they reach the shallow aquifer (Wall 1989).

Subsequent to these cleanup actions the King County Solid Waste Division conducted a remedial investigation of the portion of the Cedar Hills Landfill adjoining the Queen City Farms property. The remedial investigation concluded that the landfill was not contributing to ground water contamination at the Queen City Farms site (King County Solid Waste Division 1991).

The King County Solid Waste Division is monitoring surface water and ground water flow and quality on the portion of the landfill adjoining the Queen City Farms property (Orlean 1994). The King County Solid Waste Division provides the data collected from this site to the U.S. Environmental Protection Agency.

In addition, Queen City Farms, Inc. and the Boeing Company have conducted a remedial investigation of the Queen City Farms site. This remedial investigation concluded that there are three shallow aquifers beneath the site. The upper two aquifers are contaminated with volatile organic compounds due to the past waste disposal practices on the property. The U.S. Environmental Protection Agency is currently negotiating with Queen City Farms, Inc. and the Boeing Company for cleanup of the two contaminated aquifers (Orlean 1994).

Further mitigation on the site was carried out in summer 1995. In the buried drums area it was found that soils were contaminated with polychlorinated biphenyls. Six hundred and twenty two tons of soil with polychlorinated biphenyls exceeding 100 parts per million were identified and will be hauled off site in drums. The remaining contaminated soil under 100 parts per million of polychlorinated biphenyls will be backfilled under the cap. This soil is presently stockpiled with a liner beneath it and a plastic cover over it.

Wells monitored in the buried drum area determined that TCE and vinyl chloride are still prevalent in the ground water on site. Boeing has also been monitoring wells off site.

In the Initial Remedial Measure Area, a barrier (slurry) wall is to be erected to contain any contamination and prevent it migrating off site. This wall will be erected in spring/summer 1996 and will include soil from the buried drums area. The design of this wall will be finalized by the end of 1995.

The results of samples taken at the 4-Tek Industries site on the Queen City Farms were satisfactory. More monitoring wells are to be installed by Boeing for monitoring both on and off site. Monitoring of the site is ongoing by the U.S. Environmental Protection Agency (McPhillips, L. October 23, 30, 1995).

Presently, the Cedar Grove composting facility operates on the Queen City Farm site. While the composting operation is on the same property as the industrial waste site, it is outside the Issaquah Ground Water Management Area.

### 5.5.3 Areas of Concern and Future Information Needs

To better understand the potential risk to ground water posed by landfill activities in the Issaquah Ground Water Management Area, specific information is needed in the following areas:

- Ground water quality on and surrounding both the Cedar Hills Landfill and Queen City Farms, Inc. sites should continue to be evaluated. Data should be shared with the Seattle-King County Health Department's Drinking Water Program and entered into their database.
- The report findings and proposed future activities concerning ground water quality impacts both off- and on-site.
- The direction of ground water flows in the area of the landfills, as well as the depth and range of aquifers exposed to leachate contaminants.

## 5.6 Underground Storage Tanks

### 5.6.1 Description

Underground storage tanks represent another potential threat to ground water quality and quantity in the Issaquah Creek Basin. Faulty underground storage tank system components and poor facility management practices are the most cited causes of leaks and spills, collectively and commonly referred to as releases, from underground storage tanks. Releases from underground storage tank systems are especially problematic in areas with shallow aquifers or where ground water drawn from private wells is the primary source of drinking water (Knowlton 1994).

Ecology maintains a list of underground storage tanks in the Issaquah Ground Water Management Area. There are presently 78 underground storage tanks operational in the Issaquah Ground Water Management Area (see Table 5.4). The 1989 Ecology list had 123 operational underground storage tanks (1991 Issaquah Area Characterization report). This is consistent with a statewide trend toward fewer underground storage tanks in operation. This list is not all-inclusive, it reflects only those systems reported to Ecology. The list does represent the majority of regulated underground storage tank systems in the area. Table 5.5 lists the age ranges of the underground storage tanks in the Issaquah Ground Water Management Area, and Table 5.6 lists the types of substances found in those underground storage tanks. Table 5.7 summarizes the sizes of underground storage tanks.

Figure 5.4 shows some of the underground storage tank locations on Ecology's list. While underground storage tanks are concentrated in the City of Issaquah, some are also found at the Cedar Hills Landfill, along the Issaquah-Hobart Road, near quarries and mines, in Hobart, at Lake Sammamish State Park, and at other commercial and industrial locations (Ecology 1989). The locations of underground storage tanks such as small, home heating oil tanks have not yet been identified.

Ecology implements Washington's Underground Storage Tank Regulations (Chapter 173-360 WAC). Written into this regulation are performance standards that must be achieved for all operational systems. These standards address released detection for tanks and ancillary piping, corrosion protection for tanks and ancillary piping; spill and overflow prevention and financial responsibility (i.e., an insurance policy that covers the costs for cleaning up a release). An annual underground storage tanks permit is issued for each system whose owner certifies compliance with Chapter 173-360 WAC. The cost of the annual permit is $75. The purpose of underground storage tank regulation is to preserve the quality of ground water (i.e., a pollution prevention program). The responsibility of complying with Chapter 173-360 WAC is that of the underground storage tank system's owner or operator. Ecology does not maintain underground storage tanks, but it does work to facilitate the owner's comprehension of the regulation. By regulation design compliance with performance standards translates into pollution prevention. Ecology regularly coordinates facility inspections to ensure compliance with Chapter 173-360 WAC (Knowlton 1994).

State regulation requires that underground storage tanks be upgraded to include a leak detection system (water tanks are exempt). The initiative to regulate underground storage tanks started with a federal law passed by the U.S. Congress (Hazardous and Solid Waste Amendments to Resource Conservation and Recovery Act, 1984 gave the U.S. Environmental Protection Agency the responsibility of writing federal regulations (40 CFR Parts 280 and 281, 1988). Within the federal regulation was the opportunity for states to pass and implement their own laws and regulations that would be no less stringent than the federal. Washington took advantage of the opportunity and now has its own law and regulation in place (90.76 RCW, 1989 and Chapter 173-360 WAC 1990, respectively). Ecology received final authority from the U.S. Environmental Protection Agency to implement its regulation in summer, 1993. It is very similar to, but not identical to, the federal regulation. As of December 1993, all regulated underground storage tank systems were required to employ an approved method of release detection for tanks and piping. The only exception is any underground storage tank used for emergency power generation that was installed between 1980 and 1988. The release compliance dates for these underground storage tank systems is December 1995 (Knowlton 1994).

### 5.6.2 Potential Ground Water Impacts

Underground storage tanks without special leak containment or leak detection systems represent a potential threat to ground water quality. At some point during the active life of any underground storage tank without environmental controls, hazardous substances stored in ground water recharge zones will probably lead to some form of ground water contamination.

Ground water in the City of Issaquah is presently susceptible to contamination from an underground storage tank leak or accident. In 1987, several service stations experienced gasoline leaks from their tanks. Where required, contaminated soil from around the leaking tanks was excavated to Ecology standards and taken to the Cedar Hills Landfill. A soil venting system was installed to exhaust gasoline vapors from the soil, and the leaking tanks were repaired or replaced. In addition, ground water monitoring wells were installed to detect petroleum hydrocarbons in the ground water. Drinking water wells for the City of Issaquah, located less than one-half mile away from one of the service stations, have been tested. Thusfar, no petroleum hydrocarbon based contamination has been detected.

Since January 1989, Ecology has maintained a database of current and former underground storage tanks that have caused known contamination.. Table 5.8 (Ecology 1994) lists 18 sites in the Issaquah Ground Water Management Area where underground storage tank cleanups are in progress or have taken place. Under the Model Toxic Control Act, underground storage tank owners are responsible for site cleanup and for sending the report to Ecology, which gives them a cleanup status. Ecology is not an active participant; the sites are independently remediated by the owners(s). Of the 18 sites, seven (7) have completed remediation. Of these seven, only one had caused known ground water contamination. Four of the remaining sites have only soil contamination. Seven sites have ground water contamination. At one of these sites where Ecology is awaiting a report, Ecology is not aware that any remedial action and cleanup is necessary. At the remaining sites, cleanup is in progress or has occurred and site monitoring is ongoing.

### 5.6.3 Areas of Concern and Future Information Needs

Although underground storage tanks represent a potential threat to ground water in the Issaquah Ground Water Management Area, some incidents are either unreported or undetected. The documentation of unregulated home heating oil tanks is difficult not only due to the hidden nature of the tanks, but also because not enough is known about the location, composition, and contents of many of the abandoned underground storage tanks in the area. Homes that once used or still rely upon fuel oil stored in underground storage tanks are common in western Washington. Home heating oil tanks are small (between 300-500 gallons) compared to most regulated underground storage tanks, but more common. Smaller tanks were typically constructed of thinner gauge steel and provide shorter service than larger, regulated systems. The average useful life of a 500-gallon steel tank that does not have corrosion prevention (i.e. cathodic protection) has been estimated at about 20 years. Most underground home heating oil tanks in western Washington are old and not cathodically protected. Ecology does not regulate nor track information about underground home heating oil tanks (Knowlton 1994).

A priority of future research should be the identification of both commercial and residential underground storage tanks located in areas where there is significant recharge to aquifers. Special guidelines may be designed for the location and monitoring of underground storage tanks in these recharge zones. Oil tanks that have not been permanently decommissioned, whether by removal or closure on-site, may pose a serious threat to ground water resources in the Issaquah area. Improperly closed heating oil tanks (i.e. those which still contain petroleum products or have not been secured from reuse) are the greatest concern (Knowlton 1994).

## 5.7 Quarries and Mines

### 5.7.1 Description

Quarries and mines can pose problems for ground water management in that they often leave large portions of an aquifer directly exposed to surface water and industrial contaminants. These areas may be significant ground water recharge zones.

Coal, peat, sand, and gravel resources are all found in the Issaquah Ground Water Management Area. Although coal mining drew most of the original settlers into the area in the late 1800's, in recent decades, sand-gravel and bulk-fill activities have been the primary industries in the Issaquah Ground Water Management Area (King County Planning 1984).

Sand and gravel resources are located primarily northeast of the City of Issaquah, north of Mirrormont, and along Cedar Grove Road. Sand and gravel extraction currently takes place north of I-90 along the Issaquah-Fall City Road, at the crest of the Issaquah-Renton Road, and in the Cedar Grove area (King County Planning 1980). The largest sand and gravel pit in the Valley, the Lakeside site, north of I-90, now operates using surface water control measures that limit the ability of surface contaminants to reach ground water. Surface and industrial waste water is contained on-site by transporting the water to a series of ponds where it percolates down through gravel and sand (Devitt 1989).

The Tibbetts Creek Basin west of the City of Issaquah contains two rock quarries. Surface water runoff from the Sunset quarry is turbid; however, it is not known whether this runoff carries pollutants or contaminates ground water. In addition, the Hazen Quarry, a new quarry, operates just south of the Sunset Quarry.

Although there are no active coal mines in the Issaquah Ground Water Management Area, coal resources are known to exist in many parts of the Issaquah Creek Valley. Abandoned coal mines are located primarily within the city limits of Issaquah, in the hills southwest and east of the city, and in the Tiger Mountain area (Walsh 1989).

### 5.7.2 Potential Ground Water Impacts

The gravel mines north of the city have a recorded history of surface water contamination. It is likely that contaminants do reach ground water at some point in the operation of a quarry. However, the quantity and type of pollutants that reach aquifers and their impacts on water quality are not yet known.

Abandoned coal mines represent additional points where an aquifer may be exposed to surface water contaminants. However, because they are either sealed or located in isolated areas, abandoned coal mines pose little known threat to water quality in the Issaquah Ground Water Management Area (Walsh 1989).

Short-term ground water fluctuations were clearly observed at the Lakeside Gravel Pit in response to wells pumping on an eight-hour work-day schedule. Short-term and longer-term declining and rising water level trends were due to climate and the effect of pumping at the Sammamish Plateau Water and Sewer District's well number 9 (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates, November 1993). This indicates a level of hydraulic connection between the ground water at the gravel pit and the District's Drinking Water Well Number 9.

### 5.7.3 Areas of Concern and Future Information Needs

Future quarry and mine development should be of special concern to ground water management in the area. However, additional information is needed to show how existing operations affect ground water quality. At this time, little is known about the impacts of industrial contaminants that seep into exposed aquifers at quarries, or of the potential ground water impacts of an accidental hazardous material spill at a quarry.

The impacts on ground water quantity caused by recharge and pumping in the vicinity of mines should also be assessed.

## 5.8 Agriculture

### 5.8.1 Description

Agricultural activities causing nonpoint pollution can be divided into two groups: (1) practices associated with livestock keeping and (2) practices associated with crop production. Pollutants most identified with farming activities are sediment, nutrients, organic materials, pesticides and pathogens. Activities that can generate these pollutants in crop production are soil tillage, improper application of fertilizers and pesticides, and irrigation. Animal production activities that generate these pollutants include: animal confinement, overgrazing of pastures, unrestricted livestock access to streams, and improper application of fertilizers and pesticides (Fitch 1994).

Livestock keeping is the primary agricultural activity in the Issaquah Ground Water Management Area, consisting of approximately 30 percent cattle, 55 percent horses, and 0.7 percent sheep. The remainder is equally divided between goats and llamas. Most of the livestock keeping is in hobby farming (Fitch 1994).

The background of these rural residents is varied and includes people from all professions and walks of life. The sizes of their operations may range from less than one acre to more than forty acres. Some residents are there just for the rural setting, while others treat five acres as a large backyard where they can keep horses. Other types of land uses include hobby farms, gardeners, part-time farmers and "alternative" farmers.

Prime agricultural land is formed on soils that were derived from alluvium (Qa) or Vashon outwash (Qo). The Qa (Alluvium) is mostly unconsolidated silt, sand, and gravel valley fill with some clay. Because of this mix of material, the soil has variable permeability and water-holding capability. More often than not soils formed in alluvium are considered to be hydric. Soils that formed in the Qo (Vashon Outwash) are composed of advance and recessional outwash, stratified drift and associated deposits. Soils that developed in this material have high permeability and are considered recharge soils. Both soil formations are highly vulnerable to pollution resulting from poor animal-keeping and crop-management practices (Fitch 1994).

Based on several hydrogeologic factors that influence the behavior and movement of contaminants in the ground, it is unlikely that the present livestock practices in the Issaquah Ground Water Management Area threaten ground water quality. These hydrogeologic factors (seepage) are (1) the horizontal distance between the site and the point of water use; (2) slope of the land; (3) the depth to water table; (4) the vadose zone material; (5) the aquifer material; (6) soil depth and; (7) the attenuation potential of the soil. However, the same is not true for their impact on surface waters, streams and ponds. For example, there is very little use of fertilizers on pastures and/or hayfields in the area. The potential ground water threat from fertilizers is from truck crop farms, nurseries, Christmas tree farms, etc. Generally, this type of operation is commercial in nature. Fertilizer is generally applied once or twice a year and is applied in accordance with the requirements of the crop. When applied according to label directions there should not be a pollutant source (Fitch 1994).

The Washington State Department of Agriculture requires all commercial applicators and all applicators applying restricted-use pesticides (includes all aquatic applications) to be licensed. As licensed applicators, they are required to keep records for seven years including the type of chemical applied, quantities, location of applications, and other such information. The Department of Health is the agency responsible for public health effects and possible emergency measures in case of poisoning and Ecology regulates spill response requirements (Fitch 1994).

The Washington State Department of Agriculture can request records from anyone required to keep records. A general record call-in from a significant land area, however, is financially unfeasible unless there is significant cause. Record availability outside the agency (Washington State Department of Agriculture) may be constrained by legal requirements also. Since the basin is changing from rural to urban, a record request may not provide the type of information needed by a given plan (Fitch 1994).

### 5.8.2 Areas of Concern and Future Information Needs

Additional research is needed on the types and quantities of agricultural fertilizers and pesticides used in the Issaquah Creek Basin. This information would allow for a complete analysis of how agricultural activities affect ground water quality.

## 5.9 Residential Fertilizer and Pesticide Use

Residential use of fertilizers and pesticides can cause increases in the levels of nitrate in ground water in highly susceptible areas. This is especially true for cases where 1-5 acre residential lots are kept in turf and irrigated regularly in the summer months. Landscaping practices such as keeping portions of large lots in native growth can help to reduce risk of nitrate contamination from residential fertilizer use.

## 5.10 Transportation

### 5.10.1 Roadside Spraying

**Description**

Roadside spraying usually attempts to accomplish one of four objectives: (1) to control excess weed growth; (2) to limit the spread of brush and trees; (3) to protect newly planted beds from disease and insects; and (4) to control insects and weeds at specific spots (Uyeda 1988).

Within the state of Washington, labeling, distribution, transportation, application, use restrictions, and disposal of pesticides are governed by Chapter 16-288 WAC. The issuance and monitoring of statewide pesticide use permits is the responsibility of the Washington State Department of Agriculture.

Three public agencies conduct roadside spraying in the Issaquah Ground Water Management Area: the Washington State Department of Transportation, the King County Department of Natural Resources, and the City of Issaquah. Each of these agencies is required by law (RCW 17.21) to record the details of each spraying event and to retain those records for a period of 7 years. Spraying records, showing specific quantities and locations of herbicidal applications in the Issaquah Ground Water Management Area, may be obtained from the Department of Transportation's Bellevue office, from the Road Services Division in the King County Department of Transportation, and from the City of Issaquah Department of Public Works

The State Department of Transportation is responsible for vegetation control on I-90, State Route 18 and State Route 900. The Department of Transportation sprays weeds appearing within 2 feet of roadsides, around fire hydrants and manholes, and in drainage ditches. The amount of herbicide sprayed by the Department of Transportation fluctuates between 4 and 5 pounds per acre and is heavily diluted with water when applied. State roadsides in the Issaquah Ground Water Management Area are sprayed once a year, usually during the month of April, primarily using three herbicide products: Karmex, Krovar, and Roundup. (The above are trade-name formulations containing herbicides diuron, bromacil, and glyphosate.)

The King County Road Services Division of the Department of Transportation serves unincorporated portions of the Issaquah Ground Water Management Area. The King County Roads Division applies herbicides to control noxious weeds on right of ways and weed and grass growth on gravel shoulders and around guard rails. Either Escort or Garlon is used for broad leaf control. Oust or Roundup is used for the non-selective control on the shoulders. The use of the chemicals simazine and atrazine was discontinued after 1989 because they are water soluble and can't be used in permeable soils. All herbicides, including those not on a "restricted use," are applied by certified pesticide applicators (Matsuno 1994).

The City of Issaquah Department of Public Works does not have an active roadside spraying program. The spraying of herbicides is limited to around tanks, pump stations (not well houses), fire hydrants, and some guard rails. Roundup is the herbicide being used, except in certain areas where Arsenol is being used.

The City of Issaquah Parks Department uses herbicides to control unwanted vegetation in turf and for spot weed control in landscape beds and tree wells. Confront is used over turf areas to control broadleaf weeds. Roundup, Crossbow, some Surflan/Gallery, and very little Casaron is used for spot control of weeds in the landscaped beds and tree wells.

The Seattle-King County Health Department conducts soils and water monitoring to determine the residual levels of pesticides over time. According to the 1989 monitoring report, no residuals for simazine and atrazine were found in surface water samples. As expected, low levels of herbicide residuals were found in soil samples taken at a depth of 4 inches. The results indicate that roadside spraying does not appear to pose a significant threat to water quality. Further, the amount of herbicides applied in the area has decreased over the years through improved application methods, such as overall decreased application rates (Issaquah Creek Basin Current/Future Conditions and Source Identification Report, King County Surface Water Management Division, October, 1991).

**Potential Ground Water Impacts**

The application of herbicides for roadside plant control can threaten ground water quality in two ways: (1) chemicals may be transported by storm water into high ground water recharge areas and, (2) pesticides may percolate into shallow aquifers through fissures or dry and sandy soils. Vegetation and clay soils along roadsides in the Issaquah Ground Water Management Area may act to effectively absorb some pesticides before they reach ground water. Particular attention should be paid to the quantity and type of chemical applied, especially if a chemical is likely to destroy or inhibit grass growth (Horner and Mar 1982). However, the preferred method of vegetation control is the use of machinery or manual removal.

**Areas of Concern and Future Information Needs**

Additional information on ground water impacts from roadside chemical applications are needed in four areas:

- The location of dry and sandy soils and any exposed aquifers that may facilitate the contamination of ground water by chemicals applied at roadsides;
- The types of roadside chemicals most likely to percolate through soils to an aquifer, as well as those that inhibit grass growth;
- The quantities and locations of chemical applications;
- Reports of any accidents or improper storage, handling or transport of pesticides and herbicides used for plant control in the Issaquah Ground Water Management Area.

### 5.10.2 Highway Runoff

### Description

As rain washes over a roadway, it carries away contaminants depositing them into soils and storm water systems. Runoff of this kind is likely to occur on highways and heavily traveled roads. As noted earlier, there are several major roads in the Issaquah Ground Water Management Area: Interstate 90, State Routes 900 and 18, the Issaquah-Hobart Road, Vaughn Hill Road, and SE 56th Street. Common contaminants found in storm water runoff from roads include petroleum products, heavy metals, and soot. In areas where existing roads cross streams, untreated road runoff may be discharged directly to local streams in the Issaquah Ground Water Management Area. For example, untreated roadway runoff is discharged into the North Fork of Issaquah Creek at river miles 0.2 and 1.2 (Issaquah Creek Basin Current/Future Conditions and Source Identification Report, King County Surface Water Management Division, October, 1991). Trucks transporting waste to the Cedar Hills Landfill on the Cedar Grove and May Valley Roads may also account for significant highway runoff.

#### Potential Ground Water Impacts

Ground water infiltration by highway runoff is possible in very porous earth and in areas of exposed aquifer. Studies of highway runoff in Western Washington have shown that vegetation may effectively capture pollution in upper soil layers (Horner and Mar 1982). However, the precise conditions under which runoff pollutants may be contained in surface soil is not yet known. Highway runoff for Interstate 90 and other heavily traveled roads in the Issaquah Ground Water Management Area flows into vegetated storm water channels thus decreasing the chances of ground water contamination. However, some channels are maintained with mechanical blades that may clear soil and vegetation allowing highway runoff to infiltrate into ground water.

#### Areas of Concern and Future Information Needs

The most comprehensive study of highway runoff in Washington State was conducted by the Washington State Department of Transportation between 1977 and 1982 (Horner and Mar 1982). Although these reports discuss the conditions under which runoff may lead to ground water contamination, the degree and impact of potential contamination is never quantified. Since the 1982 study no comprehensive studies of highway runoff have been conducted in Washington State. However, the Washington State Department of Transportation will be conducting a highway runoff characterization and Best Management Practices effectiveness monitoring program in King County for the National Pollutant Discharge Elimination System Permit Program and the highway runoff Rule Chapter 173-270 WAC. Samples will be collected for a complete range of parameters including metals and priority pollutants (Schaftlein 1994).

Additional research is necessary to determine the type and quantity of contaminants that flow from road surfaces. In addition, more information is needed on storm water drainage for major roads in the study area.

### 5.10.3 Hazardous Material Spills

#### Description

The term "hazardous material" refers to "hazardous waste" as well as "hazardous substances," both generally defined as materials that pose a substantial present or potential threat to human health or the environment (Horner and Mar 1982). The majority of hazardous substances traveling on Issaquah Ground Water Management Area roads are petroleum products. These products are most frequently transported in the Issaquah Ground Water Management Area along Interstate 90, the Issaquah-Hobart Road, and State Route 18.

### Potential Ground Water Impacts

The exact frequency and routes of hazardous material traffic is not yet known. Preliminary information from Ecology indicates that for the Interstate 90 portion of the Issaquah Ground Water Management Area there was only one hazardous material accident from January 1985 through September 1988, with no resulting spill. Future research should determine the probability of a hazardous material accident occurring in the study area and the circumstances under which such an accident would threaten ground water quality.

The Ecology Bellevue office responds to reports of petroleum or hazardous material spills in the Issaquah Ground Water Management Area. A spill response team is available on a 24-hour basis to implement and monitor cleanup operations for accidents that occur on highways or roads, at manufacturing plants, or any location in the Issaquah Ground Water Management Area. Ecology's procedure for responding to spills depends on the substance spilled as well as on the severity and location of the accident (Baker 1990).

### Areas of Concern and Future Information Needs

The goal of evaluating the risk of a hazardous material spill is to provide information to decision makers in the following areas:

- The location of accident zones where hazardous material spills are likely to occur;
- A description of sensitive areas where spills would threaten ground water quality; and,
- An estimation of the resources needed in any remediation effort resulting from a spill.

To complete this evaluation, the following research process may be followed:

- State traffic volume data will estimate the number of trucks that have used major roads in the Issaquah Creek Basin in past years;
- Accident statistics will then help to determine the probability of a truck accident occurring on these roads;
- Additional data is then needed to determine the percentage of trucks carrying hazardous materials in high physically susceptible areas in order to locate principal accident zones and the likelihood of a hazardous material accident occurring;
- Further research will indicate the number of hazardous material accidents that result in spills, as well as the quantity and substance of those spills; and
- Research is needed to estimate the probability of spilled hazardous materials reaching and contaminating ground water.

## 5.11 <u>Hazardous Waste</u>

### 5.11.1 Description

Hazardous waste is a material that is ignitable, corrosive, reactive, or toxic. Inadvertent or intentional discharges to storm water disposal systems represent another release mechanism.

To be regulated under the state Dangerous Waste Regulations Chapter 173-303 WAC, a commercial or industrial facility must generate at least 220 pounds per month of hazardous waste; transport dangerous/hazardous waste; treat, store or dispose of dangerous/hazardous waste; or burn or blend dangerous waste fuels. Several commercial and industrial facilities located within the Issaquah Ground Water Management Area generate quantities of hazardous or extremely hazardous waste regulated under Resource Conservation and Recovery Act.

Small quantity generators produce less than 220 pounds. of hazardous waste per month. The Local Hazardous Waste Management Program assesses how small quantity generators store, use and dispose of hazardous waste. The Seattle-King County Health Department and the King County Department of Metropolitan Services co-staff the Local Hazardous Waste Management Program field unit that inspects any business that has the potential to generate hazardous waste. Hazardous waste spillage at small quantity generators is a high priority. Businesses where hazardous waste spillage is observed are referred to Ecology for follow-up These businesses must still handle their waste properly according to Chapter 173-303 WAC and Title 10 of the King County Board of Health.

There is one site listed in the U.S. U.S. Environmental Protection Agency Superfund Program List within the Issaquah Ground Water Management Area. Queen City Farms, and industrial waste site, is currently under investigation and remediation. This site is discussed in further detail in Section 5.5.2.

### 5.11.2 Potential Ground Water Impacts

Hazardous waste can be introduced to the environment, including ground water, in a number of ways. If hazardous wastes are discharged to septic systems (through sinks), toilets or floor drains), the wastes discharged may contaminate soil and ground water.

Any hazardous wastes that are discarded from households or businesses to the environment along with normal solid waste refuse can be placed in landfills and contributed to leachate contamination of underlying ground water. Finally, hazardous wastes that are deposited on exposed ground surfaces from traffic accidents, spills, or from improper storage can percolate into the soil and may migrate via recharging precipitation into the ground water environment.

### 5.11.3 Areas of Concern and Future Information Needs

Ecology maintains a record of businesses that identify themselves as generating, storing , treating or transporting hazardous waste in the state. This list (notifier's list) was reviewed to identify business that may generate hazardous waste in the Issaquah Ground Water Management Area. Businesses shown on Ecology's notifier's list that are also located in the Issaquah Ground Water Management Area are listed in Table 5.9. At least one type of hazardous waste is associated with the normal operations of each type of generator listed in Table 5.9. For example, automotive repair shops typically handle large quantities of volatile solvents and oil-based products containing organic compounds such as benzene, chlorinated ethylenes, toluene, and methylene chloride. Dry cleaners use solvents and cleaning solution containing chlorinated ethanes and ethenes, especially trichloroethane and tetrachloroethylene. Paint supply stores sell products containing heavy metals, phenols, and toluene. When these materials are discarded because their usefulness has diminished due to age or contamination (e.g., spent solvents), they will probably be classified as hazardous wastes. There are potential hazardous waste generators, including small quantity generators, that have not notified Ecology (because they don't have to) and businesses that don't generate waste now but could because they store or use hazardous materials. If hazardous waste is improperly managed, they may cause damage to the environment and/or human health.

The Seattle-King County Health Department should monitor data collected by Ecology and the Local Hazardous Waste Program, regarding hazardous waste generator impacts on ground water quality.

## 5.12 Ground Water Quantity

The amount of ground water available and the amount of water available to recharge ground water is affected by precipitation, land use, population growth, and water use.

Ground water recharge is naturally affected by the amount of vegetation, soil and surficial geologic conditions, and the topography of the potential recharge area. Vegetation decreases the velocity of stormwater runoff as water is diverted around plant stems and roots. This is a benefit to recharge because slowing the runoff increases the time available for infiltration and thereby increases infiltration. By clear-cutting the land and removing vegetation, ground water recharge can be diminished.

Soils composed of coarse-grained material such as sand and gravel are generally more porous and better for recharge than those composed of fine-grained particles such as clay. Sealing over these recharge areas with parking lots, and residential and commercial buildings reduces the amount of ground water recharge.

The slope of the surface upon which precipitation falls affects the amount of precipitation that recharges into the ground. More rain tends to run off a steep slope than off a level plain.

With population growth there is an increase in the number of residential and commercial buildings, roads, and parking lots which are impervious surfaces that decrease or prohibit ground water recharge. There is also an increased demand for water. Ground water withdrawals from the aquifer, when combined with an increase in impervious surface area in a recharge area, can lead to a diminished ground water supply for drinking water purposes. Because ground water and surface water are interconnected, surface water features such as lake levels and the base flow of creeks are impacted by diminished ground water levels.

With the demands for more ground water, agencies and purveyors need to implement methods to protect this valuable finite resource. A method to retain recharge is to maintain portions of residential areas in their natural state or permit the planting of vegetation in these areas. Storm water facilities can be constructed to promote recharge of ground water provided that the storm water is first adequately treated so as not to contaminate ground water. The State of Washington is also currently investigating ways to treat and reuse wastewater.

## 5.13 Summary of Land Use Information Needs

From the descriptions of land use activities in the Issaquah Ground Water Management Area, it is clear that the effects of existing and potential water and land use activities on ground water are still uncertain. This section of the report presents information relevant to the IGWMP and points to areas where additional information will provide decision makers with a complete picture of ground water management issues in the study area. Future research priorities should address the topics discussed below:

### 5.13.1 Ground Water Recharge Zones

Locating those surface areas where aquifers are most heavily recharged is important to every land use activity previously described, because these are areas where surface contamination is most likely to lead to ground water contamination. Also, ground water loss can occur if these areas are covered over by parking lots, buildings, or if other changes are made to the soil mantle.

A map of aquifer susceptibility to contamination based on three factors (surficial soils, surficial geology, and ground water depth) is presented in Figure 5.5. Efforts to minimize the possibility of contaminants reaching these areas and to prevent the paving over of these areas should be undertaken. Land use activities are relevant to ground water management only as they affect ground water quality and quantity. Surface activities described in this report will have the greatest impact on ground water when they take place in ground water recharge zones. The map (Figure 5.5) should be further refined as more information becomes available from wellhead protection studies and SEPA reviews.

### 5.13.2 Future Development

A detailed analysis of existing land use activities in the Issaquah Ground Water Management Area, together with projected residential, commercial, and industrial development trends, is needed to assess land use activities that account for ground water contamination and to determine to what extent the demand for ground water is likely to increase in the future.

### 5.13.3 On-Site Septic Systems

Improper discharges to on-site septic systems (e.g. industrial discharges) and the overloading and inadequate treatment of sewage in on-site septic systems threaten ground water quality and should be of particular concern whenever development occurs where sewer service is unavailable. The location of all on-site septic systems, especially those receiving improper discharges or with a history of failure and located in potential ground water recharge zones, should be tabulated and evaluated. Homeowners and businesses should be reminded to maintain their on-site septic tanks and to pump their on-site septic tank every 3 to 5 years, depending on use.

### 5.13.4 Sewers

Additional information is needed on existing and projected sewer quantities, and sewer line leaks. Also needed is a detailed account of future service options and system expansion plans.

### 5.13.5 Underground Storage Tanks

Without proper prevention or detection systems in place, there is a high risk of ground water contamination due to an underground storage tank leak or accident. Additional information on appropriate commercial underground storage tank locations and safety measures is needed to minimize this risk. Underground storage tanks research should also focus on smaller privately owned tanks, especially those installed to hold heating oil. Although no known record of these tanks exists, parallel studies in other areas may help to estimate potential ground water threats posed by residential underground storage tanks. An additional research priority should be to identify the extent and type of contamination from leaking underground storage tanks.

### 5.13.6 Stormwater

The extent to which stormwater runoff represents a threat to ground water quality should be researched, particularly in sensitive recharge areas where significant amounts of vehicular oil and grease occur in runoff.

### 5.13.7 Landfills

Evaluating the extent of ground water contamination from landfills is a complex process. Water quality information from ground and surface water monitoring stations at Cedar Hills Landfill and Queen City Farms would help determine the extent of ground water contamination and the effectiveness of past and current remediation efforts. A complete hydrologic analysis of the areas surrounding the landfills is also needed to measure the impact of landfill leachate on surrounding land uses. The direction of ground water flow beneath the landfills, and the depth and range of aquifers exposed to contaminants, should be evaluated.

### 5.13.8 Quarries and Mines

Additional information is needed on how existing operations affect ground water quality. Mines and quarries, while opening the ground surface to potential higher recharge, also increase the potential for contaminants entering the aquifer. The operation of and reclamation of quarries and mines should be evaluated for their potential impacts on ground water.

### 5.13.9 Hazardous Waste

It is also necessary to monitor and evaluate the impacts on ground water quality caused by hazardous waste generators. Data collected about these facilities can help with such monitoring evaluation.

### 5.13.10 Hazardous Material Spills

The potential catastrophic impact of a hazardous materials spill in the study area warrants further investigation. Specifying accident zones where spills are most likely to occur and estimating the severity of contamination that may result from a spill should be the two initial priorities of this research effort.

### 5.13.11 Plant Control

Use of Pesticides and fertilizers could pose a future threat to ground water quality in the Issaquah Ground Water Management Area. These chemicals are applied in a broad range of activities including: residential, agriculture, the maintenance of powerline corridors, roadside clearing, and park and landscape maintenance. Additional information is needed on the quantities and applied location of chemical applications, the types of roadside chemicals most likely to percolate through soils and the location of exposed aquifers that may facilitate contamination of ground water by chemicals applied at roadsides.

## 6.0 WATER APPLICATIONS

This section discusses sources of water and water service providers in the Ground Water Management Area, water rights, aquifer capacity, existing and potential water demand, and the need for further analysis of aquifer capacity and the combined effects of pumping on the ground water system.

### 6.1 Water Sources

#### 6.1.1 Ground Water

Ground water currently provides 100 percent of the potable water supply in the Issaquah Ground Water Managment Area. Ground water investigations to date in the lower Issaquah Creek Valley indicate the presence of what appears to be a hydraulically interconnected system of aquifers. A description of the aquifers and their primary sources of recharge is provided in Section 7.3.

New data, collected as described in the Recommendations Section of this Plan (Section 8), will help to more clearly define the ground water resource in the Issaquah Ground Water Managment Area.

#### 6.1.2 Surface Water

Surface water is not known to be used as a source of potable water in the Issaquah Ground Water Managment Area. Surface water and ground water within the Issaquah Creek Basin are, however, believed to be hydraulically connected. Issaquah Creek, with its system of tributaries, and Tibbetts Creek represent the primary sources of surface water in the ground water management area. Issaquah Creek extends 17.35 miles (27.8 km) from the Hobart Plateau to Lake Sammamish. Elevations for Issaquah Creek range from 2,500 feet mean sea level at headwaters to 25 feet mean sea level at Lake Sammamish. King County rates both general water quality and habitat suitability for Issaquah Creek as good. With a length of 4.3 miles (6.8 km), Tibbetts Creek covers a comparatively smaller area than Issaquah Creek. The headwaters for Tibbetts Creek are measured at elevation 1,080 feet mean sea level, while the mouth of the creek at Lake Sammamish is at an elevation of 25 feet mean sea level. King County lists general water quality for Tibbetts Creek as good and habitat suitability as fair (Metro 1988).

### 6.2 Water Services

The boundaries for all water service areas in the Issaquah Ground Water Management Area are shown in Figure 5.3. In addition, data from some of the major producing wells in the study area are provided in Table 6.1. Existing water rights granted to each water purveyor that provides service in the Ground Water Management Area are listed in Table 6.2. The East King County Coordinated Water System Plan (August 1989) lists all the major water suppliers (Group A) in the Issaquah Ground Water Management Area and the quantities of water drawn from these wells. The plan also describes future expansion plans for each water purveyor, water level depths of each Group A well, and the number of service connections for these wells. More detailed plans for expansion and additional supply can be found in individual purveyors' Water System Plans and subsequent Plan updates.

**City of Issaquah**

The City of Issasquah has historically relied upon ground water to meet its potable water supply needs. Recently, increased demands on the ground water resource combined with concerns of the State of Washington Department of Ecology (Ecology) about hydraulic continuity between ground water and surface water, and other issues have resulted in closure of the Issaquah Valley Aquifer to development of additional new sources of ground water (City of Issaquah, Water System Plan Update, 1996). Continued growth within the existing City limits, combined with requests for service outside the existing City limits, have prompted the need to develop strategies for providing additional supply capacity. These strategies include demand management (e.g., water conservation) and development of conventional and nonconventional supply alternatives.

The City of Issaquah water service area extends beyond the city limits to include Grand Ridge, Lake Sammamish State Park, a large portion of the Tibbetts Creek Valley, and the area around the Issaquah-Hobart Road between the City's boundary and the Mirrormont area (see Figure 5.3). However, some residences located on steep hillsides in the City of Issaquah use wells that are not included in the City's service area (Rothnie, 1989).

The City of Issaquah operates a Group A public water system. The City has five wells ranging in depth from 97 to 412 feet. These wells are located in the lower Issaquah Valley aquifer. Water rights allow water to be pumped at rates of 250 gpm to 1,200 gpm depending on which well is being pumped (Lynne 1994). However, water rights do not necessarily reflect the true capacity of the aquifer. The City of Issaquah also holds certified water rights on the Gun Club wells, which are currently inactive. These water rights may be reactivated in the future.

**Sammamish Plateau Water and Sewer District**

The Sammamish Plateau Water and Sewer District (SPWSD) is located within the boundaries of the Issaquah Ground Water Management Area, as shown in Figure 5.3. SPWSD aquired Cascade View (Water District 122) in 1995. Cascade View is also included in the Issaquah Ground Water Management Area. Water provided by SPWSD serves commercial uses, light industrial activities, and residential areas.

Sammamish Plateau Water and Sewer District draws all of its water from wells. Wells 7, 8, and 9 operate in the Lower Issaquah Valley aquifer system and serve approximately 70 percent of the water demand of the Sammamish Plateau Water and Sewer District. Located between Interstate 90 and East Lake Sammamish Parkway, wells 7 and 8 have an actual depth of 150 feet and carry a potential capacity of 2,000 and 3,500 gpm, respectively. Well 9 is located north of Interstate 90 and east of East Lake Sammamish. It is completed to a depth of 200 feet and has a potential capacity of 3,500 gpm (Little, 1994). However, Well 9 has only been approved for supplemental winter time rights in the case where wells 7 and 8 must shut down, due to the fact that it is located in what is considered a closed basin by Ecology. Sammamish Plateau Water and Sewer District also operate wells on the Sammamish Plateau including wells 1, 2, 3, 4, 5, 6, 10, and 11-2 and in the area previously served by Water District 122 (wells 12 - 14).

**King County Water District #90**

Water District #90 operates a Group A water system serving the King County community of Newcastle. Only a small portion of this district lies within the boundaries of the Issaquah Ground Water Management Area. The Lake MacDonald residential area represents the largest area served by District #90 in the Issaquah Ground Water Management Area. No Group A source wells for this district are located in the Issaquah study area (King County Planning, 1983).

**King County Water District #123**

District #123 operates a Group A water system serving Preston. Only a small portion of this district falls within the boundaries of the Issaquah Ground Water Management Area.

**Other Purveyors**

The largest private Group A water system in the study area serves the Mirrormont area. Water provision in the Mirrormont area is from five Group A wells that range in depth from 209 feet to 325 feet; these wells have a combined potential capacity of 1,000 gpm (Nordie/Heintze 1994).

In addition to the purveyors listed in Table 6.1, there are numerous Group B water systems and individual wells in the Issaquah Ground Water Management Area.

**Areas of Concern and Information Needs**

Additional data are needed to complete the analysis of water users and for conservation planning in the Issaquah Ground Water Management Area:

- Map Group B water system locations within the ground water planning area.
- Identify the key private wells in the basin and develop an estimate of water use in the basin. Key private wells will be those wells within 1-, 5-, and 10-year time of travel of the major Group A public water supplies, and those private wells in the Sensitive Aquifer Areas.

## 6.3 Water Rights

A water right is a purveyor's permitted right to withdraw water. A water right is specified in two ways:

- A maximum pumping rate (expressed in gallons per minute or GPM) is specified based on the capacity of the well (note that well capacity is a function of c onstruction specifications and the pump, and not an indication of aquifer capacity).
- A maximum annual volume of ground water that can be withdrawn from the well (typically expressed as Acre Feet per Year). This volume is based upon the water needs of the population served by the well and is not a function of well or aquifer capacity.

Ecology is the state agency responsible for granting or denying a water right application. In a review of technical reports for the Issaquah Creek Basin, Ecology concluded that ground water and surface water are in direct continuity. Further, they have denied water right applications in areas where ground water is in hydraulic continuity with a closed surface water body. Because Issaquah Creek flows into Lake Sammamish, which feeds the Sammamish River and eventually Lake Washington, all wells within the Issaquah Creek drainage are assumed to be in some degree of hydraulic continuity with Lake Washington. Therefore this basin is considered to be closed by Ecology, and many water right applications have been denied with justification that pumping would decrease surface water flows.

Sammamish Plateau Water and Sewer District also operates wells above the Issaquah Valley on the Sammamish Plateau and in Cascade View (previously serviced by Water District 122) , where hydraulic continuity with Issaquah Creek is not an issue. Sammamish Plateau Water and Sewer District has been granted water rights in this Plateau region. Table 6.2 lists the current water rights held by the Sammamish Plateau Water and Sewer District.

Currently, the State does not require a water rights claim for wells that withdraw less than 5000 gallons per day. Therefore, some individual wells associated with rural residences are not accounted for by existing water right volumes. An estimation of total ground water withdrawal from wells without water rights will be necessary to allocate future ground water resources.

Table 6.2 lists the major permitted water rights in the study area. These figures represent the total amount of water a supplier is appropriated. However, they do not necessarily reflect the capacity of the aquifer.

## 6.4 Aquifer Capacity

The actual capacity of an aquifer to provide ground water cannot be determined without an in-depth study of cumulative impacts of pumping on the aquifer system. However, long-term water level data for the Lower Issaquah Creek Valley Aquifer indicate a downward trend in water table elevations. This declining trend in ground water elevation may indicate that the aquifer system is being pumped (cumulatively by all water users) beyond it's capacity, or the trend may be a result of climatic influences. The capacity of the aquifer systems from which the Sammamish Plateau Water and Sewer District and the City of Issaquah withdraw their water is unknown. (Lynne 1994)

A comparison of withdrawal volumes specified by water rights (Table 6.2) and annual water demand (current and projected) from each purveyor (Table 6.3) indicates that future demands may not be met by the current water right. It is unknown at this time whether actual aquifer capacity could sustain projected demands. Purveyors are beginning to use creative alternatives to maximize their current water appropriation and increase the overall annual volume of water pumped from the aquifers in the valley to accomodate accelerated growth in the area. These alternatives include aquifer storage and recovery (ASR) techniques and use of peak day pumping rates coupled with reservoir storage. In both cases, a greater volume of ground water will be withdrawn from the aquifers involved.

Some preliminary testing of specific wells screened in the Lower Valley Aquifer System has been performed. In September 1990, the Sammamish Plateau Wells 7 and 8 were pumped for 3 days. Analysis of pumping tests on Wells 7 and 8 indicated that the zone of influence from pumping of Well 8 extended in a northwest-southeast direction along the valley margin for a distance of 7,000 feet from the pumping wells. In July 1992, Carr & Associates conducted a 9½-day pump test of Sammamish Plateau Water and Sewer District Well 9. Extensive water level and water quality data were collected from 51 ground water monitoring sites, 15 surface water stations and two precipitation gauges. Test results suggested that pumping of Well 9 should have little impact on surface waters and only limited impact on other production wells.

### 6.4.1 Areas of Concern and Future Information Needs

The following water rights analysis elements will require further investigation during implementation of the IGWMP:

- Estimate the capacity of the aquifer system.
- Determine the numbers and locations of Group B and individual wells without water rights in the Issaquah Creek Valley.

## 6.5 Existing and Potential Water Demand

### 6.5.1 Major Suppliers and Water Demand

Existing and anticipated future water demand for major suppliers in the Issaquah Ground Water Management Area is reflected in Tables 6.3, 6.4 and 6.4A. These data show an average annual increase in water demand (between 1986 and 2000) of 3.9 percent for Issaquah, 5.1 percent for Sammamish Plateau Water and Sewer District, and 2.6 percent at Mirrormont. If this period is extended from 1986 to 2040, the average annual increase becomes 2.5 percent in Issaquah, 3.5 percent with Sammamish Plateau Water and Sewer District, and stays at 2.6 percent for Mirrormont.

Water demand projections used in the report prepared by Economic and Engineering Services, Inc. (1988) for the East King County Coordinated Water System Plan are estimates based on variables such as individual utility data, weather projections, the price of water, and demographic data. These demand estimates are derived from base assumptions that reflect the projections most likely to occur for each category. The most significant variations from base estimates range from 20.4 percent with a low scenario to 9.8 percent using the highest possible projections.

The City of Issaquah in 1990 had a population of 7,786 within its corporate boundaries. The average annual water demand in 1990 was 1.22 million gallons per day (MGD), with a maximum day demand of 3.1 MGD (see Table 6.4A). In the year 2020, the population of the corporate area is projected to be 12,815, with the total population for the City of Issaquah, including annexation, to be 58,643. The maximum day demand in 2020 is projected to be 8.0 MGD (City of Issaquah Water System Plan Update, August 1995). The current water right for the city of Issaquah is 5.6 MGD. Use of conservation measures will slightly reduce demand figures. The Department of Ecology has closed the Issaquah Creek Basin to further water right appropriations due to the interconnection of ground water and surface water in the basin.

### 6.5.2 Demographic Projections for the Issaquah Ground Water Management Area

Demographic indicators are helpful in estimating the amount and types of increased water demand predicted for the Issaquah Ground Water Management Area.

Small Area Zones (SAZs) are used by King County transportation planning for the purpose of transportation analysis. These SAZ numbers were used for the purpose of population forecasting in the Issaquah Ground Water Management Area. SAZ projections are taken from the King County Comprehensive Plan, and are current as of February of 1995. SAZ projections include only those areas that lie within unincorporated King County. Therefore, they do not include the City of Issaquah. Projections for the City of Issaquah were provided by growth target numbers taken from the City of Issaquah Comprehensive Plan.

SAZ projections were used to estimate household growth in the Issaquah Ground Water Managment Area between 1990 and 2020. Table 6.5 indicates estimated growth between 1990 and 2020 by number of households. Data indicate that the total number of households requiring water in the Issaquah Ground Water Managment Area was 18,317 in 1993 and projected to be 25,893 in the year 2020, reflecting a 41% increase in water demand within the Ground Water Managment Area .

Another predictor of future population and development patterns in the study area is available through the Puget Sound Regional Council. Projections are presented in terms of forecast and analysis zones. Six different forecast and analysis zones fall within the boundaries of the Issaquah Ground Water Management Area, these being Klahanie/Pine Lake (4605); Beaver Lake (4607); Issaquah (4300); Cougar Mountain (4225); Maple Valley/Hobart (3330); and the Renton Plateau (4230) (see Figure 6.2). All six forecast and analysis zones are not entirely within the Issaquah Ground Water Management Area.

### 6.5.3 Areas of Concern and Future Information Needs

Research in the following areas will provide a more complete understanding of existing and future water demand and supply in the Issaquah Ground Water Management Area:

- Future research involving the City of Issaquah and Sammamish Plateau Water and Sewer District water demand projections should focus on determining the type and magnitude of demands to be made on all sources in the Issaquah Ground Water Management Area.

- Assess the capacity of both the Lower Issaquah Valley Aquifer System and the Sammamish Plateau Aquifer System(s). Determine whether increased pumping to provide service to growing areas will begin to deplete the ground water resource before certificates of water availability are granted for large supply requests. Assess long term trends in ground water levels in these systems.

## 7.0 HYDROGEOLOGY

### 7.1 <u>Geology</u>

This section briefly describes the geology of the area using generalized geologic units appropriate for an analysis of surface and ground water movement. The geologic units of significance in the Issaquah Ground Water Management Area were deposited since the early Tertiary period (approximately 60 million years ago). The composition of these units is characterized by a complex history, that indicated the Issaquah Ground Water Management Area was related for some time to advancing and retreating oceans and glaciers. This history also included earth's internal processes of volcanism (tectonics) and mountain building (orogeny), and currently involves erosive forces from stream and rivers.

Much of the development of the Cascade mountains is due to their regional tectonic setting. This orogenic event occurred as a result of the subduction of an oceanic plate under a less dense continental plate. As a result, the topographic features in the Issaquah Ground Water Management Area formed from mountain building processes. The Issaquah Ground Water Management Area is underlain by Eocene age (approximately 40 million years old) igneous and sedimentary rocks. The igneous rocks include magma that solidifies underground (intrusive andesite) and magma that solidifies on or near the ground surface (extrusives like volcanoclastics and lavas). The consolidated sediments (bedrock) in the Issaquah Ground Water Management Area consist of sedimentary rocks like sandstone, siltstone, coal, conglomerate, and shale. These formed from geologic processes characterized by shallow ocean, near shore, and estuarine environment. The rocks are exposed at the surface in the surrounding highlands of Cougar Mountain, Squak Mountain, Tiger Mountain, and Grand Ridge. Locally, they are overlain by younger sedimentary rocks, exposed mainly in the northern upland areas of the basins.

This sequence of rocks, many thousands of feet thick, has been folded along northwest-trending horizontal axes. The dominant fold here is the Lake Sammamish syncline, a pronounced downwarp that extends from Lake Sammamish through the City of Issaquah, and which is truncated by faulting east of West Tiger Mountain. The syncline is flanked on the southwest by the Newcastle Hills anticline, whose axis and corresponding bedrock uplift now separate the lower Issaquah valley from the May valley and the May Creek Basin to the southwest. On the northeast side of the Issaquah Creek Basin, rocks climb up the southwest limb of the Raging River anticline, a less pronounced fold near the eastern basin boundary.

The surface and subsurface expression of the Lake Sammamish syncline dominates the structure in the basins. Particularly in the northern third of the basin, not only the bedrock structure but also the glacial sedimentation and the surface topography follow the trend of this trough. Glacial ice has scoured out a valley in the rock, filling it with unconsolidated sediment; these sediments were again scoured to form the yet narrower valley now occupied by the south end of Lake Sammamish and the Issaquah Creek floodplain.

In the remainder of the basin, the structure of folds in the bedrock is still discernible in the rocks themselves. Yet the contact between the rocks and the later glacial and nonglacial sediments that overlie them does not follow the folds in the strata. Instead, erosion of the rock surface follows a much larger subsurface valley extending southeast out of the Issaquah Creek basin, crudely along the modern Cedar River valley, at a maximum depth of over 500 feet below ground level (Hall and Othberg 1974). The southwest part of the Issaquah Creek basin lies on the northeast flank of that valley, presumably an infilled arm of an ancestral Puget Sound (Issaquah Creek Basin Report October 1991).

In the Puget Lowland, the geologic record indicates discontinuous periods of Pleistocene glacial and interglacial processes. In the basins of the Issaquah Ground Water Management Area, glacial deposits can be assigned to the Vashon stage of the Fraser glaciation. The effects of the glaciation lasted 2,000 years and were gone from the area about 13,000 years ago. During these glacial periods an advancing thick mass of ice inched southward for thousands of years. The mechanics of a glacier work like a giant conveyor belt. The ice sheet plucks and plows chunks of soil and rock from the countryside and incorporates them into its mass. The effect of the glacier is to scour and scrape the landscape, then transport its load in melt water and deposit it in three typical geologic units.

In the front of the advancing glacier, water from melting glaciers deposited a sheet of sand and gravel known as advance outwash. The advance outwash was subsequently covered by the glacier, which left a deposit of compact silty-sandy gravel known as "Till." As the glacier retreated, the till was subsequently covered by sand and gravel (deposited from the meltwater stream) known as recessional outwash deposits. In some places, areas of ice-contact deposits occur. These sediments were deposited on the surface of the melting glacier and are silty sand and gravel that can resemble till.

The last glaciation left a mantle of advance outwash, till, recessional outwash, and ice-contact deposits over older glacial deposits on the uplands and in some valleys; it left thick deposits of recessional outwash in most valleys.

## 7.2 Soils

Knowledge of soil properties and distribution is essential to understanding relationships between ground water distribution, movement, and contamination processes. Given the diverse physical and biological nature of the Issaquah Ground Water Management Area, a large number of widely varying soils are present. Each presents a unique set of considerations in developing future management alternatives.

Approximately two-thirds of the Issaquah Ground Water Management Area, excluding the Tiger Mountain peaks complex, has been mapped (Figure 7.1A). The four soil associations mapped in the Issaquah Ground Water Management Area are the Alderwood, Beausite-Alderwood, Everett and Puget-Earlmont-Snohomish Association Soil series. For more detailed information on these four soils and other soils, see Table 7.1 and Appendix A. Soils that appear in several associations are described only once. Water quality and ground water recharge factors related to soil series characteristics are also presented. These factors are interpreted from the information extensively researched and prepared by the U.S. Soil Conservation Service. The Soil Conservation Service produces maps with greater detail about the location of various soil types. The maps are too large in scale to reproduce for this report.

### Alderwood Association

The Alderwood association blankets over one-fourth of the Issaquah Ground Water Management Area. It is found in upland areas, including the southeast portion of the Sammamish Plateau and Cedar Hills and Hobart Plateau in their entirety. It is composed of 85 percent Alderwood soils, 8 percent Everett, and 7 percent less extensive soils. In general they are moderately well drained, variable sloped soils underlain by very low permeability glacial till at a depth of 20 to 40 inches.

### Beausite-Alderwood Association

The Beausite-Alderwood association is the most extensive association in the Issaquah Ground Water Management Area, covering primarily the mountainous areas (Cougar and

Squak Mountains, Grand Ridge, and likely the mostly unmapped Tiger Mountain peak complex). Major soils represented include approximately 55 percent Beausite soils, 30 percent Alderwood soils, 10 percent Ovall soils, and 5 percent miscellaneous soils. These soils are found on rolling to very steep surfaces underlain at 20 to 40 inches depth by sandstone, shale, or dense glacial till. In general, these soils do not contribute any significant recharge to the ground water.

**Everett Association**

Everett association soils are found on northern upland units in the vicinity of Tradition Lake Terrace, lower Grand Ridge, and an adjacent portion of the Sammamish Plateau. A substantial portion of the City of Issaquah and the upstream valleys also consists of Everett soils. The association typically consists of 70 percent Everett soils, 15 percent Neilton soils, 7 percent Alderwood soils and 8 percent less extensive soils. The dominant soils are found on both gently undulating surfaces, and steep terrace faces. They are underlain by sand and gravel, and are exceedingly well drained.

**Valley Soils**

A number of soils are represented in the valleys, including: Sammamish, Bellingham, Briscot, Puyallup, Puget, Oridia, and Sultan. Most of the above soils are found in developing areas of the lower Issaquah Valley.

Although not extensively distributed elsewhere in the Issaquah Ground Water Management Area, these soils are significant due to the industrial, urban, and residential development that has occurred or is planned in their vicinity. Large scale development is likely to include drainage rerouting or enhancement, and substantial earth moving or placement of fill. Such activities greatly disrupt the natural drainage and permeability related properties of native soils. The number of potential contaminant sources also increases with intensive land use activities.

**Puget Soils**

Puget soils are formed in valley alluvium and are composed of a silty clay loam. Slopes are very flat, less than 1 percent, and permeability is low. The seasonal water table is at or near the surface. Recharge to shallow aquifers is slow, yet significant.

## 7.3 Ground Water

Ground water hydrology, or hydrogeology, the study of the interrelationship of geologic materials and processes with water, is both a descriptive and an analytic science (Fetter 1994). The development and management of water resources is also an important part of hydrogeology. Hydrogeology is recognized as an important part of environmental planning.

Most of the ground water in the Issaquah Ground Water Management Area comes from direct precipitation onto the ground surface. Precipitation that is neither evaporated, transpired by plants, nor lost rapidly by surface flow enters the ground water system. Ground water is accessible for water use or discharge to surface water bodies only where it can move freely through subsurface deposits. In the Issaquah basin, the various outwash deposits of the last glaciation form the most common aquifers. Some shallow aquifers and many major ground water recharge areas are formed in recessional outwash and ice-contact deposits. These are characterized by relatively large pore spaces and they freely transmit water (Issaquah Creek Basin, Current/Future Conditions and Source Identification Report, King County Surface Water Management, October, 1991).

The infiltration, movement, and storage of ground water is controlled by the characteristics of the surficial and subsurface geology. Infiltration at the surface depends on the permeability of the surface sediments and the accessibility of those sediments to precipitation. Thus outwash deposits, consisting of silt-poor sand and gravel, provide the best opportunities for infiltration. In contrast, Vashon Till has a much higher percentage of silt and clay and so offers significantly more resistance to flow. It acts as the uppermost aquitard, with rates of infiltration through the unweathered deposit of approximately 1 inch per month (Olmstead 1969). The soil layer developed on top of the till, however, has much greater infiltration, but the movement of water is largely restricted to that thin upper zone.

In the Lower Issaquah Valley, a large ice-dammed lake formed south of the retreating glacier front. Meltwater rivers flowing down to the lake formed a large delta. This delta is the eastern margin of the Lower Issaquah Valley; its coarse-grained deposits grade westward and northward into finer-grained lake deposits. The major aquifer system providing ground water to wells in the City of Issaquah and the Sammamish Plateau Sewer and Water District receives a substantial amount of recharge from these deltaic deposits (Carr/Associates 1993; Golder Associates 1993).

Subsequent to the lowering of Lake Sammamish to its present level, Issaquah Creek began flowing through the Tiger Mountain Gap and down the Lower Issaquah Valley. It eroded some of the lake and deltaic deposits and deposited a mantle of silty-sandy alluvium over the older, more permeable deposits.

### 7.3.1 Surficial Geologic Deposits

Geologic deposits form the basis for the different hydrogeologic units in the study area. A map of surficial geology showing post-glacial, glacial, and bedrock deposits is presented in Figure 7.1B. The deposits beginning with the most recent, are listed below:

#### Recent Bog Deposits

Bog deposits are found in both upland and valley depressions and contain organic material such as peat, muck, and decaying vegetable matter. Drainage is poor because of factors such as poor surface drainage, impervious subsoils, a discharge zone for higher gradient aquifers, or simply a depression in an unconfined aquifer with a high water table. Because of the accumulation of water, these areas could contribute to local recharge.

Bog deposits can have an important, natural influence on water quality because decaying organic materials produce humic acids, and associated geochemical conditions are highly reducing. As a result, adverse effects to local ground water quality can include:

- increased corrosivity,
- elevated concentrations of dissolved iron, manganese, hydrogen sulfide and nitrates, and
- undesirable color, taste, and odor characteristics.

**Alluvium**

Alluvium consists of stream deposits ranging from cobble-sized gravel through sand to sandy silts. The deposits are found in valley fill, along stream channels, floodplains, and as alluvial fans where steep gradient streams meet lower gradient valley floors. Many wells are completed in alluvium and are capable of yielding large quantities of water.

Permeability of alluvial materials varies considerably. Depending on grain size and sorting, alluvial aquifers can be perched, unconfined, and confined. Hydraulic continuity between aquifer zones varies laterally and with depth.

Surface water and downslope drainage provide ample recharge to alluvium. Where thick and extensive upper aquitards are absent, alluvial aquifers are vulnerable to contamination from surface sources, or from vertical and horizontal movement of contaminated water from one aquifer to another.

**Landslide Deposits**

Landslide deposits are found along the side and base of slopes. Geologic materials are variable. These deposits are not known to be an exploitable source of ground water.

**Vashon Stade Glacial Deposits**

Table 7.2 summarizes the characteristics of these deposits, and Figure 7.1B shows their locations.

**Vashon Recessional Outwash**

Recessional outwash is predominantly gravel, sand, and minor amounts of silt that were deposited by melt water from the retreating ice. Large delta deposits are exposed in bluffs east of Issaquah. Other similar deltaic deposits are located southwest of Cedar Hills and north of Hobart.

Most of the recessional outwash is highly permeable. Much of these deltaic deposits lie above the water table, but provide an important recharge medium to adjacent inter-connected aquifers. Unpredictably distributed lenses of silt intercept downward percolating ground water and redirect it laterally, creating locally perched water table zones and surface weeps. Where saturated and endowed with a good source of recharge, recessional outwash readily yields large quantities of water.

Due to the unit's high permeability and exposure to the surface environment, recessional outwash is vulnerable to contamination. Interconnected aquifers are vulnerable to contamination transported through this unit.

## Vashon Recessional Lacustrine Deposits

These fine-grained materials were deposited in the ancestral Lake Sammamish. Unit materials are predominantly clay and silt, but include sand and rare occurrences of gravel.

Individual textural layers such as clay, sand, or silt are probably not laterally continuous. Vertical hydraulic continuity between textural layers and more permeable deposits probably varies widelyIn general, the unit likely functions as a leaky aquitard.

## Vashon Ice Contact Deposits

Ice contact deposits are a heterogeneous (complex) mixture of till and outwash deposits. Grain size changes abruptly. Due to this physical variability, characteristics such as permeability and recharge cannot be generalized.

## Vashon Till

Till is a massive, compact, heterogeneous mixture of silt, sand and gravel. Random sand and gravel lenses are present. Much of the upland and mountainous areas are covered with till
varying in thickness from a thin veneer to 30 feet or more.

The permeability of till at the surface is low and tends to decrease with depth. Downward percolation is slow.

Upper portions can contain perched and semi-perched water tables. Isolated lenses of sand and gravel yield limited quantities of water to shallow, domestic wells. Recharge to these lenses is usually slow. Seasonal fluctuations in water level occur, and some wells are vulnerable to drought or overdrafting.

Shallow wells are very susceptible to contamination. Permeable areas in the till surface provide an avenue for local recharge and migration of contaminants to underlying materials.

## Vashon Advance Outwash

Advance outwash is composed principally of sand to cobble-sized gravel. Thin beds of silt are present. Materials in the advance outwash range from well sorted to poorly sorted. The unit is irregularly distributed throughout the basin, although exposed only in the north part of the Issaquah Ground Water Management Area.

Permeability is generally high. Where saturated, the unit yields large quantities of water. Surface exposures or shallow deposits may be vulnerable to contamination.

## Unconsolidated pre-Vashon Deposits

The following unconsolidated sediments are not found exposed at the surface, but local drilling records and exposures outside the Issaquah Ground Water Management Area confirm their presence. Some deep wells in these sediments are known to yield significant amounts of water.

Table 7.2 briefly summarizes the composition of the pre-Vashon units and general hydrogeologic properties. The unit names are informal.

## Bedrock

Bedrock units present in the Issaquah Ground Water Management Area are not known to yield large quantities of water to wells. However, in some areas they may be the only available source for domestic supply.

Saturated thicknesses of sandstone and conglomerate have yielded usable water supplies, yet declining water levels indicate that recharge may be insufficient to sustain discharge for an extended period. The potential presence of mineralized, saline, or brackish connate water in these units diminishes their potability and usefulness for irrigation.

Fractured, porous, volcanic rocks can yield significant water; however, the volcanic rocks in the Issaquah Ground Water Management Area are easily weathered and decomposed along fractures. Thus, it is unlikely that any productive volcanic rock aquifers occur in the Issaquah Ground Water Management Area.

Low-permeability bedrock is not expected to readily transmit ground water or potential contaminants to aquifers; however, two potential contamination processes should not be overlooked:

- Contaminant migration through porous layers, joints, and fractures to wells completed in relatively shallow bedrock
- Intrusion of poor quality (mineralized, brackish, saline) ground water from bedrock to aquifers in hydraulic continuity through pumping influences.

Descriptions of the bedrock units are summarized in Table 7.2.

### 7.3.2 Aquifers

Information describing hydrostratigraphy, ground water movement, and the supply potential of aquifers is available only for small portions of the Issaquah Ground Water Management Area where major sources have been developed. Future project drilling, monitoring, data collection and analysis efforts will substantially improve the present knowledge and provide a basis for further investigations. For this discussion, aquifer systems and flow direction are described according to physiographic situation.

#### Mountain Aquifers

Mountain aquifers are mostly bedrock which is capable of providing only individual domestic water supplies. However, in saturated, permeable glacial sediments, small public supply wells may be possible. The Mirrormont subdivision is a Group A public supply system with several wells completed in permeable glacial sediments. One Mirrormont well is reportedly capable of producing 330 gpm.

Mountain aquifers located well above the regional water table are expected to have steep ground water gradients. Where low-permeability layers laterally redirect the flow, water erupts as springs or surface weeps. Beneath the unconsolidated sediments, flow would logically follow along buried erosional surfaces, bedding planes, faults, and fractures. Shallow ground water flow that does not emerge as runoff likely recharges lower elevation upland and valley aquifers.

#### Upland Aquifers

Numerous domestic wells are completed in unconsolidated materials with highly varying degrees of success. There are no known large production wells completed in upland aquifers. Two wells located in and next to Cedar Hills Landfill produce 127 gpm and 50 gpm. Most upland aquifer wells are completed in unconsolidated sediments, and a few are completed in sandstone.

Deep and shallow upland aquifer flow patterns may not be in similar directions. Valley aquifers are the likely recipients of recharge from upland ground water. Deep upland aquifers may be continuous with valley aquifers in some areas.

#### Valley Aquifers

Drilling reports and well logs indicate that unconsolidated sediments in the Issaquah Creek valley may be present at depths of over 650 feet below ground surface (Robinson & Noble, Inc. 1986). A narrow gap in the Issaquah Creek valley south of Issaquah is bounded by bedrock. Deep unconsolidated sediments are found in the valley north and south of this gap. The degree or manner of interconnection is unknown. Some wells drilled near the valley gap encountered bedrock at relatively shallow depths. If a bedrock sill or barrier is present, it could restrict or alter deep ground water flow.

Aquifers north of the gap are hereafter referred to as lower valley aquifers and are discussed in the following sections. Those aquifers south of the gap are referred to as upper valley aquifers. In addition to the upper and lower valley aquifers (see Figure 7.2), there may be distinguishing characteristics for aquifers found in the tributary stream valleys drained by East Fork, North Fork, Mason Creek, and the unnamed drainage along the Cedar Grove Road.

In the lower valley, at least three major aquifer zones have been identified. They are informally designated A1 - Upper Zone, A2 - Lower Zone, and A3 - Deep Zone. Their known characteristics are summarized in Table 7.3.

Several high-yield production wells are completed in these zones. Table 7.4. lists wells indicating yields and aquifer characteristics. All three aquifer zones have been demonstrated to be in hydraulic continuity with Well 9 (SPWSD). Well 9, completed in zone A3, when tested there was drawdown interference observed in all 3 aquifer zones within 4 hours. Figure 7.2 shows the location of SPWSD and City of Issaquah Production Wells.

In zones A1 and A2, wells up to 6,000 feet away had less than 1 foot of drawdown, and wells with over 1 foot of drawdown were within 3,400 feet of Well 9. One well with over 2 feet drawdown interference is located just over 3,000 feet from Well 9. The general ground water gradient is toward Lake Sammamish (Carr/Associates 1988, 1992/93).

In the upper valley there are no known high-capacity production wells. However, given the relatively sparse population of the area, there has not been an economic incentive to develop high yield wells, and so the potential productivity of ground water resources is unknown.

Flow in shallow aquifers is expected to follow in the approximate direction of surface drainage. The direction of ground water movement in deeper aquifers in the upper valley is not fully understood. There is some flow from the upper to lower valley.

### 7.3.3 Lower Issaquah Valley Aquifer System

**Hydrogeologic Boundaries**. Hydrogeologic boundaries can restrict ground water flow (e.g. bedrock boundaries) or enhance it (e.g. stream boundaries). They also constitute the ultimate source areas and discharge areas of the aquifer system. The boundaries recognized in the Lower Issaquah Valley Aquifer system are as follows:

- The lower Issaquah valley system aquifer is bounded on the south by low-permeability bedrock, at the Tiger Mountain Gap, and by bedrock outcrops occurring in the higher elevations along the margins of the ground water basin. The assumed low permeability of the bedrock constitutes a no-flow boundary to the base of the aquifer system;

- The lower Issaquah valley aquifer system is bounded on the north by Lake Sammamish, which is a regional discharge area. All ground water flowing through the area ultimately discharges either to Lake Sammamish, the wetland area directly south of the Lake, or to Issaquah Creek which drains into Lake Sammamish;
- The uppermost boundary to the aquifer system is the most complex, consisting of wetlands, streams, lakes, open-space (recharge areas), and urbanized areas. The water entering the ground water flow system originates from precipitation within the confines of the ground water basin. Streams may "lose" water to the aquifer, "gain" water from the aquifer, or have no interaction with the aquifer. Lake Tradition likely contributes water to the lower Issaquah valley aquifers through vertical infiltration from the Tradition Lake Plateau to the lower Issaquah valley aquifer. Urbanized areas tend to reduce the natural infiltration to the ground water through stormwater collection. Undeveloped open areas and rural residential areas represent potential recharge areas (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates 1993).

**Ground Water Flow in the Lower Issaquah Valley**. Ground water generally flows to the northwest through the lower Issaquah Creek valley area and discharges to Lake Sammamish, or the wetland area immediately south of the Lake. Ground water flow converges on the central valley area from the North Fork, East Fork and Lower Fork Subbasins of Issaquah Creek. Flow directions in the western lower Issaquah valley (near Newport Way) are not well known. The deltaic sediments of the North and East Forks readily transmit ground water downwards into the lower Issaquah valley from the upland areas, causing steep hydraulic gradients at the margins of the valley, then the gradients flatten within the delta itself. A water table contour map was constructed using water level data from selected wells and USGS topographic maps. Figure 7.2 shows the general topography of the area and the wells used for constructing the water level contour map. Figure 7.3 shows ground water levels, indicating that ground water moves from higher elevations toward the lower valleys and lowlands in the Issaquah Ground Water Management Area.

Ground water flow directions in the Grand Ridge and Tradition Lake areas are less certain, owing to a lack of wells and water-level measurements. It is presumed that flow mimics topography and is primarily westward toward the Issaquah valley, with components of flow directed towards the North Fork (particularly the wetland areas) and the East Fork valleys. Near the western margins of these areas, vertical infiltration through the deltaic sediments probably dominates. Quasi-horizontal flow may occur along distinct delta strata, but the continuity of individual strata within deeper zones in the lower Issaquah valley aquifer cannot be substantiated.

Ground water elevations vary throughout the year in response to winter and spring recharge. The direction of ground water flow within the valley appears to shift from a primarily northern direction during the summer and fall, to a northwestern direction during the winter and spring (see Figure 7.4). This was noted in the Wellhead Protection Plan wells as well as the monitoring wells at the ARCO site (Geraghty and Miller 1991). This westward shift in flow direction indicates a large influx of ground water from the east during the winter and spring. This has important implications with regard to the source of recharge to the aquifers within the valley and well capture zones (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates 1993).

A Ground Water Pollution Study of the Issaquah Plateau was conducted by the Puget Sound Power and Light Company in 1978. This study identified the existence of two standing water bodies, Lake Tradition and Round Lake, in the upper water table. The surrounding geology, the near identical lake body elevations and corresponding seasonal fluctuations of the lake's levels indicate the hydraulic continuity between the two lake systems. Test borings between the lakes encountered large quantities of ground water at depths of less than 6 feet, and deeper borings located ground water closely corresponding to the nearby lake elevations. The ground water appears to be the seasonal overflow progressing north from Lake Tradition. The study also showed that the major movement of this upper ground water table is west-southwest from Round Lake.

Surface runoff from the northwest side of Tiger Mountain and the Plateau migrates and concentrates in the Lake Tradition trough and moves westward and to some minor degree, northward. Most of the ground water movement continues west, showing up as a surface exposure in Round Lake and vicinity. From here, ground water flows in a southwest direction (A Ground Water Pollution Study, Puget Sound Power and Light Company 1978).

**Ground Water Flow through the Gap**. The Tiger Mountain Gap is located in the south central part of the Issaquah Ground Water Management Area between Squak and Tiger Mountains (Figure 7.2). In April of 1992, resource protection well RP-1 was installed near Tiger Mountain Gap (Carr/Associates, Inc. 1992) to determine the extent of ground water resources in this vicinity and the depth to bedrock. An aquifer encountered between depths of 27 to 42 feet yielded a transmissivity of 30,000 gallons per day per foot (gpd/ft). Bedrock was encountered at a depth of 63 feet below ground surface.

As shown by the water level contours on Figure 7.3, Tiger Mountain Gap appears to act as a restricting ground water conduit, limiting drainage from the southern portion of the Issaquah Ground Water Management Area. To quantify the effect of Tiger Mountain Gap on ground water movement, two calculations were performed. First, to determine the amount of ground water discharge available to flow through Tiger Mountain Gap, a water balance was calculated for the area south of it. Second, to determine how much water can potentially move through Tiger Mountain Gap, its hydrogeological capacity was calculated using Darcy's Law. Results are discussed below.

**Available Discharge (Water Balance)**. The ground water discharge from the upper basin (GDu) that is available to move through Tiger Mountain Gap can be estimated from the relationship of:

GDu=P - ET - (SF + BF)

where upper basin values are:
P=148 cfs (precipitation)
ET= 47 cfs (evapotranspiration)
(SF+BF)= 87 cfs (stream outflow)
GDu= 14 cfs (ground water discharge)

As shown, the ground water discharge of the basin upstream from Tiger Mountain Gap is 14 cfs. This represents about 50 percent of the total discharge from the lower Issaquah valley drainage basin (24.5 cfs), as calculated in the water budget section (Section 7.5).

**Discharge Capacity (Darcy's Law)**. Darcy's Law was used to calculate the amount of possible ground water flow through Tiger Mountain Gap, based on permeability (hydraulic conductivity), area, and gradient.

Q=K A dh/dx (Darcy's Law)
where values for Tiger Mountain Gap are:

K=400 ft/day (hydraulic conductivity estimated from well RP-1; Carr/Associates, Inc. 1992)

A=36,000 sq. ft. (area = 480 ft. wide x 75 ft. deep)

dh/dx=0.01 (gradient)

Q=(400) (36,000) (0.1)
=144,000 $ft^3$/day
=1.7 cfs (capacity for ground water discharge)

This calculation indicates that Tiger Mountain Gap's ground water discharge capacity is about 1.7 cfs of the 14 cfs of available discharge from the upper basin. These results indicate an order of magnitude difference between the available ground water and the amount that could move through Tiger Mountain Gap. Three possible explanations for these differences are evaluated below:

*Data used to calculate the water balance and hydraulic capacity were inaccurate*. The water balance calculation is as reliable as that done for the entire basin. The values used in Darcy's equation are conservative and probably overestimate underflow through Tiger Mountain Gap. The extent of the aquifer in Tiger Mountain Gap may be underestimated.

Additional monitoring wells are needed to provide better data on actual ground water flow through Tiger Mountain Gap.

*Ground water exits via paths other than Tiger Mountain Gap.* Ground water may also exit the Issaquah Creek basin via shallow valleys south of Squak Mountain. South of Cedar Hills Landfill, the ground water gradient is very flat and the flow intermittent. Here, ground water may recharge deeper sediments and flow southwest toward the Cedar River. Further investigation of the valleys north and south of the Cedar Hills landfill is needed to determine the amount of ground water leaving the Issaquah Ground Water Management Area. If upper basin ground water actually flows toward the Cedar River basin, then estimates of the ground water discharge to Lake Sammamish could be reduced by 50 percent.

*Ground water emerges as surface water.* Ground water could be forced to the surface at Tiger Mountain Gap, flow through Tiger Mountain Gap in Issaquah Creek, and reenter the lower valley aquifer downstream. This potential exfiltration and reinfiltration could be evaluated by additional stream monitoring stations, above, in, and below the Tiger Mountain Gap.

**Ground Water Elevations**. Ground water elevations (or water-table elevations) determine, in part, the rate and direction of ground water flow. Elevations are referenced to mean sea level. Ground water flows from high to lower elevations at a rate proportional to the slope of the water-table and the hydraulic characteristics of the aquifer. Ground water elevations fluctuate in a somewhat predictable fashion because of annual fluctuations in precipitation and ground water recharge. The annual high and low ground water elevations are typically used to evaluate general aquifer behavior. The high and low water-table configuration, based on observed water levels, is shown on Figure 7.4. Water level contours for both the Upper and Lower Valley are shown in Figure 7.3. Water-level elevations are extrapolated to the western portion of the valley based on assumed conditions. There are very little data on ground water conditions in the western lower Issaquah valley.

Seasonal high ground water elevations in the lower Issaquah valley occur in February, based on 1992 data, and range from 150 to 200 feet in the South Issaquah/Hobart area to approximately 50 feet about two miles south of Lake Sammamish. Ground water elevations in the immediate vicinity of Lake Sammamish are uncertain, because no wells exist in this area. However, ground water elevations are expected to approach 25 feet near the lake, which is the average elevation of Lake Sammamish. Seasonal high ground water elevations in the central valley area, where most of the wells are located, vary from approximately 60 to 70 feet. Ground water elevations increase to the east to as much as 80 feet or higher.

Seasonal low ground water elevations occur in August and September (based on the 1992 data) and range from 150 to 160 feet in the South Issaquah/Hobart area to approximately 47 feet approximately two miles south of Lake Sammamish. Seasonal low ground water elevations in the central valley area, where most of the wells are located, vary from approximately 55 to 60 feet.

Little data are available on Grand Ridge and the Tradition Lake Plateau. Recently installed shallow wells at the proposed Grand Ridge development indicate that ground water elevations vary from about 400 feet to over 800 feet, and are likely representative of shallow perched aquifers over low-permeability bedrock or till. Ground water levels in a private well (Dean Well) located west of the proposed development are relatively constant at approximately 338 feet. This well is completed below till (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates, 1993).

**Ground Water Level Fluctuations**. Fluctuations in ground water levels are often indicative of the overall behavior of the aquifer, the location of recharge/discharge areas, and the response to recharge/infiltration.

In general, the lower Issaquah valley aquifer responds very quickly to precipitation events. These water-level responses are seen in both shallow and deep wells. This response suggests continuity with the ground surface and/or stream network. Additionally, the wells in the lower Issaquah valley respond to pumping of the various production wells in the area. Short-term fluctuations are clearly observed in response to the Lakeside Gravel Pit, which operates wells on an eight-hour work-day schedule. Figure 7.5 shows a hydrograph of one shallow monitoring well at the ARCO site. The hydrograph shows the short-term fluctuations in water levels caused by pumping at Lakeside, short-term and longer term declining and rising water level trends due to climate, and the effect of pumping at Sammamish Plateau Water and Sewer District's well 9. The various responses result in "noise" in long-term water-level observations caused by these short-term effects.

Within the valley area, the annual change in ground water elevations was between 7 and 10 feet in 1992. Greater annual fluctuations of up to 15 feet occurred in the vicinity of Sammamish Plateau Water and Sewer District's wells 7 and 8. The annual change in water elevations appears to decrease to 7 feet or less north towards Lake Sammamish, while higher annual water-level fluctuations of 10 feet or more occur south and east of the central valley area (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates 1993).

Water levels in wells are related to rainfall, however, the relationship has been modified by significant ground water withdrawals in some areas. Long term rainfall trends should be assessed with long term well water level data. Then pumping effects could be compared to water level data. Pavement as a result of urbanization has also affected this relationship due to a higher volume of rainfall lost to storm flows which have decreased ground water recharge (Liszak, 1995).

**Hydraulic Gradients**. Hydraulic gradients indicate the rate of ground water movement. Gradients are unitless parameters, equivalent to a slope.

The average horizontal hydraulic gradient within the central valley area, based on data from 14 wells, is relatively flat at between 0.001 and 0.002. Hydraulic gradients are less well known on Grand Ridge and in the Tradition Lake area. Within the proposed Grand Ridge development, the horizontal gradient is about 0.067, 10 times higher than in the lower valley.

Vertical gradients are also important, because they indicate the upward or downward component of ground water flow. In general, downward gradients are expected in recharge areas and upward gradients are expected in discharge areas.

The vertical hydraulic gradients vary considerably throughout the lower Issaquah valley area. In general, the vertical gradient is, as expected, directed upward in the northern area near Lake Sammamish. Primarily downward vertical gradients occur in the central valley area, probably as a result of the high-volume pumping within this area. Locally, both upward and downward gradients may be created because of the completion interval of the production wells, which may induce downward leakage from above and upward leakage from below. At Sammamish Plateau Water and Sewer District's wells 7 and 8 the vertical hydraulic gradient appears to be downward from the surface to the 117-foot completion interval and upward from the deeper 177-foot completion to the 117-foot completion interval.

Vertical gradients on Grand Ridge and Tradition Plateau are unknown. However, the vertical gradient is directed upward along the flanks of the Tradition Lake area (near well WH-1, and wells COI 1 and 2). The upward gradients in this area may be the result of infiltration originating from higher elevations at a high head and discharging to the lower valley area.

In general, the vertical hydraulic gradients observed within the lower Issaquah valley in 1992 appeared to remain relatively constant throughout the year, with the exception of wells COI 1 and 2 and SPVT6 (Figure 7.2). At these sites, the vertical gradient decreased between the winter/spring recharge period and summer/fall period, when the vertical gradients are at a minimum. This trend suggests that recharge to the deeper sediments during the winter/spring may increase the upward vertical gradient in places and then decay during the ensuing dry period (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates, 1993).

**Aquifer System Characteristics**. The present understanding of the aquifer system indicates the total sediment thickness ranges from over 600 feet in the central lower Issaquah valley near wells COI 4 and 5, to 300 feet at the Grand Ridge margin of the Lower Issaquah Valley (Sammamish Plateau Water and Sewer District's well 9), to 150 feet at the Lake Tradition margin of the lower Issaquah valley (well WH-1), to 63 feet at the Hobart Gap (well RP-1). Actual aquifer thicknesses are assumed to be similar to sediment thicknesses, since there is little regional geologic continuity between strata.

Production wells within the lower Issaquah valley tap highly permeable aquifers. Testing of these wells has provided data on the hydraulic characteristics of the aquifer.

Carr/Associates conducted a 3-day pumping test of Sammamish Plateau Water and Sewer District's wells 7 and 8 between September 12 and 15, 1990. The wells were pumped at a combined rate of 5,600 gpm. During the test, water-levels were monitored in 17 wells and at 6 surface water stations. The 17 monitoring wells included 11 piezometers and 6 production wells. During the test, water-levels in the observation wells were drawn down between 1 and 3 feet, and the cone of depression extended a distance of approximately 7,000 feet from the pumping wells. Analysis of the pumping test was complicated to some degree by interference resulting from the pumping of other production wells, and by the complex hydrogeology of the valley. Based on the test, a transmissivity of approximately 67,000 $ft^2/d$ was calculated (Carr/Associates 1990). Assuming an aquifer thickness of between 200 and 300 feet, a bulk hydraulic conductivity of between 220 and 330 ft/day for the aquifer is estimated. The calculated storativity varied from 0.2 to $1 \times 10^{-4}$. During the test, the Reid Pond, located over 1,300 feet to the northwest of the pumping wells, demonstrated over 1½ feet of drawdown interference due to pumping (Liszak, 1995).

A long-term pumping test of Sammamish Plateau Water and Sewer District's well 9 was conducted at a rate of 2,340 gpm for about 9.5 days by Carr/Associates in July 1992. During the test, water-levels were monitored in 55 observation wells. In addition, 15 surface water monitoring stations were established and monitored. The test was designed to minimize interference from surrounding, pumping wells and attempt to achieve steady-state conditions in the aquifer through an extended test length. Analysis of the well 9 test (Carr Associates 1993) suggests the following:

- Well 9 is completed in a thin (50-foot) isolated aquifer zone (termed Zone C), with a high transmissivity, separated from the overlying sediments by a leaky aquitard;
- Pumping of Well 9 caused drawdowns of between 1.4 and 0.2 feet in shallower zones of the aquifer;
- Flow paths towards Well 9 do not intersect the known contamination at the ARCO site;
- Steady-state conditions were not achieved;
- Transmissivity of the aquifer as a whole is similar to that observed at Sammamish Plateau Water and Sewer District's wells 7 and 8 at 70,000 $ft^2$/day based on a late-time drawdown analysis of all wells monitored; and
- Strong, downward vertical gradients are established from the water table towards the deeper portions of the aquifer.

In July 1992, Golder Associates conducted a series of slug tests in the monitoring wells. The tests were analyzed using the Bouwer/Rice (1967) method and the method of Van der Kamp (1976). The hydraulic conductivity calculated from the tests ranged from 100 to 470 ft/day, which is consistent with the pumping test results (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates 1993).

**Stream/Aquifer Interaction**. Stream-aquifer interaction is important in an aquifer system and can be a source of recharge to the ground water. It is often difficult to measure the "hydraulic continuity" between a stream and aquifer and, in most cases, indirect assessments of stream-aquifer interaction are necessary. The parameters controlling stream-aquifer interaction are:

- The elevation difference between the stream and the ground water; and
- The hydraulic characteristics of the streambed.

Three major streams traverse the lower Issaquah valley (Figure 4.1). The North Fork and East Fork Issaquah Creek descend from elevated upland areas into the lower Issaquah valley, losing more than 200 feet of elevation over a relatively short distance. The Lower Fork of Issaquah Creek gradually descends through the lower Issaquah valley from the Hobart Gap to Lake Sammamish, losing about 100 feet of elevation. From a hydraulics standpoint, it is expected that the steep sections of the North and East Forks of Issaquah Creek would provide coarser bedload (sands and gravels), and have a higher hydraulic conductance. When the stream enters the lower Issaquah valley, its gradient decreases and finer sediments (sands and silts) are deposited, potentially reducing the hydraulic connection between the streambed and the underlying aquifer.

Stream gauging was performed in March 1992 on the North Fork and East Fork of Issaquah Creek. On the North Fork, three stations were gauged between the McDonald Well and 60th Street (approximately 1,000 feet apart). On the East Fork, two stations were gauged (approximately 1,000 feet apart) near the Sunset Overpass of I-90. The objective of the stream gauging was to determine whether significant stream/aquifer interaction was occurring at the edge of the upland areas surrounding the lower Issaquah valley. The accuracy of the survey is estimated at +/- 1 cfs, due to the shallow stream depth and low velocity of water flowing through the stream. On the North Fork, measured streamflow decreased from 3.3 cfs upstream of the McDonald well to 2.8 cfs downstream of the McDonald well, and then increased to 4.1 cfs below the 60th Street bridge farther downstream. These results do not indicate large streamflow losses or gains and are within the accuracy of the survey.

At that streamflow, stream/aquifer interaction of less than 1 cfs per 1,000 feet of streambed was estimated along the North Fork at its confluence with the valley floor. Along the East Fork, a similar conclusion was reached. Streamflows measured upstream and downstream of the Sunset overpass were 9.8 and 9.3 cfs, respectively. These values are within the accuracy of the survey and are consistent with streamflows used by King County Surface Water Management. Thus, stream/aquifer interaction along the East Fork between the Sunset overpass and confluence with the Lower Fork Issaquah Creek is estimated at less than 1 cfs per 1,000 feet of streambed. Because of the limited extent of stream gauging, these streamflow relationships may not be representative for all seasons or flow regimes. Additional stream gauging data are needed to fully characterize stream/aquifer interaction along the edge of the lower Issaquah valley.

Mini-piezometers were installed at six locations in the lower Issaquah valley (four on the Lower Fork and two on the North Fork) in June 1991. These piezometers were placed in or directly adjacent to the streambed to a depth of 5 to 8 feet. They measure the relative water levels in the stream and underlying shallow ground water. The results at four of the six locations indicated that stream water levels were "perched" 1 to 3 feet above the ground water level, indicating little interaction between the stream and aquifer. At two of the stations, ground water levels were equal to or higher than the stream water level, suggesting continuity between the systems.

Monitoring of streamflow and shallow ground water levels during the pumping test at Sammamish Plateau Water and Sewer District's Well 9 also indicated limited hydraulic continuity with the streams. The cone of depression created by the 9-day pumping test extended over nearly two square miles, and the drawdowns observed at the water-table (based on a hand-contoured drawdown map) can account for over 80 percent of the water pumped from the aquifer during the test assuming a bulk porosity of 20 percent. If stream infiltration provided a significant contribution to the water pumped from the well, drawdowns in distant observation wells would be much less. Thus, infiltration from the stream to the aquifer is interpreted to be a minor component of the water drawn to the well when it is pumped. There is still a long-term impact to surface waters during pumping, but this impact occurs at the discharge areas (i.e. the wetlands directly adjacent to Lake Sammamish) of the ground water system because there is less ground water moving through the aquifer as a result of pumping (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates, 1993).

**Data Sources**. Data for generating hydrostratigraphic cross sections were obtained from copies of Ecology's well logs supplied by King County, well logs from Carr/Associates and other consultants' project files, and the Issaquah Ground Water Management Area well log database file. Issaquah Ground Water Management Area database incorporates data from all these sources and includes files for water levels, well construction data, and lithologic logs. Most of the well logs were originally recorded by the well drillers. This information was entered into the database by Seattle-King County Health Department personnel as part of this project. Selected well logs are included in Appendix E (available upon request). The locations of wells included in the database are shown in Figure 7.2.

**Hydrostratigraphic Units**. The lithologies described in the well logs were categorized into three hydrostratigraphic units. These units are described in Table 7.5 and illustrated in cross sections as Figures 7.6 through 7.9. The location of each cross section is shown in Figure 7.10.

**Extent and Significance of Hydrostratigraphic Units**. To illustrate the extent and significance of these hydrostratigraphic units, four hydrogeologic cross sections were generated from the well logs. The locations of the four cross sections are shown on Figure 7.10. Cross sections A-A' and A'-A" (see Figures 7.6 and 7.7) parallel the main stem of Issaquah Creek from Lake Sammamish south to Hobart. Cross section B-B' (see Figure 7.8) begins in the Tibbetts Creek Valley, crosses Lower Issaquah Valley, extends up the North Fork of Issaquah Creek, and ends on the south flank of the Sammamish Plateau. Cross section C-C' (see Figure 7.9) begins at the City of Issaquah's Gun Club Well (34F03), bisects the Lake Tradition Plateau, and follows the East Fork of Issaquah Creek toward the town of Preston.

The well numbers (i.e., 34F03) for each well used in the sections are shown on the map (Figure 7.10) and the cross sections (see Figures 7.6 through 7.9). Logs for all wells used in the cross sections are included in Appendix E (available upon request). Some wells near the cross sections with duplicative, incomplete, or inadequate logs were not included in the figures.

The extensive topographic relief in the study required use of relatively high vertical exaggeration (28x) on the cross sections. This exaggeration makes some bedrock and sedimentary shapes appear very steep and unnatural. For example, the steep chevron-shaped aquifer in cross section A-A' (see Figure 7.6) looks unlikely. However, this correlation accurately depicts coarse-grained aquitard sediments, deposited at about 10 degrees, opposite flanks of the ancestral North Fork delta. Hydrostratigraphic relationships in the Lower Issaquah Valley were confirmed by water levels and drawdown interference measured during recent extensive aquifer tests (Carr/Associates, Inc. 1990 and Carr/Associates, Inc. 1993).

*Cross Section A-A'-A."* Cross section A-A'-A" is segmented into north (A-A') and south (A'-A") illustrations (see Figures 7.6 and 7.7). The section shows significant changes in depth to bedrock along the main valley of Issaquah Creek. Wells located near the southern end of Lake Sammamish, where the modern delta of Issaquah Creek is forming, have the lowest ground surface elevations and exhibit flowing artesian conditions (i.e., water levels above ground surface).

Multiple aquifer zones of high permeability sand and gravel were encountered by numerous Lower Issaquah wells, such as 28A06, 27E03, and 27E04. These include a shallow aquifer zone (depth less than 60 feet below ground surface), a middle aquifer zone (depth 80 to 170 feet), and a deep aquifer zone (depth 195 to 220 feet). These major aquifer zones are used by production wells of the Sammamish Plateau Water and Sewer District and the City of Issaquah. At Sammamish Plateau Water and Sewer District's Well 9 (27E03) a substantial layer of silt separates the middle and deep aquifer zones. The deeper sediments logged at well 34F03, east of Issaquah High School, may be related to these sediments of the lower Issaquah valley.

At well 27E03, bedrock was encountered at a depth of 301 feet. Most other lower valley wells were not drilled deep enough to encounter bedrock. Bedrock was found at a depth of 18 feet below ground surface at well 15P02. The ground surface elevation at this well is 330 feet above sea level. Within the Section 15 area, the depth to bedrock is highly variable ranging from 18 feet to 194 (Well 15A02) feet below ground surface. At monitoring Well 15E08, bedrock is encountered at 65 feet below ground surface.

South of Tiger Mountain Gap (see Figure 7.10), the bedrock basement deepens at well 26B02 and then rises sharply at well 05N03 near Hobart. Limited available data indicated that aquifers south of the Gap are less productive than the permeable deltaic sands and gravels in the lower Issaquah valley. Lacustrine silt and clay aquitards occur both north and south of Tiger Mountain Gap and, where present, impede the vertical migration of ground water.

*Cross Section B-B'.* Cross section B-B' illustrates the sediments southwest to northeast from Tibbetts Creek up the North Fork of Issaquah Creek. As shown in Figure 7.8, a series of deltaic sands and gravel was deposited from the North Fork of Issaquah Creek into ancestral Lake Sammamish. Test drilling at City of Issaquah well 5 (28B04) showed the presence of shallow aquifer zones and a deep silty-sand aquifer.

The upland east of the lower Issaquah valley consists of bedrock mantled by glacial deposits. Although numerous wells are shown along the North Fork Valley (see Figure 7.10), few of them encounter extensive aquifers.

Cross sections through the deltaic deposits south of the North Fork appear in reports by Carr/Associates 1993 and Golder Associates 1993.

*Cross Section C-C'.* Cross section C-C' (see Figure 7.9) shows the bedrock that is beneath Lake Tradition Plateau and that is overlain by about 100 feet of sediments in the upper East Fork Valley. Relatively permeable aquifers separated by silty aquitards are present in the upper East Fork Valley and in Issaquah Valley at wells 27P02 and 34A01. In the eastern part of the East Fork Valley, the more productive wells are completed in these aquifers. Shallow bedrock penetrated by wells 25P01, 25J01, and 30L01 contains shale with some coal seams. This bedrock provides limited water to a few domestic wells.

*Data Limitations.* In the Issaquah Ground Water Management Area, the quality and quantity of reliable data are extremely varied. Ground water resources of the lower Issaquah valley have been explored extensively and evaluated professionally on several projects, including the Lower Issaquah Valley Wellhead Protection Plan (November 1993). By contrast, very little ground water exploration or professional evaluation has occurred in upstream parts of the Issaquah Ground Water Management Area (the Upper Valley) other than at the Cedar Hills Landfill. In the remaining parts of the Issaquah Ground Water Management Area where development can occur, domestic wells drilled only as deep as necessary have been installed. As a result, limited geologic data are available in areas where shallow aquifers are adequate (typically in the valleys), and geologic data are abundant where shallow aquifers are inadequate (typically in the foothills).

Drillers' and geologists' descriptions of sedimentary units are subjective and can produce inconsistencies in descriptions of similar units. For example, soft shale bedrock has been mistakenly identified as "silt" or "clay." The three hydrostratigraphic units used in this report accommodate some of these potential problems. However, future, more detailed analysis should recognize the potential differences in nomenclature.

The locations of some of the wells shown in the cross sections have been verified. However, other wells may be mislocated by the incorrect entry of a quarter-quarter section. More than one-third of the wells used in the cross sections have been accurately surveyed to provide locations and elevations. For other wells, Seattle-King County Health Department personnel entered the estimated elevations and locations with the designated 40-acre quarter-quarter section. Consequently, some locations may not be accurate, and well elevations for non-surveyed wells may be inaccurate.

Cross sections illustrating hydrostratigraphy generally are not impaired by imprecise elevations as long as reasonable values are used. However, evaluation of ground water gradients based on inaccurate elevations is not appropriate. In addition, many of the test wells have different water levels for each zone of completion, and seasonal changes of more than 10 feet are not reflected by water levels measured only once when the well was completed.

Future analysis could benefit from greater detail on wellhead and surface water elevations. These data would help refine the surface/ground water relationships in various parts of the study area. Moreover, the location of wells should be verified and noted in latitude and longitude coordinates to facilitate entry into computerized data banks.

### 7.3.4 Data Collection Activities for Hydrogeologic Characterization

**Water Level Measuring**. Water level measurement data are critical to both ground water flow patterns and to trend analysis of impacts of climate, water use, and regional growth on the aquifer system.

Water levels in wells were monitored on a monthly basis between 1989 and 1992 at 48 well sites. The data were collected by personnel from the City of Issaquah, Sammamish Plateau Water and Sewer District, the Seattle-King County Health Department and Carr and Associates. Water level data collected between 1989 and 1992 are listed in Appendix F (available upon request).

The well sites were selected based on the following criteria:

- Hydrogeologic Significance - Appropriate location for defining ground water flow directions, gradient, divides, as well as water level trends.
- Representative - The water level measurements are representative of a single aquifer (i.e., well is not completed over several aquifer zones).
- Well Log - The well has a complete and reliable well log.
- Locatable - The well can be located in the field and verified with the well log.
- Easily Measurable - the well is accessible with a sounder.

- Non-Pumping Water Levels - The well should have limited use to facilitate obtaining static water level measurements.

Selection of monitoring wells was restricted to wells having geologic logs and well completion information. The process for site selection included the following:

- The project database was queried for all wells having geologic logs, and a well summary table and well location map were prepared.
- General areas where additional hydrogeologic data were needed were identified on the well location map.
- Field surveys and interviews were conducted by the project consultants to locate wells that satisfy the above criteria and whose owner agreed to allow access for periodic measurements.
- The selected sites were reviewed by the Issaquah Ground Water Advisory Committee.

Well construction and hydrogeologic information has been entered into the database for all monitoring wells. All monitoring wells were surveyed in 1991.

Water levels from wells included in the Issaquah Ground Water Management Area monthly monitoring program were plotted to view seasonal water level trends. Figure 7.11 shows the monitoring wells included in the monitoring program, and Figures 7.12.A through 7.12.H show the water level changes in these wells. The apparent variations in water level may arise from seasonality in precipitation and the effects of prior pumping. Thus, general trends should be sought without undue emphasis on small variations.

As indicated in Figures 7.12.A through 7.12.H, high water levels occur during the months of February through May, while low water levels occur from September through December. Water levels can fluctuate seasonally as much as 15 feet. Because high precipitation periods generally occur during the months of November through February, a time lag of two to four months is presumed to occur for ground water recharge. The length of this lag period depends on the depth to ground water and the type of overlying sedimentary material.

Long term data collection from these 48 wells is needed to determine ground water level trends. The City of Issaquah Wells #1 and #2 monitored as part of the well network have data available from 1981 to 1994 (Appendix F, available upon request). The water level in Well #2 has declined 3 feet between 1981 and 1994 (Liszak, J. 1995).

**Exploratory/Test Wells**. An electrical resistivity survey was conducted in the lower Issaquah valley (Carr/Associates November 1989) to make a preliminary evaluation of the ground water potential of the area, and to help select sites where test drilling would have the greatest opportunity for success. Electrical resistivity surveying is a geophysical technique for measuring electrical properties of subsurface geologic materials. By measuring these electrical properties, subsurface hydrogeologic features can be identified. The Wenner Array resistivity method was used.

Results of resistivity surveying in the lower Issaquah valley showed permeable sediments present as isolated lenses and short channel segments. Less permeable, fine sediments are widely distributed and increase in dominance to the west and north.

the recommendations from the survey were for the Sammamish Plateau Water and Sewer District to drill five 8-inch-diameter test wells of approximately 200 feet deep. The five test sites recommended were:

- One well site in the vacant lot immediately north of the Meadow Creek Office Park.
- Two wells in the I-90 Corporate Park greenbelt.
- One well in the I-90 Corporate Park "tailpiece property."
- One well in the pastures east of 230th Avenue South East.

The three new exploratory/test wells were installed in 1990 and one in 1992 to provide additional information with which to evaluate hydrostratigraphy, ground water flow, and water quality. The three wells VT-1, VT-2 and VT-3 drilled in 1990 were based on the 1989 Carr/Associates resistivity recommendations and the criteria below.

The criteria used to select the test well sites include the following:

- Hydrogeologic Significance - Aquifers, ground water flow directions and water quality are of interest and satisfy the program objectives.
- Property Accessibility - The property is accessible to heavy drilling equipment and access for long-term monitoring is available.
- Property Availability - The property is publicly owned or the owner is agreeable to terms of drilling and long-term monitoring at no cost.
- Site integrity - The site is secure from vandalism and free from contamination or any disturbance from future land use activities (e.g., road construction, gravel pit expansion, etc.).

Three of the new wells (VT-1, 2, 3) were drilled, using the cable tool method for the City of Issaquah and Sammamish Plateau Water and Sewer District as part of their ongoing efforts to characterize and manage the ground water resources within their local service areas (Sections 21 and 27, Township 24 North, Range 6 East). These sites lie in the lower Issaquah valley. The wells have a casing depth of 160 feet (well VT-1), 79 feet (well VT-2) and 158 feet (well VT-3), respectively.

These three wells were drilled to:

- Determine the potential alluvium for 1,000 to 3000 gallons per minute production well (VT-1).

- Determine aquifer characteristics and install piezometers for future water level monitoring. The results of the drilling and testing were used to evaluate the suitability of the site for a future production well. The exploration also provided additional information on the relationship between the shallow aquifer system and the aquifer penetrated by the City of Issaquah's deep well 5 (VT-2).
- Determine the suitability of well VT-3 site for construction of one or more high-yield production wells.

The fourth site (RP-1) lies in the Squak/Tiger Mountain Gap area and within Section 10 of Township 23 North, Range 6 East. The new well was drilled using the air rotary method to a depth of 80 feet. Bedrock was encountered at 63 feet below ground surface. Two piezometers of 2- and 4-inch diameter were installed to 59 feet (2 inches) and 39 feet (4 inches), respectively. The gap area represents a narrow constriction between the upper Issaquah Creek Valley and the lower Issaquah Creek Valley. Data collected from this well will help evaluate horizontal and vertical ground water gradients, seasonal and long-term ground water trends, and ground water quality relationships in the valley. An access agreement for long-term water level and water quality monitoring was established for a period of 10 years by Seattle-King County Health Department.

The wells were installed in accordance with Ecology's guidelines for "Data Collection from Wells used in the Ground Water Management Area Program, May 1989" as well as according to "Standards for the Construction and Maintenance of Wells, Chapter 173-160 WAC."

The results of the drilling of these four wells were:

- Drilling at the VT-1 site revealed a permeable aquifer which is used by the Sammamish Plateau Water and Sewer District wells 7 and 8. This production well is capable of producing 2,000 to 3,000 gallons of potable water per minute.
- At the VT-2 site, the low permeability of the aquifer zones limits the productivity of any future productions wells. The maximum yield of such wells probably would not exceed 200 gallons per minute.

The high iron and manganese content of the water from the shallow aquifer zone has been observed in other shallow aquifer zones in the valley. Most of these occurrences are associated with wetlands.

These water level and water quality relationships suggest a lack of continuity between the shallow and deep ground water. The VT-2 site will be useful for water level and water quality monitoring.

The RP-1 well is screened in a thin, water-bearing zone consisting of gravel and sand. This zone is not considered a major water-bearing zone, with production limited to about 25 gallons per minute. The upper 4-inch piezometer installed to a depth of 39 feet is hydraulically connected to the 2-inch deeper piezometer, installed to a depth of 59 feet.

The hydraulic relationship between this well and the nearby Hayes Nursery well cannot be determined because the Hayes well was pumping during the testing of this well. Available data suggest complex hydrogeologic relationships between existing wells and surface water features in the vicinity of the RP-1 well.

Water chemistry results indicate that the water samples for this well meet the state drinking water standards, with the exception of manganese. Manganese is a secondary health constituent which has an undesirable taste and discolors water. Manganese occurs naturally in the ground. It is an essential trace element for humans. Manganese toxicity from drinking water has not been reported. (Drinking Water and Health National Academy of Sciences, Washington D.C. 1977).

Wells VT-1 and VT-2 are being monitored for water levels by the Sammamish Plateau Water and Sewer District, and data are forwarded to Seattle-King County Health Department for inclusion in the Issaquah Ground Water Management Area database (Table 7.6).

## 7.4 Aquifer Recharge and Protection

This section summarizes ground water recharge in the Issaquah Ground Water Management Area. It describes the source of ground water and how it enters the system, compares the relative physcial susceptibility of ground water to contamination in various parts of the basin, provides an estimate of the amount of recharge, and evaluates the vulnerability of the ground water resource to various potential sources of contamination.

This information is important for developing an effective program of ground water management in the basin. The ground water recharge described here considers the water which reaches the water table. The deeper aquifers generally are recharged from shallow aquifers. However, deep aquifer recharge is more complex and merits further investigation.

### 7.4.1 Sources of Ground Water

The available information indicates that all ground water in the Issaquah Creek basin originates as precipitation on the basin. In perimeter areas where data are sparse, some contribution may occur from outside the topographic basin which forms the boundary of the study area. Precipitation falling on the basin's land surfaces above the water table infiltrates the unsaturated zone to the saturated zone and then moves downgradient. Once infiltrated, ground water may re-emerge to form springs and streams or enter other surface water bodies. Part of the infiltrated water also may migrate through deeper sediments to underlying aquifers. The ground water in the lower basin discharges to Issaquah Creek, Tibbetts Creek, and finally to Lake Sammamish. Ground water in the upper basin may discharge to the lower basin through the Tiger Mountain Gap or to the Cedar River.

### 7.4.2 Recharge and Aquifer Susceptibility

The potential for ground water recharge varies from one part of the Issaquah Creek basin to another. Ground water recharge occurs when precipitation infiltrates and reaches the water table of the uppermost aquifer. This process is influenced by many factors, including land use, precipitation, vegetation, topography, soil permeability and moisture, and the permeability of geologic materials between the ground surface and the water table. Some of these factors have been incorporated into ranking schemes that estimate relative recharge potential, such as those used in the Vashon/Maury Island Water Resource Study (Carr/Associates 1983), the Redmond Ground Water Management Report (EMCON 1992), and the DRASTIC method (USEPA/600-2-85/018).

A map of infiltration potential for the Issaquah Ground Water Managment Area was created and presented in the December 1994 Draft Issaquah Creek Valley-GWMP. The physical parameters (criterion) used to prepare this map included soils, slope and geology. Subsequent to the December 1994 Draft, a county-wide methodology was adopted to define and rank areas that are physically susceptible to ground water contamination (King County Department of Development and Environmental Services, August, 1995). The county map of physically susceptible ground water supersedes the previous infiltration potential map. The King County Department of Natural Resources has plans to develop a county-wide map of critical ground water recharge areas based on the strategies used to rank areas in the ground water susceptibility mapping process coupled with precipitation data and impervious surface coverage.

The county wide map of physically susceptible ground water areas is shown in Figure 5.5. This map shows areas where ground water is ranked by it's relative susceptibility to contamination. Areas are ranked as being of high, medium, and low susceptibility to ground water contamination. The map, initially published in the 1994 King County Comprehensive Plan, was created under requirements of the Growth Management Act. Since the initial map was published, a revised county wide map has been created using criteria specifying surficial geology, soils and depth to ground water. Each criteria was rated individually as high, moderate, or low according to the protocols listed in Tables 7.7 through 7.9. The three individual scores were combined to yield an overall rating of aquifer susceptibility. It should be noted that soils were assigned one-quarter of the weight assigned to geology and depth to ground water because their occurrence is a result of the physical and chemical weathering processes of surficial geology. A full rating for soils would duplicate surficial geology in the mapping equation.

Soils that are excessively drained or are somewhat excessively drained are rated highly susceptible; soils that are well drained or moderately well drained are rated moderately susceptible; and soils that are somewhat poorly drained, poorly drained or very poorly drained are rated low in susceptibility. Table 7.7 indicates the susceptibility ranking of the USDA, NRCS soil units.

For surficial geology, a clean sand and/or gravel were rated as highly susceptible, tight silt or clay were rated low, and materials (mixtures of and, silt or clay) that fall between the two categories were rated as moderate. Table 7.8 indicates the susceptibility ranking of the USGS geologic units.

The data used to determine depth to ground water was obtained from well logs from the Department of Ecology. Only wells with water levels less than or equal to 100 feet were used in constructing water level contour maps. This reflects the assumption that where depth to water was greater than 100 feet, a relatively impermeable layer would likely exist above the water table. The susceptibility ranking for the depth to ground water criterion is presented in Table 7.9.

Precipitation and land use are not considered in this study of physical susceptibility, but should be considered at a later date in the determination of critical aquifer recharge areas. The Issaquah Ground Water Management Area, ranked by the physical susceptibility of the aquifer, is shown schematically in Figure 5.5.

The areas where ground water is most physically susceptible to contamination in the Issaquah Ground Water Management Area are those areas of soils with very high permeability. They overlie sand and gravel, which were deposited by meltwaters from the receding Vashon glacier. Here, the topography is generally level, although occasionally it is hummocky or steeply sloping, as on the scarps of terraces. In these high-infiltration areas, most surplus water recharges ground water, as little surface runoff occurs. The most important of these areas lies east of the City of Issaquah on the uplands between the East and North Forks of Issaquah Creek.

Most areas mantled with Vashon Till have a low potential for infiltration, and hence, ground water recharge. The local till is a dense mixture of sediment sizes with low permeability. Some water infiltrating the till's surface layer, which has a slightly higher permeability, percolates downslope on the top of the unweathered till to discharge into wetlands. Some of the water in the soil slowly percolates through the till or along scattered fractures in the till to deeper zones. The till is usually underlain by outwash sand and gravel, which forms an important aquifer in the area. Over large areas, the slow recharge through the till can provide substantial quantities of water to the deeper aquifers. Till-covered areas probably provide most of the recharge in the southwestern portion of the Issaquah Ground Water Management Area.

Areas of steep bedrock slopes probably have a low potential for infiltration. Many of the soils in this area have a high permeability, which promotes infiltration. Below the soil, the water encounters low-permeability bedrock, which sheds the water downslope along the bedrock surface to the valleys where it either enters streams or recharges the valley aquifers. Some of the percolating water may enter fractures to recharge deeper bedrock aquifers of limited extent and importance.

The valley floors are underlain by diverse sediments ranging from fine sand and silt to coarse sand and gravel. These deposits are oftentimes overlain by silt and muck, which seal them from surface infiltration. Some areas with coarser-grained surface deposits and a water table below the land surface receive local recharge. In most of the lower valley, a high water table and fine-grained surface deposits located above underlying aquifers prevent local recharge.

Land use, both current and historic, influences actual recharge. Precipitation also affects the actual quantity of recharge. These effects were not included in determination of physically susceptible ground waters (see Figure 5.5). These criterion will be included in critical aquifer recharge maps for King County which are expected to be produced using the physical susceptibility maps in conjunction with land use information and precipitation data.

### 7.4.3 Ground Water Vulnerability

Aquifer vulnerability is a composite of susceptibility and contaminant loading. Susceptibility refers to the ease with which contaminants can move from the land surface to the ground water. The greater the susceptibility, the more readily a contaminant can reach the water table. Contaminant loading refers to the actual presence of activities with the potential to contaminate. Thus, a vulnerable aquifer is one under an area with high susceptibility which has a high contaminant loading, without an upper confining layer.

Aquifer susceptibility is assessed by the same factors that were used to delineate potential recharge areas: soils, geology, and ground water levels. Areas with high recharge potential are highly susceptible because the recharging water may transport contaminants to the water table.

A map showing potential sites where contaminant loading may occur is shown in Figure 5.4. These maps show where contamination sources have occurred in the basin to 1991.

Activities with the potential to contaminate are listed in Table 7.10. Appropriate mitigation should be associated with these activities. These activities should be discouraged in sensitive aquifer recharge areas, as should activities which reduce recharge (Table 7.11).

#### Lower Issaquah Creek Valley

Lower valley aquifers are a productive source of ground water used for the Issaquah Ground Water Management Area's major public supply systems. Soils in the area are subject to fluctuating high water table conditions. The degree of hydraulic continuity between the surface and aquifer zones is largely unknown. On the east side of the lower valley, there is evidence that the upper aquifer zone A1 recharges the lower A2 zone under pumping conditions, thus raising concerns that surface contaminants may have hydraulic access to lower aquifer zones.

Several potential contaminant sources are present in the City of Issaquah and surrounding areas. These potential contaminant sources, such as underground storage tanks, are likely to increase in number due to growing development pressures. Most large supply wells are located near major transportation corridors and in the vicinity of high-intensity land uses. The potential impact to water quality from upstream contaminant sources in the upper Issaquah Creek valley and Cedar Hills area is unknown. Monitoring of on-site and off-site wells and springs between the Cedar Hills Landfill and Issaquah Creek is conducted by King County. This is discussed in detail in Section 5.5 of this report (Landfills and Industrial Waste Sites).

During the period of this study, several spills and related events have occurred in the lower Issaquah Creek Valley. These events have threatened the water quality in some existing high-capacity production wells. The actual impact of these spills has been lessened by rapid remedial response and modified withdrawal patterns from the potentially affected wells.

At the present time, the lower Issaquah Creek valley is probably the most vulnerable part of the ground water resource. In this area, high-capacity wells have been completed at relatively shallow depths in coarse-grained sediments which generally are not separated from the surface by impermeable sediments.

**Upper Issaquah Creek Valley**

Upper valley aquifers are used primarily for small community and domestic supply systems. Soils and geologic materials vary greatly in permeability and properties affecting vulnerability to contamination. Water tables are high in some areas and the extent of surface water and ground water interconnection is not documented.

Septic tank systems, animal keeping, isolated commercial and industrial sites, and transportation corridors represent the more obvious potential sources of ground water contamination. Development activities in the area are likely to result in introduction of a number of additional contaminant sources. Upgradient contaminant sources such as Cedar Hills Landfill and Queen City Farms Superfund Site are also a potential threat to water quality.

**Upland and Mountain Areas**

With the exception of Mirrormont, water is provided by Group B public water systems and individual domestic wells. Contamination of a mountain or upland aquifer would result in serious problems for rural residents because alternative water supply sources are not readily available. Here too, the incidence of ground water contamination is less likely to be discovered because water quality monitoring is not routinely performed.

Upland and mountain aquifers vary greatly in their susceptibility to contamination. Mountain soils and some upland soils are typically thin, steeply sloping, and poorly suited for septic tank systems. In general, wells completed in shallow aquifers are subject to contamination, especially from septic tank systems and animal-keeping practices. Many mountain and upland wells are completed in shallow, relatively unprotected aquifers.

Residential development in these areas is expected to intensify; thus, the number and density of potential contaminant sources will increase. The Cedar Hills Landfill and the Queen City Farms Superfund sites represent contaminant sources with potential for great impact upon the water quality of shallow and lower aquifers in the Cedar Hills area.

### 7.5 Water Budget

Ground water used in the Issaquah Ground Water Management Area is only replenished by precipitation. The following sections describe processes influencing the Issaquah Ground Water Management Area hydrologic cycle. A water budget was prepared to put these processes into a quantified relationship with each other.

This budget is a hydrologic accounting tool used for estimating the annual quantity, availability and movement of water entering and exiting a basin. Components of the budget include precipitation, evapotranspiration, storm runoff and baseflow, ground water basin transfers, ground water discharge, and change in storage. These processes are in reality far more complex than the variables represented in the water budget equation. Values used in the equation are derived from estimates and imperfect data, but nonetheless are useful for developing a general sense of the water regime. Future investigations and ground water management decision-making should be mindful of the limitations of these estimates.

A simplified equation for this budget is: Inflow = Outflow + Change in Storage

The water balance equation can be expressed in greater detail by the following equation:

$$P = ET + SF + BF + GT + GD + dS \quad (1)$$

where:

P=Precipitation
ET=Evapotranspiration
SF=Storm Runoff
BF=Baseflow
GT=Ground Water Basin Transfers
GD=Ground Water Discharge
dS=Change in Storage

### 7.5.1 Precipitation

Precipitation data, a critical component in all water balance calculations, are available for 18 local monitoring stations within or near the study area and for six regional monitoring stations. The local monitoring stations include four Department of Natural Resources sites, five King County Surface Water Management sites, eight sites that were established through the Issaquah Ground Water Management Area program, and King County's Cedar Hills Landfill station. The four Department of Natural Resources sites are Fifteen Mile Creek, Tiger Mountain, Preston and the Issaquah Fish Hatchery. Data have been collected at these sites since 1986. The five King County Surface Water Management sites set up in 1988 are located at upper Tibbetts Creek, Grand Ridge, East Fork of Issaquah Creek, McDonald Creek and Holder Creek. The eight sites established in 1989 by Seattle-King County Health Department are Francis Lake, LeRoux, Rothnie, Maple Hills Park, Cougar Mountain, Grand Ridge, High Valley and Issaquah. These sites were selected to provide additional coverage within the planning area. The precipitation measurements at these sites are collected by volunteers. Locations of the rain gages are depicted on the map in Figure 7.13. The list of the location of precipitation and stream gaging stations, numbered in Figure 7.13, can be found in Table 7.12. The criteria used to select precipitation gauging sites include:

- Site Distribution - Establish sites in areas where data are not presently being collected. Focus data collection on higher elevation sites where existing data are limited.
- Representative - The site is not obstructed in a 45 degree cone projecting from the orifice of the gauge, shielded from nearby ground turbulence, and is offset from roof spray and gutter splash.
- Orographic Significance - Establish sites where terrain and seasonal storm directions are likely to influence precipitation patterns.
- Accessibility - The site is easy to measure on a regular basis (e.g. backyard, work place, or routine checkpoint).
- Security - The site is protected from vandalism, animals, and accidental damage.
- Permanency - The location of the gauge is not likely to change.
- Commitment and Responsibility - The data collectors must be committed to collecting data for the term of the project.

Data for these stations are presented in Appendix G (available upon request). The regional monitoring stations include SeaTac Airport, Kent, Cedar Lake, Snoqualmie Falls, Sand Point, and Landsburg.

The Cedar Hills station has the longest period of record in the project area (1974 to present). The average annual precipitation at this station is 54.44 inches per year (in/yr). Because precipitation for 1988 was very close to the long-term average conditions (98 percent of normal), this period was selected to assess the distribution of average precipitation within the study area. Precipitation data were available for all local and regional stations during 1988 with the exception of the Issaquah Ground Water

Management Area monitoring stations established in 1989. Estimates of 1988 precipitation for Issaquah Ground Water Management Area sites were derived by normalizing 1990 values by the ratio of 1988 to 1990 values available from other sites.

A contouring program (Surfer) was used to generate a precipitation isohyetal map showing lines of equal precipitation for the area. The results of this analysis are presented in Figure 7.14., along with the station locations and 1988 precipitation totals.

Precipitation inflow within the Issaquah Ground Water Management Area was calculated by adding the amounts of precipitation in each precipitation interval and averaged over a year. Based on this analysis, the total precipitation inflow for 1988 is 244.4 cfs. The adjusted precipitation inflow for a normal year is 249.4 cfs.

### 7.5.2 Evapotranspiration

Evaporation and transpiration, collectively referred to as evapotranspiration, represent a loss of liquid water from the water budget through its transformation to vapor. Transpiration is performed by living plants (such as trees) when water is taken up through the roots, processed and released as vapor through tissue cells in the leaves and bark. Evaporation includes the vaporization of water from the soil, parking lots and rooftops, forest canopies and plant surfaces, or open water such as lakes and streams.

This component was estimated using the Blaney-Criddle method (USSCS 1970). This method uses crop, latitude, and temperature to calculate potential evapotranspiration. A simple water balance within the soil, based on rainfall and potential evapotranspiration, was then used to relate potential evapotranspiration to actual evapotranspiration. In this balance, actual evapotranspiration equals potential evapotranspiration as long as precipitation is sufficient to keep the soil moist enough to provide plants with water. When the soil is drier, actual evapotranspiration is less than the potential rate.

For this analysis, the soil mass balance procedure has been computerized to calculate the actual evapotranspiration rate on a weekly basis. In this analysis, monthly data (rainfall and temperature) are distributed evenly over four weeks of the month.

When precipitation was equal to or greater than potential evapotranspiration: AET=PET

When precipitation was less than potential evapotranspiration:

$AET=PET$ (when $SM/SMC \geq 0.75$)

or

$AET=PET * 1.333 * (SM/SMC)$ (when $SM/SMC < 0.75$)

where:

AET=Actual evapotranspiration (in/yr)

PET=Potential evapotranspiration (in/yr), calculated by the Blaney-Criddle method

SM=Soil moisture content from the previous week (in)

SMC=Soil moisture holding capacity (in)

This linear function of the ratio of actual water content to soil moisture holding capacity is one of at least five methods used to relate actual evapotranspiration to potential evapotranspiration, reported in Dunne and Leopold (1978). The soil moisture holding capacity over the project area varies and is not accurately known. This analysis assumes a soil moisture holding capacity of six inches.

The choice of values for representative evaporation and transpiration estimates related to crops is problematical. It is related to variable climatic conditions and the amount of sunlight received and soil moisture utilized by vegetation over an annual year. Figures for crops in eastern Washington will be higher than those in western Washington. It is expected that conifers in western Washington will produce more evapotranspiration than most crops under unirrigated conditions. This is because the conifers will intercept more precipitation and evaporate it away than conventional crops in our geographic location, and because their rooting depth is generally greater than most grass crops. This allows for greater moisture extraction during low moisture conditions. In addition, conifers are capable of transpiring some moisture during periods of relatively low sunlight. This grass crop factor was used in this analysis because of the availability of the data from eastern Washington studies. Comparison of this data with US weather service information on evapotranspiration that is 40 years old is similar. Updated information on evapotranspiration is needed. (Martin, W., Fisher, J., DeBell, D., and Handson, J., personal communications, and Kelliher and Lenning, *Evaporation and Canopy Characteristics of Conifer Forests and Grasslands,* US Weather Bureau, *Normals of Precipitation and Evaporation, and* Dunne, Leopold, *Water in Environmental Planning.*)

Based on the above-stated methods and assumptions, the average calculated evapotranspiration rate for the basin is 18.8 in/yr. Based on Issaquah Creek's total basin drainage area of 56.6 square miles, the total evapotranspiration outflow from the system is 78.3 cfs based over one year.

### 7.5.3 Storm Runoff and Baseflow

Stream flow data are critical elements in evaluating a water balance relationship and when providing an insight into possible hydrogeologic impacts related to ground water development. The interrelationship of ground water and surface water is a crucial concept in the management of these resources. This is particularly true to maintaining streamflow and wetlands given that ground water development can reduce inflow to these features.

Historical stream flow data are available for 17 gauging stations within or near the study area. The gauging stations include four Department of Natural Resources sites, seven King County Surface Water Management sites, and six United States Geological Survey sites. Continuous recording data loggers are used to record stage data at most of the sites. The United States Geological Survey sites generally provide the longest period of recorded data. The Surface Water Management stations were installed in 1988. The stream gauging stations are summarized in Table 7.13, and station locations are shown on Figure 7.13. Data for these stations are presented in Appendix G (available upon request).

Storm runoff and baseflow quantities were evaluated using the stream gauging data for USGS Station 121216. This station is located near the mouth of Issaquah Creek just upstream from Lake Sammamish. All surface water runoff for the Issaquah Creek basin discharges through this point. The total drainage area above the gauge is 56.6 square miles.

A 3-year hydrograph for Station 121216 is presented in Figure 7.15. Included on the hydrograph is the baseflow curve which reflects the ground water discharge input to the stream. Storm runoff is the difference between the total stream flow and the baseflow curves. A portion of this baseflow is a diversion of the Cedar River watershed.
Average stream flow (total flow) from 1988 through 1990 was 115.2 cfs. Baseflow for this same period was 79 cfs, or about 69 percent of the total average stream flow. The average storm runoff during this period was 36.2 cfs, or about 31 percent of the total.

### 7.5.4 Interbasin Transfers - Imports and Exports

Imports of water to the Issaquah Ground Water Management Area are not thoroughly identified or quantified. USGS stream records indicate that flow from 1.9 square miles of the upper Rock Creek watershed (Cedar River drainage), south of the Issaquah Ground Water Management Area, is diverted into Issaquah Creek. How this diversion takes place is beyond the scope of this study. However, Issaquah Creek basin discharge calculations already take into account contributions from the upper Rock Creek watershed.

Some public water supply systems on the periphery of the Issaquah Ground Water Management Area are importing relatively small quantities. King County Water District No. 90 serves residential development in the May Valley area and near Lake McDonald with water purchased from the Seattle Water Department. The water originates in the Cedar River Watershed.

Export of water from the Issaquah Ground Water Management Area basin is significant. The City of Issaquah, Sammamish Plateau Water and Sewer District, Darigold Dairy, and various small public supply systems use a supply entirely derived from ground water. After use for water supply purposes, most of this water becomes wastewater. Wastewater from these areas, where sewered, is pumped out of the Issaquah Ground Water Management Area to Metro's Renton sewage treatment plant. The remaining percentage is lost to consumption as evapotranspiration, runoff, or system leakage (see Table 7.14).

Infiltration and inflow into sewer systems within the City of Issaquah and Sammamish Plateau service areas also represent potential export losses. Another export is the leachate collected at Cedar Hills Landfill and sent to Metro's Renton treatment plant (see Table 7.14 for estimated exports based on Metro and water use records). Table. 7.14 includes only the most significant exports.

### 7.5.5 Intrabasin Translocation

Intrabasin translocation is water artificially moved from one hydrologic location to another or the distribution of ground water to areas not in direct hydraulic continuity with their source. For example, the provision of drinking water to distant homes and the subsequent disposal of this water through on-site septic tank systems may result in loss of water from one aquifer system, and artificial recharge to another shallow aquifer.

Except for losses to consumption or runoff, the net effect on the basin is minor. Intrabasin translocations are not computed in the basin water budget because they are not sufficiently known. Although they are suspected not to be significant overall, nonetheless they should be recognized as a potential local ground water management concern.

### 7.5.6 Change in Storage

Analysis of short-term water level trends (see Figures 7.12A through 7.12H) indicates that water levels within the basin are stable at this time. It appears that present ground water withdrawals are not causing significant changes in storage. Thus, changes in basin storage are assumed to be zero in the water balance assessment. However, long term collection of water level data is needed to determine water levels trends in the basin.

### 7.5.7 Ground Water Discharge

Ground water discharge (GD) consists of the subsurface underflow that exits the Issaquah basin. It is estimated by the residual or unaccounted for portion of the water balance and is calculated from Equation 1 as follows:

$$GD = P - ET - SF - BF - GT - ds \quad (2), \text{ or}$$
$$GD = 249.4 - 78.3 - 42.9 - 96.2 - 7.5 - 0 = 24.5$$

Based on the above analysis, the calculated ground water discharge from the system is 24.5 cfs. This discharge is to Lake Sammamish and possibly the Cedar River.

## 7.6 Water Quality

Historical ground water quality was compiled from the Washington Department of Health, the U.S. Environmental Protection Agency, and the Department of Ecology data sources. Little long-term data are available for the area. Monitoring of organic compounds is almost non-existent outside the limits of the Cedar Hills Landfill and Queen City Farms.

Data collection efforts were directed towards achieving the following:

- Long-term trend data
- Identification of potential sources of contamination

- Baseline organic and inorganic ground water chemistry for the project area
- Water quality of shallow ground water systems
- Assessing water chemistry of public water supplies as it relates to primary maximum contamination limits.

The monitoring network's purpose was to provide adequate background data to assess the impacts of land use activities on ground water quality. The type of land use activity can have a direct impact on water quality parameters found in ground water. For example, measuring a trend of increasing nitrate, chloride, or conductivity levels may indicate the failure of on-site sewage facilities. Likewise, detecting a pesticide in ground water quality samples would imply the possibility of nearby agricultural activity.

Group A sampling and analysis is oriented towards definition of the general inorganic ground water chemistry within the project vicinity. Monitoring for Group A parameters was carried out in 19 wells (see Table 7.6). The King County Department of Natural Resources, Solid Waste Division samples four wells for Group A and B parameters at the Cedar Hills landfill and Queen City Farms. The Seattle-King County Health Department Solid Waste Division samples seven wells for Group A and B parameters around the Cedar Hills landfill and Queen City. A listing of the Group A parameters is presented in Table 7.15.

The criteria used in site selection included the following:

- Site Distribution - Establish sites in areas where data are not presently being collected.
- Hydrogeologic Significance - Appropriate location/depths for defining horizontal/vertical variability of ground water chemistry.
- Sampling Access - Select sites where a sampling tap exists or can be easily installed.
- Well Log - The well has a complete and reliable well log.
- Locatable - The well can be located in the field and verified with the well log.

The process for site selection was similar to that used to select water level monitoring sites.

Three sampling rounds for Group A parameters were collected in March 1990, June 1990, and December 1990.

Group B sampling and analysis is oriented towards detection of ground water contamination in the project area and the evaluation of the extent to which land use patterns affect ground water quality. Monitoring for Group B parameters was carried out in eight wells. The list of Program B water quality monitoring sites is presented in Table 7.6. The locations of the sampling wells are shown on Figure 7.16. A list of the Group B parameters is presented in Table 7.16 (volatiles), Table 7.17 (semi-volatiles), Table 7.18 (pesticides, PCBs) and Table 7.19 (priority pollutants).

The criteria used in the Program B site selection was similar to that used for Program A, with the exception that new sites (i.e., in addition to the on-going Program B monitoring in vicinity of Cedar Hills Landfill and Queen City Farms) were primarily located in the northern portion of the study area where urbanization and land use activities pose the greatest threat to water quality. Additional Group B sampling sites were not selected in the vicinity of the Cedar Hills Landfill or Queen City Farms because water quality monitoring is currently being conducted by King County Solid Waste Division and Seattle-King County Health Department.

Group B (volatiles) samples were collected from eight wells in March 1990 and December 1990. Samples were collected in accordance with the procedures listed in the Issaquah Ground Water Management Plan, Quality Assurance Project Plan, March 1990. Samples collected were analyzed by AmTest, a laboratory certified by the Washington Department of Health. Samples results and laboratory procedures were validated by the Pacific Ground Water Group.

Water quality data collected during the course of this study and available from earlier analyses indicate that the ground water quality in the Issaquah Ground Water Management Area basin is generally excellent. The ground water generally meets all State of Washington Department of Health standards for public drinking water supplies. The iron and manganese results from a few wells exceeded the Washington Department of Health Standards. However, manganese and iron are naturally occurring elements which effect taste and cause fixture staining. They are only a health concern in that they can interfere with the treatment of drinking water.

### 7.6.1 Organic Compound Results

Of the 130 volatile and semi-volatile organic, pesticide, and PCB compounds analyzed, only two, acetone and methylene chloride, showed concentrations which were slightly above detection limits. Reported concentrations near detection limits are difficult to interpret because such results can be influenced by other sources, such as laboratory or other errors. Data from other sources have shown the presence of hydrocarbon compounds in shallow ground water at some locations in lower Issaquah Creek valley (Geraghty & Miller March 1991 and 1992; Applied Geotechnology 1989; Rittenhouse-Zieman & Associates 1990; EA Engineering 1990; Kleinfelder 1991). These contaminants are present as a result of spills and leaks which have occurred at local service stations. To date, no such compounds have been identified in production wells in the lower valley. The real potential for similar, future incidents mandates continued monitoring and analysis for volatile and semi-volatile organic compounds.

### 7.6.2 Inorganic Compound Results

The inorganic analyses showed the presence of ions characteristic to Puget lowland ground water. These include inorganic compounds, such as iron and manganese, which can occur naturally in local ground water. Such metals are present in the soils and sediments of the basin and can be dissolved by contact with ground water. Key inorganic indicators have been evaluated during this testing period, as shown in Figures 7.17 through 7.23.

Figure 7.16 shows the locations of sampled wells by number and owner name. The key inorganic indicators evaluated here include:

- Total Dissolved Solids Sodium
- Total Hardness Nitrate
- Calcium Chloride
- Magnesium Arsenic

These parameters represent some of the important ions and indicators of dissolved constituents. Total dissolved solids, hardness, calcium, and magnesium are indicators of the amount of time ground water has been in contact with the sediments. Sodium also can be an indicator of residence time, sea water intrusion, or contamination by septic effluent. Nitrate and chloride can be indicators of effluent contamination. Arsenic occurs in some similar settings in the Cascade foothills and merits more detailed analysis in the Issaquah Ground Water Management Area.

### 7.6.3 General Discussion of Water Quality

As ground water infiltrates through the soil and moves through sediments and rocks, its quality changes. These changes result from the exchange of gases, such as oxygen and carbon dioxide, and the solution of minerals from surrounding rocks. The type(s) and degree(s) of change are effected by differences in geology and residence time. Geologic differences can produce different ionic ratios, such as the calcium to potassium ratio and the chloride to sulfate ratio.

Concentrations generally increase with residence time, because the longer the ground water is in contact with mineral matter, the greater the opportunity for dissolution to occur. Ground water that has moved over a long distance, or to great depths, or traveled more slowly will have higher concentrations of dissolved minerals than ground water which has flowed only a short distance, to shallow depths, or at high rates.

These influences can be assessed by comparing water quality in wells located in different parts of the basin and those completed at different depths and in different materials. In the study area, these influences were analyzed using the results from three sampling episodes for selected wells. These results are illustrated in Figures 7.17 through 7.23. The data are presented in Appendix H (available upon request).

Comparison of water quality data is complicated by temporal variations of some parameters that are larger than the differences between wells. For instance, the variation in concentration between sampling episodes for total dissolved solids (TDS) ranges from

30 to 200 mg/L. For hardness, the temporal variation is 40 mg/L, and for sodium, it is 20 mg/L. These variations may reflect the influence of seasonal recharge patterns or other causes. The duration of the sampling period was too short to fully evaluate seasonal water quality variation.

However, some generalizations are possible. Water from wells completed in bedrock tends to have higher concentrations of sodium and lower concentrations of calcium than those of water from wells completed in sand and gravel. The Agnew, Mitchell, and Preston wells are completed in bedrock. Water analyses show the sodium concentration in two of them (Agnew and Mitchell) exceeds 80 mg/L, and the calcium is less than 20 mg/L. The Adams, Greening, Overdale, and Pommer wells are completed in sand and gravel, and analyses of water samples show sodium concentrations below 20 mg/L and calcium concentrations above 20 mg/L. Some exceptions exist. Samples from the Preston well, completed in bedrock, show only 4 to 6 mg/L sodium and 10 to 30 mg/L of calcium. Samples from the Pommer Well, completed in sand and gravel, show over 30 mg/L sodium and less than 20 mg/L calcium. These differences in sodium probably result from the weathering of sodium-rich minerals in the igneous rocks.

The available water quality data show no spatial variations. No definitive changes in water quality are apparent in the downstream direction. The water quality of water from the Greening and Adams wells in the southern portion of the basin is similar to the water quality of the Overdale well in the northern portion of the basin.

In the Issaquah Ground Water Management Area, local land use can influence water quality. Slightly elevated concentrations of nitrate and chloride in the Greening Well (see Figure 6.20) may be related to septic tank effluent or runoff from livestock pens. As shown in Appendix H (available upon request), similarly elevated concentrations of nitrate appear in several other sampled wells, including Leroy, 23N/6E-33; Jackson, 23N/6E-27C01; Hall, 23N/6E-03K02; Zetec, 24N/6E-28F02; and others.

In the March 1990 sampling event, nitrate levels were detected in 19 of the 24 wells sampled. The nitrate results ranged from 0.10 to 2.5 mg/l.

In the June 1990 sampling event, no nitrate levels were above the 0.2 mg/l detection level in the 19 wells sampled. As nitrates were not detected in the June 1990 sampling event, this suggests that winter conditions, due to precipitation, may allow local nitrates to infiltrate the aquifer while summer conditions, due to a lack of precipitation, arrest infiltration. In the December, 1990 sampling event, 7 of the 19 wells sampled were above the nitrate detection level with results ranging from 0.96 to 2.1 mg/l.

The wells where nitrate levels were detected are scattered throughout the Issaquah Ground Water Managment Area. Further monitoring of these wells to assess and determine the nitrate source(s) is necessary.

Table 7.10 shows the causal linkage between land use activities and potential resultant contaminants.

Ground water contamination investigations have been conducted by the U.S. Environmental Protection Agency at the Queen City Farms Superfund Site. Studies have also been conducted by Ecology at sites in and outside the City of Issaquah where underground storage tanks were discovered leaking. Surface water quality studies have been performed by Ecology, Metro, and King County Surface Water Management. King County Solid Waste Division has an extensive water quality data base for Cedar Hills landfill.

### 7.6.4 Wellhead Protection Study

As part of the Lower Issaquah Valley Wellhead Protection Plan (Golder Associates 1993) three rounds of water quality samples were taken from wells located throughout the lower Issaquah valley between May 1992 and April 1993, as summarized on Table 7.20. The samples were analyzed for various constituents, including the major anions and cations, priority pollutant metals, iron and manganese, nitrate, turbidity, volatile organics, pesticides, herbicides, and PCBs. Additionally, water quality sampling was performed between 1990 and 1992 (Geraghty and Miller 1992) in 18 monitoring wells around the ARCO Station at the corner of Gilman Blvd. and Front Street after a leak in one of the underground storage tanks was detected. These data were provided to the Wellhead Protection Plan study. The Department of Ecology also performed sampling at six sites in Issaquah and analyzed for lead and organic compounds (The Department of Ecology 1992).

Four of the eleven City of Issaquah and Sammamish Plateau Water and Sewer District's wells monitored in the Issaquah Ground Water Management Area program were monitored for water quality parameters in the Wellhead Protection Study (see Table 7.21). The remaining seven wells monitored in the ground water study were monitored for water levels only in the wellhead protection study (see Table 7.21).

The ground water within the lower Issaquah valley generally contains few dissolved solids, and is classified as a calcium bicarbonate type of water. In general, the ground water quality from production wells within the lower Issaquah valley is excellent, with only slightly elevated iron and manganese concentrations. Pesticides or PCBs were not detected within the lower Issaquah valley, and priority pollutant metals are below regulated limits. The pesticides sampled for were the same as those listed in Table 7.18. Shallow ground water contamination from volatile organic compounds associated with underground gasoline storage tanks has been documented above drinking water standards in shallow monitoring wells in the lower Issaquah valley. The organic compounds (benzene, toluene, ethylbenzene, and xylene) have been detected in other monitoring wells and are discussed in the City of Issaquah's and the Sammamish Plateau Water and Sewer District's Wellhead Protection Plan (Golder Associates 1993).

Surface water quality in the lower Issaquah valley is important to ground water quality since it is often indicative of the quality of storm water runoff, which may reach ground water through direct infiltration. Stream water quality is summarized briefly below, with an emphasis on drinking water constituents rather than toxicity to fish or riparian habitat.

During baseflow conditions, Metro monitors several sites within the watershed on a monthly basis. The monitoring is part of its annual quality of local lakes and streams program. Three sites on Issaquah Creek and one site on Tibbetts Creek are monitored. In addition, Metro has collected grab samples during high flows and storms since 1987 from one site on Issaquah Creek. Metro further collected five samples from five sites within the Issaquah basin during 1989 and 1990 as part of a storm water quality sampling program.

Between 1989 and 1990 dry season fecal coliform geometric means of four of the five stream locations exceeded state water-quality standards. The East Fork Issaquah Creek location did not exceed the standard. Yearly geometric means exceeded state standards in three of the five sites, while the wet-season state standard was exceeded in only Tibbetts Creek. An evaluation of baseflow metal concentrations indicated that copper, chromium, iron, nickel, and zinc concentrations were below their respective aquatic standards, and cadmium, mercury, and lead concentrations were below detection limits. There is hydraulic continuity between surface and ground water, with ground water providing the baseflow for streams during periods of low or no rainfall. Constituents found in streams can infiltrate into the ground and may impact ground water quality.

Two fish kills occurred on the North Fork Issaquah Creek in March and April, 1990. Water and tissue samples indicated the fish kill was due to a combination of elevated metal, ammonia, sulfides, 1,2 Benzenedicarboxylic Acid, and Diisonyl Ester along with low hardness (Lower Issaquah Valley Wellhead Protection Plan, Golder Associates 1993).

## 7.7 Conclusions

The results presented in this report are based on previously existing data, data collected as part of the the Lower Issaquah Valley Wellhead Protection Plan, (Golder Associates 1993) and data collected during the course of this Ground Water Management area study. Current regional planning suggests that ground water resources of the Issaquah Valley will remain a primary source of subregional public and private domestic water supplies for the foreseeable future. Maintenance and enhancement of the existing quantity and quality of water will require careful management of the resource. The findings of this project have resulted in the following conclusions:

1. Precipitation inflow within the Issaquah Ground Water Management Area was calculated by adding the amounts of precipitation in each precipitation interval. The precipitation inflow for 1988 was 244.4 cfs. The adjusted precipitation inflow for a normal year is 249.4 cfs.

2. The average stream flow (total flow) from 1988 through 1990 was 115.2 cfs. Baseflow for this same period was 79 cfs, or about 69 percent of the total average stream flow. The average storm runoff during this period was 36.2 cfs, or about 31 percent of the total.

3. The average stream flow from 1988 through 1990 (115.2 cfs) was 82 percent of normal conditions (140.7 cfs). Therefore, the storm runoff and baseflow quantities were adjusted to reflect long-term average conditions. Assuming that the ratio of baseflow to total runoff remains constant over time, the normalized storm runoff and baseflow quantities are 42.9 cfs and 96.3 cfs, respectively.

4. The 56.6 square-mile Issaquah Creek drainage basin produces an estimated ground water discharge of 25 cfs (not including baseflow). The actual discharge may be less than this estimated amount if drainage from the upper basin above the Tiger Mountain Gap is being naturally diverted toward the Cedar River drainage.

5. The basin has three distinct hydrostratigraphic units. These are bedrock, aquitard and the aquifer as described in Table 7.5. Local bedrock forms a basement aquitard which retards ground water movement from the basin. The bedrock's structural features, coupled with its recent glacial erosion, have created a highly variable bedrock surface.

6. The major aquifers of the basin are present as deltaic and alluvial sediments and are located adjacent to the valleys. In the lower valley, these aquifers are capable of supplying in excess of 1,000 gallons per minute to properly constructed wells. Other parts of the basin with less permeable aquifers allow development of wells capable of producing 5 to 100 gallons per minute.

7. In most parts of the basin, the major aquifers are separated by discontinuous aquitards of silt and clay and low-permeability, glacial sediments.

8. Water quality in the basin is generally excellent. Volatile organic compounds have been found in shallow ground water at spill sites in the lower valley. To date no volatile organic compounds have been found in major aquifers or wells. Analyses of inorganic ions show the presence of parameters characteristic to those of Puget Sound area ground waters. At some locations, iron, manganese, and other naturally occurring contaminants occur in excess of the secondary maximum contaminant levels. Water quality in the bedrock is typically inferior to water quality in the unconsolidated aquifers. Some seasonal variation in water quality has been noted. Local land use activities appear to influence local water quality and could impair it.

9. The basin has areas of low, medium, and high infiltration potential. Most of the ground water recharge occurs in high infiltration potential areas. These areas are present along permeable outwash slopes of the lower valley and in areas of coarse-grained deltaic sediments in the upper and lower parts of the basin. The total ground

water recharge in the basin is estimated to be between 21 and 51 cubic feet per second (13 to 33 million gallons per day), normalized over a one year period.

10. From well logs, cross sections A-A'-A", B-B' and C-C' were constructed to define the distribution and extent of aquifers and aquitards. These cross sections show some of the geology and extent of the aquifers. New wells drilled will further refine the geology, the extent of aquifers and directional flow of ground water.

11. The four wells drilled in the Issaquah Ground Water Management Area in 1990 and 1992 provide data on aquifer permeability, quality and the hydraulic connection between aquifers. Two wells were drilled in permeable zones, while two wells were drilled in zones not considered major water-bearing zones.

12. Two wells had manganese levels above the maximum contamination level and one well had iron levels above the maximum contamination level. In one well there was a lack of continuity between the shallow and deep aquifers while in another well the peizometers were hydraulically connected.

13. The results of drilling these four wells show the complexity and diversity of the ground water resource and geology in the Issaquah Ground Water Management Area. More data from these wells and new monitoring wells drilled in the Issaquah Ground Water Management Area will further refine the characterization of the aquifers in the Issaquah Ground Water Management Area.

14. The well water levels monitored monthly from forty-eight well sites in the Issaquah Ground Water Management Area had variations resulting from seasonal fluctuations and the effects of pumping of the aquifer. Monitoring of water levels for trends over a long period—to assess the impacts of recharge, pumping, and population growth on the ground water resource—is needed.

The Lower Issaquah Valley Wellhead Protection Plan study by Golder Associates in 1993 concluded that:

1. The stratigraphy within the lower Issaquah valley is highly complex, consisting of shallow alluvium, recessional outwash, delta, till, lacustrine, and undifferentiated glacial deposits. The delta deposits are highly permeable and are the most important source of ground water within the lower Issaquah valley. Recessional outwash is also highly permeable, and occurs in the eastern higher elevations providing an important media for ground water recharge. The shallow alluvial deposits vary in permeability, and may or may not be fully saturated. The other hydrogeologic units are less permeable, and may provide local aquitards within the lower Issaquah valley.

2. The lower Issaquah valley hydrogeologic system is bounded at depth and along the border of the ground water basin by low-permeability bedrock; on the south by

Tiger Mountain gap, which allows only a limited quantity of ground water to pass from the upper Issaquah valley; on the north by Lake Sammamish where the ground water within the lower Issaquah valley discharges; and at the surface by streams, lakes, and permeable and impermeable areas.

3. Ground water elevations within the lower Issaquah valley vary from about 25 feet mean sea level near Lake Sammamish to about 200 feet mean sea level in the Tiger Mountain Gap. In the central valley area, ground water elevations are generally between 50 and 70 feet. In the Grand Ridge area ground water elevations vary from 400 to over 800 feet.

4. Ground water levels fluctuate annually between 7 and 15 feet within the lower Issaquah valley. The timing and magnitude of the fluctuations is the same for shallow zones and deeper zones. Ground water levels respond rapidly to precipitation events.

5. The direction of ground water flow within the lower Issaquah valley is generally northwestward toward Lake Sammamish, but varies annually within the central valley area from a northwestern direction during periods of high ground water levels to a more northern direction during periods of low ground water levels.

6. Within the central valley area of the lower Issaquah valley, the horizontal hydraulic gradient is relatively flat at between 0.001 and 0.002 ft/ft. Vertical hydraulic gradients are generally directed upwards except in the vicinity of the City of Issaquah's and Sammamish Plateau Water and Sewer District's production wells (COI 4/5, and wells 7/8). On Grand Ridge the horizontal hydraulic gradient is 0.067 ft/ft. A steep vertical hydraulic gradient exists between the Grand Ridge terrain and the valley floor.

7. Transmissivity in the lower Issaquah valley is estimated at 67,000 to 70,000 $ft^2/d$, based on two long-term pumping tests. Average hydraulic conductivity is estimated at between 200 and 300 ft/day.

8. Streams are a minor source of water to the wells in the central portion of the lower Issaquah valley.

9. The average annual recharge to the lower Issaquah valley aquifer system is between 20 and 25 cubic feet per second. The eastern plateau areas (Grand Ridge and Lake Tradition) may provide up to 30 percent of the direct recharge to the lower Issaquah valley, with the remainder occurring within the main valley. Average annual discharge to Lake Sammamish and the adjacent wetland area is between 10 and 20 cubic feet per second.

10. There appears to be little stream/aquifer interaction in the central lower Issaquah valley area. Stream gauging, mini-piezometer installations and pumping test

results suggest limited hydraulic continuity between surface and ground water within the central valley area. Additional stream gauging data are needed to further assess hydraulic continuity with the central lower Issaquah valley.

11. Analysis of pumping tests and long-term water-level fluctuations indicates that ground water withdrawals in the lower Issaquah valley affect shallow ground water levels and cause downward vertical gradients from the water-table toward the completion zones of the wells.

12. The lower Issaquah valley aquifer system behaves as an unconfined to locally semi-confined aquifer. Analyses of pumping tests, water-levels, and hydraulic gradients do not suggest that significant regional confining layers are present within the aquifer system. As such, the aquifer is highly vulnerable to contamination from surface sources.

13. The ground water sampled from wells by the City of Issaquah and Sammamish Plateau Water and Sewer District as part of the Lower Issaquah valley Wellhead Protection Plan were generally excellent with only slightly elevated iron and manganese concentrations. Herbicides, pesticides and PCBs were not detected and priority pollutants were below the regulated limits.

## 8.0 RECOMMENDATIONS

Future ground water management of the Issaquah Ground Water Management Area needs reliable data on ground water quality and quantity impacts. Information on ground water quantity can be used to determine aquifer recharge, ground water/surface water continuity and source capacity. Information on ground water quality can be used to determine appropriate land use and, if needed, remediation priorities. Information on both ground water quality and quantity can be used to better manage the ground water resource in the Issaquah Ground Water Management Area and to educate the public in protecting this valuable finite resource.

Additional ground water quantity information will require an expanded monitoring program and additional test and monitoring wells. These should be cooperative endeavors between the Seattle-King County Health Department, King County Surface Water Management Division, the Washington State Department of Natural Resources, Washington State Department of Ecology, Washington State Department of Health, particularly its Wellhead Protection Program, the City of Issaquah, the Sammamish Plateau Water and Sewer District, and private interests. A monitoring program is expensive, and care should be taken to select stations that provide the most useful data.

Ground water quantity determination relies on information on precipitation, ground water levels, stream discharge, and water levels in selected lakes and wetlands, as well as information from existing wells.

## 8.1 Precipitation Stations

The meteorological monitoring network provided by the existing Washington State Department of Natural Resources and King County Surface Water Management Division stations appears adequate to define precipitation variations within the area. Additional data should be obtained from stations maintained by the water purveyors and the City of Issaquah, King County, and the Washington State Highway Department. The eight sites monitored by volunteers for Seattle-King County Health Department should be provided with automatic data logger rain gauges.

## 8.2 Surface Water Monitoring

The stream gauging stations within the Issaquah Ground Water Management Area are maintained and operated by others and, with one exception, provide adequate coverage. Data are lacking for the Tiger Mountain Gap, where three additional stations are required upgradient from, within, and downgradient from the Gap.

The Lower Issaquah Valley Wellhead Protection Plan recommends additional stream gauges be installed in the central lower Issaquah valley to determine the hydraulic conformity between surface and ground water.

Water level monitoring stations should be considered for selected wetlands and lakes. Data collected from these stations will allow assessment of the long-term combined impact of climatic variations and ground and surface water utilization. These stations should be located in the southern and northern portions of the basin.

The continuity between ground water and surface water should be evaluated by identifying gaining and losing stretches of streams, and the role of the ground water system, through the interpretation of nearby ground water levels.

## 8.3 Ground Water Monitoring Network

Additional monitoring wells are required in several areas, particularly along Tibbets, Fifteen Mile, and Holder creeks; along the divide between the Cedar River and Issaquah Creek drainage basins in the southern portion of T23N; and in the Tiger Mountain Gap. In most of these localities, wells exist and could be used if long-term permission to measure can be obtained. The latter two localities are critical. Here, new monitoring wells may need to be installed to define the ground water flow and the extent of aquifers. They should be located in areas with transmissive sediments, as indicated by a resistivity survey. The criteria used to select wells in this study phase shall be the basis used for well selection.

- Tiger Mountain Gap: Two to three additional monitoring wells should be located along a north-south line with an existing Issaquah Ground Water Management Area monitoring well to determine the stratigraphy, transmissivity, and hydraulic gradient of the sediments within the Gap. These data are required to assess the potential ground water contribution of the southern portion of the Issaquah Creek Basin to the northern portion.

- Cedar River - Issaquah Creek Divide: Further exploration should be done in sections 17, 18, 28 and 33 (T23N, R6E) to determine whether ground water is discharging from the Issaquah Creek Basin into the Cedar River Basin.
- The degree to which Lake Sammamish serves as a recharge reservoir to lower valley aquifers should be further evaluated through the interpretation of hydraulic gradients and conductivities in the lake vicinity.
- Additional research is required of water purveyors' wells about the types of activities the wells support (i.e., residential commercial, industrial or agricultural).
- Future research on the Sammamish Plateau Water and Sewer District's water demand projection should focus on determining the type and amount of demands to be made on all sources in the Issaquah Ground Water Management Area, whether or not those demands come from within Issaquah Ground Water Management Area boundaries.
- Information on the number and location of individual wells presently without water rights and metering of individual wells is necessary to more accurately determine actual withdrawals from source aquifers.

## 8.4 Ground Water Quality

Ground water quality information should be obtained from existing and new data sources. The existing monitoring network of wells and new wells drilled should be sampled twice yearly (wet and dry seasons) for inorganic and where necessary for organic, pesticide, and PCB parameters pertaining to relevant land use activities; to establish ground water quality trends and to provide data of potential contamination sources.

All the wells within the monitoring network should be accurately located and have accurate elevations located using the Global Positioning System. Most of the existing monitoring wells have surveyed elevations, but these have not been located with equal accuracy.

- The location of all septic tank failures in the Issaquah Ground Water Management Area should be researched to determine the ground water quality impacts.
- The water quality of stormwater outlets during storm events should be monitored where these outlets discharge to ground water and creeks.
- The water quality (and water quantity) of ground water at and around sand and gravel mines should be monitored.
- The water quality data collected from wells at and surrounding the Cedar Hills Landfill and Queen City Farms by King County Solid Waste Division and Seattle-King County Health Department Solid Waste Section should be assessed and entered into the Seattle-King County Health Department database. The shallow and deep aquifers should be assessed to see whether they are interconnected and whether ground water quality is being impacted.

- The location of commercial and residential underground storage tanks needs to be identified to determine the extent and type of ground water contamination.
- The types and quantities of fertilizer and pesticide applications, including roadside spraying, need to be monitored for their impacts on ground water quality.
- Hazardous material spills, particularly transportation spills, need to be monitored for their impacts on ground water.
- Data collated by the Department of Ecology, the Seattle-King County Health Department Local Hazardous Waste Management Program, and Metro on hazardous waste generators' impacts on ground water quality needs to be monitored.

## 8.5 Use of Data Analysis

The results of future ground water and surface water quality monitoring should be analyzed periodically as data become available to determine whether ground water contamination has occurred or is occurring. If any contamination is discovered, recommendations should be made as to what modifications and/or additions to the monitoring system would enable increased definition of the extent of contamination. Also, the natural geochemistry of the water sample analyses should be analyzed to determine the water quality characteristics of specific aquifers and areas where ground water exchange or mixing may be occurring. These data should be entered into the Seattle-King County Health Department database.

- An aquifer susceptibility map for the Issaquah Ground Water Management Area has been produced based on the physical factors of soils, slope, and geology. A recharge map should be produced and updated periodically for the Issaquah Ground Water Management Area based on the spatial distribution of factors such as potentially hazardous land use activities, depth to ground water, precipitation, recharge potential and well head protection data studies by purveyors in the Issaquah Ground Water Management Area. Determination of recharge areas within the drainage basin will be accomplished by comparative weighing and ranking of these factors. The vulnerability assessment could be further refined through use of contamination scenarios and risk assessments.
- The aquifer recharge map, susceptibility map, a water level contour map, and the estimates of total ground water recharge should be updated as new information becomes available.
- Future data collection should also focus on the characterization of, and recharge to, the deep aquifers in the Issaquah Ground Water Management Area.
- The management plan should include efforts to evaluate the impacts of continued development on the ground water resources. The ground water recharge areas in the Issaquah Basin are located on the uplands, with the area of highest potential recharge being in the northeast portion of the Issaquah Ground Water Management Area along the East Fork. This is the area currently undergoing extensive development and designated for continued development under the Growth Management Act. An extensive ground water monitoring program should

be established to guide evaluation of the future impacts. These monitoring results could be used to assess the potential impacts of much larger developments.

- The Issaquah Ground Water Management Area aquifer source capacities should be estimated. This information is necessary for water right evaluation and land use planning.
- Maximum (aquifer-specific) water source capacity data are necessary for all future water sources in the Issaquah Ground Water Management Area. Water rights capacities must be derived from the same data used to determine maximum water source capacities.
- Peak usage requirements for water suppliers would also help to determine their ability to deliver water under existing water rights and source capacities.

## 8.6 Public Awareness

The ground water resources of the Issaquah Ground Water Management Area are limited. Although the estimated total discharge from the basin appears large, this water is not available everywhere, and some areas have insufficient ground water resources. The ground water management program should include an extensive education program to encourage water conservation and protection.

City officials, government agencies, businesses, purveyors, school children and the public need to be educated about protecting the ground water resources from contamination and depletion. Moreover, the protection strategies should be updated regularly as new information becomes available.

## 9.0 REFERENCES

Allen, M. 1994. Seattle-King County Health Department, On-site Program. Information on on-site sewage systems.

Bishop, R. Department of Ecology. Personal communication April 25, 1994.

Booth, D. 1994. King County Department of Natural Resources, Surface Water Management Division, Information on Stormwater and Highway Runoff.

Burnette, D. 1994. City of Issaquah. Data on building permits.

Canty, D. 1994. King County Department of Natural Resources, Surface Water Management Division. Information on the Issaquah Creek Basin and Surface Water Management's role.

Carr/Associates. December 7, 1990. *Report on Impacts of Increased Pumping from Wells 7 and 8.* Prepared for Sammamish Plateau Water and Sewer District.

Carr/Associates, 1992. *Volume I, Draft Status Report, Description of Test and Presentation of Data on Well 9 Pumping Test.* Consultant report for Sammamish Plateau Water and Sewer District.

Carr/Associates. September 15, 1993. *Issaquah Ground Water Management Plan.* Task 5: Hydrogeological Report.

Carr/Associates, 1993. *Volume II, Evaluation and Interpretation of Well 9 Pumping Test. Consultant report for Sammamish Plateau Water and Sewer District.*

*City of Issaquah Water System Plan Update.* City of Issaquah Natural Resources Department. August 1995.

DeBell, D., US Forest Service. Personal communication on evapotranspiration, 1995.

Dunn and Leopold. *Water in Environmental Planning.* Chapter 5, Water Use by Vegetation. 1978.

Economic and Engineering Services, Inc. August 1989. *East King County Coordinated Water System Plan.*

Fetter, C. W. 1994. *Applied Hydrogeology*, Third Edition.

Fisher, J. State Department of Natural Resources. Personal communication on evapotranspiration, 1995.

Fitch, L. 1994. King Conservation District. Information on agriculture.

Golder Associates in Association with Carr/Associates and the Barton Group. November 1993. *Lower Issaquah Valley Wellhead Protection Plan.* For Sammamish Plateau Water and Sewer District and the City of Issaquah.

Handson., J. US Forest Service. Personal communication on evapotranspiration, 1995.

Heintze, D. 1994. Interlake Associates. Personal communication of January 27, 1994.

Hickok, D. 1994. Seattle-King County Health Department, Solid Waste Division. Information on Cedar Hills landfill.

Kelliher, F. M., Lenning, R., Schulze, E. D. *Evaporation and Canopy Characteristics of Coniferous Forests and Grasslands.* 1993

Knowlton, D. 1994. Department of Ecology. Information on underground storage tanks.

Komorita, J. 1994. King County Department of Natural Resources, Solid Waste Division. Information on the Cedar Hills landfill and the Queen City Farms site.

Lewine, J. 1995. City of Issaquah, Planning Department. Information on the City of Issaquah's Comprehensive Plan and Sub-Area Plans.

Liszak, J. 1995. Department of Ecology. Information on ground water level fluctuations, aquifer system characteristics, and water level measuring.

Little, R. 1993. Sammamish Plateau Water and Sewer District. Information on water withdrawals, sewer system and basin exports.

Lynne, S. 1994. City of Issaquah. Information on the Comprehensive Plan, ground water policies, commercial land industrial trends, water use, aquifer capacity, sewers and roadside spraying.

*Mapping Aquifer Susceptibility to Contamination in King County,* King County Department of Development and Environmental Services and Seattle-King Coungy Health Department, August 1995.

Martin, T. University of Washington Department of Forestry. Personal communication on evapotranspiration, 1995.

Matsuno, R. 1994. King County Department of Works, Roads and Engineering Division. Information on roadside spraying.

McPhillips, L. U.S. Environmental Protection Agency. Personal communication on Queen City Farms, 1995.

Misko, D. 1994. Department of Ecology. Information on contaminated underground storage tank sites.

National Academy of Sciences. *Drinking Water and Health,* Washington, D.C. 1977. Information on manganese.

Nordie, G. 1994. Personal communication of January 1994.

*Normals of Precipitation and Evapotranspiration (Inches).* US Weather Bureau. State of Washington.

Orlean, H. 1994. U.S. Environmental Protection Agency. Information on Cedar Hills landfill and Queen City Farms.

Pacific Groundwater Group, Inc. Carr Associates, Inc.; Parametrix, Inc. 1992. *Data Collection and Analysis Plan, Issaquah Ground Water Management Program.*

Parametrix, Inc./Carr Associates, December 1991. *Area Characterization Report. Issaquah Ground Water Management Plan for Seattle-King County Health Department.*

Petrovich, B. 1994. Department of Ecology. Personal communication of January 24, 1994.

Pierce, D. 1994. Department of Natural Resources. Information on quarries and mines.

Portman, J. 1993. Darigold, Inc. Personal communication of December 30, 1993.

Regenstreif, J. Sammamish Plateau Water and Sewer District. Personal communication of April 25, 1994.

Reid, J. 1994. King County Planning and Community Development Division. Information on the King County Comprehensive Plan, community plans, development trends and land use forecasts.

Schaftlein, S. 1994. State Department of Transportation. Personal communication of May 3, 1994.

Slagle, K. Seattle-King County Health Department. Information on illegal dumping, 1995.

# Glossary

**Draft**

**Issaquah Creek Valley**
**Ground Water Management Plan**

**March, 1996**

## GLOSSARY

**ALLUVIAL**. Pertaining to or composed of alluvium or deposited by a stream or running water.

**ALLUVIUM**. A general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope.

**AQUIFER**. A soil or geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.

**AQUIFER SYSTEM**. A body of permeable and relatively impermeable materials that functions regionally as a water-yielding unit. It comprises two or more permeable units separate at least locally by confining units that impede ground-water movement but do not greatly affect the regional hydraulic continuity of the system. The permeable materials can include both saturated and unsaturated sections.

**AQUIFER TEST**. A test involving the withdrawal of measured quantities of water from or addition of water to a well, and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition, e.g., a bailer or pump test. (These are withdrawal tests)

**AQUITARD**. An essentially impermeable geologic formation, group of formations, or part of a formation through which virtually no water moves.

**AREA OF INFLUENCE**. Area surrounding a pumping well within which the water table or potentiometric surface has been changed due to the well's pumping or recharge.

**ARTESIAN WELL**. A well deriving its water from a confined aquifer in which the hydraulic water level stands above the ground surface; synonymous with flowing artesian well.

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

**BASALT**. A general term for dark-colored iron- and magnesium-rich igneous rocks. It is the principal rock type making up the ocean floor and is easily seen in exposed cliffs in Eastern Washington.

**BASE FLOW**. That part of stream discharge not attributable to direct runoff from precipitation or snowmelt, usually sustained by ground-water discharge.

**BEDROCK**. A general term for the rock, usually solid, that underlies soil or other unconsolidated material.

**BENTONITE**. A colloidal clay, largely made up of the mineral sodium montmorillonite, [a hydrated aluminum silicate] used in sealing the annular space to create a surface or sanitary seal.

**CAPILLARY ACTION**. The movement of water within the interstices of a porous medium due to the forces of adhesion, cohesion, and surface tension acting in a liquid that is in contact with a solid.

**CAPILLARY FRINGE**. The zone at the bottom of the vadose zone where groundwater is drawn upward by capillary force.

**CARBONATE**. A sediment formed by the organic of inorganic precipitation from aqueous solution of carbonates of calcium, magnesium, or iron.
**CHLORIDE**. A compound of chlorine with one other positive element or radical.

**CLEAN WATER ACT**. Basic federal legislation regulating surface water quality.

**COLIFORM BACTERIA**. Bacteria (*E. coli*) associated with human and warm-blooded animal waste.

**CONE OF DEPRESSION**. A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a well from which water is being withdrawn. It defines the area of influence of a well.

**CONFINED AQUIFER**. A formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric.

**CONFINING BED**. A geologic unit with low permeability (hydraulic conductivity) which restricts movement of water into or out of the aquifer. See also aquiclude, aquitard.

**CONTAMINATION**. The degradation of natural water quality as a result of anthropogenic activities.

**CROSS-SECTION**. A schematic representation of geologic layers as seen in a side view.

**DISCHARGE**. Ground water that flows out of an aquifer into an adjacent aquifer or to the surface into a spring or river.

**DISCHARGE AREA**. An area in which there are upward components of hydraulic head in the aquifer. In the discharge area ground water flows toward the surface, and may escape as a spring, seep, or base flow, or by evaporation and transpiration.

**DISPERSION**. The spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.

**DRAINAGE BASIN**. The land area from which surface runoff drains into a stream channel or system of channels, or to a lake, reservoir, or other body of water.

**DRAWDOWN**. The distance between the static water level and the top surface of the cone of depression during pumping of a well.

**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.

**DRINKING WATER STANDARDS**. Federal or state water quality regulations that limit the contaminant levels of certain compounds for drinking water.

**DYNAMIC EQUILIBRIUM**. A condition of which the amount of recharge to an aquifer equals the amount of natural discharge.

**EFFLUENT**. Liquid waste discharged from a manufacturing or treatment process, in its natural state or partially or completely treated, that discharges into the environment.

**EROSION**. The general process or group of processes whereby the materials of the Earth's crust are moved from one place to another by running water (including rainfall), waves and currents, glacier ice, or wind.
**EVAPOTRANSPIRATION**. Loss of water from a land area through transpiration of plants and evaporation from the soil.

**FLOODPLAIN**. The surface or strip of relatively smooth land adjacent to a river channel, constructed by the present river and covered with water when the river overflows its banks. It is built of alluvium carried by the river during floods and deposited in the sluggish water beyond the influence of the swiftest current.

**FLOW LINES**. On a hydraulic gradient diagram, the lines indicating the direction followed by groundwater toward points of discharge. Flow lines are perpendicular to equipotential lines.

**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 altitude or structure of those units.

**GLACIAL DRIFT**. A general term for unconsolidated sediment transported by glaciers and deposited directly on land or in the sea.

**GLACIOFLUVIAL**. Pertaining to the meltwater streams flowing from melting glacier ice and especially to the deposits and landforms produced by such streams.

**GLACIOLACUSTRINE**. Deposits created in lake environments from glacial silts and clays.

**GROUND WATER**. All water that is located below the ground surface; more specifically, subsurface water below the water table.

**GROUND-WATER DIVIDE**. A ridge in the water table, or potentiometric surface, from which ground water moves away at right angles in both directions.

**GROUND-WATER MODEL**. A simplified conceptual or mathematical image of a ground-water system, describing the feature essential to the purpose for which the model was developed and including various assumptions pertinent to the system. Mathematical ground-water models can include numerical and analytical models.

**GROUNDWATER TABLE**. The surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.

**HARDNESS**. A property of water causing formation of an insoluble residue when the water is used with soap. It is primarily caused by calcium and magnesium ions.

**HAZARDOUS WASTE**. Federally regulated man-made waste that is ignitable, corrosive, reactive, or toxic.

**HYDRAULIC CONDUCTIVITY**. The rate of flow of water in gallons per day through a cross section of one square foot under a unit hydraulic gradient, at the prevailing temperature (gpd/ft).

**HYDRAULIC CONNECTION**. The condition in which two water-bearing layers or bodies may freely transmit water between them.

**HYDROGEOLOGIC**. Those factors that deal with subsurface waters and related geologic aspects of surface water.

**HYDROLOGIC CYCLE**. The cyclical movement of water from the oceans to atmosphere to the land and back to the oceans.

**HYDROSPHERE**. All waters of the Earth, as distinguished from the rocks (lithosphere), living things (biosphere), and the air (atmosphere).

**HYDROSTRATIGRAPHY**. The assemblage of layers of aquifers and aquitards.

**IGNEOUS**. A type of rock solidified from molten material.

**IMPERMEABLE**. An adjective used to describe rock, soils, or sediments that impede the flow of water.

**INFILTRATION**. The downward movement of rain water or surface water into soil.

**LACUSTRINE**. Referring to a lake environment.

**LAMINATED**. The layering or thin bedding in sedimentary rocks.

**LANDFILL**. A general term indicating a disposal site of refuse, and dirt from excavations.

**LEACHATE**. The liquid that has percolated through solid waste and dissolved soluble components.

**MAXIMUM CONTAMINANT LEVEL (MCL)**. The maximum permissible level as required by the Safe Drinking Water Act regulations, of a contaminant in water that is delivered to the users of a public water system.

**METAMORPHIC**. A rock that has been physically and/or chemically changed from an original texture and/or composition, usually by very high temperatures or pressures below the earth's surface.

**MG/L**. Milligrams per liter; a unit of concentration in water equivalent to a part per million or 0.0001 percent.

**MICROORGANISMS**. Microscopic organisms such as any of the bacteria, protozoans, or viruses.

**NITRATE**. A compound commonly associated with domestic and agricultural waste, and formed by nitrogen.

**OUTWASH**. Stratified sand and gravel removed or washed out from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of an active glacier. The coarser material is deposited nearer to the ice.

**OUTWASH PLAIN**. A broad, gently sloping sheet of outwash.

**PEAT**. A non-compacted deposit of organic material commonly developed from bogs or swamps.

**PERCOLATE**. The act of water seeping or filtering through soil without a defined channel.

**PERMEABILITY**. The property or capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure.

**pH**. A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. Originally stood for "potential of hydrogen".

**PLUME**. A contaminated portion of an aquifer extending from the original contaminant source.

**POLLUTION**. When the contamination concentration levels restrict the potential use of groundwater.

**POROSITY**. The percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.

**POTABILITY**. Ability to be used as drinking water.

**POTENTIOMETRIC SURFACE**. The surface to which water will rise in an aquifer under hydrostatic pressure.

**PPM**. Parts/per million. A unit of concentration equivalent to 0.0001 percent.

**RECHARGE**. The addition of water to the zone of saturation; also, the amount of water added.

**RECHARGE AREA**. Area in which water reaches the zone of saturation by surface infiltration.

**RUNOFF**. That part of precipitation flowing overland to surface streams.

**SANDSTONE**. A sedimentary rock composed of abundant rounded or angular fragments of sand set in a fine-grained matrix (silt or clay) and more or less firmly united by a cementing material.

**SEAWATER INTRUSION**. The entry of seawater into a fresh water aquifer.

**SEDIMENTARY ROCKS**. Rocks resulting from the consolidation of loose sediment that has accumulated in layers.

**SHALE**. A fine-grained sedimentary rock, formed by the consolidation of clay, silt, or mud. It is characterized by finely laminated structure and will not fall apart on wetting.

**STORAGE COEFFICIENT**. The volume of water released from storage per unit-volume of porous medium per unit change in head.

**STRATIGRAPHIC**. Pertaining to the composition and position of layers of rock or sediment.

**TERTIARY**. A period of earth's history estimated to have occurred between 65 and 2 million years ago.

**TILL**. Predominantly unsorted and unstratified drift, generally unconsolidated, deposited directly by and underneath a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, and boulders ranging widely in size and shape.

**TOPOGRAPHIC**. Pertaining to the general configuration of a land surface.

**TOTAL DISSOLVED SOLIDS (TDS)**. A term that expresses the quantity of dissolved material in a sample of water, either the residue on evaporation, dried at 356°F (180°C), or, for many waters that contain more than about 1,000 mg/l, the sum of the chemical constituents.

**TRANSMISSIVITY**. The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity values are given in gallons per minutes through a vertical section of an aquifer one foot wide and extending the full saturated height of an aquifer under a hydraulic gradient of 1 in the English Engineering system; in the International System, transmissivity is given in cubic meters per day through a vertical section of an aquifer one meter wide and extending the full saturated height of an aquifer under a hydraulic gradient of 1.

**TRANSPIRATION**. The process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface.

**TURBULENT FLOW**. Water flow in which the flow lines are confused and heterogeneously mixed. It is typical of flow in surface-water bodies.

**UNCONFINED AQUIFER**. An aquifer where the water table is exposed to the atmosphere through openings in the overlying materials.

**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.

**VADOSE ZONE**. The zone containing water under pressure less than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is limited above by the land surface and below by the surface of the zone of saturation, that is, the water table.

**VISCOSITY**. The property of a substance to offer internal resistance to flow. Specifically, the ratio of the shear stress to the rate of shear strain.

**WATER TABLE**. The surface between the vadose zone and the groundwater, where the pressure is equal to that of the atmosphere.

**WEATHERING**. The destructive process(es) by which the atmosphere and surface water chemically change the character of a rock.

**ZONE OF CONTRIBUTION**. The area surrounding a pumping well that encompasses all areas or features that supply ground-water recharge to the well.

**ZONE OF INFLUENCE**. The area surrounding a pumping well within which the water table or potentiometric surfaces have been changed due to ground-water withdrawal.

**Sources:**


Driscoll, F., *Groundwater Wells*,. Johnson Division, 1986.

*Groundwater Resource Protection,* King County Planning and Washington State Department of Ecology.

Redmond-Bear Creek Ground Water Management Program, *Draft Hydrogeologic Characterization Report*, prepared by EMCON Northwest, Inc., November, 1992.

*Northern Thurston County Ground Water Management Plan*, February, 1992.

# Area Characterization

# Tables

**Draft**

**Issaquah Creek Valley**
**Ground Water Management Plan**

**March, 1996**

**Table 5.1. New lots in recorded formal and short plats in the Issaquah Ground Water Management Area.**

| | North of I-90 | | Issaquah | | South of I-90 | | |
|---|---|---|---|---|---|---|---|
| | Formal | Short | Formal | Short | Formal | Short | Total |
| 1984 | 0 | 0 | 92 | 0 | 90 | 27 | 209 |
| 1985 | 20 | 7 | 100 | 0 | 13 | 72 | 212 |
| 1986 | 136 | 4 | 29 | 0 | 41 | 55 | 265 |
| 1987 | 107 | 13 | 0 | 4 | 2 | 35 | 161 |
| 1988 | 32 | 1 | 8 | 0 | 0 | 18 | 59 |
| 1989 | 296* | 0 | 31 | 0 | 0 | 14 | 341* |
| 1990 | 309* | 128 | 0 | 0 | 0 | 15 | 452* |
| 1991 | 256* | 14 | 27 | 0 | 0 | 13* | 73* |
| 1992 | 21* | 6 | 30 | 3 | 0 | 13* | 73* |
| Total | 1177* | 173 | 317 | 7 | 146 | 252* | 2072 |
| 84/85 % of change | 2000 | 700 | 8.7 | 0 | -85.6 | 166.7 | 1.4 |
| 85/86 % of change | 580 | -42.9 | -71.0 | 0 | 215.4 | -23.6 | 25.0 |
| 86/87 % of change | -21.3 | 225.0 | -2900 | 400 | -95.1 | -36.4 | -39.3 |
| 87/88 % of change | -70.1 | -92.3 | 800 | -400 | -200 | -48.6 | -63.4 |

Source: KC/LDIS, Annual Growth Reports 1985-1989
1989-1992: King County Land Development Information System 1994
* These are approximate numbers as the Issaquah Ground Water Management Area boundary dissects certain sections. These are approximate numbers for these sections.

**Table 5.2. Permit applications for the City of Issaquah.**

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Single-Family Res. | 85 | 80 | 61 | 32 | 20 | 7 | 29 | 41 | 81 | 436 |
| Multi-Family Res. | 7 | 5 | 3 | 5 | 3 | 1 | 5 | 5 | 8 | 42 |
| Commercial | 9 | 7 | 7 | 3 | 6 | 5 | 7 | 8 | 11 | 63 |
| SF/Additions | 2 | 12 | 20 | 18 | 18 | 36 | 32 | 51 | 54 | 270 |
| MF/Additions | 5 | 4 | 0 | 2 | 0 | 3 | 2 | 5 | 6 | 27 |
| Comm/Additions | 54 | 37 | 62 | 44 | 58 | 46 | 36 | 53 | 53 | 443 |
| Total | 189 | 145 | 153 | 104 | 105 | 98 | 111 | 163 | 213 | 1,281 |

Source: City of Issaquah 1989 (1985 to 1988).
City of Issaquah 1994 (1989 to 1993).

**Table 5.3. Ecology's toxic clean-up program.**

| Site Name | Address | Affected Media | Contaminant Status | Site Status | Comments |
|---|---|---|---|---|---|
| Bakamus Truck Repair/Rowley | 1500 19th Ave. N.W., Issaquah 98027 | Ground Water<br>Soil | Suspected<br>Confirmed | Remedial Action Conducted by Ecology. Residual contamination left on site. | Final Independent Remedial Action Report received by Ecology. |
| Bell-Fair Aluminum & Steel Inc. | 1480 19th Ave. N.W., Issaquah 98027 | Ground Water<br>Soil<br>Surface Water<br>Air | Suspected<br>Confirmed<br>Suspected<br>Suspected | Independent Remedial Action | Release Report received by Ecology. Awaiting Assessment by potentially liable party. |
| FOUR TEK Industries | 228 Ave. S.E.; N of Cedar Grove Rd., Issaquah 98027 | Ground Water<br>Soil<br>Surface Water | Suspected<br>Suspected<br>Suspected | Awaiting assessment by Ecology | |
| General Fabrication & Design | 1590 N.W. Maple St., Issaquah 98027 | Ground Water<br>Soil<br>Surface Water<br>Air | Suspected<br>Confirmed<br>Suspected<br>Suspected | Independent Remedial Action | Release Report received by Ecology; Awaiting assessment by potentially liable party |
| Issaquah Tire Service/Rowley | 1860 N.W. Mall St., Issaquah 98027 | Ground Water<br>Soil<br>Surface Water | Suspected<br>Confirmed<br>Suspected | Awaiting assessment by Ecology | |
| Northwest Pipeline/Issaquah | 22339 S.E. 56th, Issaquah | Soil<br>Air | Confirmed<br>Suspected | Awaiting assessment by | |

**Table 5.3. Ecology's toxic clean-up program.**

| Site Name | Address | Affected Media | Contaminant Status | Site Status | Comments |
|---|---|---|---|---|---|
| | 98027 | Sediment | Suspected | Ecology | |
| Queen City Farms A (4 Tek) | 22420 S.E. 168th Wy., Issaquah 98027 | Ground Water<br>Soil | Confirmed<br>Confirmed | Remedial Action in progress | |
| Queen City Farms A (Buried Drum) | 22420 S.E. 168th Wy., Issaquah 98027 | Ground Water<br>Soil | Confirmed<br>Confirmed | Remedial action in progress | |
| Queen City Farms A. | 22420 S.E. 168th Wy., Issaquah 98027 | Ground Water<br>Soil | Confirmed<br>Confirmed | Remedial action in progress | |

Source: Department of Ecology, Bellevue. List dated October 13, 1993. (Feb. 1994)

**Table 5.4. Operational underground storage tanks reported in the Issaquah Ground Water Management Area.**

| Site Name/Address | Substance | Size | Age (yr) |
|---|---|---|---|
| Warren Iverson/Hobart<br>20250 276 SE/Box 250 | Unleaded Gas | 5000-9999 | 14 |
| Warren Iverson/Hobart<br>20250 276 SE/Box 250 | Diesel Fuel | 1101-2000 | 3 |
| Warren Iverson/Hobart<br>20250 276 SE/Box 250 | Leaded Gas | 10000-19999 | 9 |
| Warren Iverson/Hobart<br>20250 276 SE/Box 250 | Unleaded Gas | 10000-19999 | 9 |
| Preston Maintenance Fac<br>29726 SE Preston Way | Unleaded Gas | 2001-4999 | 2 |
| Preston Maintenance Fac<br>29726 SE Preston Way | Diesel Fuel | 2001-4999 | 2 |
| Preston Maintenance Fac<br>29726 SE Preston Way | Diesel Fuel | 2001-4999 | 2 |
| Preston General Store<br>30365 SE High Point Way | Leaded Gas | 5000-9999 | 6 |
| Preston General Store<br>30365 SE High Point Way | Diesel Fuel | 5000-9999 | 6 |
| Preston General Store<br>30365 SE High Point Way | Unleaded Gas | 10000-19999 | 6 |
| Preston General Store<br>30365 SE High Point Way | Unleaded Gas | 10000-19999 | 6 |
| Arco 6162<br>1403 NW Lk Sammamish Rd | Unleaded Gas | 10000-19999 | 20 |
| Arco 6162<br>1403 NW Lk Sammamish Rd | Leaded Gas | 10000-19999 | 20 |
| Arco 6162<br>1403 NW Lk Sammamish Rd | Unleaded Gas | 10000-19999 | 20 |
| Tiger Mt. Country St<br>14331 Issaquah-Hobart Rd | Alcohol Blend | 10000-19999 | 11 |
| Tiger Mt. Country St<br>14331 Issaquah-Hobart Rd | Alcohol Blend | 10000-19999 | 11 |
| Tiger Mt. Country St<br>14331 Issaquah-Hobart Rd | Diesel Fuel | 10000-19999 | 11 |
| Tiger Mt. Country St | Alcohol Blend | 10000-19999 | 11 |

**Table 5.4. Operational underground storage tanks reported in the Issaquah Ground Water Management Area.**

| Site Name/Address | Substance | Size | Age (yr) |
|---|---|---|---|
| 14331 Issaquah-Hobart Rd | | | |
| Grange Supply Inc.<br>145 NE Gilman Blvd | Alcohol Blend | 10000-19999 | 20 |
| Grange Supply Inc.<br>145 NE Gilman Blvd | Unleaded Gas | 10000-19999 | 20 |
| Grange Supply Inc.<br>145 NE Gilman Blvd | Diesel Fuel | 10000-19999 | 20 |
| Grange Supply Inc.<br>145 NE Gilman Blvd | Kerosene | 5000-9999 | 20 |
| Grange Supply Inc.<br>145 NE Gilman Blvd | Diesel Fuel | 10000-19999 | 20 |
| Grange Supply Inc.<br>145 NE Gilman Blvd | Alcohol Blend | 10000-19999 | 20 |
| Grange Supply Inc.<br>145 NE Gilman Blvd | Diesel Fuel | 5000-9999 | 20 |
| Texaco Station<br>15 East Sunset Way | Unleaded Gas | 5000-9999 | 7 |
| Texaco Station<br>15 East Sunset Way | Unleaded Gas | 10000-19999 | 7 |
| Texaco Station<br>15 East Sunset Way | Leaded Gas | 10000-19999 | 7 |
| Texaco 63-232-0499<br>1605 NW Gilman Blvd | Unleaded Gas | 10000-19999 | 29 |
| Texaco 63-232-0499<br>1605 NW Gilman Blvd | Unleaded Gas | 10000-19999 | 21 |
| Texaco 63-232-0499<br>1605 NW Gilman Blvd | Leaded Gas | 10000-19999 | 29 |
| Texaco 63-232-0499.<br>1605 NW Gilman Blvd | Unleaded Gas | 5000-9999 | 21 |
| Texaco 63-232-0499<br>1605 NW Gilman Blvd | Leaded Gas | 10000-19999 | 21 |
| Texaco 63-232-0499<br>1605 NW Gilman Blvd | Diesel Fuel | 10000-19999 | 29 |
| Texaco 63-232-0499<br>1605 NW Gilman Blvd | Unleaded Gas | 10000-19999 | 29 |
| Fedderly Marion Frtlines | Unleaded Gas | 2001-4999 | 7 |

**Table 5.4. Operational underground storage tanks reported in the Issaquah Ground Water Management Area.**

| Site Name/Address | Substance | Size | Age (yr) |
|---|---|---|---|
| 1740 NW Maple | | | |
| Maintenance Shops 20500 SE 56th St | Diesel Fuel | 2001-4999 | 29 |
| Maintenance Shops 20500 SE 56th St | Unleaded Gas | 2001-4999 | 29 |
| Maintenance Shops 20500 SE 56th St | Used Oil/Waste Oil | 111-1100 | 29 |
| Brown Bear Car Wash 22121 SE 56th St | Leaded Gas | 5000-9999 | 1 |
| Brown Bear Car Wash 22121 SE 56th St | Unleaded Gas | 10000-19999 | 1 |
| Brown Bear Car Wash 22121 SE 56th St | Diesel Fuel | 5000-9999 | 1 |
| Brown Bear Car Wash 22121 SE 56th St | Unleaded Gas | 10000-19999 | 1 |
| Chevron 95399 25 NW Gilman Blvd | Leaded Gas | 10000-19999 | 3 |
| Chevron 95399 25 NW Gilman Blvd | Unleaded Gas | 10000-19999 | 3 |
| Chevron 95399 25 NW Gilman Blvd | Unleaded Gas | 10000-19999 | 3 |
| The Southland Corp 3302 E Lake Sammamish Par | Unleaded Gas | 10000-19999 | 8 |
| The Southland Corp 3302 E Lake Sammamish Par | Unleaded Gas | 10000-19999 | 8 |
| The Southland Corp 3302 E Lake Sammamish Par | Leaded Gas | 10000-19999 | 8 |
| James Perry 470 Front St N | | 111-1100 | 45 |
| Issaquah BP 55 NW Gilman Blvd | Leaded Gas | 10000-19999 | 15 |
| Issaquah BP 55 NW Gilman Blvd | Diesel Fuel | 5000-9999 | 15 |
| Issaquah BP 55 NW Gilman Blvd | Unleaded Gas | 10000-19999 | 6 |
| Issaquah BP | | | |

**Table 5.4. Operational underground storage tanks reported in the Issaquah Ground Water Management Area.**

| Site Name/Address | Substance | Size | Age (yr) |
|---|---|---|---|
| 55 NW Gilman Blvd | Unleaded Gas | 10000-19999 | 6 |
| Darigold Inc<br>611 Front St | Diesel Fuel | 10000-19999 | 32 |
| Darigold Inc<br>611 Front St | Diesel Fuel | 10000-19999 | 25 |
| Darigold Inc<br>611 Front St | Diesel Fuel | 10000-19999 | 25 |
| Issaquah 070584 | Diesel Fuel | 111-1100 | 17 |
| Issaquah 7340 | Unleaded Gas | 10000-19999 | 5 |
| Issaquah 7340 | Used Oil/Waste Oil | 111-1100 | 5 |
| Issaquah 7340 | Unleaded Gas | 10000-19999 | 5 |
| Lakeside Sand & Gravel Co. | Diesel Fuel | 10000-19999 | 5 |
| Lakeside Sand & Gravel Co. | Diesel Fuel | 10000-19999 | 5 |
| Lakeside Sand & Gravel Co. | Leaded Gas | 5000-9999 | 5 |
| Lakeside Sand & Gravel Co. | Used Oil/Waste Oil | 5000-9999 | 6 |
| Harold J. Ruby ARCO 4466 | Used Oil/Waste Oil | 111-1100 | 3 |
| Harold J. Ruby ARCO 4466 | Leaded Gas | 10000-19999 | 2 |
| Harold J. Ruby ARCO 4466 | Unleaded Gas | 10000-19999 | 2 |
| Harold J. Ruby ARCO 4466 | Unleaded Gas | 10000-19999 | 2 |
| Harold J. Ruby ARCO 4466 | Unleaded Gas | 10000-19999 | 2 |
| Transportation | Unleaded Gas | 10000-19999 | 2 |
| Transportation | Diesel Fuel | 10000-19999 | 2 |
| Transportation | Leaded Gas | 10000-19999 | 2 |
| Bethel Clark | Leaded Gas | 10000-19999 | 10 |
| Bethel Clark | Diesel Fuel | 10000-19999 | 10 |
| Bethel Clark | Unleaded Gas | 10000-19999 | 10 |
| Bethel Clark | Unleaded Gas | 10000-19999 | 10 |
| Kbog N Tiger Mtn/1500 | Diesel Fuel | 1101-2000 | 3 |

Source: Department of Ecology, October 8, 1993.

**Table 5.5. Age of underground storage tanks in operation in the Issaquah Ground Water Management Area.**

| Age (year) | Number of Tanks | Percent of Total |
|---|---|---|
| 1-2 | 14 | 17.9 |
| 3-5 | 12 | 15.4 |
| 6-10 | 20 | 25.6 |
| 11-15 | 7 | 9.0 |
| 16-20 | 11 | 14.1 |
| 21-30 | 12 | 15.4 |
| Greater than 30 | 2 | 2.5 |
| **Total** | **78** | **100.0** |

Source: Ecology 1994.

**Table 5.6. Substances contained in underground storage tanks in operation in the Issaquah Ground Water Management Area.**

| Substance | Number of Tanks | Percent of Total |
|---|---|---|
| Leaded gas | 14 | 18.0 |
| Unleaded gas | 32 | 41.0 |
| Diesel fuel | 21 | 26.9 |
| Kerosene | 1 | 1.3 |
| Used/waste oil | 4 | 5.1 |
| Alcohol Blend | 5 | 6.4 |
| Unknown | 1 | 1.3 |
| **Total** | **78.0** | **100.0** |

Source: Ecology 1994.

**Table 5.7. Size of underground storage tanks in operation in the Issaquah Ground Water Management Area.**

| Size (gallons | Number of Tanks | Percent of Total |
|---|---|---|
| 111-1,100 | 6 | 7.7 |
| 1,101-2,000 | 1 | 1.3 |
| 2,001-4,999 | 6 | 7.7 |
| 5,000-9,999 | 12 | 15.4 |
| 10,000-19,999 | 53 | 67.9 |
| **Total** | **78.0** | **100.0** |

Source: Ecology 1994.

**Table 5.8 Ecology current and former contaminated underground storage tank sites Issaquah Ground Water Management Area - January 7, 1994**

| Site Name | Address | City | Zip Code | Cleanup Status[a] | Media[b] |
|---|---|---|---|---|---|
| Texaco Station #004481 | 825 Front Street North | Issaquah | 98027-2508 | Awaiting | D |
| Grange Supply | 145 NE Gilman Blvd | Issaquah | 98027-2904 | Conducted | D |
| King County Fire District #10 | 175 Newport Way NW | Issaquah | 98027-3104 | Conducted | D |
| Issaquah Feed Service | 232 Front St. N | Issaquah | 98027-3232 | Conducted | D |
| Shell Station Issaquah | 1605 NW Gilman Blvd | Issaquah | 98027-5329 | In Progress | A,D |
| Fedderly Marion Freight Lines | 1740 NW Maple | Issaquah | 98027-8977 | In Progress | D |
| Car Wash Ent Issaquah Landfa | 22121 SE 56th St | Issaquah | 98027-9237 | Conducted | D |
| Southland 7-11 Station #26056 | 3302 Sammamish Pkwy | Issaquah | 98027-9649 | Awaiting | A,D |
| US West Issaquah Soc #01086 | 1200 12th NW | Issaquah | 98027 | Monitoring | A,D |
| ARCO Station #6162 | 1403 NW Lake Sammamish Rd | Issaquah | 98027 | Awaiting | D |
| Dept. of Transportation Newport Way Exit | SR 901 West Bound On-ramp | Issaquah | 98027 | In Progress | D |
| King County Issaquah Public Works | 23240 SE 74th | Issaquah | 98027 | Conducted | D |
| BP Oil Station Issaquah | 55 NW Gilman Blvd | Issaquah | 98027-2427 | In Progress | A |
| Chevron Station #9-5399 | 25 NW Gilman Blvd | Issaquah | 98027-2427 | Conducted | A,D |
| ARCO Station #4466 | 800 Front Street N | Issaquah | 98027-2507 | In Progress | A,D |
| Mobil Station #10-d6r | 30 West Sunset Way | Issaquah | 98027-3811 | Monitoring | A,D |
| Texaco Station #0244 | 15 East Sunset Way . | Issaquah | 98027-3826 | In Progress | A,D |
| Issaquah School District Bus Garage | 805 2nd Avenue SE | Issaquah | 98027-4312 | Conducted | D |

[a]Cleanup Status Legend:

| | | |
|---|---|---|
| Conducted | = | Ecology received final independent action cleanup report - no further action. |
| Awaiting | = | Ecology not aware of any remedial action and cleanup necessary. Owner may have done cleanup but has not reported it to Ecology. Ecology prioritized these sites on priority (if impacts to human health and ground water). |
| Monitoring | = | Sites where cleanup has occurred and monitoring is ongoing. As the results are near cleanup levels, site is usually monitored for a year. |
| In Progress | = | Site cleanup in progress/ongoing. |

[b]Media Legend:

| | | |
|---|---|---|
| A | = | Ground Water |
| D | = | Soil |

**Table 5.9. Hazardous waste generators**

| Business Name | Address | RCRA Type Generator[a] |
|---|---|---|
| Captain's Cleaners | 1025 Gilman Blvd., Issaquah | 3 |
| Quantum Medical Systems, Inc. | 1040 12th Ave. N.W., Issaquah | 2 |
| Ecology's RAS Issaquah | 1145 12th Ave. N.E., Bldg. C., Issaquah | 2 |
| USWCOM Issaquah | 1200 12th Ave. N.W., Issaquah | 3 |
| ZETEC | 1370 N.W. Mall, Issaquah | 3 |
| Silicon Designs Inc. | 1445 N.W. Mall St.,Issaquah | 3 |
| Auto Works Two | 145 N.W. Gilman Blvd., Issaquah | 2 |
| Texaco SS 63 232 0280 | 15 E. Sunset Way, Issaquah | 2 |
| Evergreen Ford | 1500 18th Ave. N.W., Issaquah | 2 |
| Bakamus Truck Repair Co. | 1500 19th Ave. N.W., Issaquah | 2 |
| ZETEC Machine Shop 2 | 1505 N.W. Mall St., Issaquah | 3 |
| Circuit Partners Inc. | 1575 N.W. Mall St., Bldg. C, Issaquah | 1 |
| Autoworks of Issaquah | 1590 N.W. Mall, Issaquah | 2 |
| Texaco SS 6323499 | 1605 Gilman Blvd. Issaquah | 2 |
| United Autobody | 1650 N.W. Mall, Issaquah | 2 |
| Midas Muffler & Brake Shop | 1655 N.W. Mall St., Issaquah | 2 |
| Express Tune | 1655 N.W. Mall St., Suite C., Issaquah | 3 |
| Issaquah Honda Kubota | 1875 N.W. Poplar Way, Issaquah | 2 |
| Ecology's NRO May Valley Drug LAB | 19523 May Valley Rd., Issaquah | 2 |
| Baxter Healthcare Bartels Div | 2005 N.W. Sammamish Rd., Issaquah | 1 |
| WP & R Maintenance | 20500 S.E. 56th St., Issaquah | 2 |
| Gilman Auto Body | 220 N.E. Gilman Blvd., Issaquah | 2 |
| Brown Bear Car Wash | 22121 S.E. 56th St., Issaquah | 3 |
| Lawson Disposal | 22819 S.E. 64th, Issaquah | 2 |
| Dirk's Fine Drycleaning | 240 N.W. Gilman Blvd., Issaquah | 2 |
| Chevron USA Inc. 95399 | 25 N.W. Gilman Blvd., Issaquah | 2 |
| City of Issaquah | 525 1st Ave. N.W., Issaquah | 1 |
| CA Carey Corp. | 537 N.W. Locust, Issaquah | 2 |
| Stone Dry Cleaners | 5614 E. Lk. Sammamish Pky. S.E., Issaquah | 3 |
| All Tech Collision Ctr. | 6018 221st Pl. S.E., Issaquah | 2 |
| Cadman Premix Co., Inc. | 6600 230th Ave. S.E., Issaquah | 1 |
| Lakeside Ind. Issaquah Div. | 6600 230th Ave. S.E., Issaquah | 2 |
| Daniells Cleaners | 730C N.W. Gilman Blvd., Suite 105, Issaquah | 3 |

| Business Name | Address | RCRA Type Generator[a] |
|---|---|---|
| Captain's Cleaners | 1025 Gilman Blvd., Issaquah | 3 |
| Texaco SS 63231468 | 825 Front St., Issaquah | 2 |

Source: Department of Ecology, Bellevue. February 1994.
[a]Generator Type Legend:
1 = Generates or accumulates >2,200 lbs. (large quantity generator)
2 = Generates or accumulates <2,200 but >220 lbs.(medium quantity generator)
3 = Generates or accumulates <220 lbs. (small quantity generators)

**Table 6.1 Preliminary data on major producing wells in the Issaquah Ground Water Management Area.**

| Well Owner | Well No. | Yield/Drawdown (gpm/Dd-ft) | Static Water (ft) | Aquifer Material | Aquifer Transmissivity (gpd/ft) |
|---|---|---|---|---|---|
| City of Issaquah | 1 | 1000/11.6 | 67 | sand & gravel | NA |
| | 2 | NA | 67 | sand & gravel | NA |
| | 3 | 275/15.7 | 33[1] | sand & gravel | NA |
| | 4 | 225/51 | 54.5 | sand & gravel | 25,000 |
| | 5 | 1000/120 | 52.5 | fine sand | 50,000 |
| SPW&SD | 7 | 2000/38 | 64 | sand & gravel | 110,000 |
| | 8 | 2000/22 | 64 | sand & gravel | 150,000 |
| Overdale Water Association | S21J 1 | 190/NA | flows | sand & gravel | NA |
| Darigold | S28J 1 | 400/10 | 70[1] | sand & gravel | NA |
| Lakeside Sand & Gravel | S27D 1 | 650/5 | 60[1] | sand & gravel | NA |
| Reid Sand & Gravel | S21R 1 | 500/NA | 62[1] | sand & gravel | NA |

Source: Department of Social and Health Services 1989.
[1] not screened entire length
NA = not available
Note: Static water is the level at which water stands in a well or unconfined aquifer when no water is being removed from the aquifer either by pumping or free flow. It is generally expressed as the distance from the ground surface (or from a measuring point near the ground surface) to the water level in the well.

**Table 6.2. Existing Water Rights for the Issaquah Ground Water Management Area[1].**

| Purveyor | Use | Gallons Per Minute (GPM) | Millions of Gallons Per Day (MGD) | Acre Feet Per Year (AF/YR) |
|---|---|---|---|---|
| Mirrormont | D[2] | 110 | 0.16 | 118 |
| Four Lakes | D | 150 | 0.22 | 82 |
| First City Develop. Corp. | D | 800 | 1.16 | 260 |
| Overdale | D | 190 | .27 | 30 |
| WA St. Parks | D | 150 | .22 | 18 |
| Issaquah[3] | D | 3,880 | 5.6 | 2,800 |
| SPW & SD[6] | D | 5500 | | 2109 |
| Consolidated Dairy | C/I[4] | 1,100 | 1.58 | 1,232 |
| Lakeside Gravel | D/C/I[5] | 1,500 | 2.16 | 566 |

Source: Economic and Engineering Services, Inc. 1988.

[1] Public water systems work in million gallons per day.
GPM in this table reflect the sustained yield of a well during a 24-hour pump test.
MGD is calculated based upon GPM. For example, Mirrormont MGD = 110 gpm x 1,440 minutes/day divided by a millions gallons = 0.16 MGD. AF/YR is not based upon GPM.
Acre feet per year is the maximum amount of water that a well can pump in one year under water rights which are determined by the Department of Ecology based upon the population served by the water system and the rate of use by gallons per person per day.
AF/YR for SPW&SD (936) is for wells 7 and 8 only. SPW&SD has 2,000 gpm emergency water rights for well 9.

[2] Domestic

[3] Source: Sheldon Lynne, City of Issaquah, personal communication

[4] Commercial/Industrial

[5] Domestic/Commercial/Industrial

[6] Includes only SPWSD wells located in the Issaquah Valley Aquifer

Table 6.3. **Annual water demand by use\forecast by use in acre-feet.**

| Year | Single Family | Multi-Family | Commercial Industrial | Government Education | Total | Total with Conservation | Total with Losses of 15% |
|---|---|---|---|---|---|---|---|
| **[a]City of Issaquah** | | | | | | | |
| 1986 | 420 | 580 | 145 | 50 | 1195 | 1195 | 1374 |
| 1990 | 451 | 802 | 188 | 54 | 1746 | 1480 | 1702 |
| 2000 | 649 | 1136 | 298 | 78 | 2160 | 2042 | 2348 |
| 2010 | 814 | 1416 | 390 | 98 | 2718 | 2591 | 2980 |
| 2020 | 1019 | 1761 | 510 | 122 | 3413 | 3282 | 3774 |
| 2030 | 1238 | 2127 | 639 | 149 | 4152 | 3995 | 4595 |
| 2040 | 1457 | 2493 | 767 | 175 | 4892 | 4709 | 5415 |
| **[a]Sammamish Plateau Water and Sewer District** | | | | | | | |
| 1986 | 1141 | 23 | 78 | 13 | 1255 | 1255 | 1443 |
| 1990 | 1440 | 51 | 99 | 16 | 1605 | 1583 | 1821 |
| 2000 | 2353 | 117 | 161 | 26 | 2658 | 2512 | 2889 |
| 2010 | 3247 | 287 | 223 | 36 | 3793 | 3616 | 4158 |
| 2020 | 4478 | 610 | 307 | 49 | 5445 | 5236 | 6022 |
| 2030 | 5823 | 934 | 399 | 64 | 7221 | 6980 | 8027 |
| 2040 | 7168 | 1258 | 476 | 77 | 8978 | 8706 | 10,012 |
| **[b]Mirrormont Services** | | | | | | | |
| 1986 | 0.138 | | 0.092 | | 0.413 | 0.002 | 0.445 |
| 1990 | 0.185 | | 0.076 | | 0.458 | 0.002 | 0.490 |
| 2000 | 0.343 | | 0.074 | | 0.824 | 0.003 | 0.907 |
| 2006 | 0.491 | | 0.074 | | 1.179 | 0.003 | 1.296 |

[a]Source: Economic and Engineering Services, Inc. 1988. CWSP.
Notes:
Classes shown as zero may be grouped in other classes.
Conservation Program started in 1990.
[b]Source: Interlake Associates 1994.
Notes:
Classes shown as zero may be grouped in other classes.
Conservation Program started in 1990.

**Table 6.4A. Population Projections Versus Forecast Demand - City of Issaquah**

| YEAR | Corporate Area Population | Potential Annexation Area Population | Total Population | Average Annual Demand (MGD) | Maximum Day Demand (MGD) |
|---|---|---|---|---|---|
| 1990 | 7,786 | 16,880 | 24,666 | 1.22 | 3.10 |
| 2000 | 9,492 | 28,915 | 38,407 | 2.60 | 4.50 |
| 2020 | 12,815 | 45,828 | 58,643 | 4.50 | 8.00 |

Source: City of Issaquah Water System Plan Update. City of Issaquah Natural Resources Department, August 1995.

MGD = Million gallons per day

**Table 6.4. Total annual water demand forecast in acre-feet.**

| Year | Issaquah | Mirrormont | SPW&SD |
|---|---|---|---|
| 1986 | 1374 | 0.445 | 1443 |
| 1990 | 1702 | 0.490 | 1821 |
| 2000 | 2348 | 0.907 | 2889 |
| 2010 | 2980 | 1.296 | 4158 |
| 2020 | 3774 | 1.296 | 6022 |
| 2030 | 4595 | 1.296 | 8027 |
| 2040 | 5415 | 1.296 | 10,012 |

Source: Economic and Engineering Services, Inc. 1988.
Interlake Associates 1994 (for Mirrormont only).

**Table 6.5 Population Forecasts Using SAZ Data**

| GWMA | Acreage | Jurisdiction | Estimated Growth[a] 1990-2020 | 1993[a] Population | 2020[a] Population |
|---|---|---|---|---|---|
| Issaquah | 45,672 | King County | 4,882 | 14,252 | 19,134 |
| | | City of Issaquah | 2,694 | 4,065 | 6,759 |
| | | Total | 7,576 | 18,317 | 25,893 |

[a]Population in number of household

**Table 7.1. Summary of soil characteristics.**

| Name | Type | Location | Important Characteristics |
|---|---|---|---|
| **Alderwood Association** | | | |
| Alderwood soils | Gravelly sandy loams | Common throughout Issaquah Ground Water Management Area on 6% to 35% slopes; 75% Alderwood - 25% Kitsap soil unit occurs on 25% to 75% slopes | Vertical recharge probably slow except that lateral subsurface movement to permeable zones could contribute substantially to recharge; severely limiting to septic tank filter fields; runoff slow to medium (6-15% slopes) to rapid (steep slopes) |
| **Beausite-Alderwood Association** | | | |
| Beausite soils | Gravelly sandy loams | Concentrated in central portion of Issaquah Ground Water Management Area on 6% to 75% slopes | Underlain by fractured sandstone; recharge probably not significant although lateral movement to permeable zones may contribute substantially to recharge; severely limiting to septic tank filter fields; runoff moderate to very rapid |
| Ovall Soils | Gravelly loams | Similar location as Beausite | Underlain by weathered andesite breccia; other characteristics same as Beausite |
| **Everett Association** | | | |
| Everett Soils | Gravelly sandy loam underlain by gravelly sand | South Sammamish Plateau on 0% to 30% slopes | Rapid permeability; recharge is probably significant; few limitations to septic tank filter fields, although these soils offer little protection to ground water quality; runoff slow to rapid; excessively well drained |
| Neilton Soils | Gravelly loamy sand underlain by stratified glacial drift | Similar location as Everett on 2% to 15% slopes | Runoff slow to medium; other characteristics same as Everett |
| **Valley Soils** | | | |
| Sammamish Soils | Silt loams stratified with fine sand and clay | Lower Issaquah Creek valley on 0% to 2% slopes | Moderately slow permeability; recharge probably slow, but may be significant in areas underlain by shallow aquifers; severe limitations to septic tank filter fields; seasonal high water table; flooding is a hazard; offers limited protection to |

**Table 7.1. Summary of soil characteristics.**

| Name | Type | Location | Important Characteristics |
|---|---|---|---|
| | | | underlying shallow aquifers |
| Bellingham Soils | Similar to Sammamish | Similar to Sammamish | Similar to Sammamish |
| Briscot Soils | Silt loam stratified with fine sand | Similar to Sammamish | Moderate permeability; recharge to shallow unconfined aquifers is likely significant; otherwise similar to Sammamish |
| Puyallup Soils | Fine sandy loams | Similar to Sammamish on slightly convex slopes | Moderately rapid permeability; recharge to shallow aquifers is likely significant; severe limitations to septic tank filter fields; seasonal high water table; flooding potential slight to severe; offers limited protection to water quality |
| Puget Soils | Silty clay loam | Similar to Sammamish | Similar to, but even more severely limiting than Sammamish |
| Oridia Soils | Silt loam interspersed with fine sand and clay at depth | Similar to Sammamish | Similar to Sammamish |
| Sultan Soils | Silt loam with clayey and sandy zones at depth | Similar to Sammamish | Similar to Sammamish |

**Table 7.2. Characteristics of geohydrologic units in the Issaquah Ground Water Management Area.**

| Geohydrologic Unit | Geohydrologic Unit Label | Characteristics |
|---|---|---|
| **Vashon Stage Glacial Deposits** | | |
| Recessional Outwash Deposits | Qvr | Predominantly gravel, sand and minor amounts of silt. Where available it is a good source of recharge that can yield large quantities of water. |
| Recessional Lacustrinal Deposits | Qvrl | Predominantly clay and silt, with some sand and rarely gravel. Functions as a leaky aquitard. |
| Ice Contact Deposits | Qvl | A heterogenous mixture of till and outwash deposits. These units have considerable hydrogeologic variability. |
| Till | Qvt | A massive heterogeneous mixture of silt, sand and gravel. The upper positions of these units can contain perched and semi-perched water tables. The isolated sand and gravel lenses yield limited quantities of water. Recharge of these lenses is usually slow. |
| Advance Outwash | Qva | Primary sand to cobble-size gravel with thin beds of silt. Where saturated, this unit yields large quantities of water. |
| **Pre-Vashon Units** | | |
| Unnamed Sand | | Chiefly well-sorted medium grade sand, lenses of gravel, silt and clay.<br>Yields water to wells where saturated. |
| Upper Clay Unit | | Massive silt and clay, peat beds: probably functions as an aquitard. Lenses of sand and gravel yield water for domestic supplies. |
| Unnamed Gravel | | Cobble gravel, pebbles and sand which is a very permeable, productive aquifer material. |
| Lower Clay Unit | | Almost entirely clay and silt with discontinuous beds of till and peat. Units have an impermeable bottom to upper units and a confining layer to lower aquifers. |
| Older Unconsolidated Deposits | | Interbedded sand, silt, clay, minor gravel, till, volcanic ash with some high yield wells. The incidence of objectionable chloride reported. |
| **Bedrock** | | |

**Table 7.2. Characteristics of geohydrologic units in the Issaquah Ground Water Management Area.**

| Geohydrologic Unit | Geohydrologic Unit Label | Characteristics |
|---|---|---|
| Unnamed Volcanic Rock | Tv | Volcaniclastic sandstone and siltstone which conglomerates with marine fossils. Unit has poor water-bearing potential. |
| Blakely (?) Formation | Tb | Marine sediments, predominately sandstone and conglomerate which have poor water-bearing potential. |
| Renton Formation | Tr | Non-marine sandstone, claystone and coal with poor water-bearing potential. |
| Tukwila Formation | Tt | Volcaniclastic rocks and lava flows with poor water-bearing potential. |
| Tiger Mountain Formation | Tim | Non-marine arkosic sandstone, siltstone and coal with poor water-bearing potential. |
| Raging River Formation | Trr | Volcaniclastic sandstone and siltstone which conglomerate with marine fossils. Unit has poor water-bearing potential. |
| Intrusive Rocks | Ti | Andesites and basalts injected as dikes. Unit has poor water-bearing potential. |

**Table 7.3. Lower Issaquah Creek Valley aquifer characteristics.**

| Aquifer Designation | Elevation (meters (ft)) | Material | Transmissivity ($m^2$/day (gpd/ft)) |
|---|---|---|---|
| A1 - upper fluvial sediments | -6.1 to -15.2 (-20 to 50) | Sand and gravel | 372.7 (30,000) |
| A2 - lower glacio-fluvial sediments | -12.2 to -33.6 (-40 to -110) | Lenses of sand and gravel | 2484.4 (200,000) |
| A3 - deep alluvial sediments | -61.0 to -106.7 (-200 to -350) | Sand | 496.9 (40,000) |

Source: Carr/Associates 1988.

**Table 7.4. Selected lower valley wells.**

| Well Owner | Well No. | Zone Completed | Yield ($m^3$/day (gpm)) | Specific Cap. (gpm/ft) | Transmissivity ($m^2$/day (gpd/ft)) |
|---|---|---|---|---|---|
| Darigold | 2 | A1 | 2180 (400) | 40 | NA |
| Reid S&G | 21R1 | A1 | 2726 (500) | NA | NA |
| Lakeside S&G | 27D1 | A1 | 3543 (650) | 130 | NA |
| SPWD | 7-1S | A1 | 409 (75) | 7 | 508 (41,000) |
| SPWD | 7-1D | A2 | 2726 (500) | 25 | 2740 (221,000) |
| SPWD | 7-3 | A2 | 1199 (220) | 33 | 1637 (132,000) |
| SPWD | 7 | A2 | 10,629 (1950) | 52 | 3757 (303,000) |
| SPWD | 8 | A2 | 19,081 (3500) | 90 | 2232 (180,000) |
| SPWD[1] | 9 | A3 | no yield | unknown | unknown |
| Overdale W.A. | 21H | A2 | 954 (175) | 2 | 1141 (92,000) |
| City of Iss. | 1 | A1? | 5451 (1000) | 86 | NA |
| City of Iss. | 2 | A1? | 5451 (1000) | 86 | NA |
| City of Iss. | 4 | A1 | 1308 (240) | 5 | 260 (21,000) |
| City of Iss. | 5 | A3 | 5451 (1000) | 8 | 503 (40,600) |

Sources: Carr/Associates 1983, 1984, 1988; Robinson & Noble 1986; Washington State Water Well Reports.
Note: Values are measured or reported rates during testing.
NA= Data not available
[1]SPWD is awaiting water rights from the Department of Ecology for well No. 9.

**Table 7.5. Hydrostratigraphic units.**

| Unit | Permeability | Description |
|---|---|---|
| Bedrock | Low | Consolidated sedimentary and volcanic sediments including: sandstone, shale (sometimes with coal), andesite, and volcanic tuff. Can provide limited amounts of water to wells. |
| Aquitard | Low to Moderate | Unconsolidated ice-contact and marginal deposits of very silty sand and gravel, including till, alluvial and lake clay, silt, and fine silty sand. |
| Aquifer | Moderate to High | Unconsolidated ice-contact, deltaic, and alluvial deposits of sand; sand and gravel, and sand, gravel, and cobbles. All relatively free of silt and clay. |

Source: Hydrogeological Report Carr/Associates, Sept. 1993.

Table 7.7 Susceptibility Ranking of NRCS Soil Units

| NRCS Map Symbol | NRCS Soil Unit Name | Relative Physical Susceptibility |
|---|---|---|
| EvB | Everett | high |
| EvC | Everett | high |
| EvD | Everett | high |
| InA | Indianola | high |
| InC | Indianola | high |
| Pc | Pilchuck | high |
| RdC | Ragnar-Indianola | high |
| Re | Renton | high |
| AgC | Alderwood | moderate |
| AgD | Alderwood | moderate |
| AkF | Alderwood | moderate |
| AmC | Arents | moderate |
| Br | Briscot | moderate |
| Ea | Earlmont | moderate |
| KpB | Kitsap | moderate |
| KpD | Kitsap | moderate |
| No | Norma | moderate |
| Os | Oridia | moderate |
| So | Snohomish | moderate |
| Su | Sultan | moderate |
| Sk | Seattle muck | moderate |
| Tu | Tuckwila muck | moderate |
| Bh | Bellingham | moderate |
| Pu | Puget | low |

**Table 7.8 Susceptibility Ranking of USGS Geologic Units**

| Geologic Symbol | Geologic Unit Name | Relative Physical Susceptibility |
|---|---|---|
| Qaf | Alluvial fan deposits | high |
| Qual | Older alluvium | high |
| Qvr | Recessional outwash | high |
| Qvrb | Recessional outwash | high |
| Qvrd | Redmond Delta | high |
| Qvro | Older recessional outwash | high |
| Qvry | Recessional outwash | high |
| Qva | Advance outwash | high |
| Qc | Colluvium | moderate |
| Qls | Landslide deposits | moderate |
| Qmw | Mass wasting deposits | moderate |
| Qob | Olympia beds | moderate |
| Qyal | Younger alluvium | moderate |
| Qsw | Swamp deposits | low |
| Qtb | Transitional beds | low |
| Qvrc | Clay | low |
| Qvt | Glacial till | low |

**Table 7.9 Susceptibility Ranking for Depth to Water Criteria**

| DEPTH TO WATER<br>Depth Below Ground Surface (feet) | Relative Physical Susceptibility |
|---|---|
| 0-25 | high |
| >25-75 | moderate |
| >75 | low |

**Table 7.10. Causal relationship between land use activities and water quality.**

| Contaminant Source | Cause | Potential Contaminants |
|---|---|---|
| **Public Infrastructure and Utility Services** | | |
| Septic tank effluent | Improper site selection, design, construction and/or maintenance | Pathogens, nitrates, chlorides, sodium, inorganic chemicals, hazardous substances (cleaning compounds, solvents, pesticides, petroleum products, organic chemicals, heavy metal(s) |
| Leaking sewer lines | Improper design, construction and/or maintenance | Same as for septic tank effluent above |
| Hazardous substance use, storage and disposal (domestic, commercial and industrial) | Improper use, inadequate containment, improper disposal, assimilative capacity of application site exceeded, spills, lack of practical disposal facilities or methods | Hazardous substances (solvents, petroleum products, heavy metals, organic and inorganic chemicals, pesticides) |
| Pumping-induced ground water contamination | Natural and altered aquifer hydrogeochemical conditions, well location and depth, pumping patterns and rates, alteration of recharge area hydrology, overpumping, inadequate well construction or seals | Iron, manganese and hydrogen sulfide, highly mineralized, saline o brackish water |
| Introduction of wastes through wells | Improper abandonment of wells, use of wells for waste disposal or injection, use of dry wells for surface drainage | Uncontrolled introduction of hazardous substances and pathogens |
| Mortuary and cemetery operations and maintenance | Inadequate disposal of wastes, improperly located graveyards, over-fertilization of grounds | Pathogens, organic chemicals, heavy metals, nitrate |
| Transportation spills of hazardous chemicals | Improper emergency response and cleanup of accidental releases | Hazardous substances (petroleum products, organic chemicals, solvents, pesticides, concentrated toxins, caustics, heavy metals, radioactive materials, pathogens |

Table 7.10. **Causal relationship between land use activities and water quality.**

| Contaminant Source | Cause | Potential Contaminants |
|---|---|---|
| Vegetation control for right-of-way maintenance | Application of herbicides in excess of surface assimilative capacity | Pesticides |
| Provision and transmission of electrical power | Leakage of insulating fluids | Organic chemicals (PCBs) |
| Storm water drainage | Conveyance and infiltration of transportation-related wastes deposited on roadways and streets | Petroleum products, organic chemicals (tire rubber), heavy metals (lead) |
| Landfill leachate | Inadequate or improper siting, design, construction, operation and closure of facilities, uncontrolled acceptance of hazardous substances for disposal | Pathogens, nitrate, iron and manganese, hazardous substances (organic and inorganic chemicals, pesticides, solvents, petroleum products, caustics, heavy metals and radioactive materials) |
| Parks, golf courses and landscaping | Over-application of fertilizers and pesticides, leaking fertilizer and pesticide storage containers | Nitrate, pesticides |
| **Commercial Agriculture and Hobby Farms** | | |
| Animal feedlots, pens, waste storage | Improper siting, animal density exceeds natural waste assimilative capacity of soils, inadequate waste collection, storage, treatment and disposal, lack of fencing through creeks | Nitrate and pathogens |
| Nurseries, commercial crops | Leakage from inadequate containers, improper storage practices, over-application of fertilizers and pesticides | Pesticides, nitrates, petroleum products, hazardous substances |
| Introduction of hazardous substances and wastes through wells | Lack of adequate backwash prevention valves for chemigation and manurigation, improper abandonment of wells, use of wells for waste disposal or injection, use of dry wells for surface drainage | Nitrate, pesticides, pathogens, hazardous substances |

**Table 7.10. Causal relationship between land use activities and water quality.**

| Contaminant Source | Cause | Potential Contaminants |
|---|---|---|
| **Sand and Gravel Mining** | | |
| Open pits in or above aquifers | Improper abandonment and filling with unsuitable wastes | Petroleum products, hazardous wastes, pathogens, iron, metals |
| Equipment fuel tank leakage | Inadequate containment, vandalism | Petroleum products |
| Illegal "midnight" dumping in excavated pits | Criminal behavior and moral turpitude, inadequate security for active operations and inadequate closure practices or law enforcement for abandoned sites | Uncontrolled varied wastes - hazardous wastes (sludges, organi and inorganic chemicals) from industrial, agricultural, commercial and domestic sources, pathogens and nitrates from septage, animal carcasses and vermin |
| **Timber Harvesting** | | |
| Fuel and pesticide storage | Inadequate containment | Petroleum products and pesticides |
| Control of weeds and pests, fertilization of seedlings | Improper application | Pesticides and nitrates |
| Removal of timber and vegetation | Stimulated vegetative nutrient release through plant death, combustion and decay | Nitrates |

**Table 7.11. Potential impacts to quantity.**

| Activity | Impact |
|---|---|
| **Residential and Commercial Development** | |
| Using private supply water wells | Increased discharge & translocation of ground water |
| Using on-site septic tank sewage disposal system effluent | Formation of shallow ground water recharge mounds |
| Constructing impermeable surfaces (rooftops, pavement, parking lots, drainage systems) | Increased runoff; decreased infiltration & recharge |
| Excavating cut slopes & fill additions | Altered evapotranspiration, surface drainage, infiltration & recharge; increased discharge for irrigation |
| Operating & Maintaining cemeteries | Altered percolation of ground water; increased discharge for irrigation |
| **Public Infrastructure and Utilities Services** | |
| Excavating utilities & pipelines | Altered percolation of ground water |
| Installing grounded bed borings for pipelines & structures | Interconnection of surface drainage & aquifer systems |
| Constructing streets & roads, highway interchanges, parking lots, facilities with impermeable surfaces & rooftops | Increased runoff; decreased infiltration & recharge; increased ponding & flooding with possible erosion downstream from collection points |
| Controlling vegetation in rights-of-way | Increased runoff; decreased infiltration & recharge |
| Constructing storm drainages | Increased runoff; decreased infiltration & recharge; increased ponding & flooding with possible erosion downstream from collection points |
| Constructing sanitary sewers | Translocation water; increased shallow ground water recharge along leaks; possible ground water infiltration into sewer pipes |
| Constructing public water supply systems | Translocation of water |
| Constructing, operating & closing landfills | Altered infiltration, surface drainages, ground water percolation, aquifer interconnections, & recharge mounding |
| Maintaining vegetation along utility corridors & transportation rights-of-ways | Increased discharge for irrigation; translocation of water; varied evapotranspiration; infiltration & recharge |
| **Commercial Agriculture and Hobby Farms** | |
| High-Density animal husbandry | Increased surface runoff; decreased infiltration |

**Table 7.11. Potential impacts to quantity.**

| Activity | Impact |
|---|---|
| | & recharge |
| Irrigation & stock watering | Translocation of ground & surface water; shallow recharge mounding |
| Field preparation & crop cultivation | Varied evapotranspiration; increased runoff; decreased infiltration & recharge |
| Operations (removal of overburden, sand & gravel, excavation site dewatering) | Decreased physical aquifer capacity, increased discharge of ground water to surface; altered surface drainage; interconnected aquifer systems |
| Abandonment of operations | Varied local ground water recharge of discharge; translocation of aquifer water; altered surface drainage |
| **Timber Harvesting** | |
| Tree & vegetation removal | Increased runoff; decreased infiltration & recharge; varied disruption of evapotranspiration processes |
| Access road construction | Increased surface runoff; decreased infiltration & recharge |

Table 7.12 Precipitation and Stream Gauging Stations as numbered in Figure 7.13

| Precipitation Station Number | Stream Gauging Station Number | Site Location | Address | Reporting Agency |
|---|---|---|---|---|
| 19 | | Preston | | DNR |
| 20 | | Issaquah Fish Hatchery | | DNR |
| 21 | | Cedar Hills | | King County |
| 22 | | Mirrormont area | 25440 SE 184 St | Seattle-King County Health Department/ Leroux |
| 23 | | Fire Station 106/Maple Hills Park | 20505 SE 152 Ave. | Seattle-King County Health Department/ Massena |
| 24 | | Grand Ridge area | 28404 SE 58 St | Seattle-King County Health Department/Weckwerth |
| 25 | | Cougar Mt. area | 17640 SE Cougar Mt. Rd | Seattle-King County Health Department/ Leake |
| | 52 | Laughing Jacobs Lake near Lk. Sammamish | | USGS |
| | 53 | Issaquah Creek near Issaquah | NW Sammamish Rd. Bridge | USGS |
| | 54 | Tibbets Creek at Lk. Sammamish State Park | Lake Sammamish ranger station | SWM |
| | 55 | Upper Tibbets Creek | Newport Way crossing | USGS |

**Table 7.12 Precipitation and Stream Gauging Stations as numbered in Figure 7.13**

| Precipitation Station Number | Stream Gauging Station Number | Site Location | Address | Reporting Agency |
|---|---|---|---|---|
| | 56 | North Fork Issaquah Creek | SE 66 St. bridge | SWM |
| | 57 | East Fork Issaquah Creek at Issaquah | | SWM |
| | 57 | East Fork Issaquah Creek at Issaquah | 1st Ave NW | USGS |
| | 58 | Fifteen Mile Creek near Issaquah Creek | May Valley Rd. Bridge | SWM |
| | 59 | Issaquah Creek above Fifteen Mile Creek | | USGS |
| | 60 | McDonald Creek | 229 Dr. SE | SWM |
| | 61 | Carey Creek | Issaquah - Hobart Rd. | SWM |
| | 62 | Holder Creek | Issaquah - Hobart Rd. | SWM |
| | 63 | Upper Fifteen Mile Creek | | WADNR |
| | 64 | Issaquah Creek | | WADNR |
| | 65 | Unnamed stream near Raging River | | WADNR |
| | 66 | Holder Creek | | WADNR |
| | 67 | Issaquah Creek | 252 Ave SE Bridge | USGS |

**Table 7.13 Summary of stream gauging stations Issaquah Ground Water Management Area.**

| Site Number | Map Ref. Number | T-R-S Location | Site Location | Period of Record | Reporting Agency |
|---|---|---|---|---|---|
| 12121720 | 52 | T24N-R6E-16M | Laughing Jacobs Cr. near Lake Sammamish | 1987-1988 | USGS[a] |
| 12121600 | 53 | T24N-R6E-21E | Issaquah Cr. near Issaquah NW Sammamish Rd. Bridge | 1963- | USGS |
| 67A SWM | 54 | T24N-463-20G | Tibbetts Cr. @ Lk. Sammamish State Park Lake Sammamish Ranger Station | 1988- | SWM[b] |
| 12121700 | 55 | T24N-R6E-29G | Upper Tibbetts Cr. Newport Way Crossing | 1963-1968; 1971-1976 | USGS |
| 46A SWM | 56 | TW4N-R63-27D | North Fork Issaquah Cr. SE 66th St. Bridge | 1988- | SWM |
| 12121510 | 57 | T24N-R6E-28J | East Fork Issaquah Cr. @ Issaquah | 1975-1981 | USGS |
| 14A SWM | 57 | T24N-R63-28L | East Fork Issaquah Cr. @ Issaquah 1st Avenue NW | 1988- | SWM |
| 25C SWM | 58 | T23N-R6E-15E | Fifteenmile Cr. near Issaquah Cr. May Valley Rd. Bridge | 1988- | SWM |
| 12121000 | 59 | T23N-R6E-15E | Issaquah Cr. above Fifteenmile Cr. | 1945-1964 | USGS |
| 25D SWM | 60 | T23N-R6E-15M | McDonald Cr. 229th Dr. SE | 1988- | SWM |
| 25F SWM | 61 | T23N-R6E-25N | Carey Cr. Issaquah-Hobart Rd. | | SWM |
| 25E SWM | 62 | T23N-R6E-25N | Holder Cr. Issaquah-Hobart Rd. | 1988- | SWM |
| | 63 | T23N-R6E-14J | Upper Fifteenmile Cr. | 1987- | DNR[c] |
| | 64 | T23N-R7E-22K | Issaquah Cr. | 1987- | DNR |
| | 65 | T24N-R7E-33M | Unnamed Stream near Raging River | 1987- | DNR |
| | 66 | T23N-R7E- | Holder Cr. | 1987- | DNR |

**Table 7.13 Summary of stream gauging stations Issaquah Ground Water Management Area.**

| Site Number | Map Ref. Number | T-R-S Location | Site Location | Period of Record | Reporting Agency |
|---|---|---|---|---|---|
| 12120600 | 67 | 19R<br>T23N-R6E-26B | Issaquah Creek<br>252nd Avenue S. Bridge | 1986- | USGS |

[a]U.S. Geological Survey.
[b]Surface Water Management.
[c]Department of Natural Resources.

**Table 7.14 1988 estimated Issaquah Ground Water Management Area major basin exports of water.**

| Exporter | Form | Quantity $m^3/y$ (MGY) | Basin-mm (Basin-in) |
|---|---|---|---|
| City of Issaquah[a] | waste water | 1,362,604 (359.7) | 7.9 (0.31) |
| Darigold | waste water | 202,652 (53.5) | 1.3 (0.05) |
| SPWD | water supply | 1,515,152 (400) | 8.6 (0.34) |
| Cedar Hills Landfill[b] | leachate | 650,000 (171) | 3.0 (0.12) |

Source: Metro 1988
[a] City of Issaquah estimates are for 1989.
[b] Cedar Hills Landfill estimates are for 1992.

Table 7.15 **Group A parameters.**

| Parameter | Unit | Detection Limit | Preferred Method |
|---|---|---|---|
| **Biological Parameters, Group A-1** | | | |
| Total Coliforms | MPN/100ml | <2.2 | EPA (5-tube)[a] |
| Fecal Coliforms | MPN/100ml | <2.2 | EPA (5-tube)[a] |
| **Physical Parameters, Group A-2** | | | |
| Total Dissolved Solids | mg/L | 1 | EPA 160.1 |
| Total Hardness, $CaCO_3$ | mg/L | 1 | EPA 130.2 |
| Alkalinity | | | |
| Bicarbonate | mg/L | 1 | EPA 310.1 |
| Carbonate | mg/L | 1 | EPA 310.1 |
| **Inorganic Parameters, Group A-3** | | | |
| Calcium | mg/L | .5 | EPA 215.2 |
| Iron | mg/L | .03 | EPA 236.1 |
| Manganese | mg/L | .01 | EPA 243.1 |
| Magnesium | mg/L | .5 | EPA 242.1 |
| Potassium | mg/L | .5 | EPA 258.1 |
| Sodium | mg/L | .5 | EPA 273.1 |
| Chloride | mg/L | 1 | EPA 325.1,.2,.3 |
| Nitrate-N | mg/L | 1 | EPA 352.1 |
| Silica | mg/L | 2 | EPA 370.1 |
| Sulfate | mg/L | 5 | EPA 375.2,.3,.4 |
| Zinc | mg/L | .02 | EPA 289.1 |
| Silver | mg/L | .01 | EPA 272.1 |
| Selenium | mg/L | .005 | EPA 270.2,.3 |
| Mercury | mg/L | .0002 | EPA 245.1,.2 |
| Fluoride | mg/L | .1 | EPA 340.1,.2,.3 |
| Barium | mg/L | .2 | EPA 208.1 |
| Copper | mg/L | .1 | EPA 220.1 |
| Cadmium | mg/L | .001 | EPA 213.2 |
| Lead | mg/L | .005 | EPA 239.2 |
| Chromium | mg/L | .005 | EPA 218.2,.3,.5 |

**Table 7.16 Volatiles—Group B-1 parameters—EPA Method 624.**

| Volatiles | Detection Level μg/L |
|---|---|
| Acrolein | 5 |
| Acrylonitrile | 5 |
| Chloromethane | 1 |
| Bromomethane | 1 |
| Vinyl Chloride | 1 |
| Chloroethane | 1 |
| Methylene Chloride | 1 |
| Acetone | 1 |
| Carbon Disulfide | 1 |
| 1,1-Dichloroethene | 1 |
| 1,1-Dichloroethane | 1 |
| Trans-1,2-Dichloroethane | 1 |
| Chloroform | 1 |
| 1,2-Dichloroethane | 1 |
| 2-Butanone | 1 |
| 1,1,1-Trichloroethane | 1 |
| Carbon Tetrachloride | 1 |
| Vinyl Acetate | 1 |
| Bromodichloromethane | 1 |
| 1,2-Dichloropropane | 1 |
| Trans-1,3-Dichloropropene | 1 |
| Trichloroethene | 1 |
| Dibromochloromethane | 1 |
| 1,1,2-Trichloroethane | 1 |
| Benzene | 1 |
| cis-1,3-Dichloropropene | 1 |
| 2-Chloroethylvinylether | 1 |
| Bromoform | 1 |
| 4-Methyl-2-Pentanone | 1 |
| 2-Hexanone | 1 |
| Tetrachloroethene | 1 |
| 1,1,2,2-Tetrachloroethane | 1 |
| Toluene | 1 |
| Chlorobenzene | 1 |

**Table 7.16 Volatiles—Group B-1 parameters—EPA Method 624.**

| Volatiles | Detection Level µg/L |
|---|---|
| Ethylbenzene | 1 |
| Styrene | 1 |
| Total xylenes | 1 |

Table 7.17. Semi-Volatiles—Group B-2 parameters—EPA Method 625.

| Semi-Volatiles | Detection Level μg/L |
|---|---|
| N-Nitrosodimethylamine | 2 |
| Phenol | 2 |
| Aniline | 2 |
| bis(-2-Chloroethyl)Ether | 2 |
| 2-Chlorophenol | 2 |
| 1,3-Dichlorobenzene | 2 |
| 1,4-Dichlorobenzene | 2 |
| Benzyl Alcohol | 2 |
| 1,2-Dichlorobenzene | 2 |
| 2-Methylphenol | 2 |
| bis(2-chloroisopropyl)Ether | 2 |
| 4-Methylphenol | 2 |
| N-Nitroso-Di-n-propylamine | 2 |
| Hexachloroethane | 2 |
| Nitrobenzene | 2 |
| Isophorone | 2 |
| 2-Nitrophenol | 2 |
| 2,4-Dimethylphenol | 2 |
| Benzoic Acid | 2 |
| bis(2-Chloroethoxy)Methane | 2 |
| 2,4-Dichlorophenol | 2 |
| 1,2,4-Trichlorobenzene | 2 |
| Naphthalene | 2 |
| 4-Chloroaniline | 2 |
| Hexachlorobutadiene | 2 |
| 4-Chloro-3-Methylphenol | 2 |
| 2-Methylnaphthalene | 2 |
| Hexachlorocyclopentadiene | 2 |
| 2,4,6-Trichlorophenol | 2 |
| 2,4,5-Trichlorophenol | 2 |
| 2-Chloronaphthalene | 2 |
| 2-Nitroaniline | 2 |
| Dimethyl Phthalate | 2 |

**Table 7.17. Semi-Volatiles—Group B-2 parameters—EPA Method 625.**

| Semi-Volatiles | Detection Level µg/L |
|---|---|
| Acenaphthylene | 2 |
| 3-Nitroaniline | 2 |
| Acenaphthene | 2 |
| 2,4-Dinitrophenol | 2 |
| Dibenzofuran | 2 |
| 2,4-Dinitrotoluene | 2 |
| 2,6-Dinitrotoluene | 2 |
| Diethylphthalate | 2 |
| 4-Chlorophenyl-phenylether | 2 |
| Fluorene | 2 |
| 4-Nitroaniline | 2 |
| 4,6-Dinitro-2-Methylphenol | 2 |
| N-nitrosodiphenylamine (1) | 2 |
| 4-Bromophyenyl-phenylether | 2 |
| Hexachlorobenzene | 2 |
| Pentachlorophenol | 2 |
| Phenanthrene | 2 |
| Anthracene | 2 |
| Di-n-Butylphthalate | 2 |
| Fluoranthene | 2 |
| Benzidine | 2 |
| Pyrene | 2 |
| Butylbenzylphthalate | 2 |
| 3,3-Dichlorobenzidine | 2 |
| Benzo(a)anthracene | 2 |
| bis(2-Ethylhexyl)Phthalate | 2 |
| Chrysene | 2 |
| Di-n-OctylPhthalate | 2 |
| Benzo(b)Fluoranthene | 2 |
| Benzo(k)Fluroranthene | 2 |
| Benzo(a)Pyrene | 2 |
| Indeno(1,2,3-cd)Pyrene | 2 |
| Dibenz(a,h)Anthracene | 2 |

**Table 7.17. Semi-Volatiles—Group B-2 parameters—EPA Method 625.**

| Semi-Volatiles | Detection Level μg/L |
|---|---|
| Benzo(g,n,i)Perylene | 2 |
| 1,2 Dipheneylhydrazine | 2 |

**Table 7.18 Pesticides/PCBs—Group B-3 Parameters—EPA Method 608.**

| Pesticides | Detection Level µg/L |
|---|---|
| Alpha-BHC | 0.05 |
| Beta-BHC | 0.05 |
| Delta-BHC | 0.05 |
| Gamma-BHC (Lindane) | 0.05 |
| Heptachlor | 0.05 |
| Aldrin | 0.05 |
| Heptachlor Epoxide | 0.05 |
| Endosulfan I | 0.05 |
| Dieldrin | 0.10 |
| 4-4 DDE | 0.10 |
| Endrin | 0.10 |
| Endosulfan II | 0.10 |
| 4-4 DDD | 0.10 |
| Endosulfan Sulfate | 0.10 |
| 4-4 DDT | 0.10 |
| Methoxychlor | 0.50 |
| Endrin Ketone | 0.10 |
| Chlordane | 0.50 |
| Toxaphene | 1.00 |
| Aroclor-1016 | 0.50 |
| Aroclor-1221 | 0.50 |
| Aroclor-1232 | 0.50 |
| Aroclor-1242 | 0.50 |
| Aroclor-1248 | 0.50 |
| Aroclor-1254 | 1.00 |
| Aroclor-1260 | 1.00 |

**Table 7.19. EPA priority pollutant metals—Group B-4 parameters.**

| Element | CAS# | Detection Level mg/L | Preferred Method |
|---|---|---|---|
| Total Antimony | 7440-36-0 | .06 | EPA 204.2 |
| Total Arsenic | 7440-38-2 | .005 | EPA 206.2,.3 |
| Total Beryllium | 7440-41-7 | .005 | EPA 210.2 |
| Total Cadmium | 7440-43-9 | .001 | EPA 213.2 |
| Total Chromium | 7440-47-3 | .005 | EPA 218.2 |
| Total Copper | 7440-50-8 | .025 | EPA 220.1,.2 |
| Total Lead | 439-92-1 | .005 | EPA 239.2 |
| Total Mercury | 7439-97-6 | .0002 | EPA 245.1,.2 |
| Total Nickel | 7440-02-0 | .04 | EPA 249.2 |
| Total Selenium | 7789-49-2 | .005 | EPA 270.2,.3 |
| Total Silver | 7440-22-4 | .01 | EPA 272.1 |
| Total Thallium | 7440-26-0 | .005 | EPA 279.2 |
| Total Zinc | 7440-66-6 | .02 | EPA 289.1 |

**Table 7.20. Summary of water quality monitoring lower Issaquah Valley wellhead protection plan.**

| Well Name | Basic Inorganic | | | Priority Metals (EPA 7000-Series) | | | Turbidity | | | Iron and Manganese | | | Nitrate | | | Volatile Organics (EPA 524.2) | | | Pesticides & PCBs (EPA 8080) | | | Herbicides EPA (8150) | | | BTEX | | | Dissolved Oxygen (Field meas.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 | May 92 | Oct 92 | Apr 93 |
| SP7-1 | X | | | X | | X | X | | X | | | | X | | | | | X | X | | X | | | X | | | | | | X |
| SP7-2 | X | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | | |
| SPVT1-1 | X | X | | X | | X | X | X | | | X | | X | X | | X | | X | X | | X | | | X | | X | | | | X |
| SPVT1-3 | X | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | | |
| SPVT2-1 | X | | | X | X | | X | | | | | | X | | | X | X | | X | | | | | | | | | | | |
| SPVT2-2 | | X | X | | | X | | X | X | | X | X | | X | X | | X | | | | | | | X | | X | | | | X |
| SPVT2-3 | X | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | | |
| SPVT5-1 | X | X | X | X | | X | X | X | X | | X | X | X | X | X | X | X | X | X | | X | | | X | | X | | | | X |
| SPVT5-2 | | X | | | | | | X | | | X | | | X | | | | | | | | | | | | | | | | |
| SPVT6-2 | X | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | | |
| SPVT7-4 | | X | | | X | | | X | | | X | | | X | | | | | | | | | | | | X | | | | |
| SPVT8-1 | X | X | | X | | | X | X | | | X | | X | | | X | | | | | | | | | | X | | | | |
| SPVT8-4 | | X | | | | | | X | | | X | | | X | | | X | | | | | | | | | X | | | | |
| SPVT3 | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | | | | X |
| SP7 | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | X |
| WH-1 | | X | X | | X | | | X | X | | X | X | | X | X | | X | | | | | | X | | | | | | | X |
| WH2-1 | | X | | | | X | | X | | | X | | | X | | | | X | | X | X | | | X | | X | | | | X |
| WH2-2 | | X | | | | | | X | | | X | | | X | | | X | | | X | X | | | X | | X | | | | X |
| WH-3-1 | | X | | | X | X | | X | | | X | | | X | | | X | X | | X | X | | | X | | X | | | | X |
| WH-3-2 | | X | | | | | | X | | | X | | | X | | | | X | | | | | | | | X | | | | X |
| Lakeside-New | | X | | | X | | | X | | | X | | X | X | | | | | | | | | | | | X | | | | |
| Lakeside-BPW | X | | | | | | X | | | | | X | | | | | | | | | | | | | | | | | | |
| Caldwell | | X | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | |
| Bell | X | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | | |
| Darout | X | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | | |

Source: Golder Associates, 1993.

**Table 7.21 Issaquah Ground Water Management Area wells monitored during Wellhead Protection Study.**

| Seattle-King County Health Department Database Issaquah Ground Water Management Area Wells | Wellhead Protection Wells (Golder Associates) |
|---|---|
| City of Issaquah Risdon Well #1 | COI-1 Water levels only |
| City of Issaquah Risdon Well #2 | COI-2 Water levels only |
| City of Issaquah Test Well | COI TW Water levels only |
| City of Issaquah Test #4 | COI-4 Water levels only |
| City of Issaquah Test #5 | COI-5 Water levels only |
| Sammamish Plateau SWD #8 | SP8 Water levels only |
| Sammamish Plateau SWD 7-1 (D) | SP7-2 Water Quality Table 2.6.17. |
| Sammamish Plateau SWD 7-1 (S) | SP7-1 Water Quality Table 2.6.17. |
| Sammamish Plateau SWD 7-3 (D) | SP7-3 (Table 1 not shown) Water levels only |
| SPWD/City of Issaquah VT-1 Test | SPVT 1-1 Water Quality Table 2.6.17. |
| SPWD/City of Issaquah VT-2.1 Test | SPVT 2-1 Water Quality Table 2.6.17. |

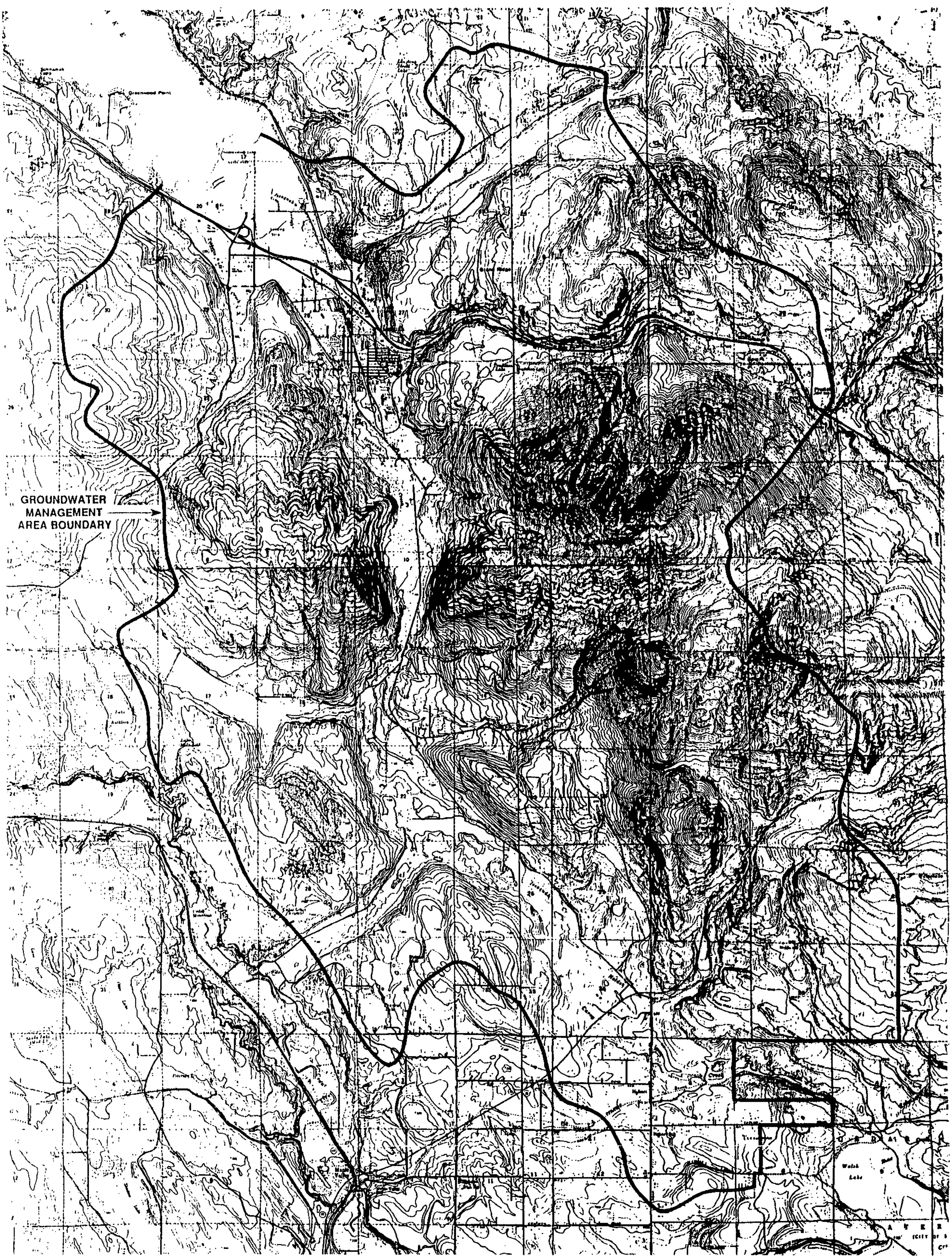
# Area Characterization

# Figures

**Draft**

**Issaquah Creek Valley**
**Ground Water Management Plan**

**March, 1996**




Source: Carr/Associates 1986

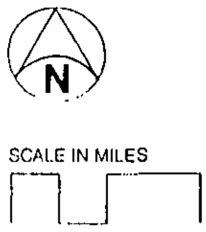



Fig. 2.1. Issaquah Ground Water Management Area

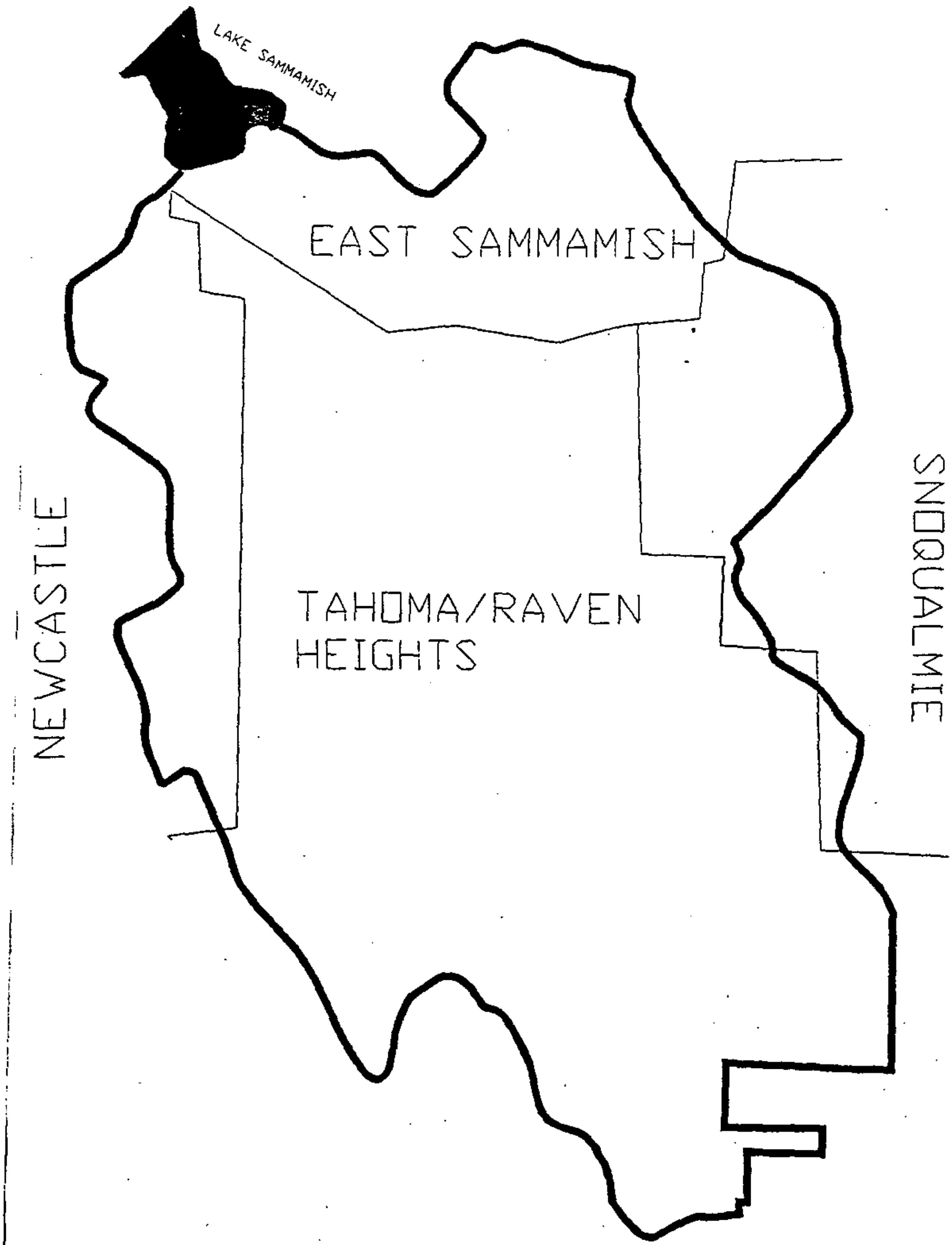
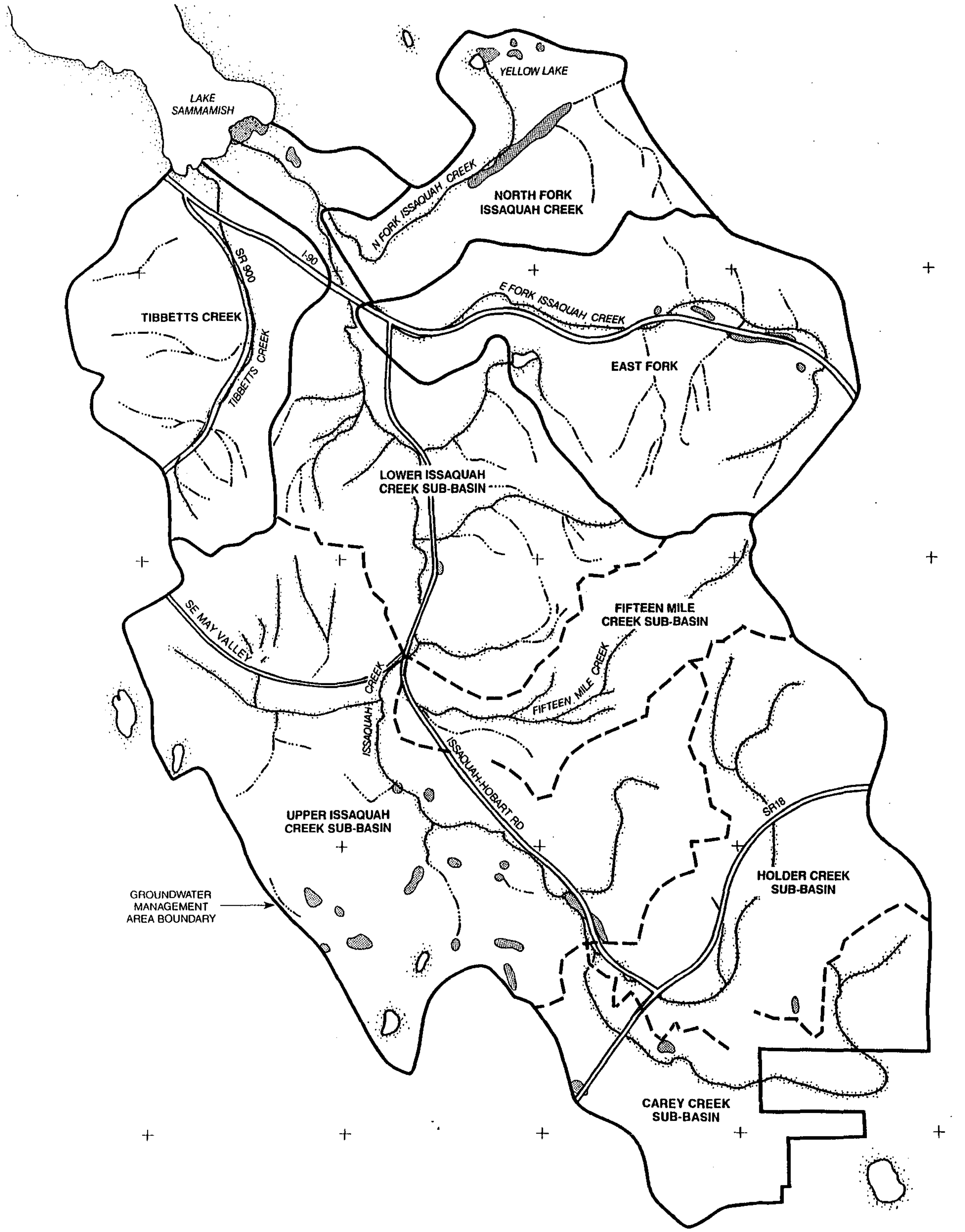
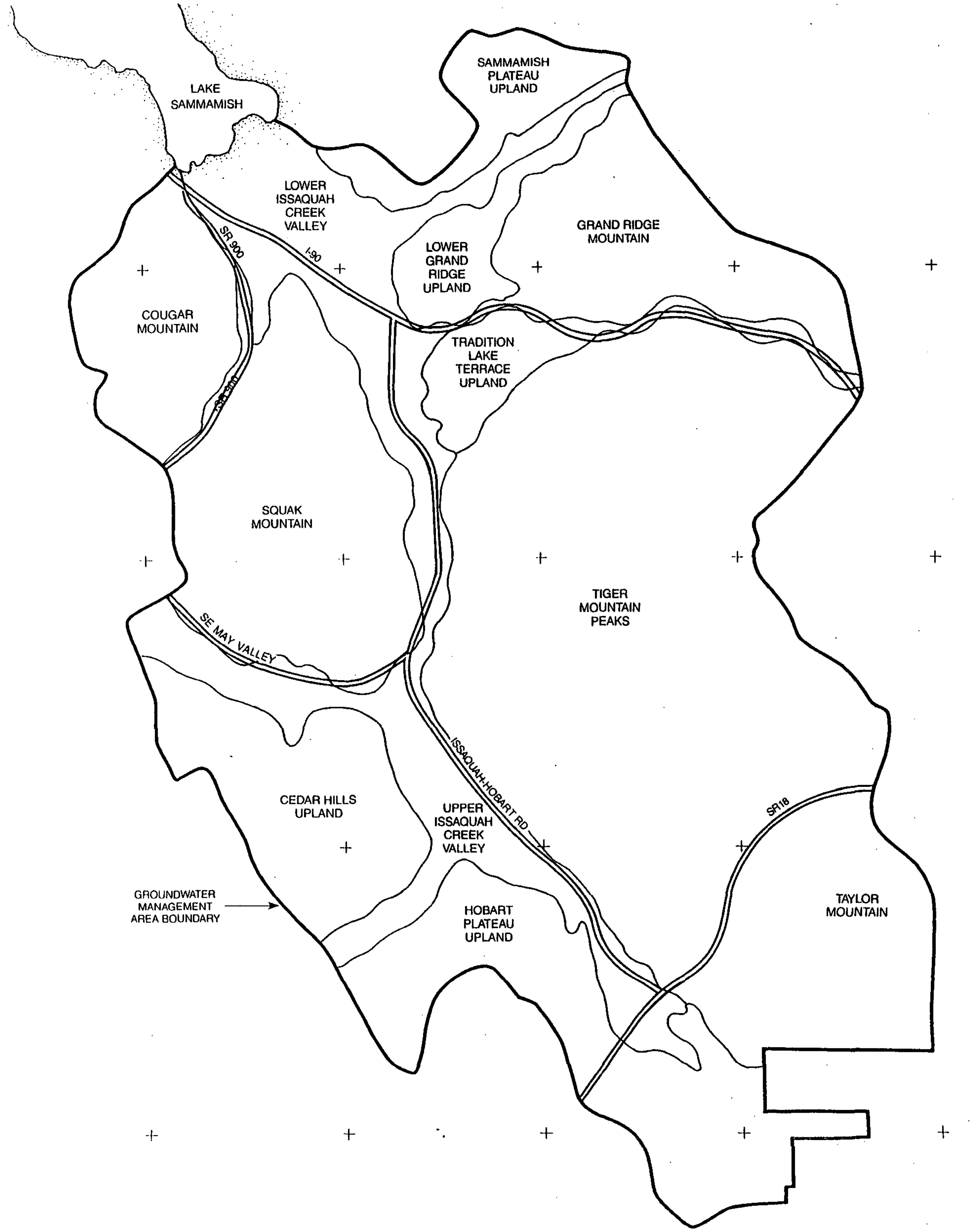



Fig. 3.1. Issaquah Ground Water Management Area Community Planning Areas




Source: Carr/Associates 1989


**Fig. 4.1. Surface Water Hydrology**




Source: Carr/Associates 1989

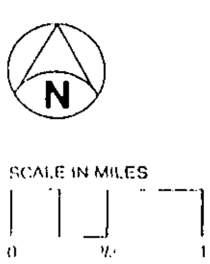
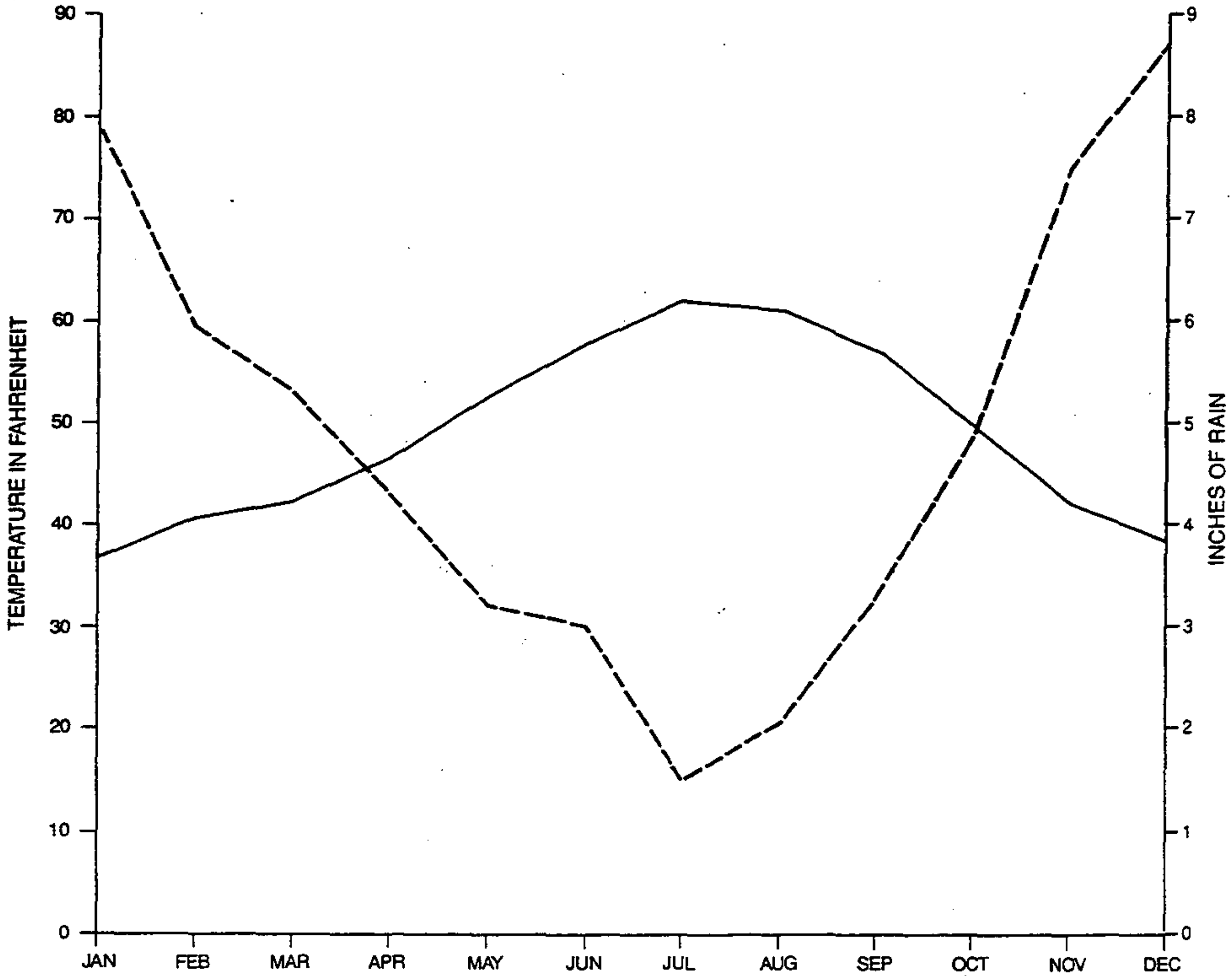



Fig. 4.2. Physiographic Map

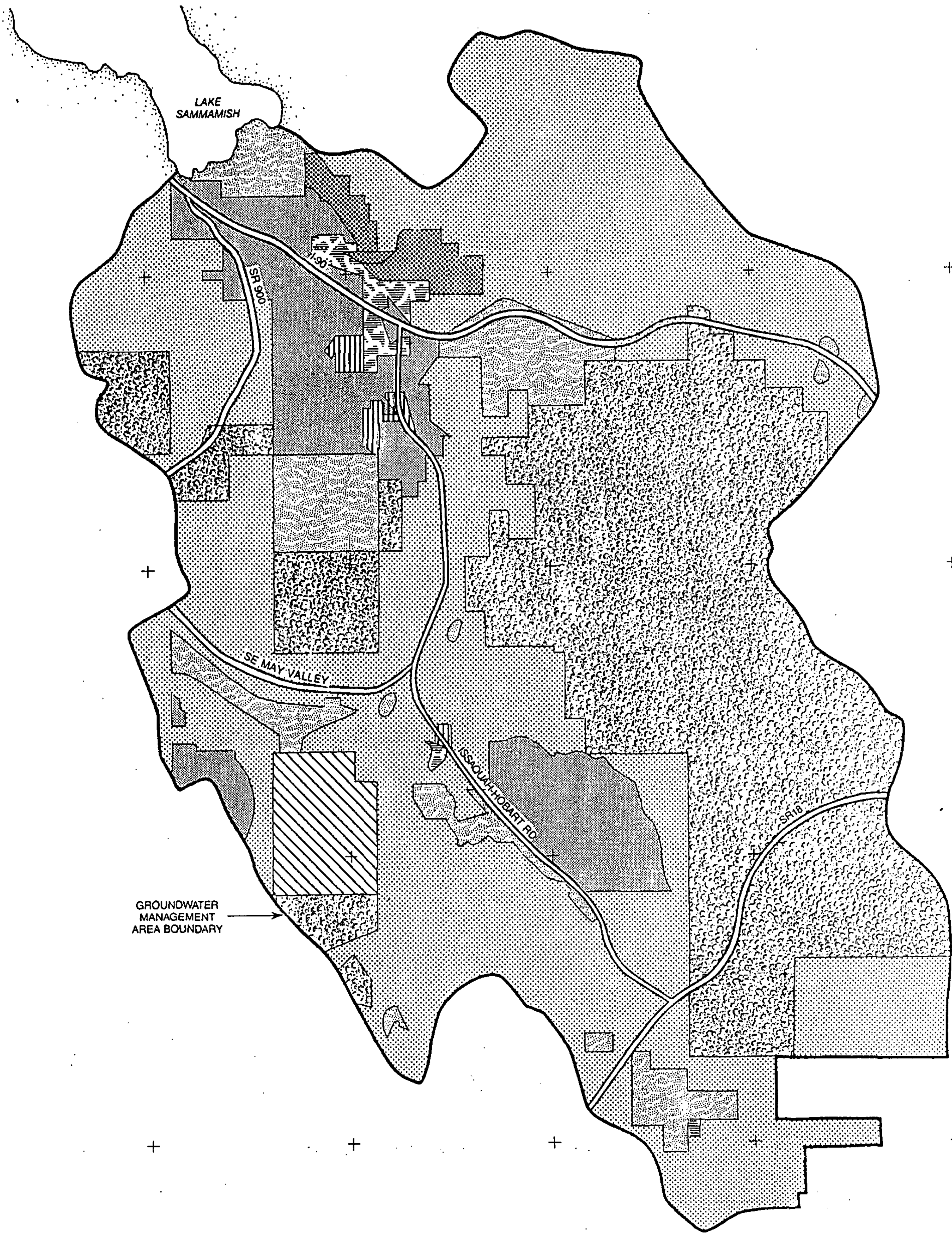



Note: Compiled from data collected from 1968-1988.

Source: NOAA 1988

Fig. 4.3. Climograph for Landsburg

——— Temperature
– – – Precipitation




Source: Compiled from King County Community Plans and City of Issaquah land use plans

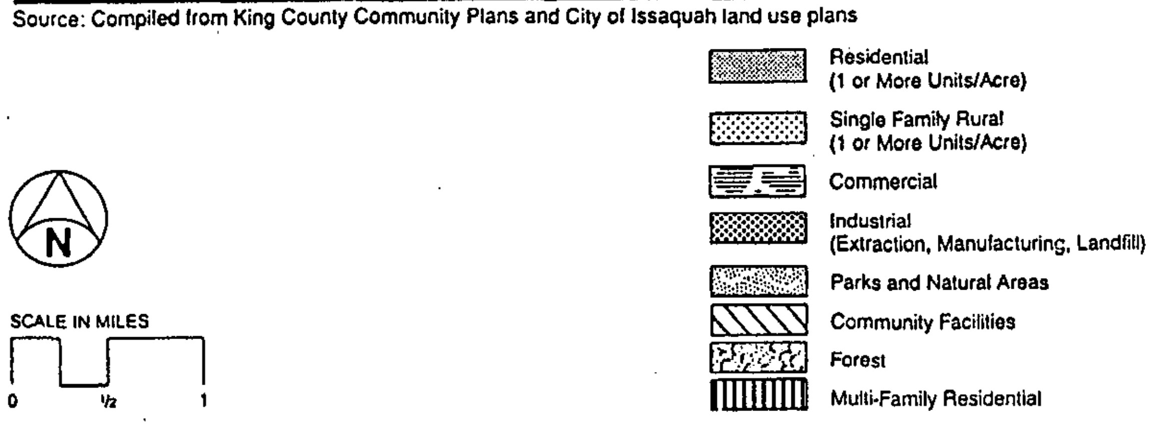



Fig. 5.1A. Existing Land Use

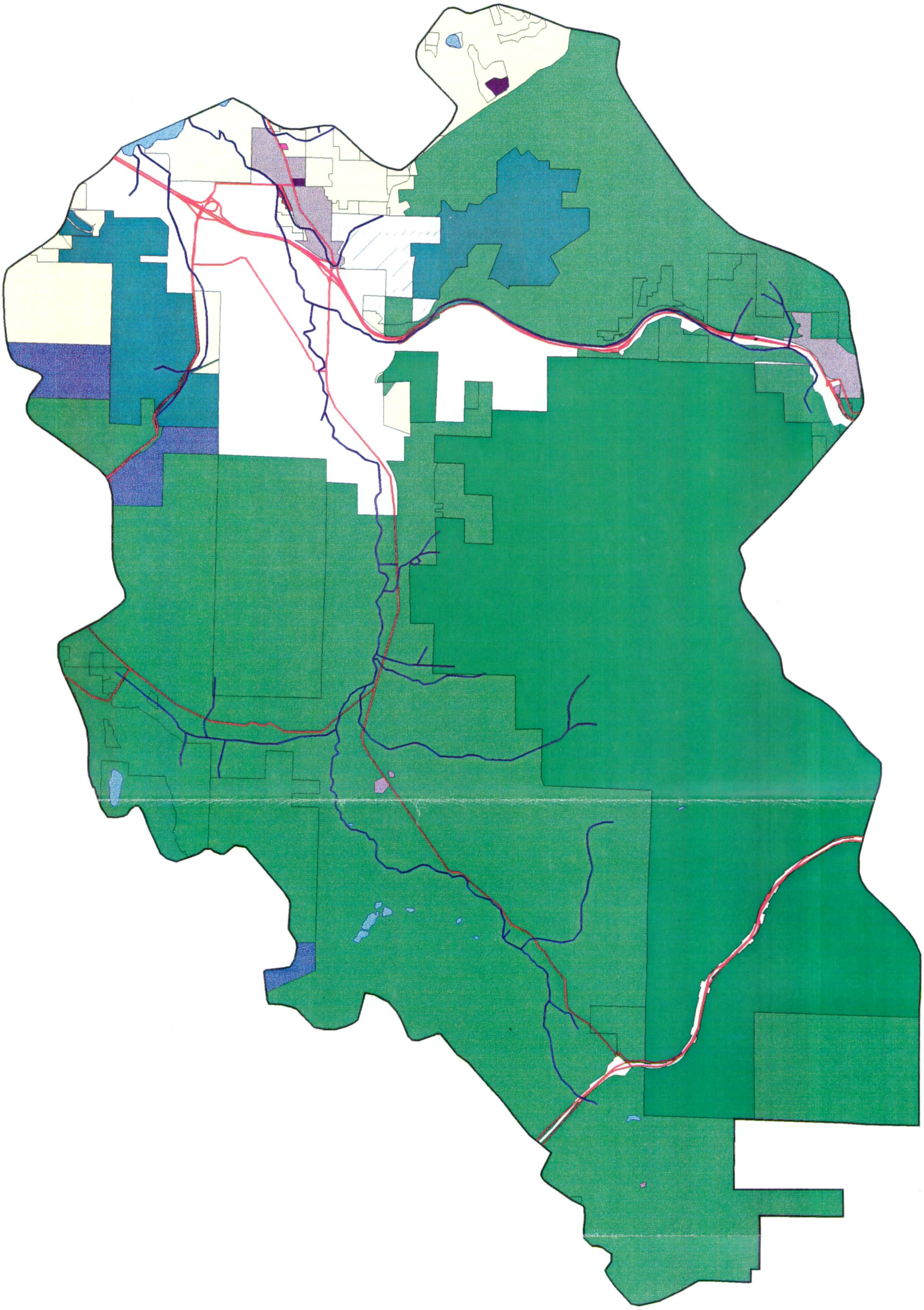


Fig. 5.1B. Future Land Use

**Legend**

| | | |
|---|---|---|
| Agriculture - 10 ac. | Resi. - 1 du/acre | Rural - 1 du/2.5 ac. |
| Agriculture - 35 ac. | Resi. - 12 du/acre | Rural - 1 du/5 ac. |
| Community business | Resi. - 18 du/acre | Regional business |
| Forest | Resi. - 24 du/acre | Urban reserve |
| Industrial | Resi. - 4 du/acre | |
| Mining | Resi. - 48 du/acre | |
| Muckleshoot I. R. | Resi. - 6 du/acre | |
| Neighborhood bus. | Resi. - 8 du/acre | |
| Office | Rural - 1 du/10 ac. | |

February 23, 1996

0 0.5 1 1.5 2

MILES

**King County Surface Water Management**

*Everyone lives downstream*

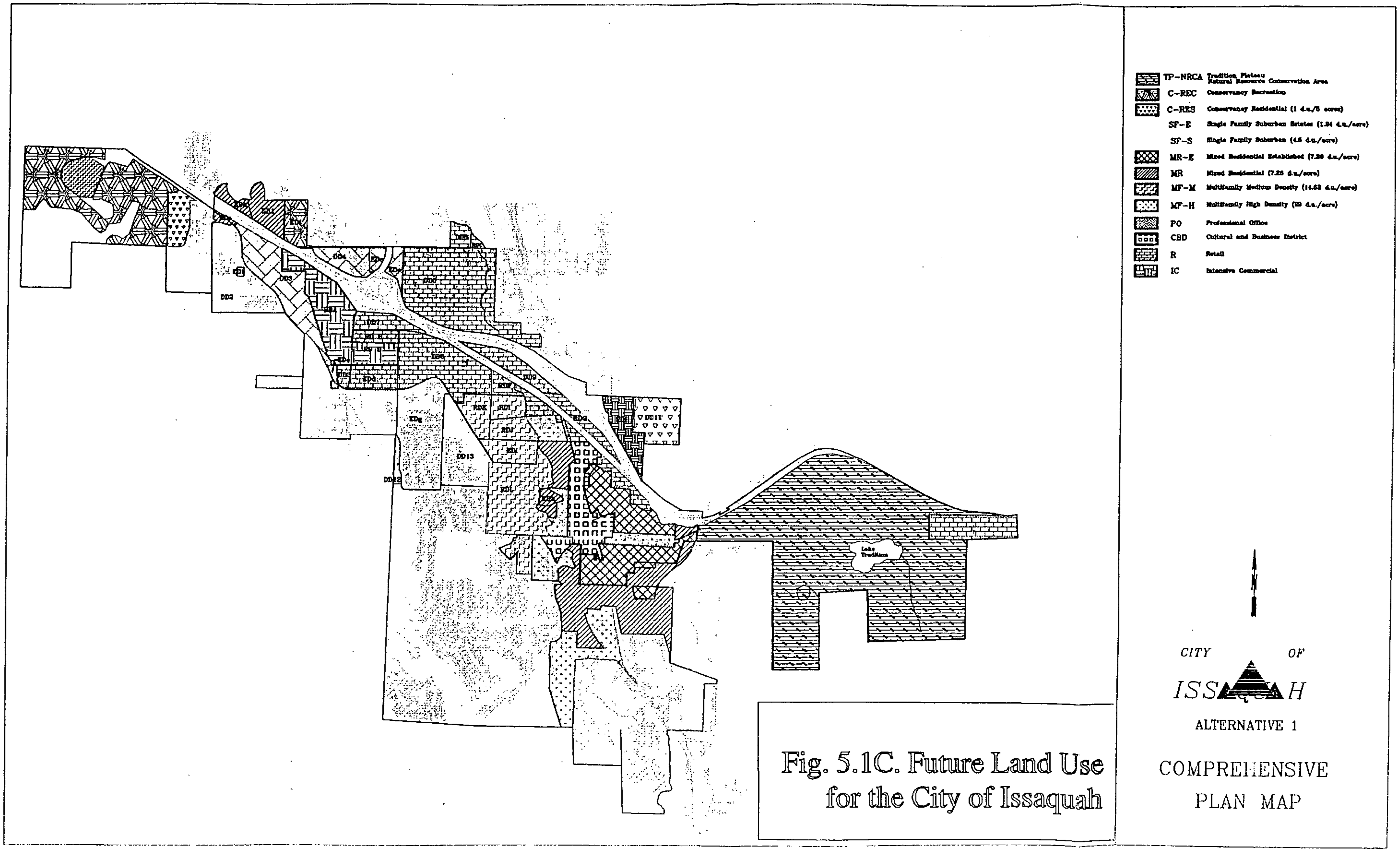



Fig. 5.1C. Future Land Use for the City of Issaquah

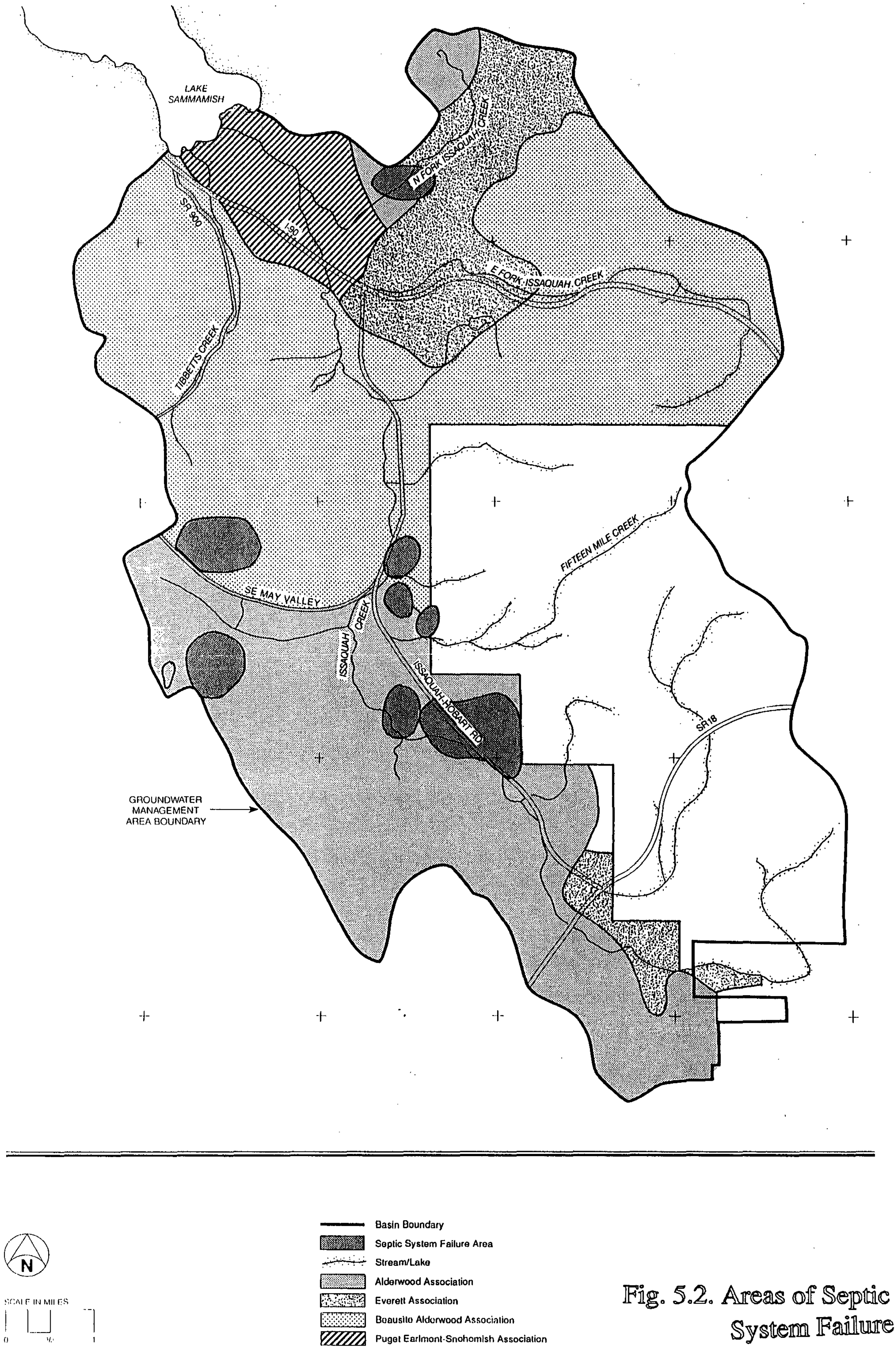
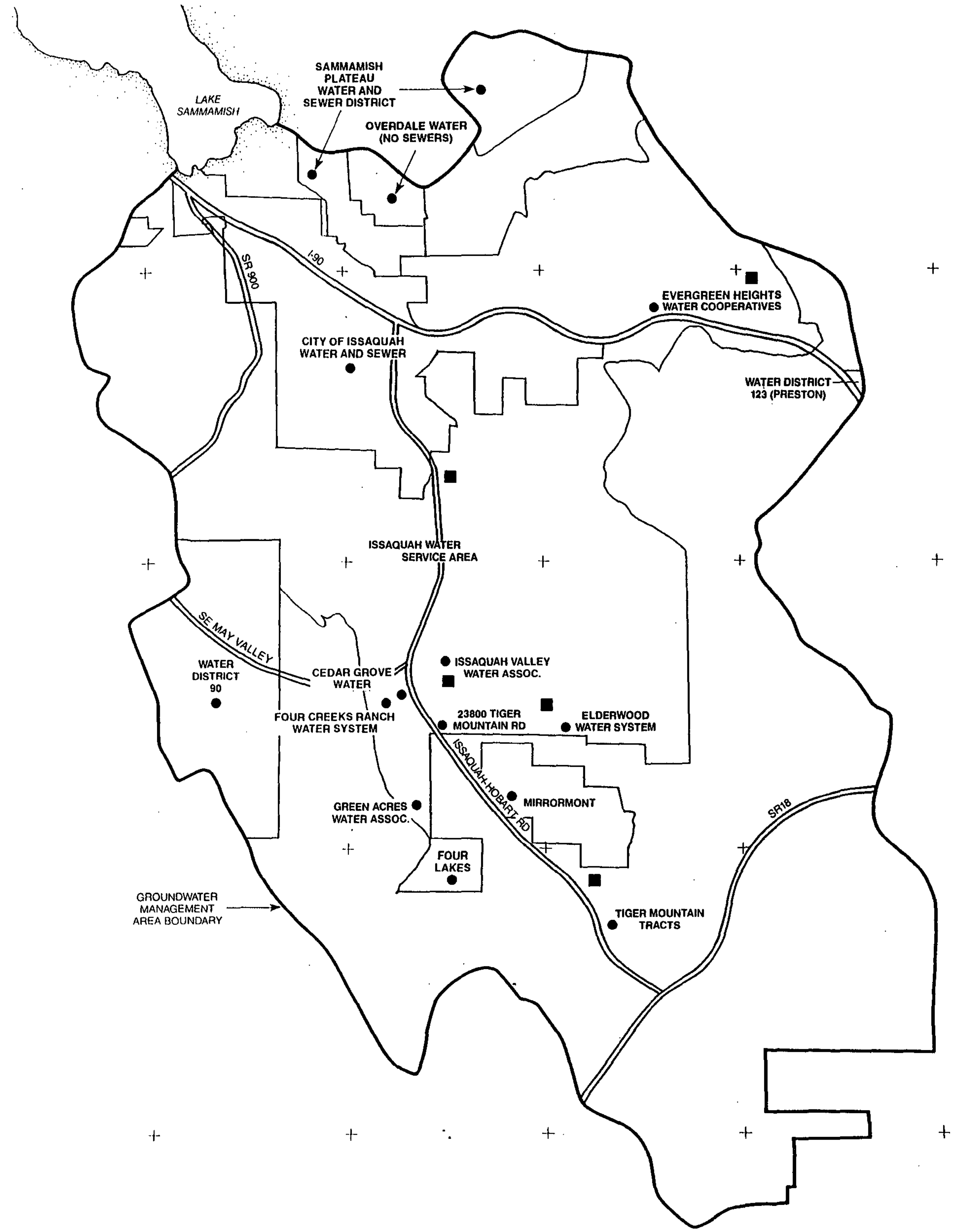
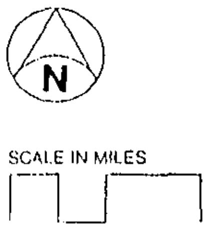



Fig. 5.2. Areas of Septic System Failure



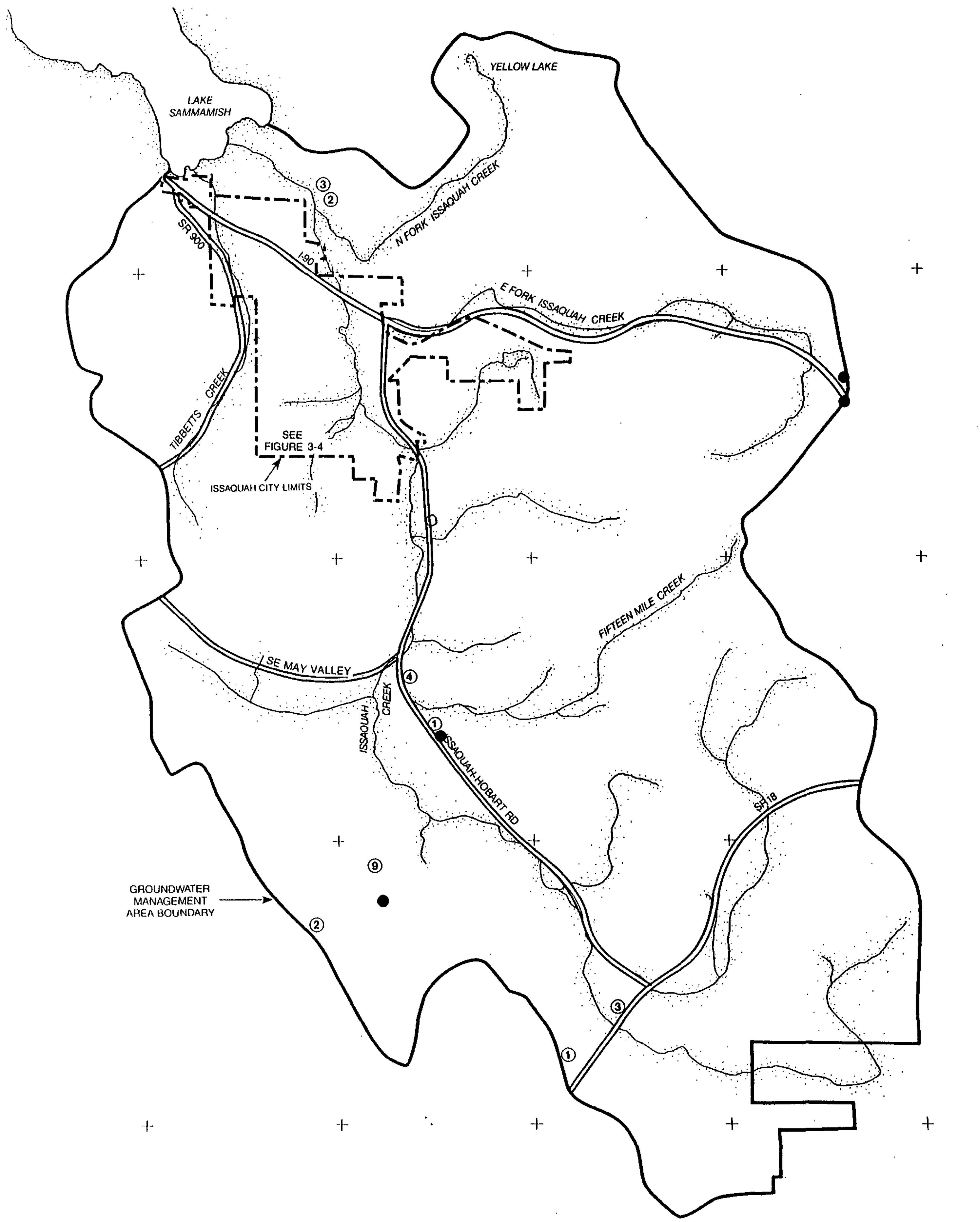

Source: Department of Social and Health Services, 1989



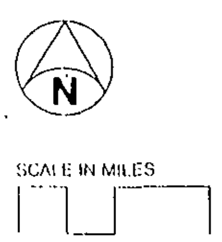

● Group A Public Water Systems

■ Concentration of Group B Public Water Systems

**Fig. 5.3. Water and Sewer Service Areas**




Source: Compiled from field surveys, maps, and historical records

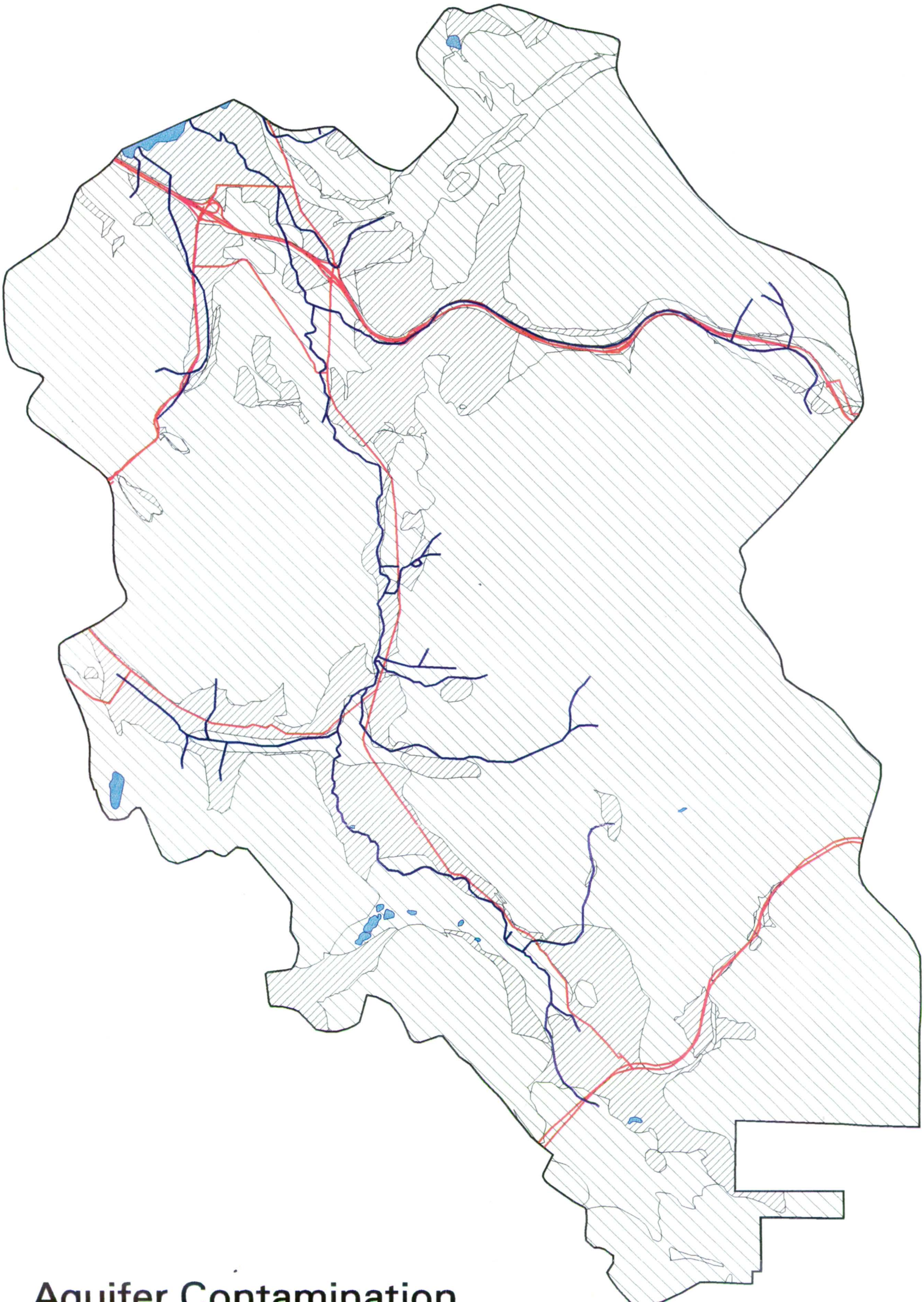



② Underground Storage Tank and Number Present On-Site

○ Gas Station, Oil and Fuel Supplier

● Manufacturing Plant

**Fig. 5.4. Potential Point Contaminant Map**



# Aquifer Contamination Susceptibility

**Fig. 5.5.**

## Legend

- Low
- Medium
- High

February 23, 1996

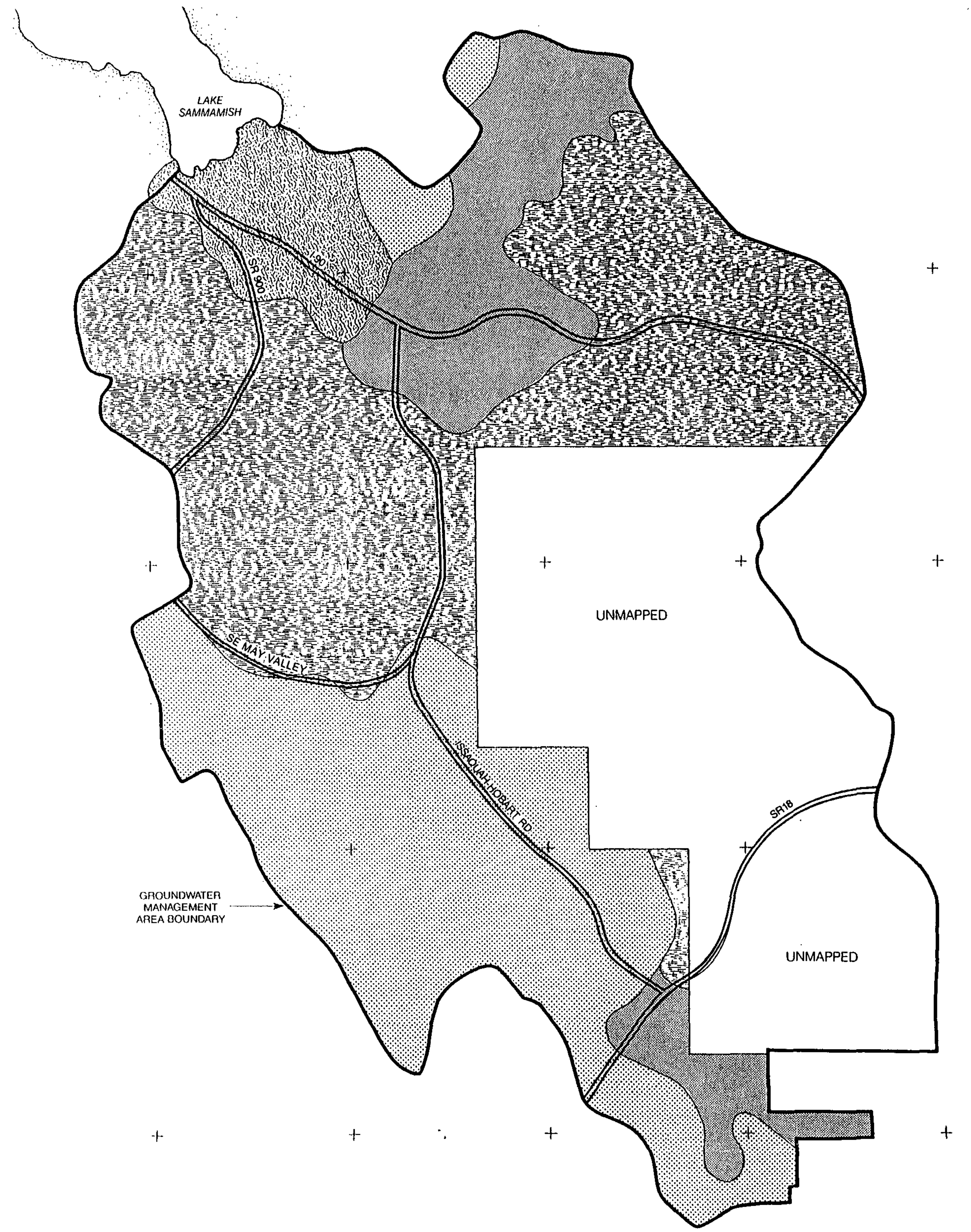
0 0.5 1 1.5 2

MILES

**King County Surface Water Management**

*Everyone lives downstream*

This map is based upon best available information. It is intended for planning purposes only and is not guaranteed to show accurate measurements.




Source: U.S. Department of Agriculture Soil Conservation Service 1973

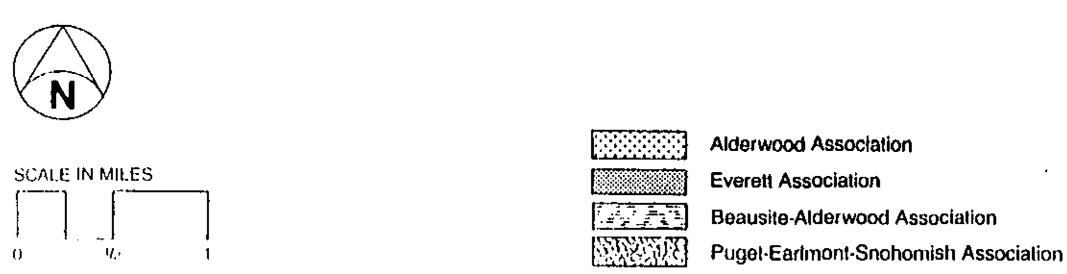
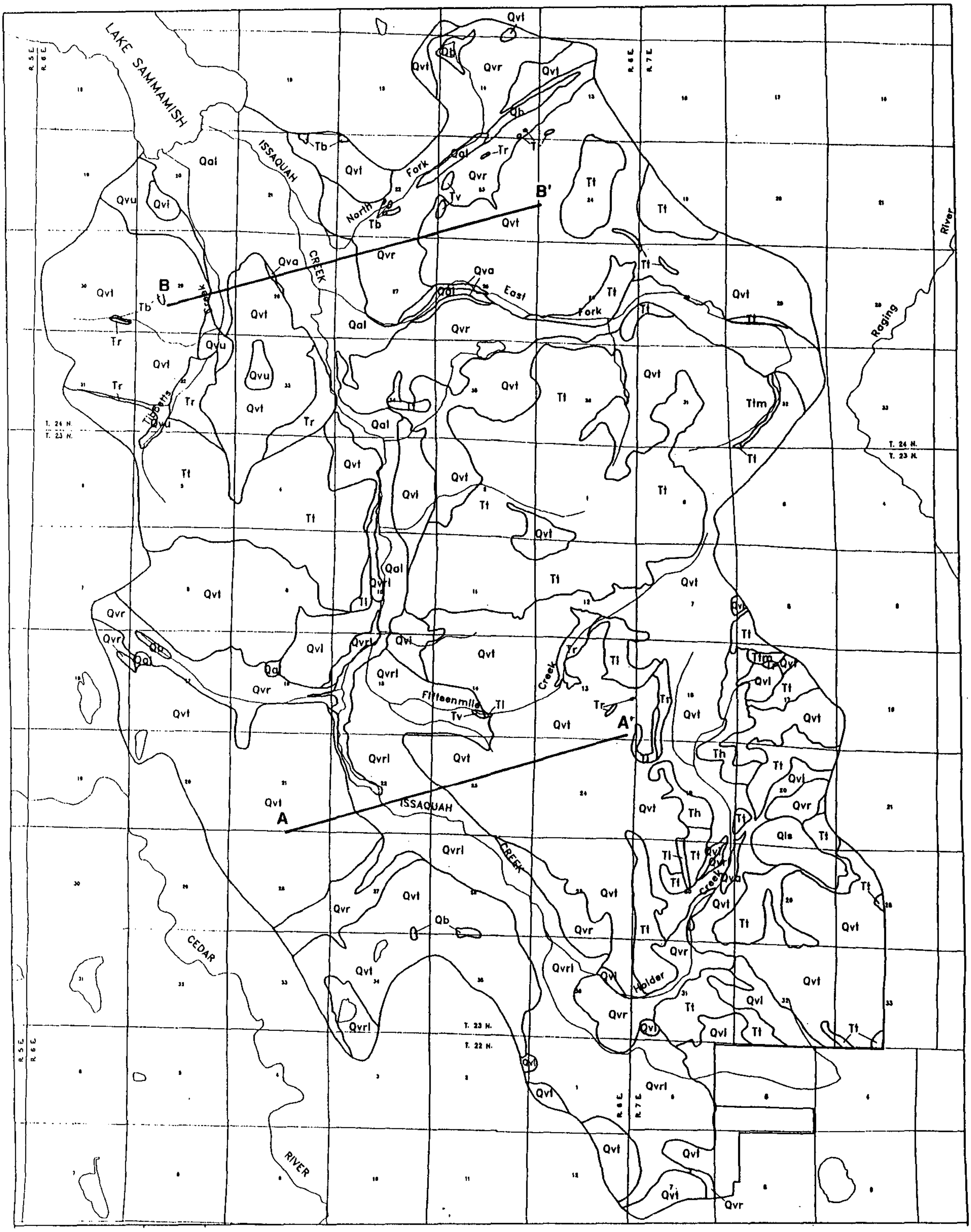



Fig. 7.1A. Issaquah Ground Wat Management Area Generalized Soil Association




**Post-Glacial Deposits**

| | |
|---|---|
| Qb | Recent Bog Deposits |
| Qal | Alluvium |
| Qls | Landslide Deposits |

**Glacial Deposits of Vashon Stade of the Fraser Glaciation**

| | |
|---|---|
| Qvrl | Vashon Recessional Lacustrine Deposits |
| Qvr | Vashon Recessional Outwash Deposits |
| Qvi | Vashon Ice Contact Deposits |
| Qvt | Vashon Till |
| Qva | Vashon Advance Outwash |
| Qvu | Vashon Age Deposits, Undifferentiated |

**Bedrock Deposits**

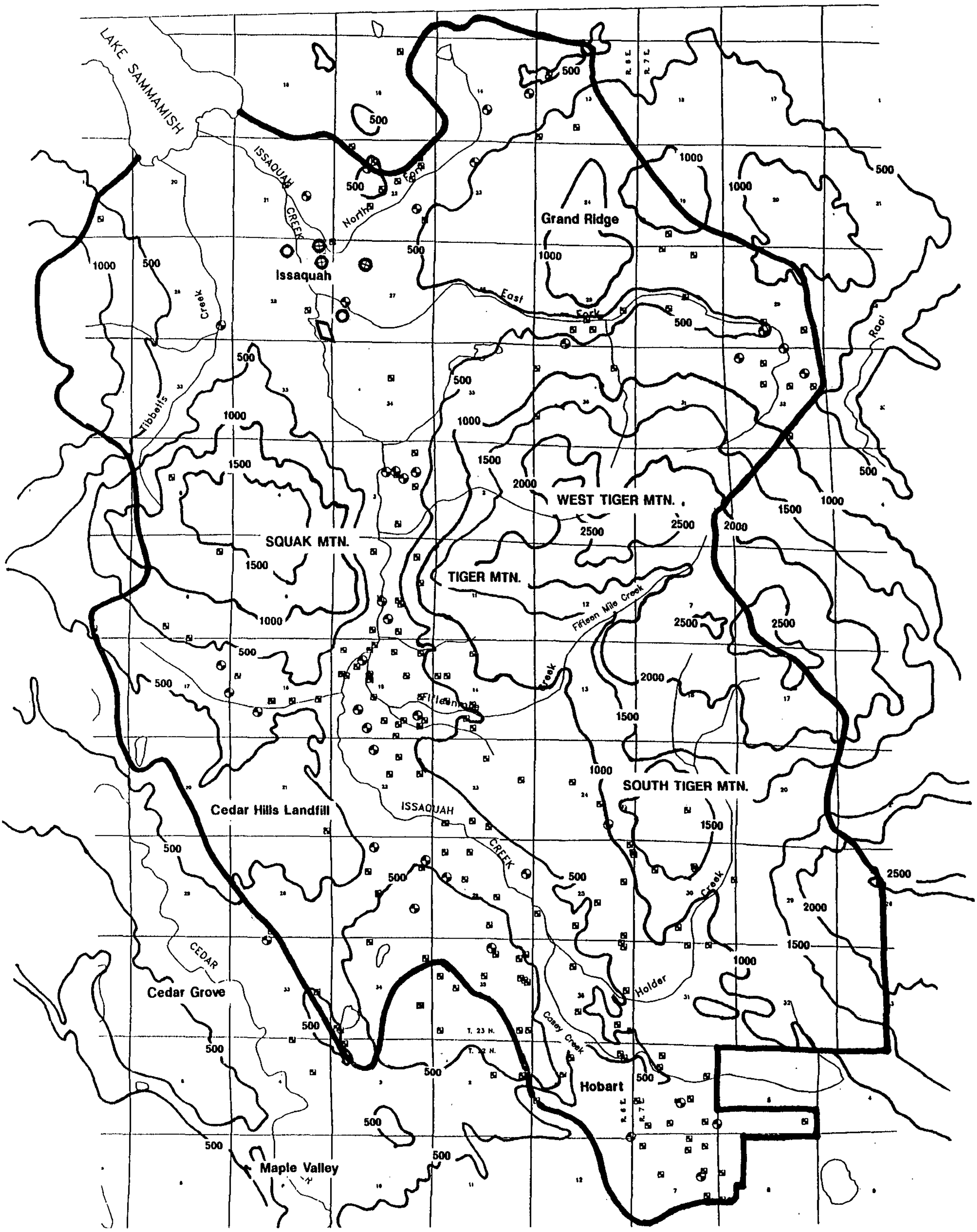
| | |
|---|---|
| Tr | Renton Formation |
| Tt | Tukwila Formation |
| Ttm | Tiger Mountain Formation |
| Tv | Unnamed Volcanic Rocks |
| Tb | Blakely(?) Formation |
| Trr | Raging River Formation |
| Ti | Intrusive Rocks |

N

SCALE IN MILES

0 ½ 1

Fig. 7.1B. Surficial Geology




-ARCO Service Station LUST Site
-City of Issaquah Water Wells
-Sammamish Plateau Water Wells

Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

WELL INCLUDED IN MONTHLY MONITORING (SURVEYED LOCATION AND ELEVATION)

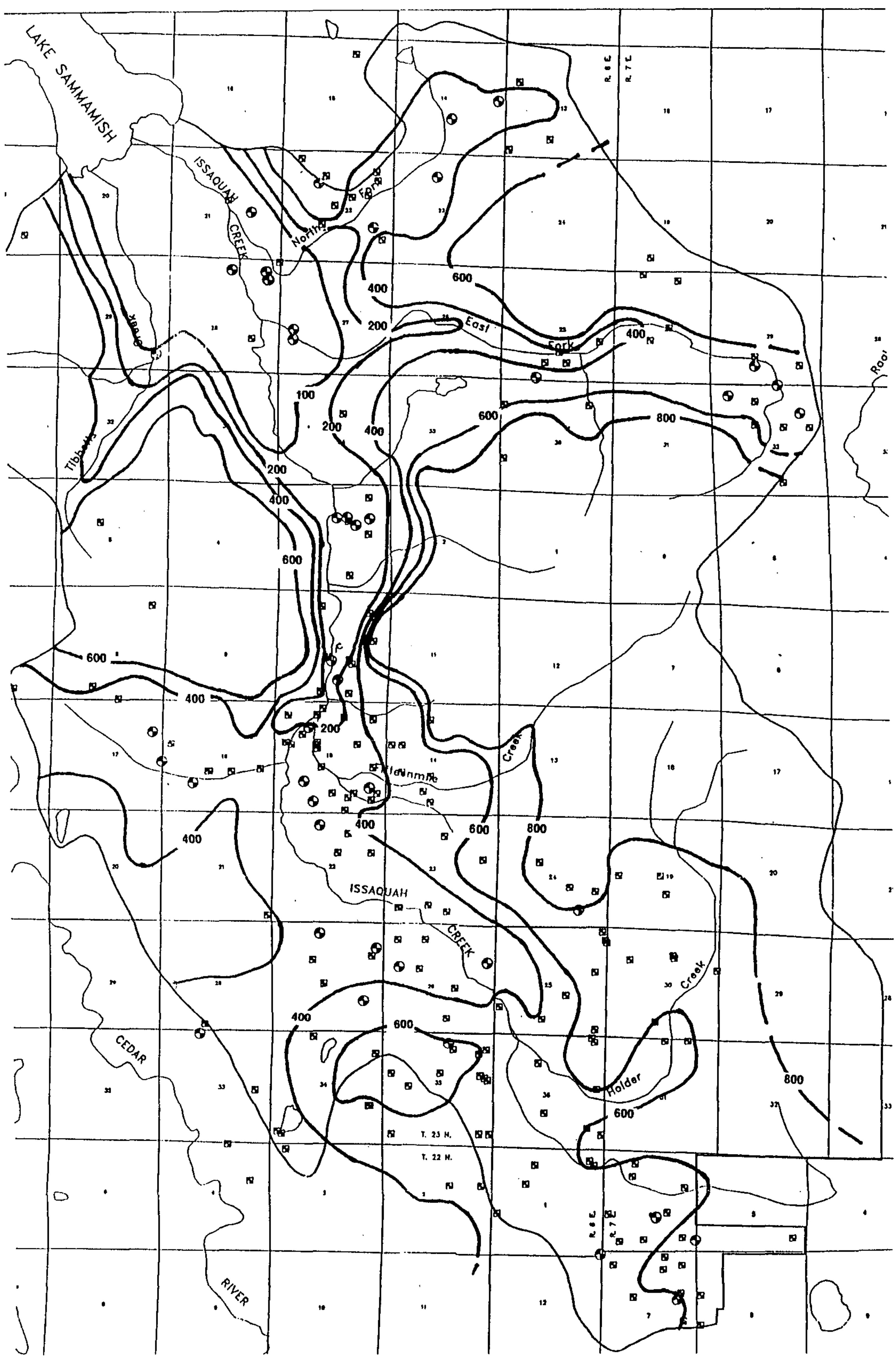
WELL LOCATION AND INFORMATION OBTAINED FROM WELL LOGS (ESTIMATED LOCATION AND ELEVATION)

- 500 - 500 FOOT CONTOUR INTERVAL

SCALE IN FEET 0 2500 5000

N

Fig. 7.2.
Well Location anc
Topographic Map




Source: Task 5: Hydrogeological Report - Carr/Associates Sept. 1993

WELL INCLUDED IN MONTHLY MONITORING (SURVEYED LOCATION AND ELEVATION)

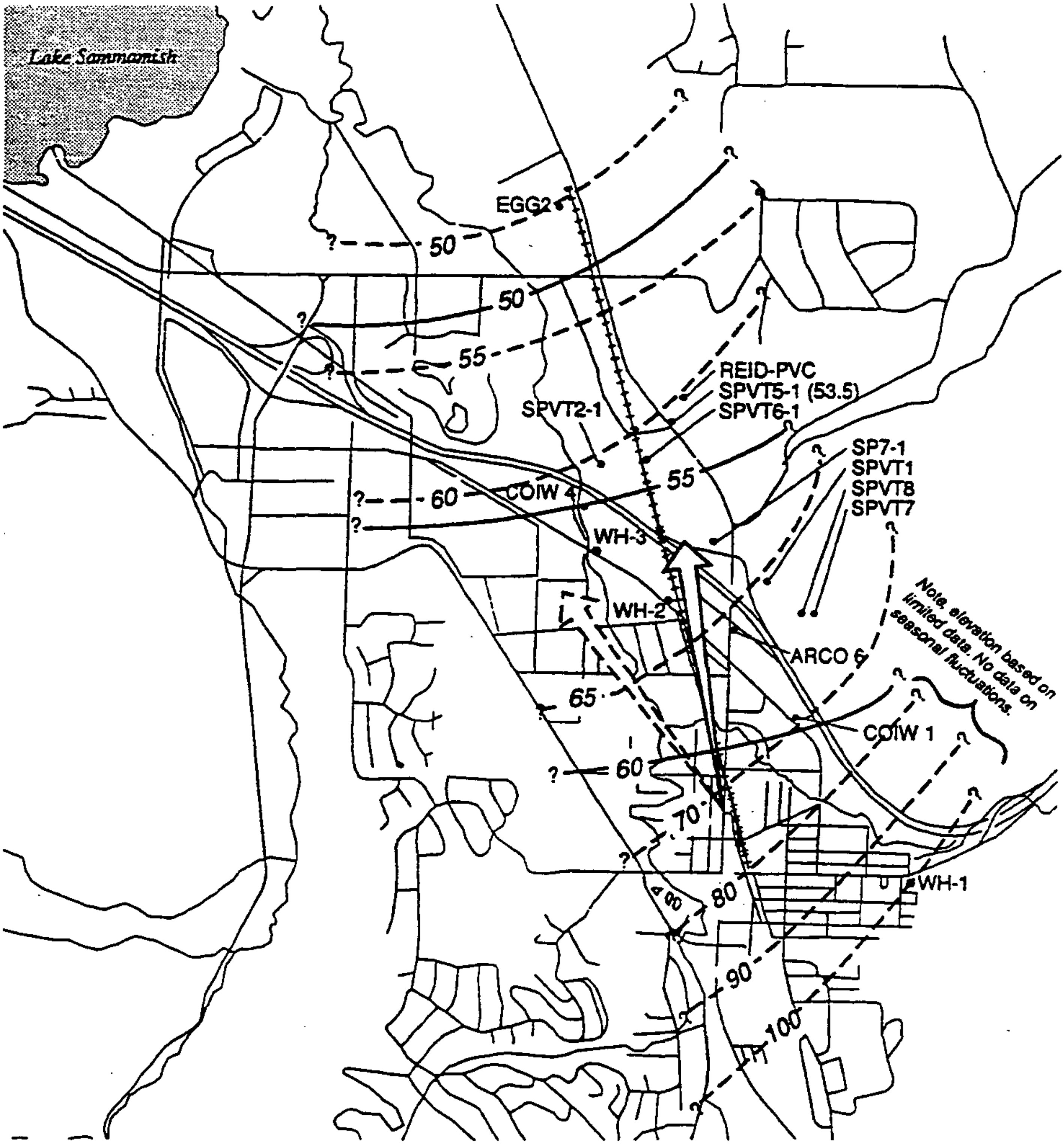
WELL LOCATION AND INFORMATION OBTAINED FROM WELL LOGS (ESTIMATED LOCATION AND ELEVATION)

SCALE IN FEET 0 2500 5000

N

- 200 - 200 FOOT CONTOUR INTERVAL

Fig. 7.3.
Well Location
Water Level Map




Note: Groundwater levels are approximate based on hand-smoothed 1992 hydrographs. A complete year of data are not available for WH-1, WH-2 and WH-3.

Source: Wellhead Protection Study
Golder Associates 1993

Low flow (September) Groundwater elevation contour (feet msl)

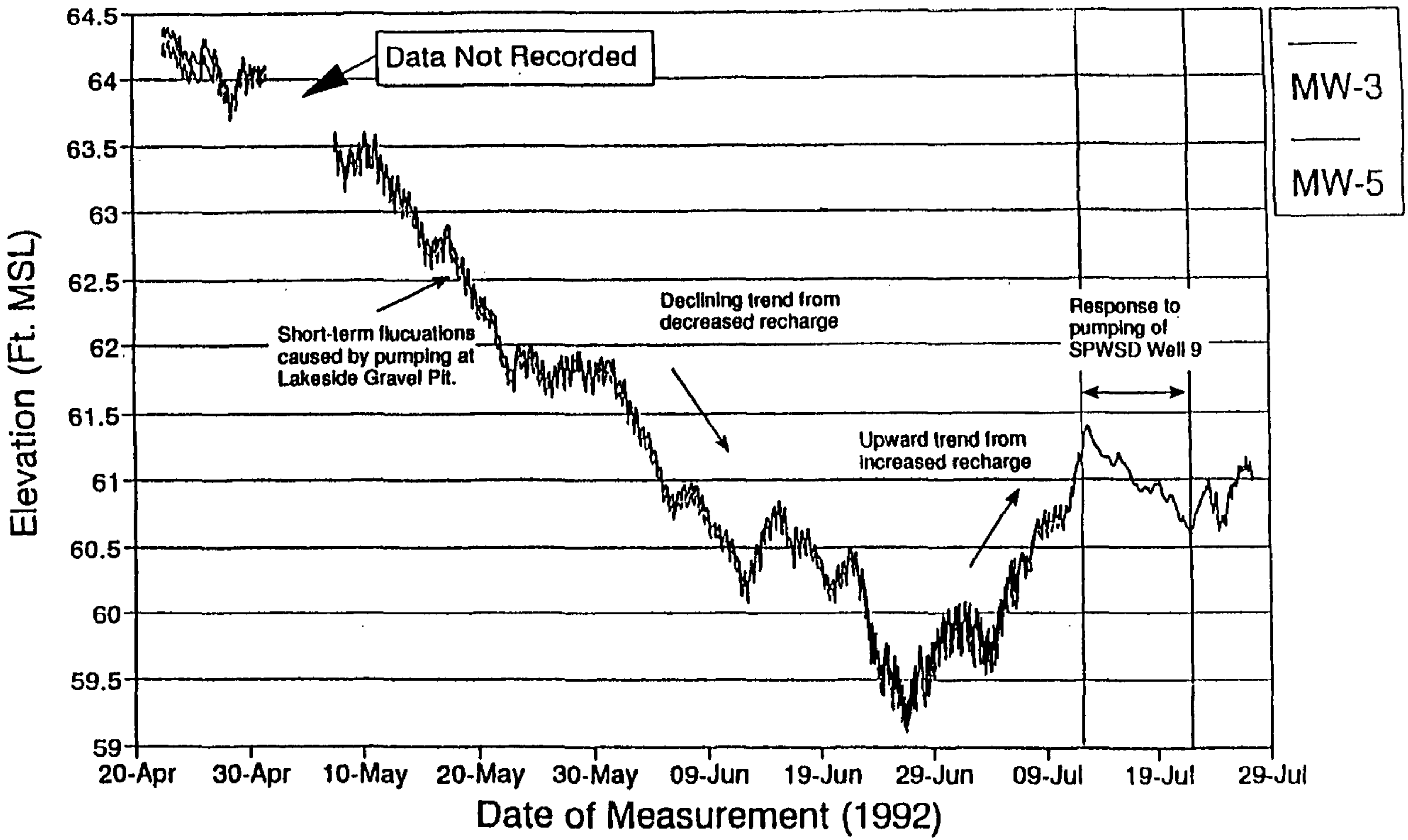
High flow (February) Groundwater elevation contour (feet msl)

Direction of groundwater flow

SCALE IN FEET
0 1000 2000

N

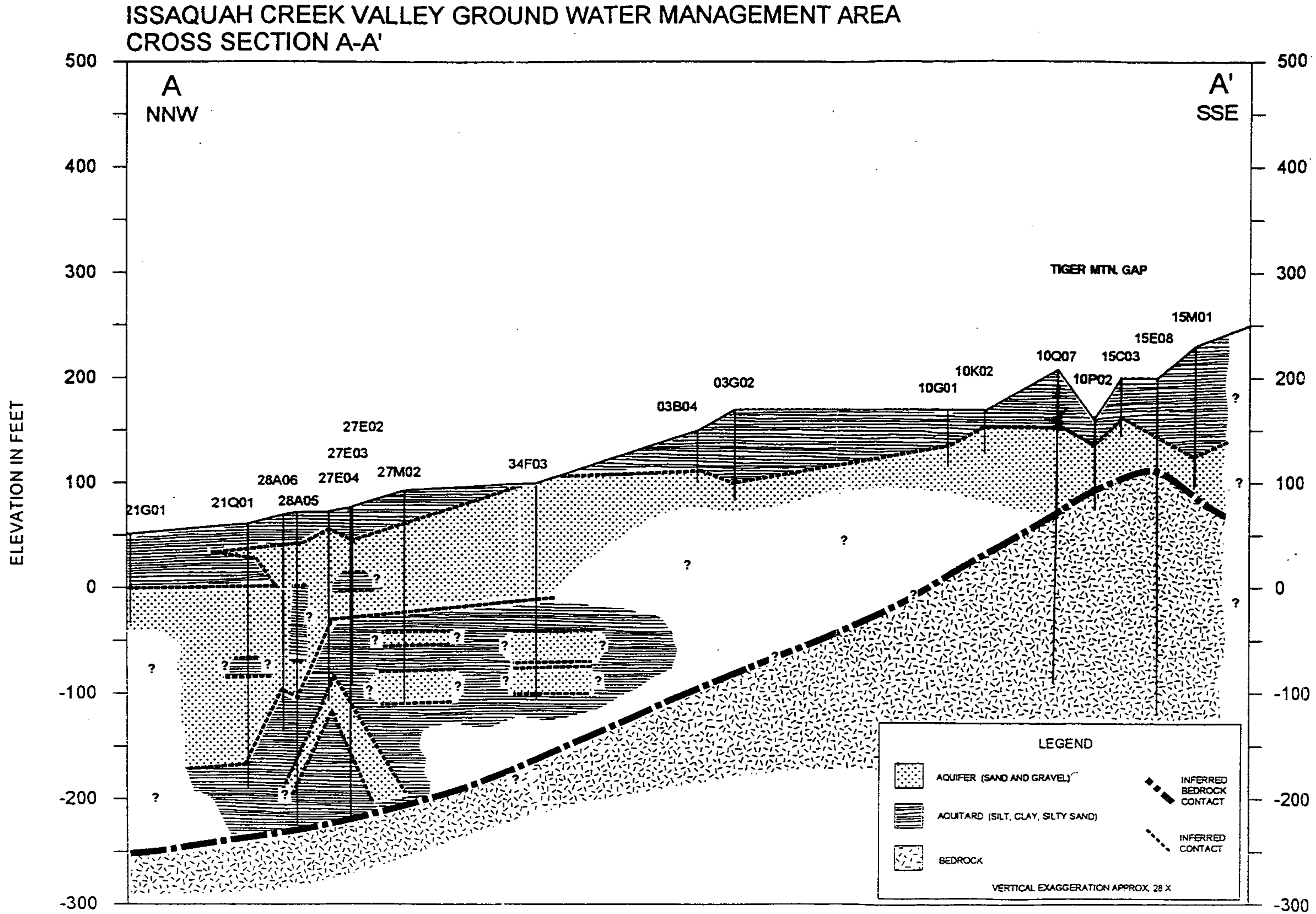
Fig. 7.4.
Seasonal Ground Water Levels and Direction of Flow



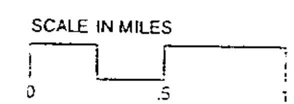

Source: Wellhead Protection Study
Golder Associates 1993

Fig. 7.5. Example Water Level Hydrograph, Arco Site

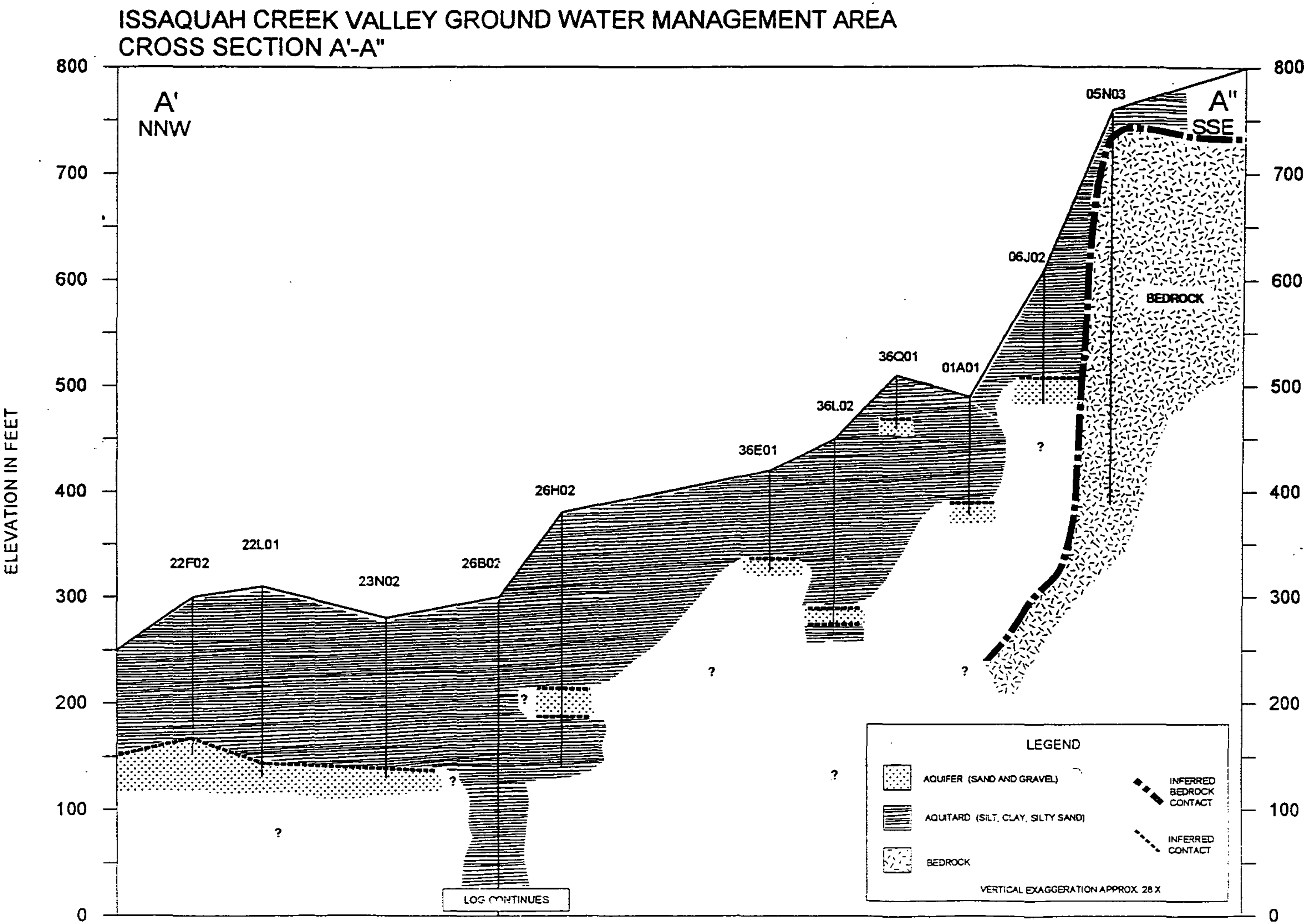
## Fig. 7.6. Cross Section A-A'




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993



## Fig. 7.7. Cross Section A'-A"

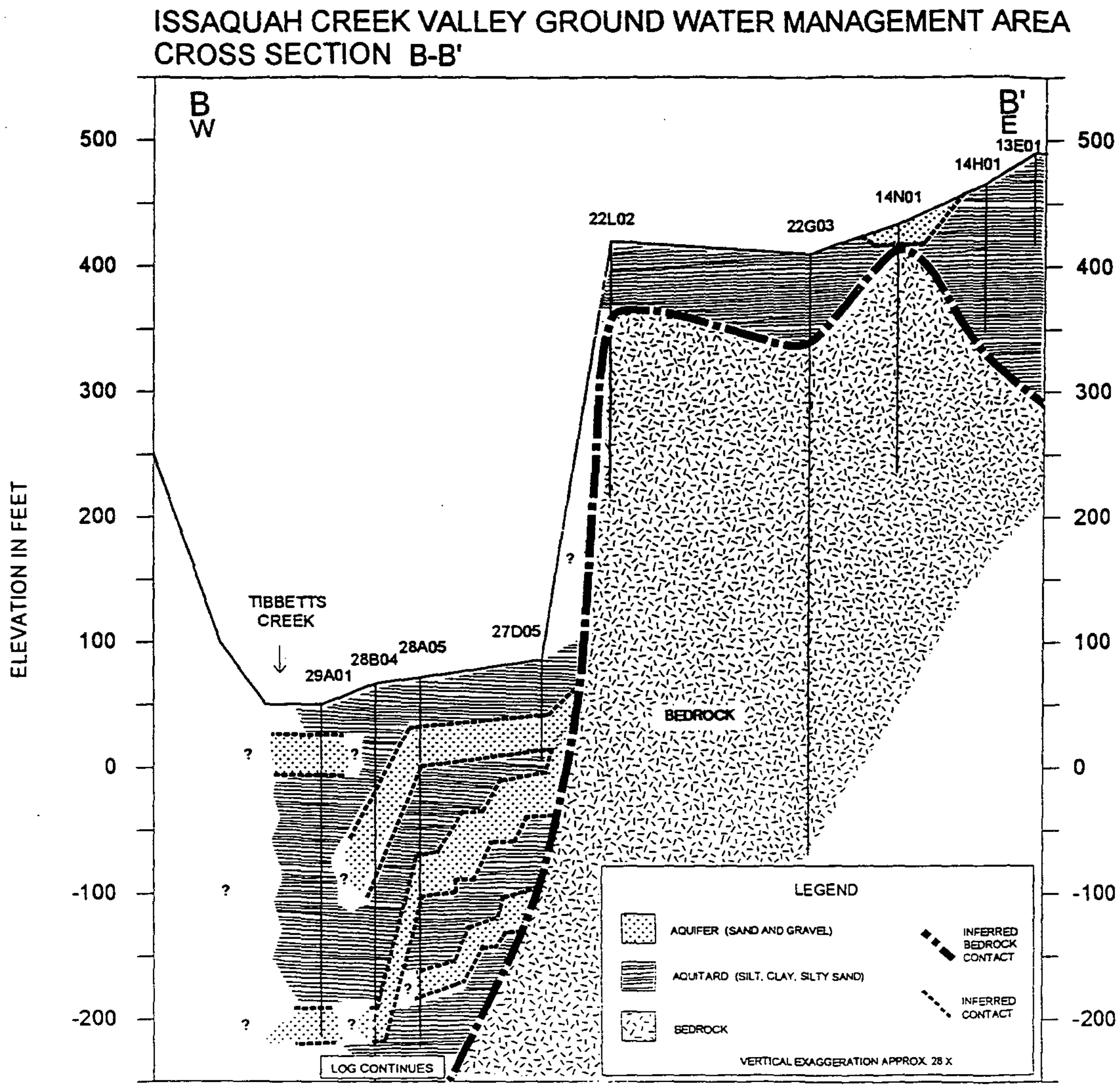



Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

SCALE IN MILES

0 .5 1

Fig. 7.8. Cross Section B-B'




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

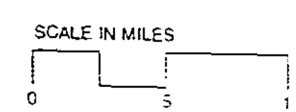
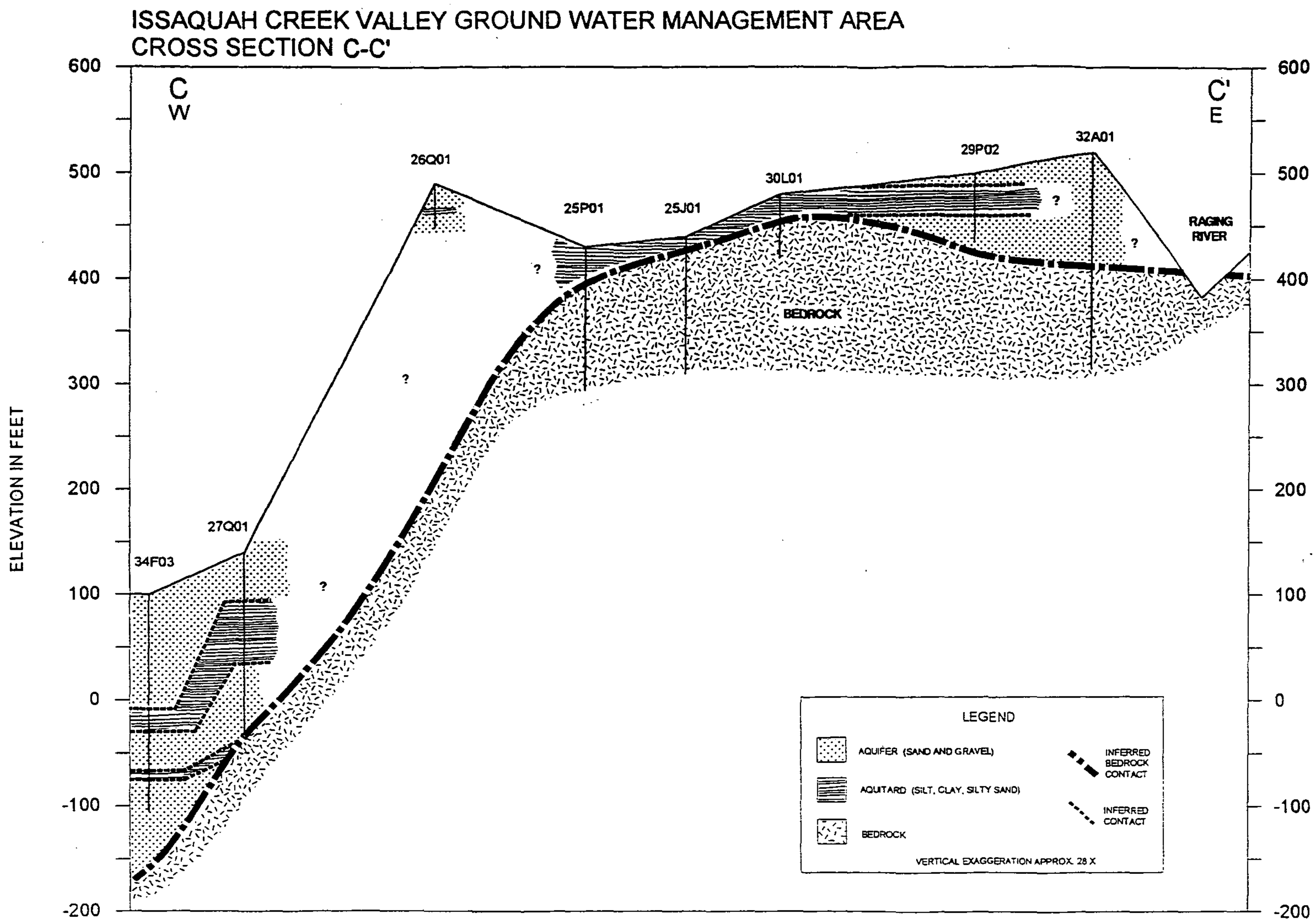
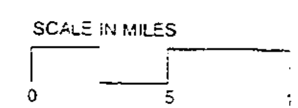
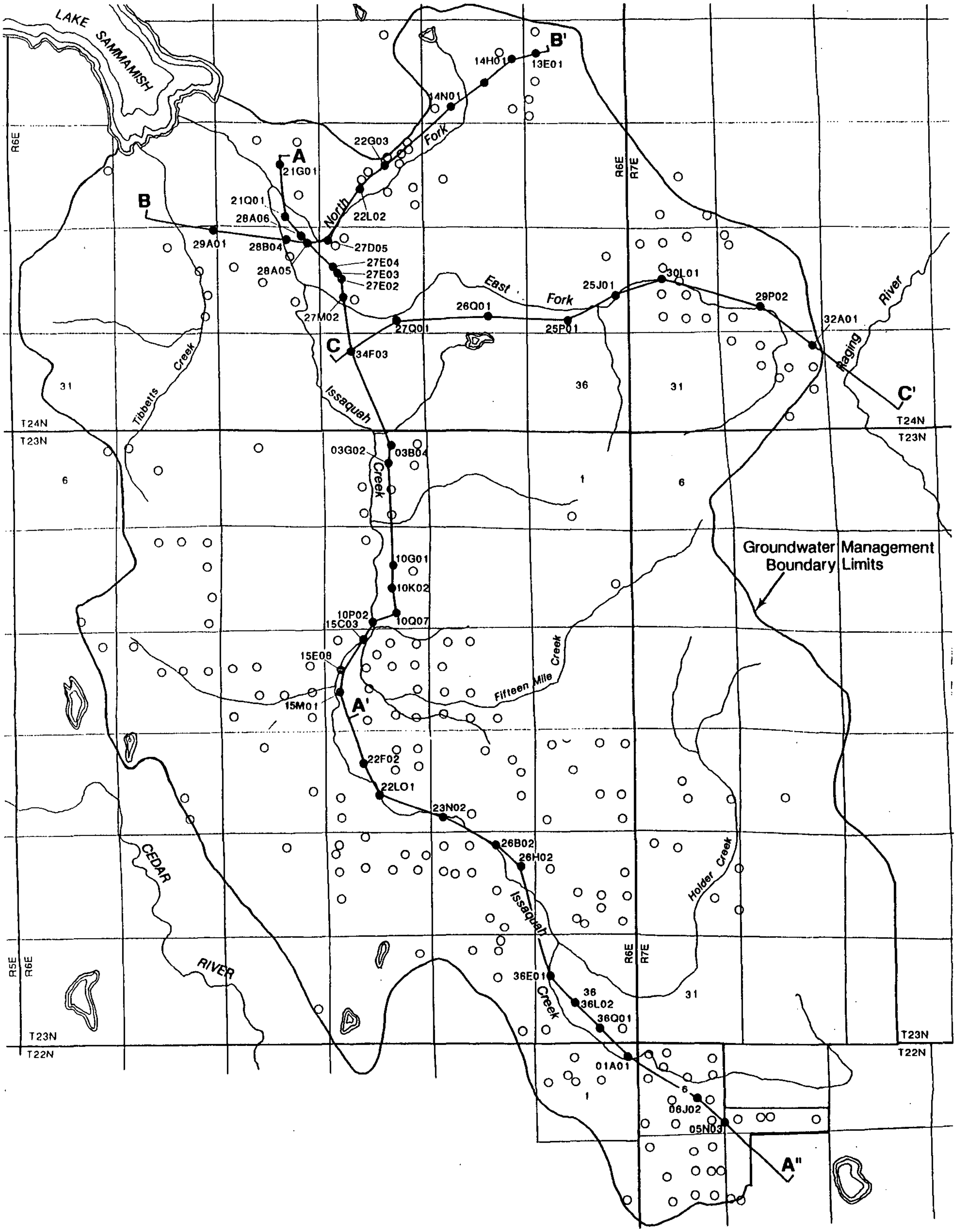


Fig. 7.9. Cross Section C-C'




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993






Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

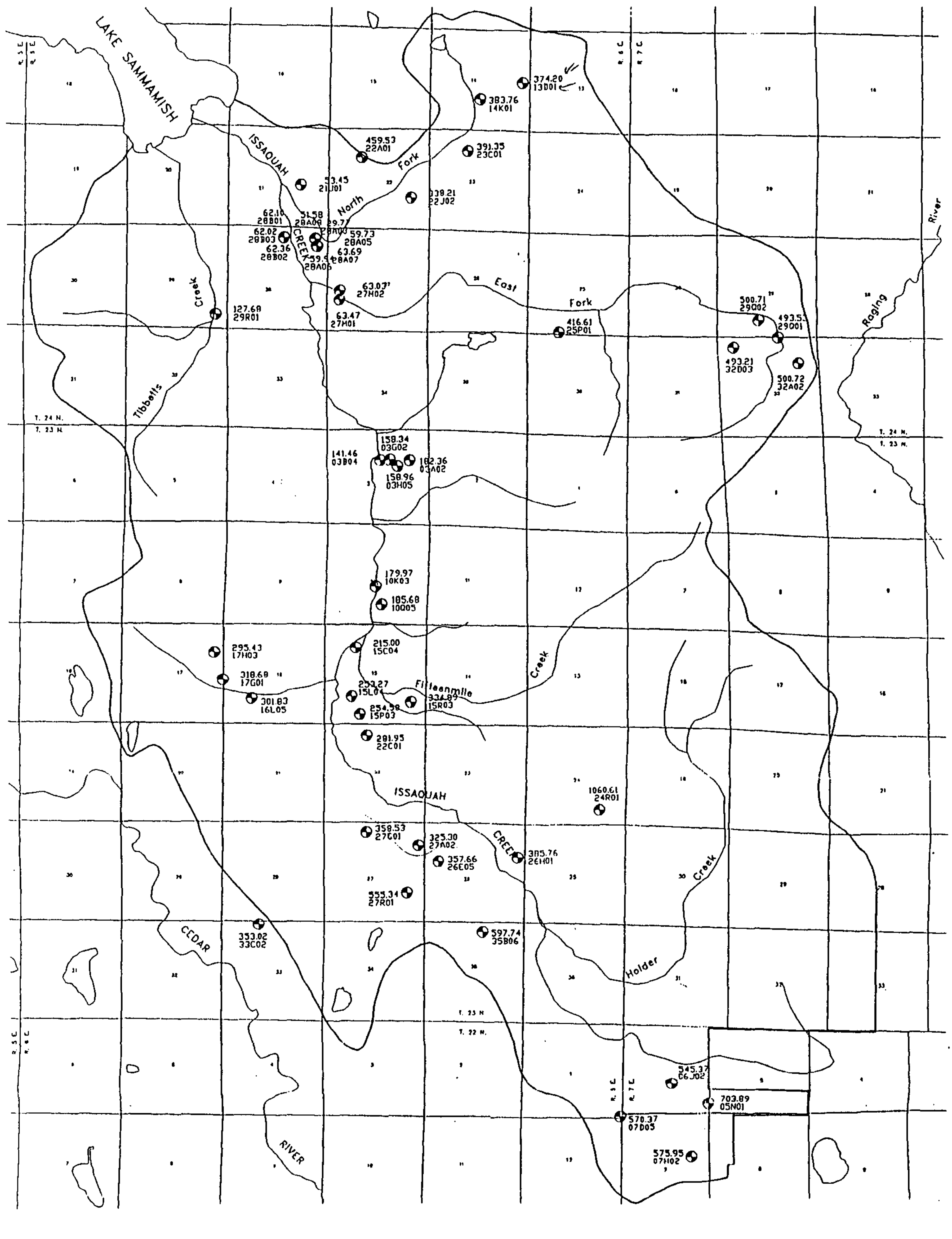
SCALE IN FEET 0 2500 5000

○ Approximate Well location from IGWMA Database

15C03 ● Approximate Well location used in Hydrogeologic Cross Section with well number identifier, use Township (T-N) & Range (R-E) from margin. First number in identifier is Section number.

A — A' Hydrogeologic Cross Section location

Fig. 7.10. Cross Section Location Map




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

338.21 — WATER LEVEL

WELL INCLUDED IN MONTHLY MONITORING

22JO2 — LOCATION IDENTIFYER

SCALE IN FEET

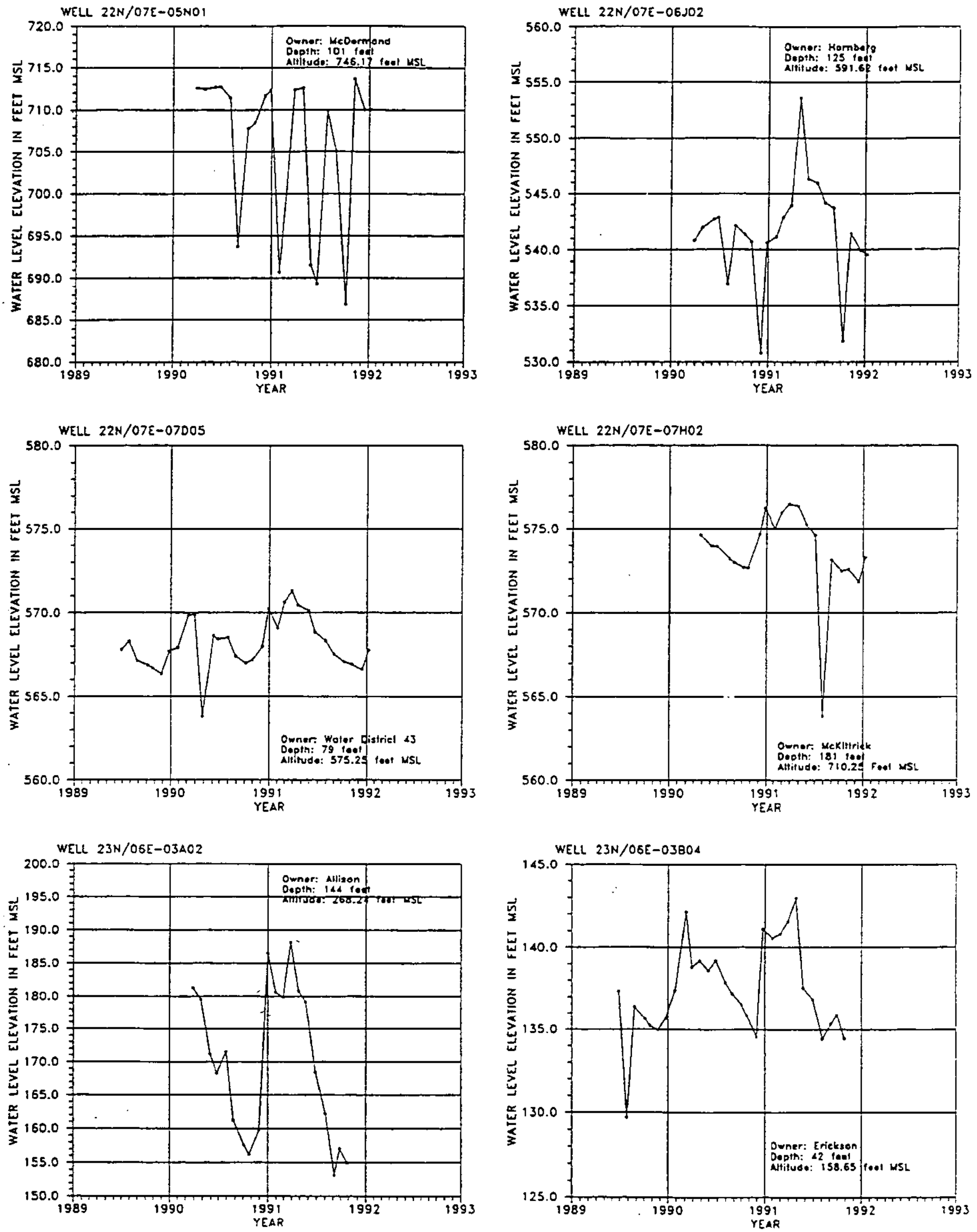
0 2500 5000

N

WATER LEVELS MEASURED DECEMBER 1990

Fig. 7.11. Well Location Map

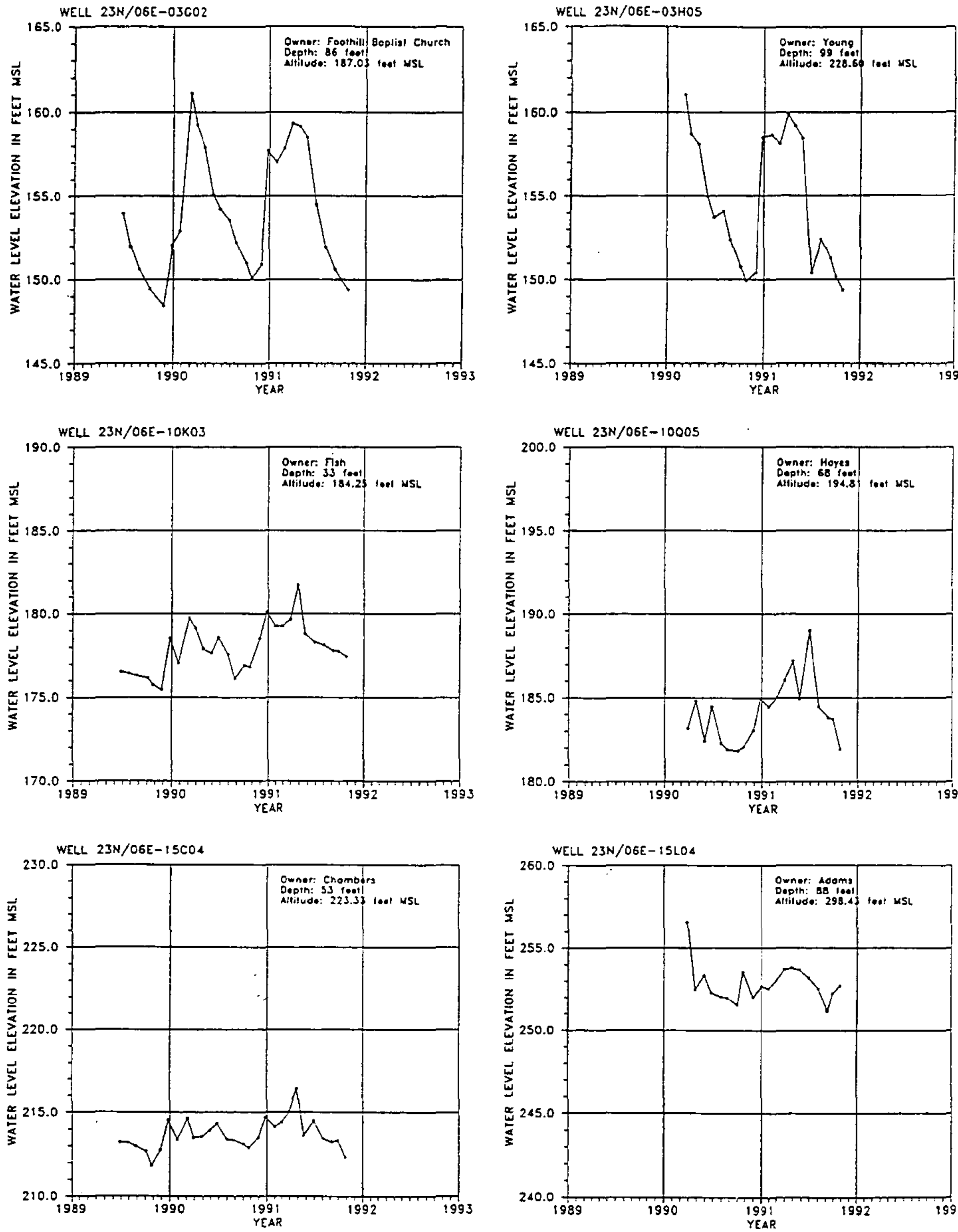
# Issaquah Ground Water Management Program




Source: Task 5: Hydrogeological Report -
Carr/Association Sept. 1993

Fig. 7.12A. Water Level Trend

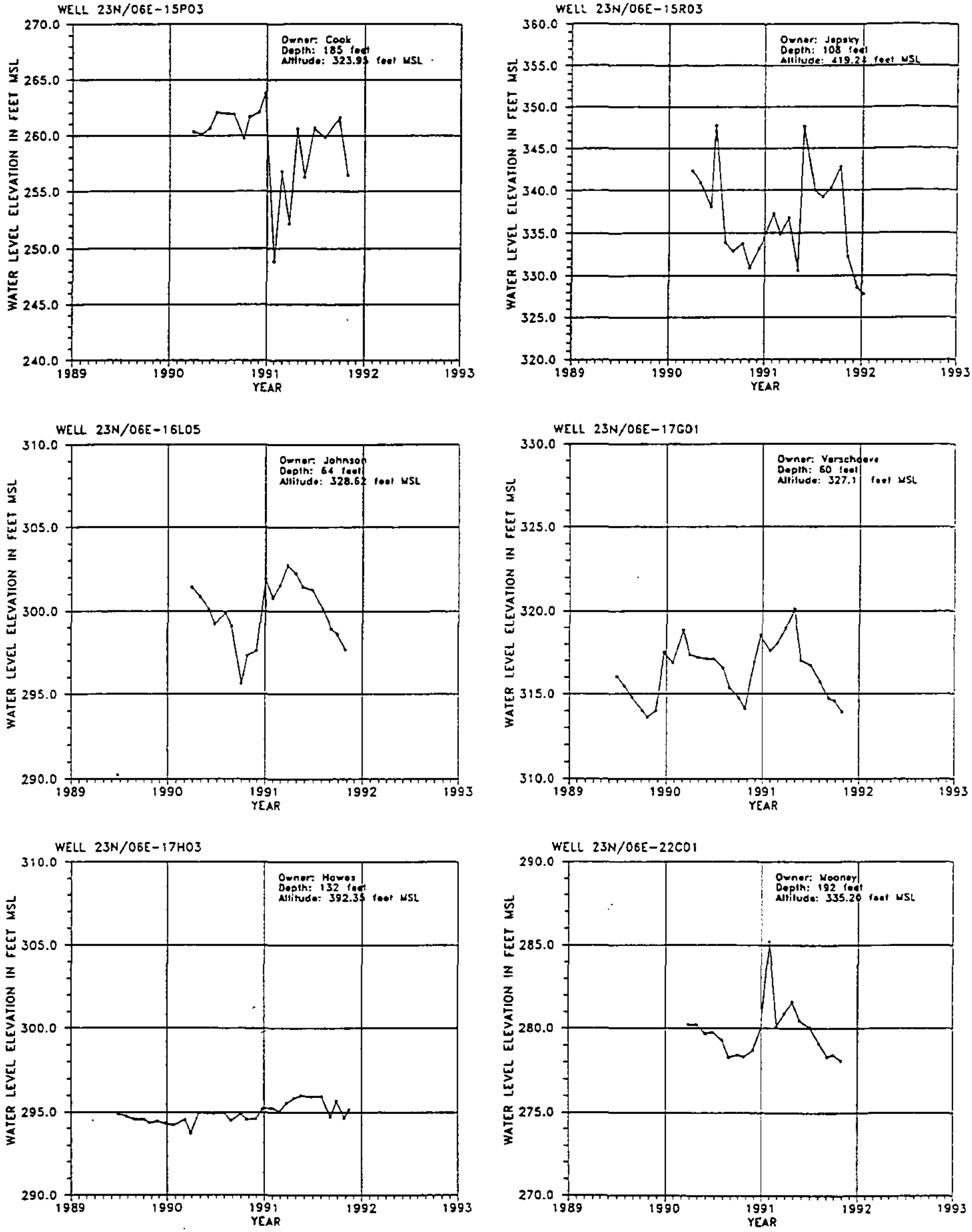
# Issaquah Ground Water Management Program




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

Fig. 7.12B. Water Level Trend

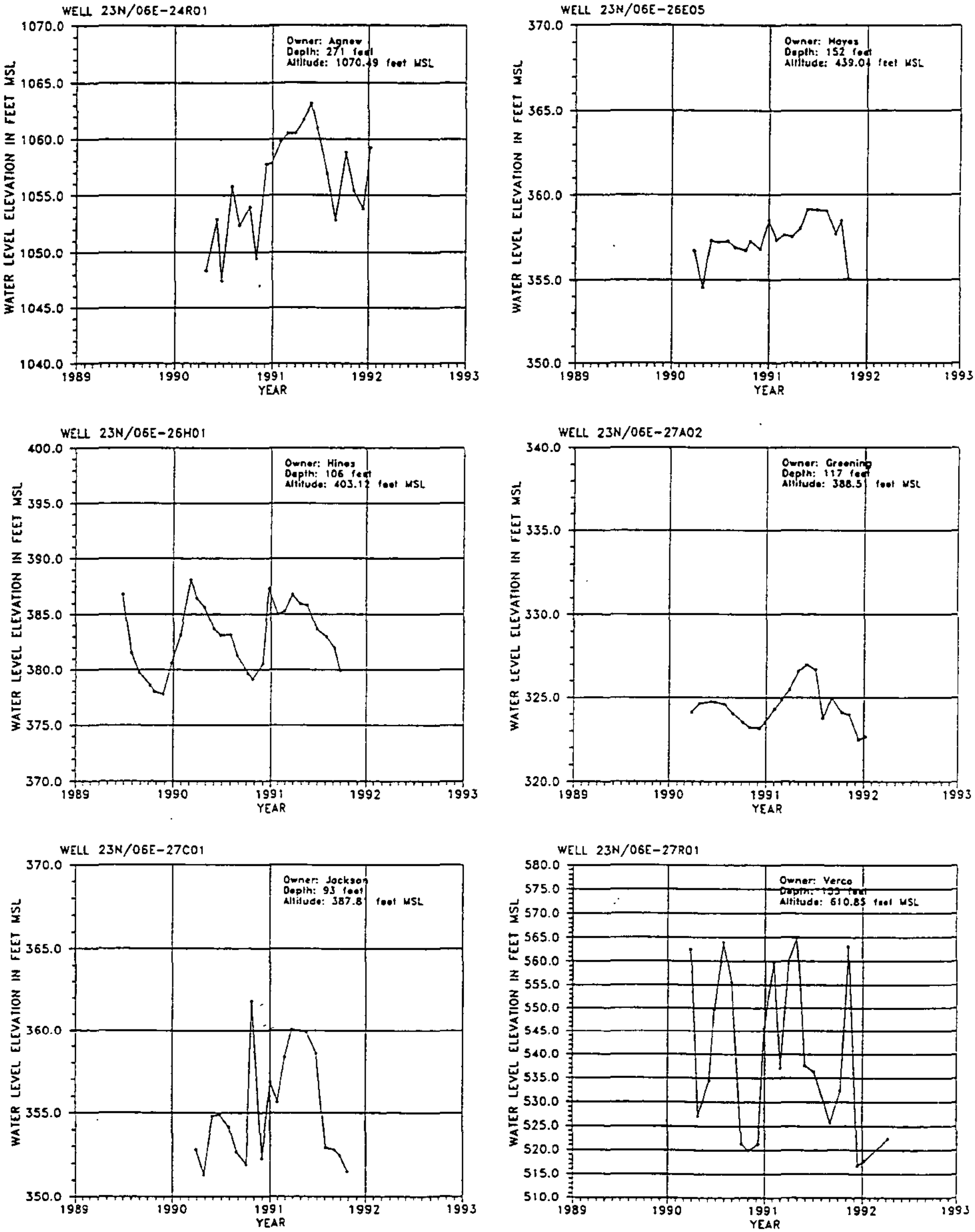
# Issaquah Ground Water Management Program




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

## Fig. 7.12C. Water Level Trend

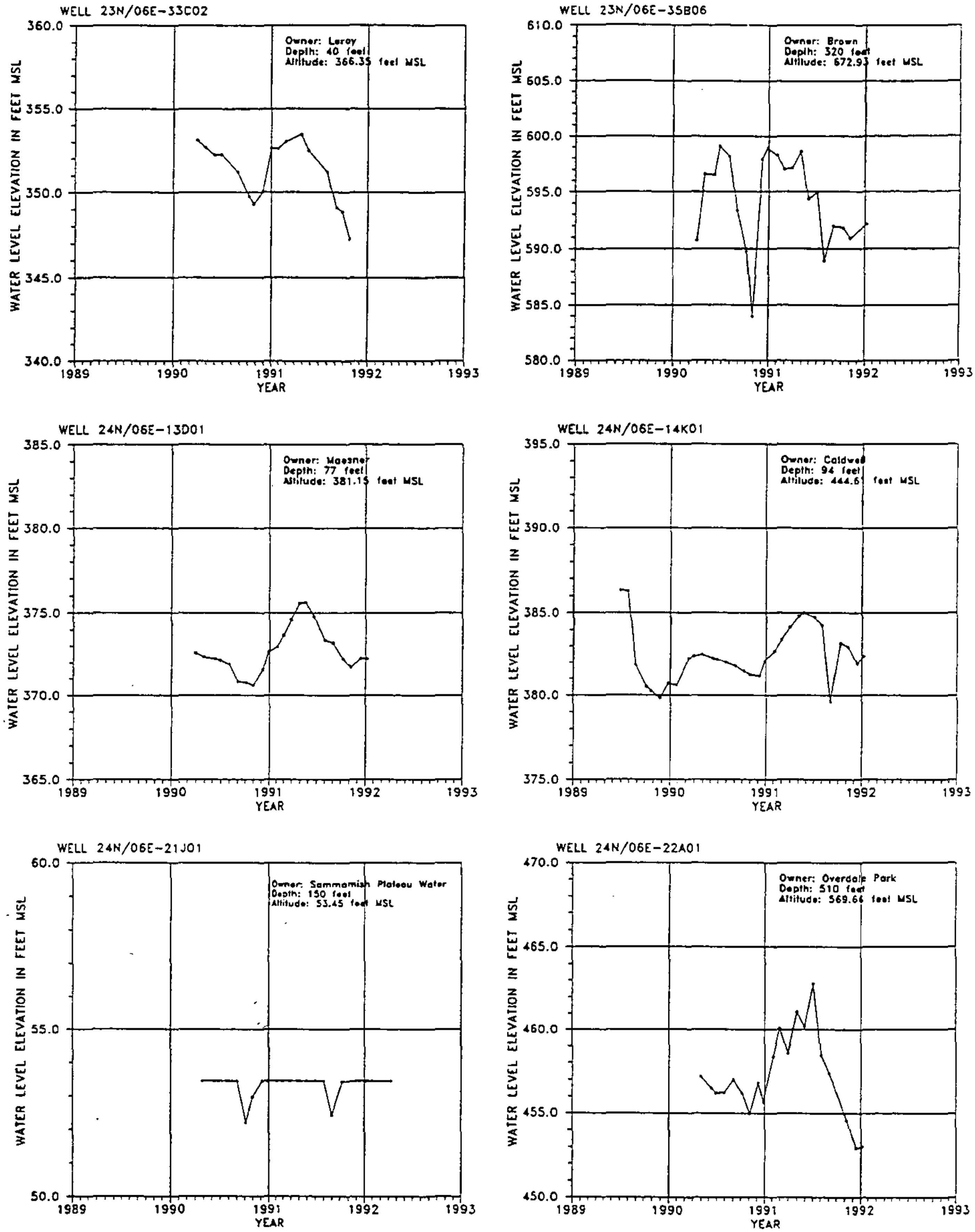
# Issaquah Ground Water Management Program




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

**Fig. 7.12D. Water Level Trend**

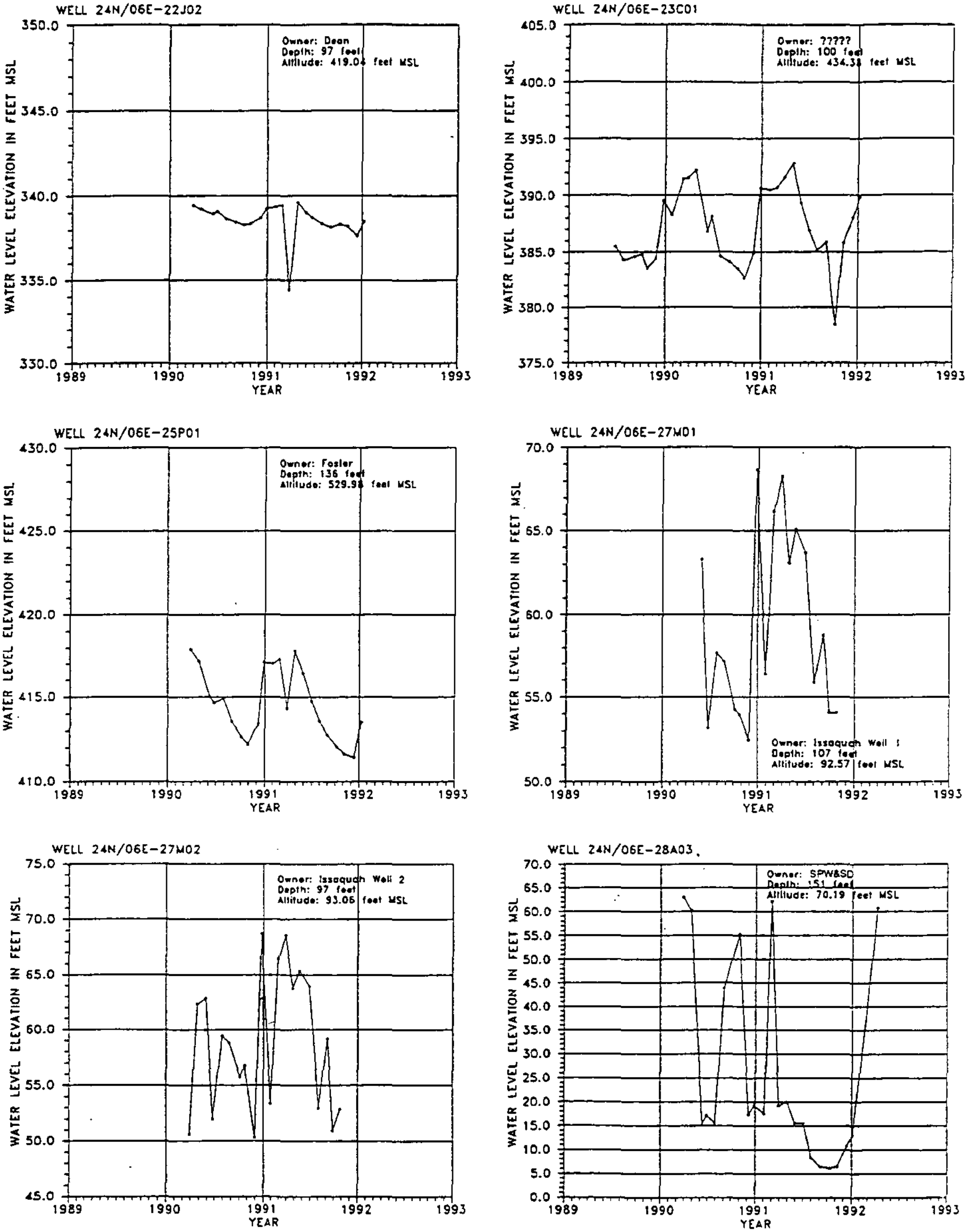
# Issaquah Ground Water Management Program




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

Fig. 7.12E. Water Level Trend

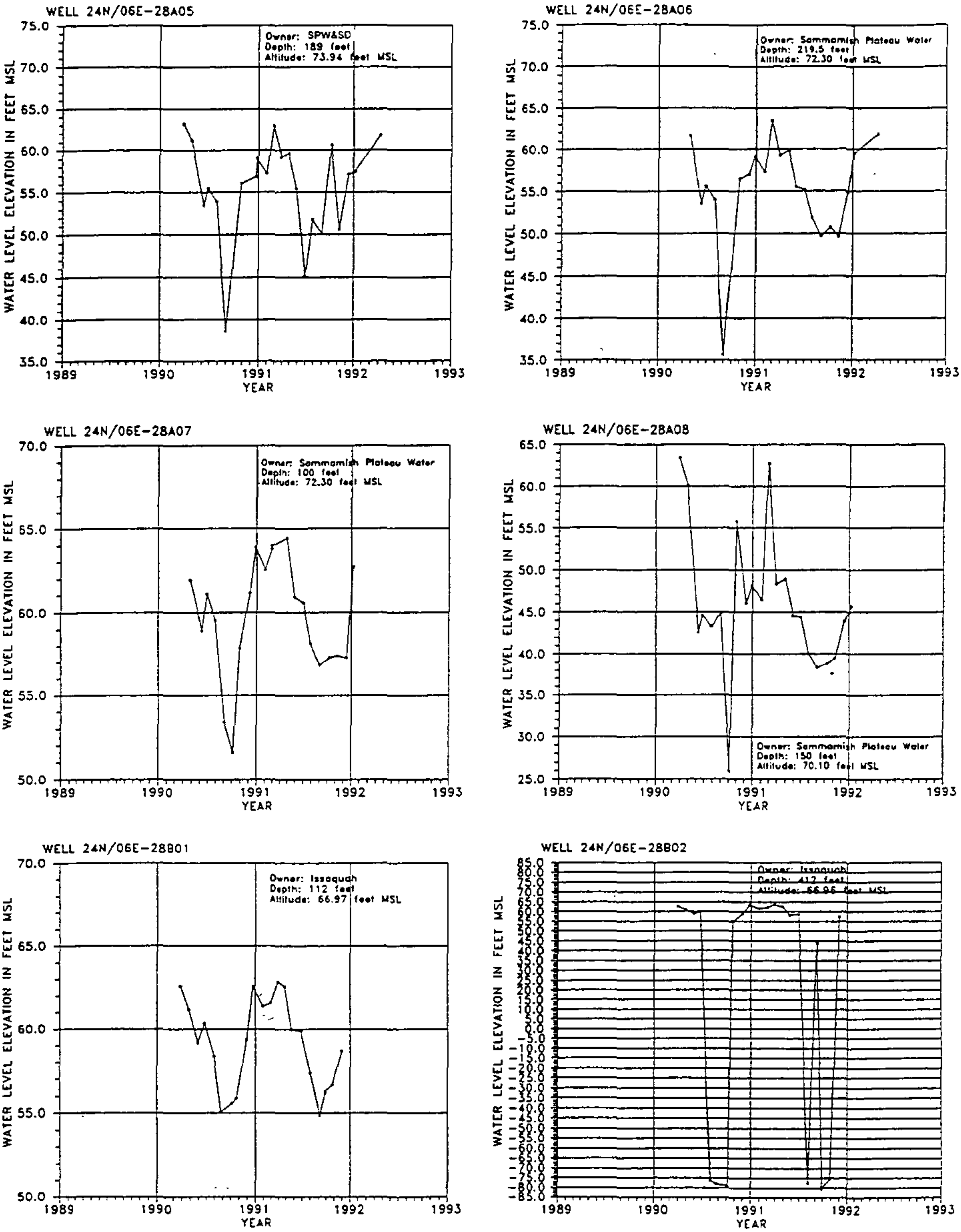
# Issaquah Ground Water Management Program




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

**Fig. 7.12F. Water Level Trend**

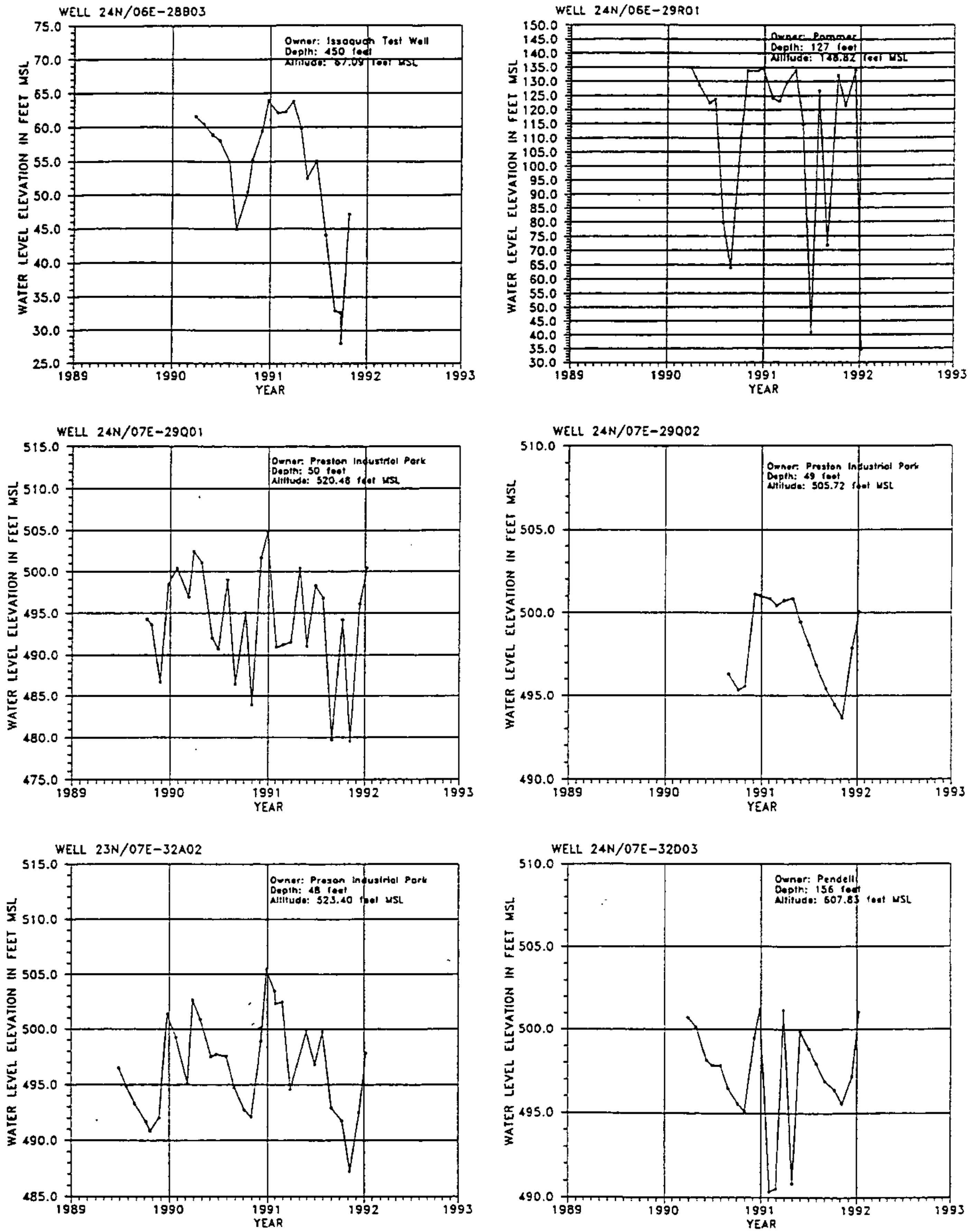
# Issaquah Ground Water Management Program




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

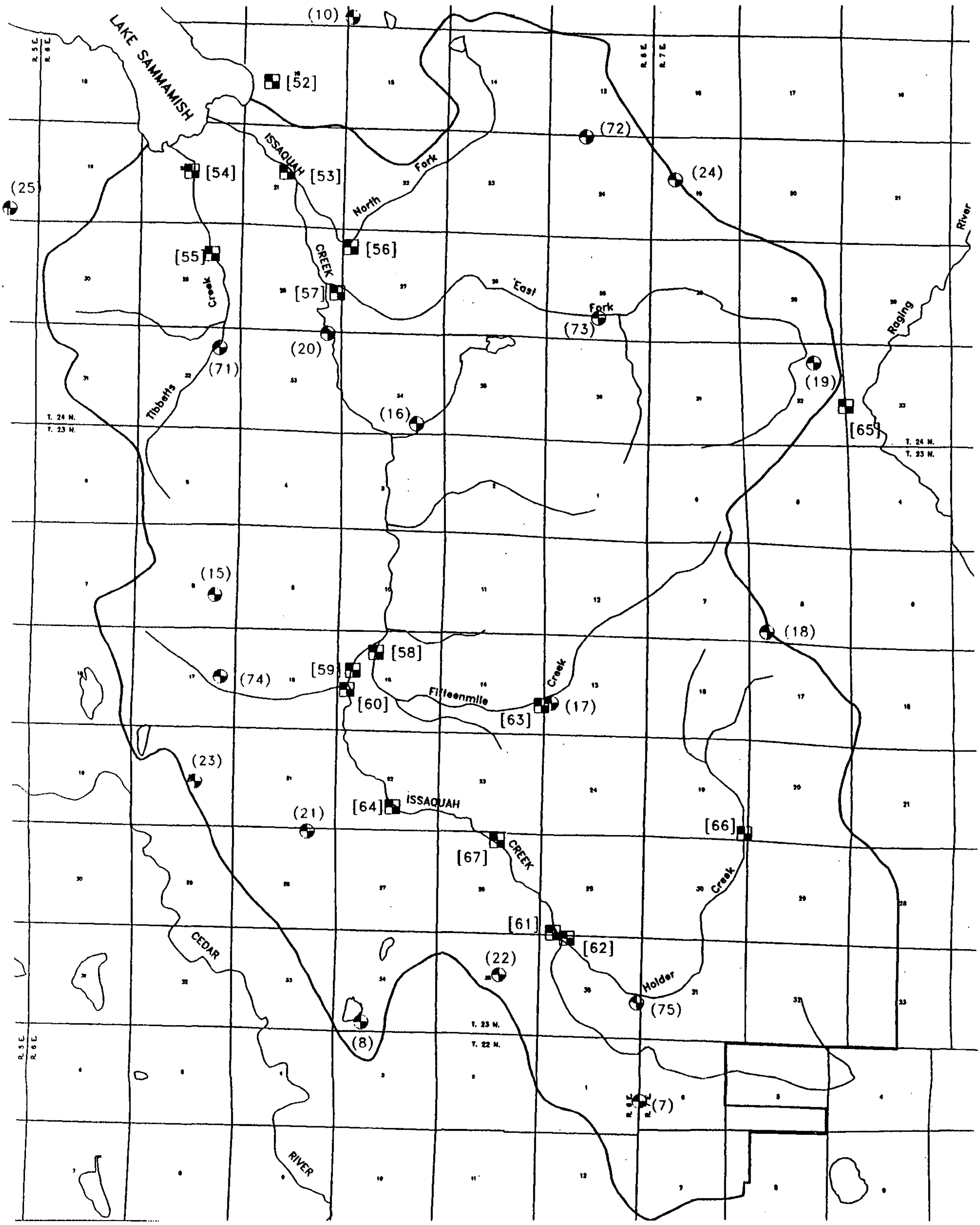
Fig. 7.12G. Water Level Trend

# Issaquah Ground Water Management Program




Source: Task 5: Hydrogeological Report - Carr/Association Sept. 1993

**Fig. 7.12H. Water Level Trend**




Source: Task 5: Hydrogeological Report - Carr/Associates, Sept. 1993

(75) Precipitation Gage and Number

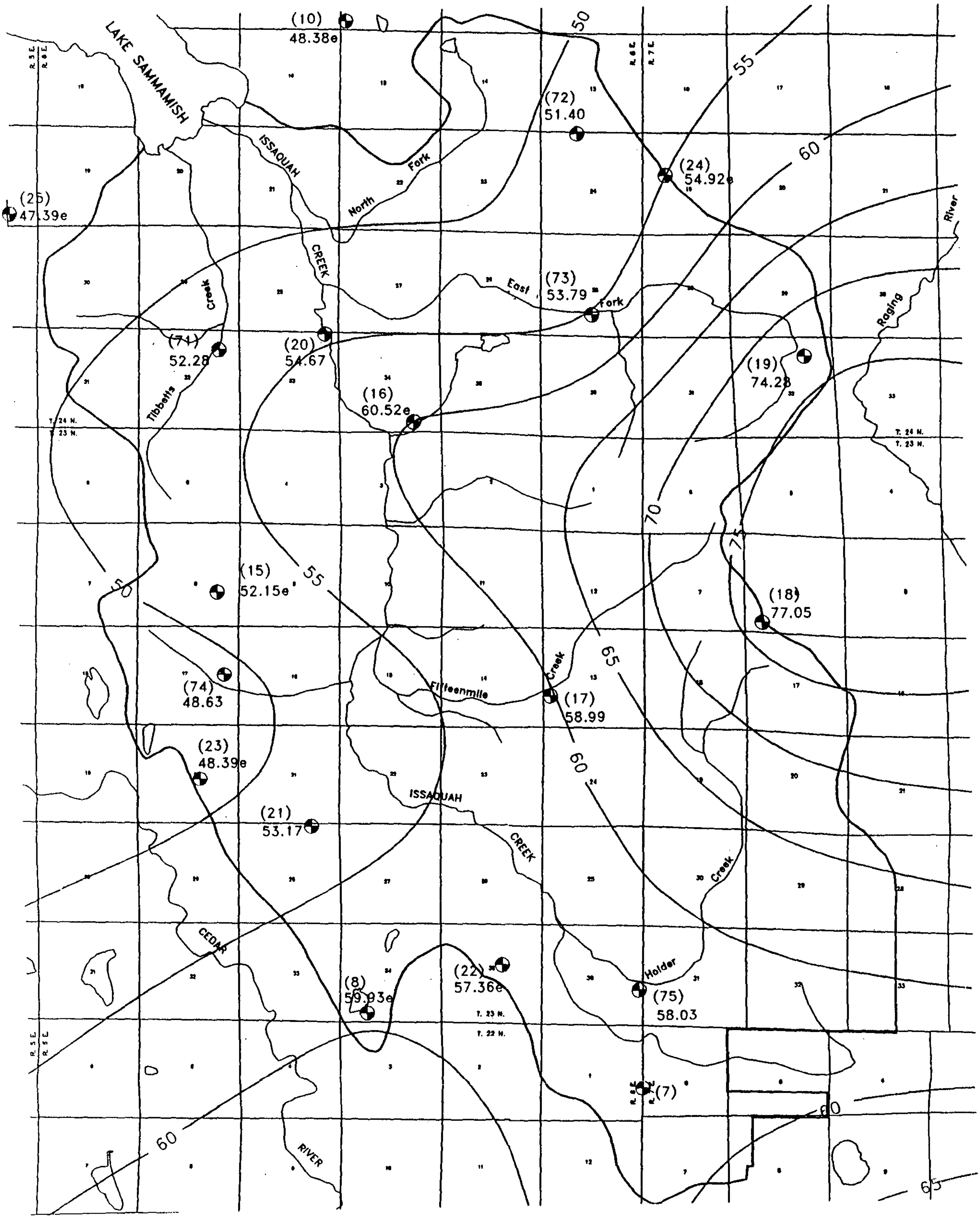
[62] Stream Gage and Number

SCALE IN FEET

0 2500 5000

N

**Fig. 7.13. Precipitation and Stream Gauging Sites**




Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

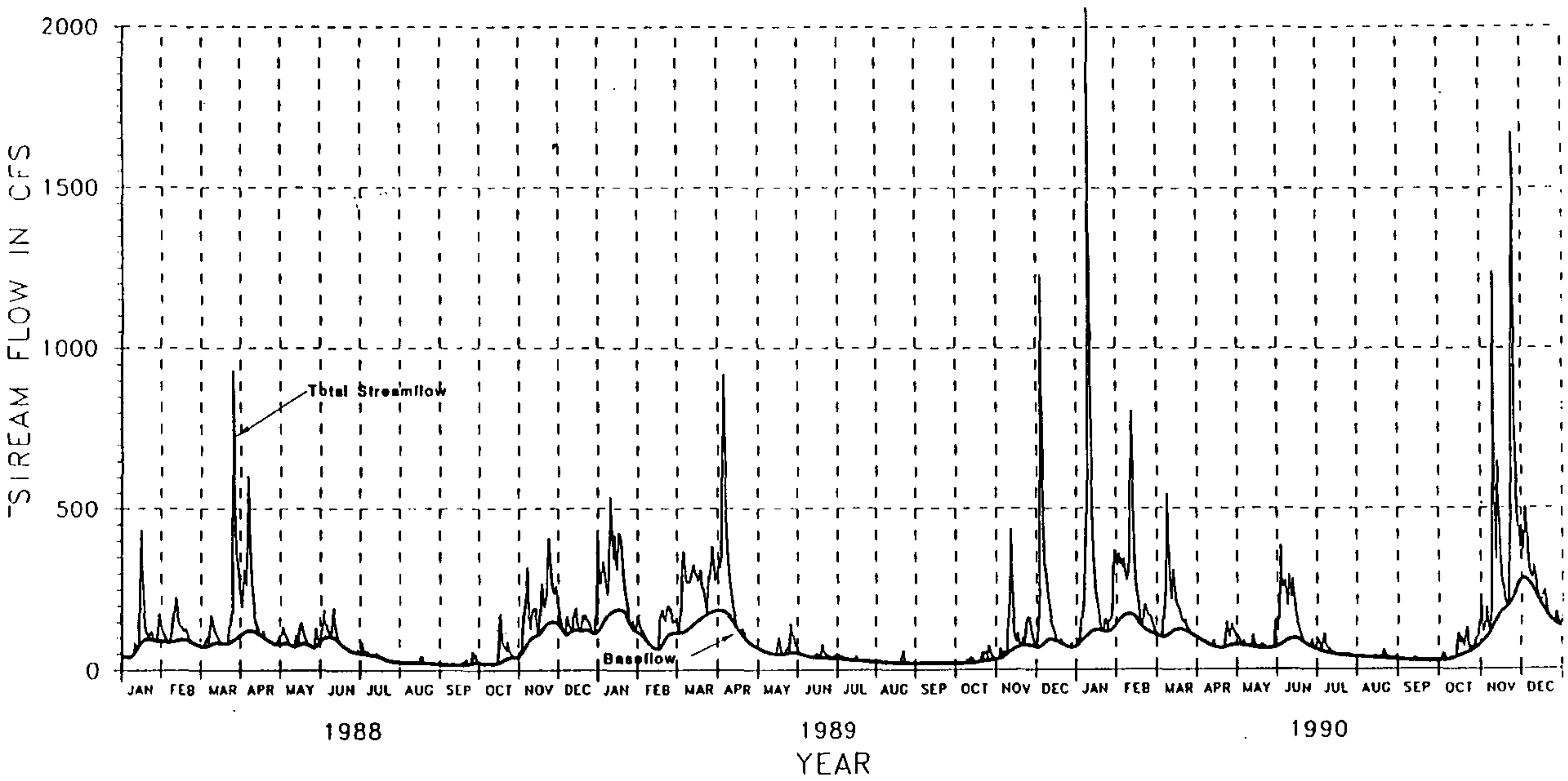
SCALE IN FEET
0 2500 5000

N

(8)
59.93e

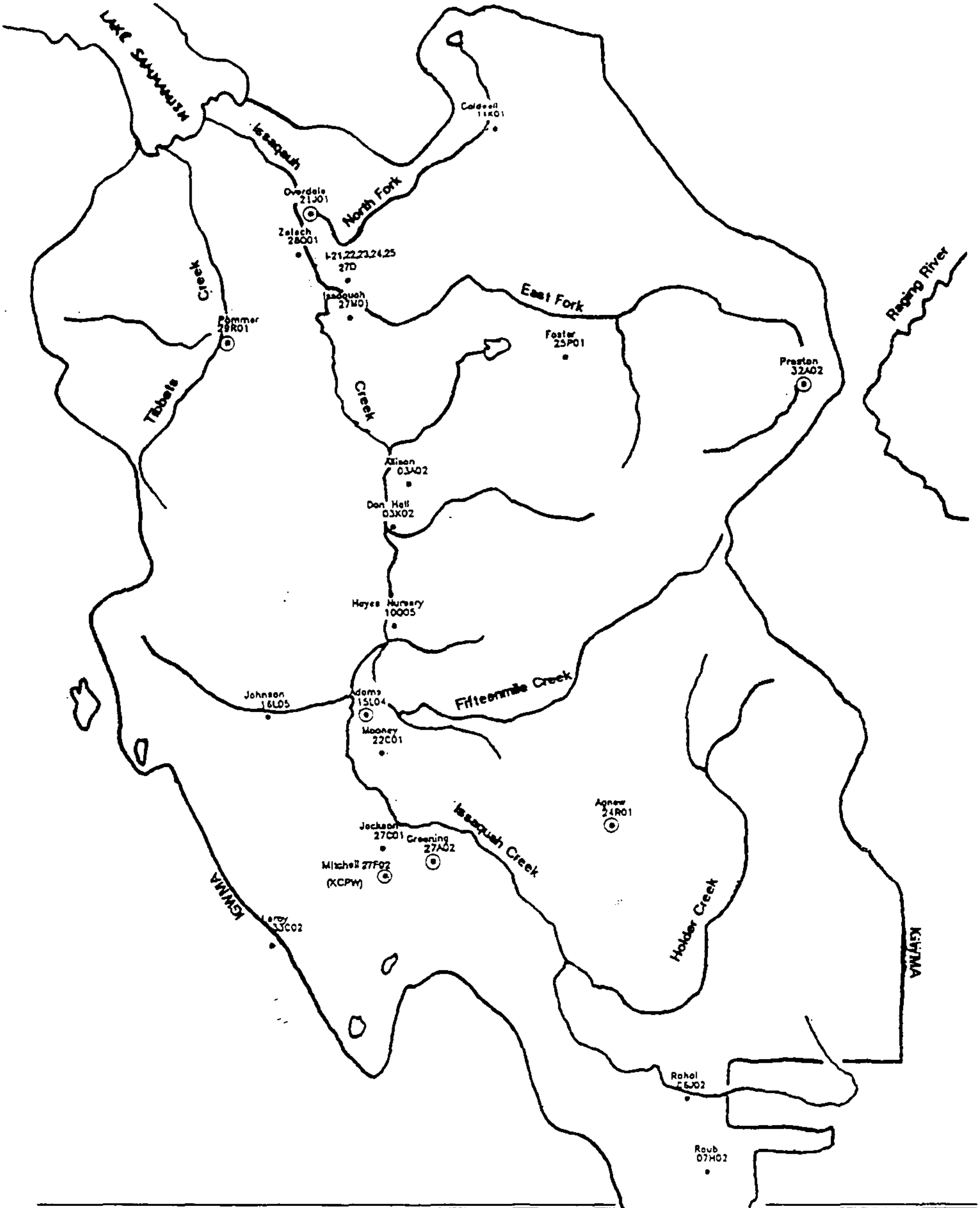
Precipitation Gage and Number and 1988 Annual Precipitation in Inches ("e" indicates that value was estimated from 1990 data)

Fig. 7.14. Precipitation Isohyetal 1988 Data Analysis




Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

Fig. 7.15. Total Stream Flow and Baseflow Hydrographs USGS Stn. 121216




Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

SCALE IN MILES

0 2500 5000

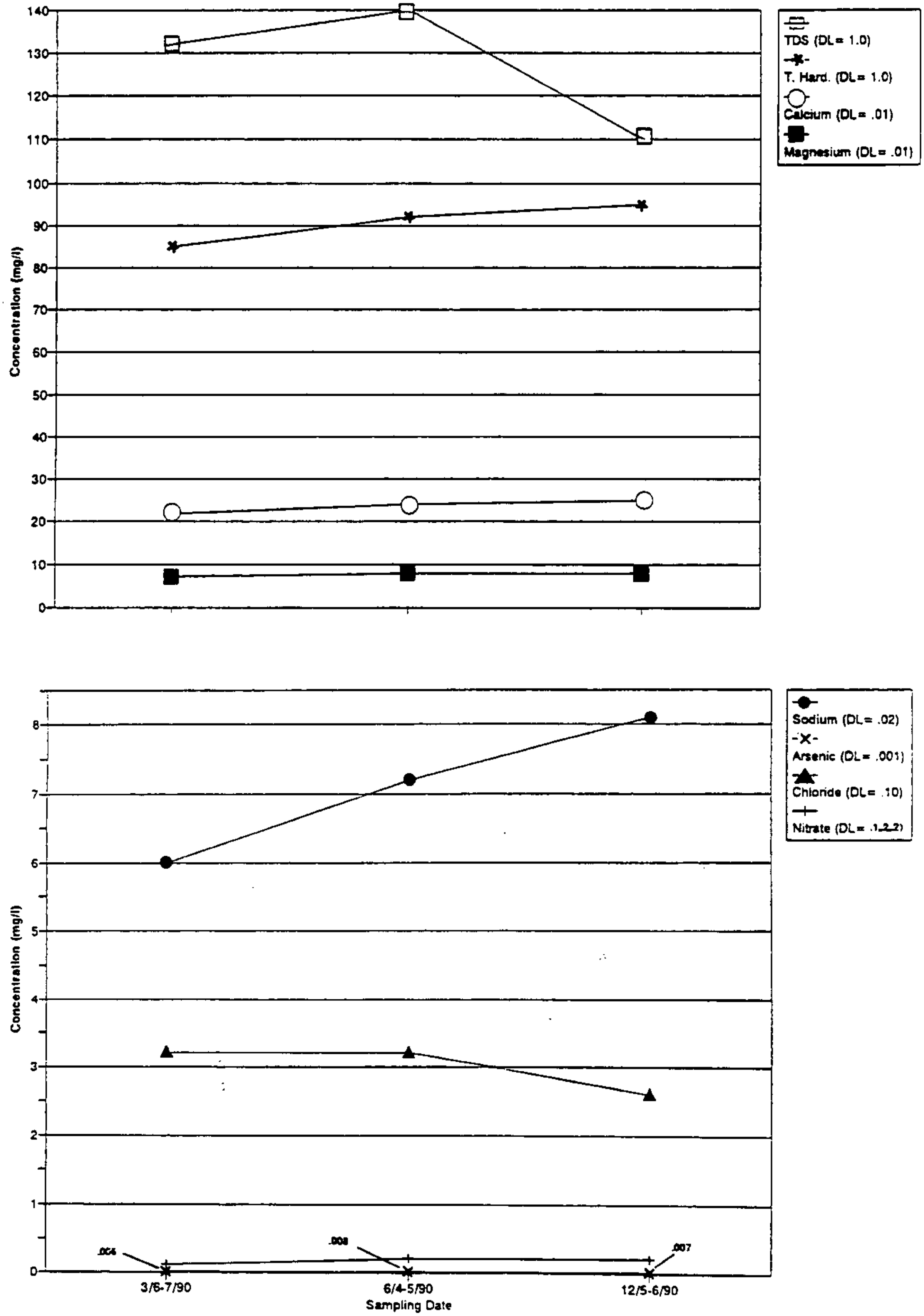
N

• - Wells sampled for the Issaquah Creek Valley Groundwater Management Program

⊙ - Wells individually graphed (figs. 4.2-4.8

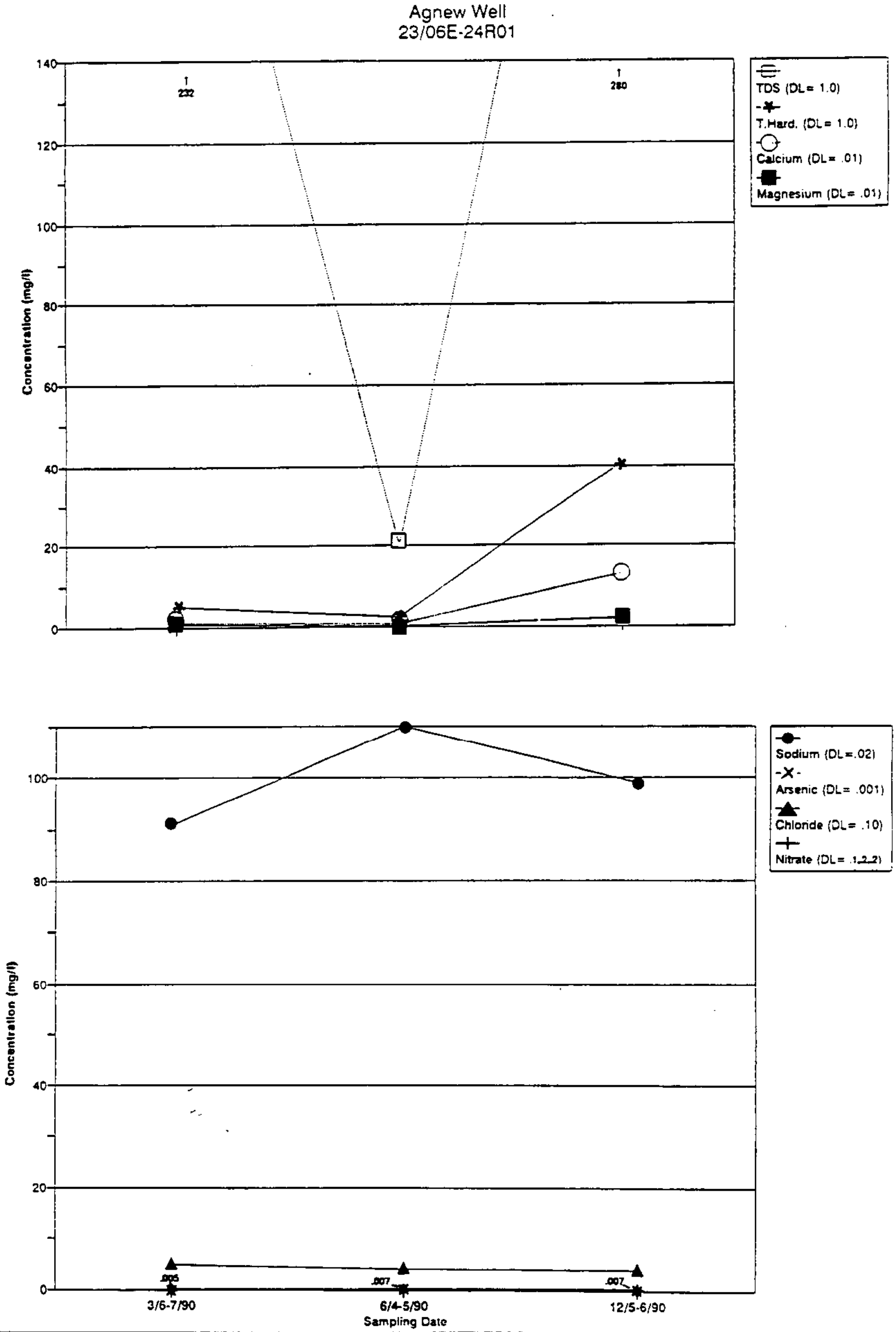
Fig. 7.16. Wells Sampled for Issaquah Ground Wate
Management Area

Adams Well
23/06E-15L04



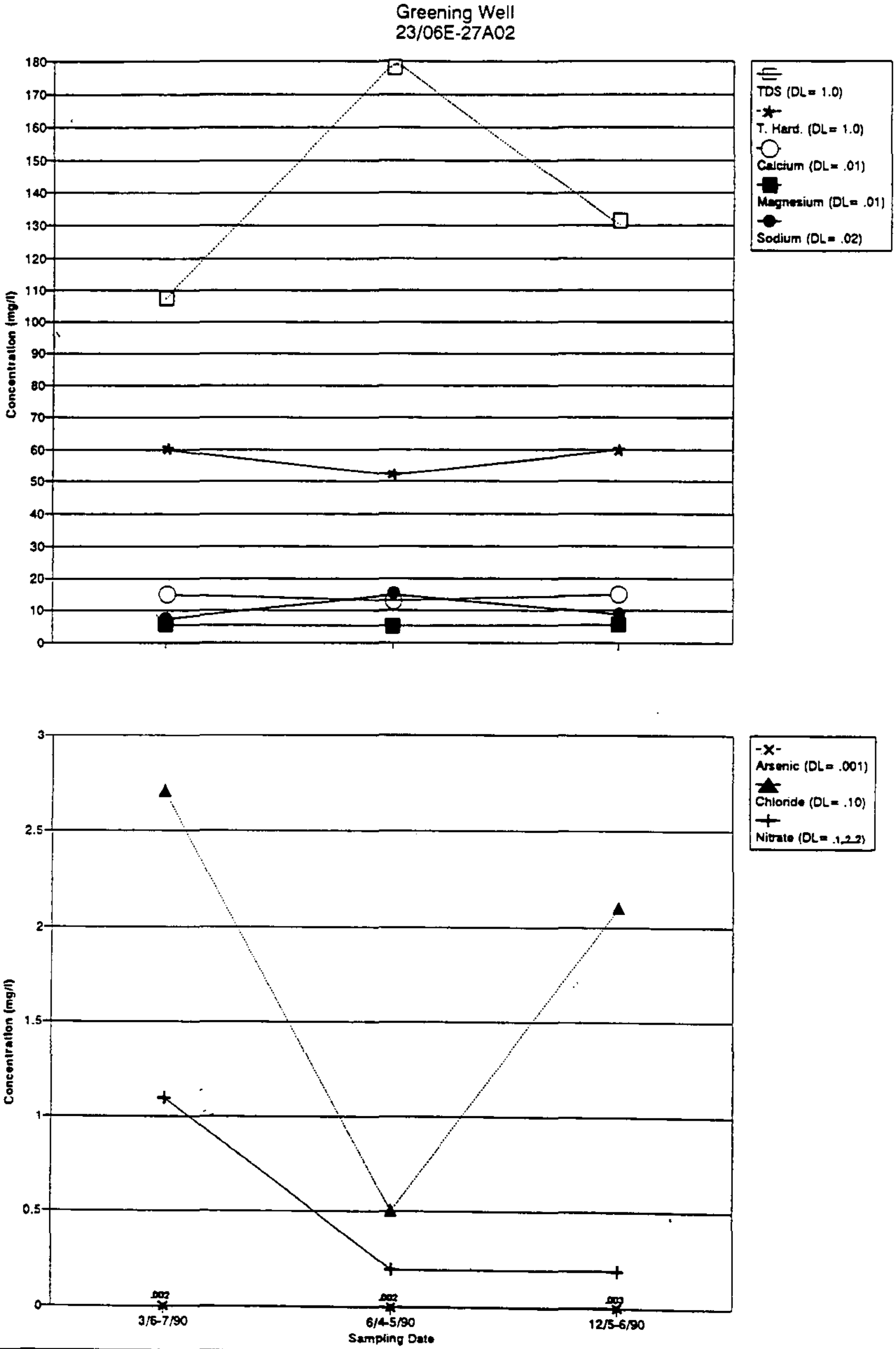

Source: Task 5: Hydrogeological Report -
Carr/Associates. Sept. 1993

Fig. 7.17. Adams Well



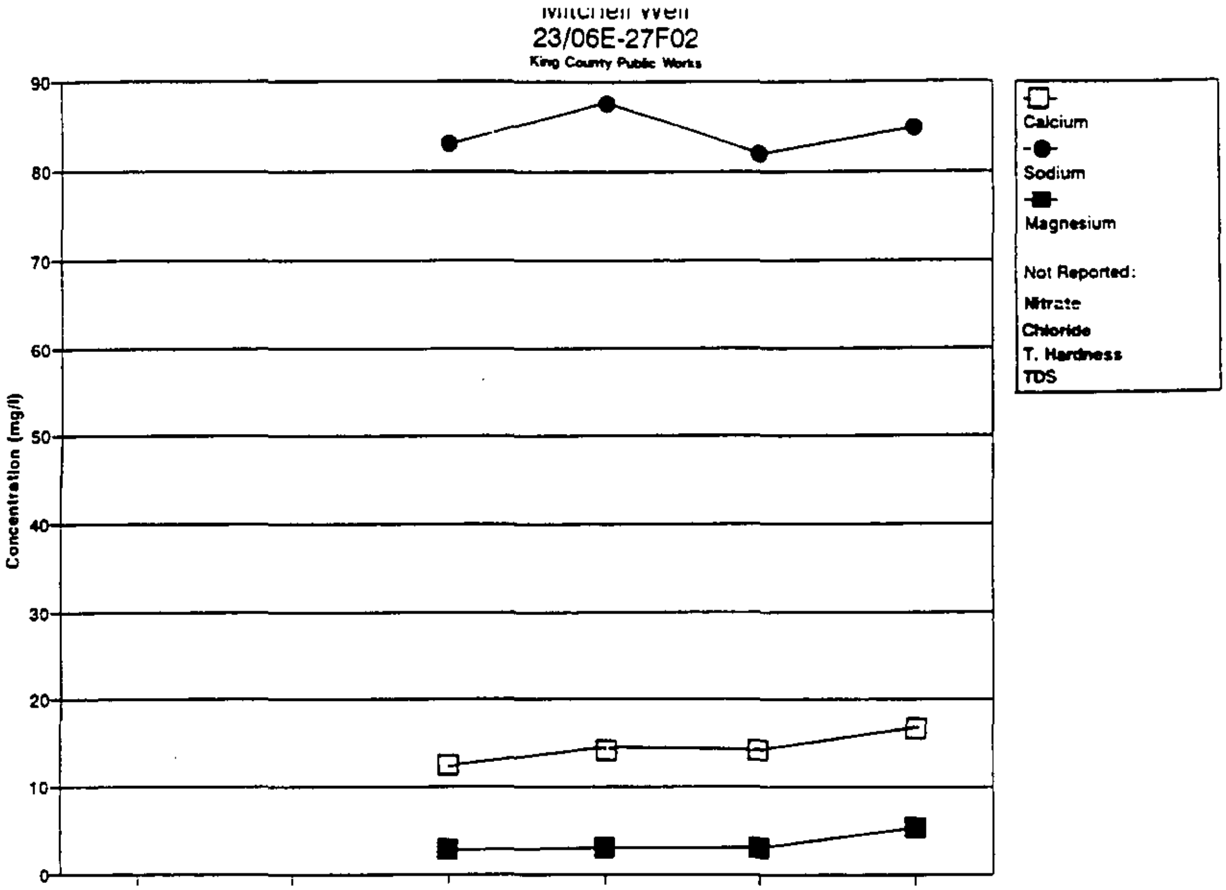

Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

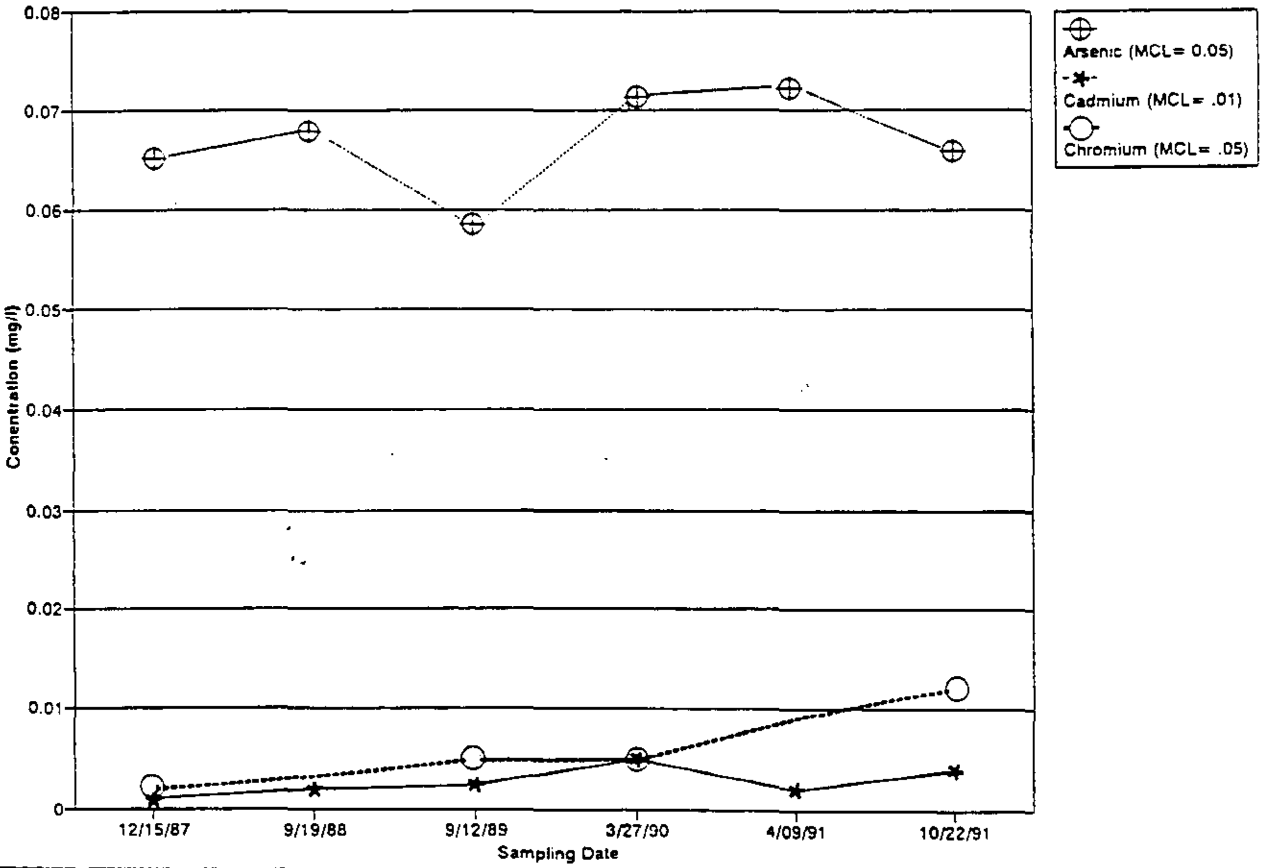
Fig. 7.18. Agnew Well




Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

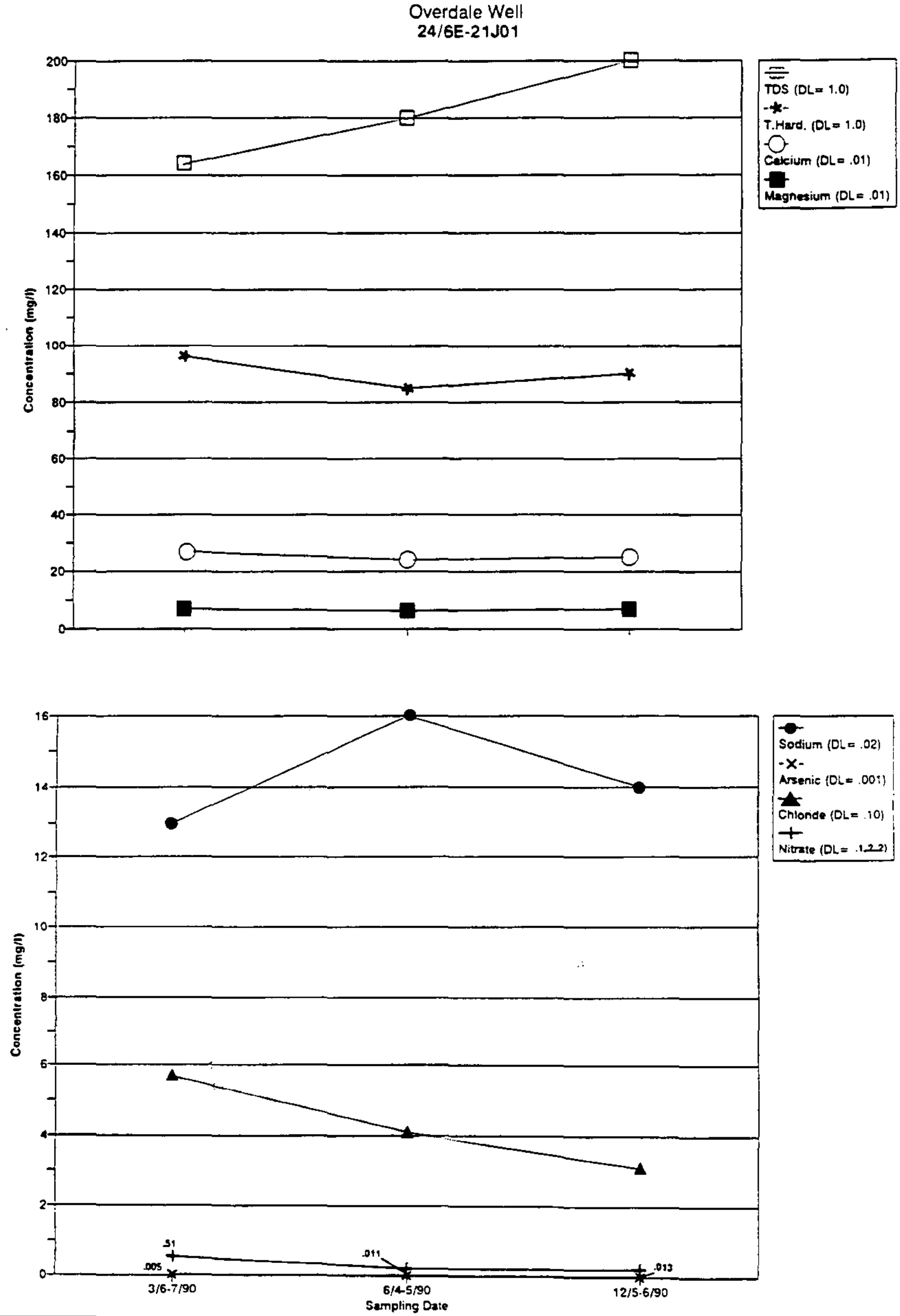
Fig. 7.19. Greening Well



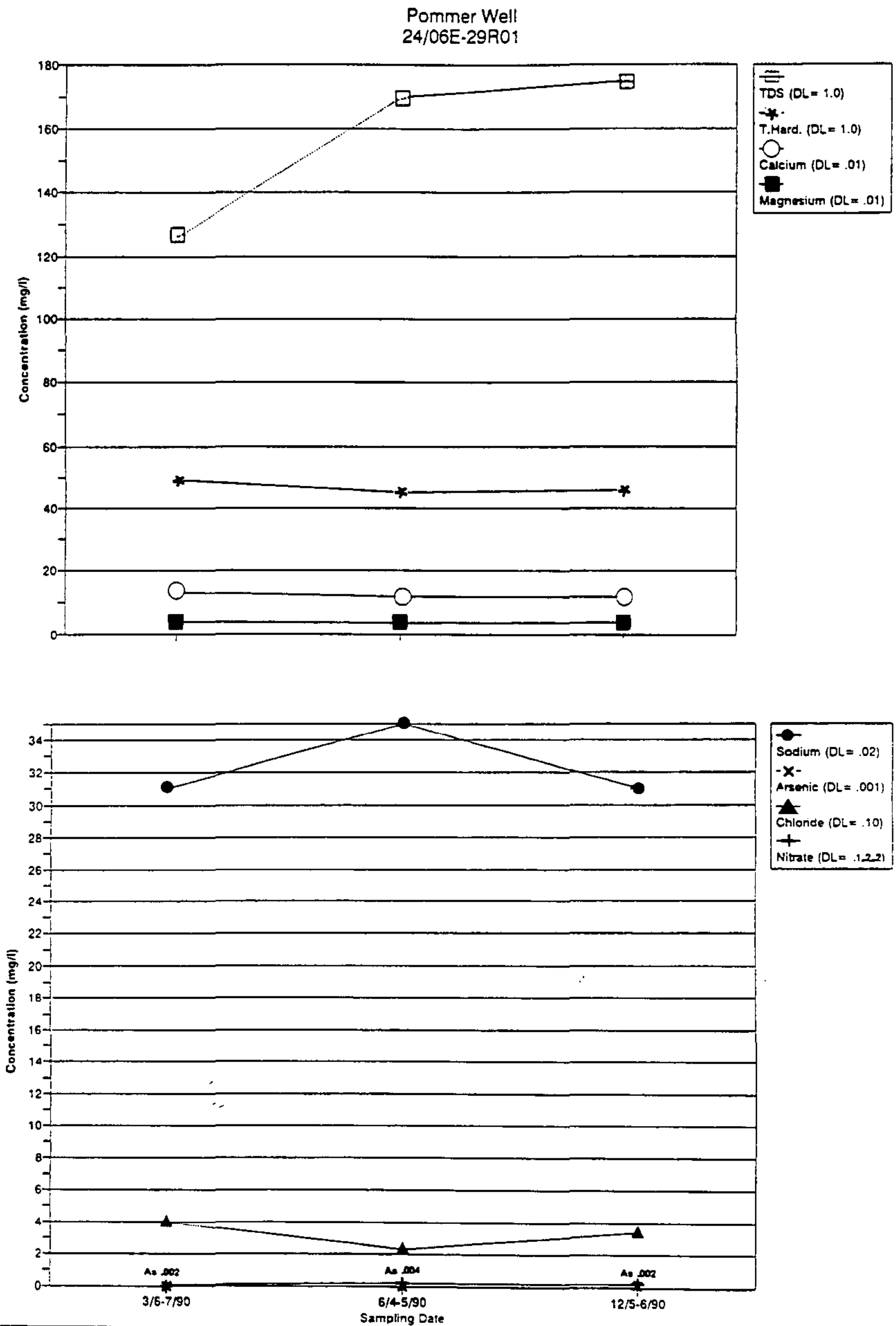

Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

Fig. 7.20. Mitchell Well



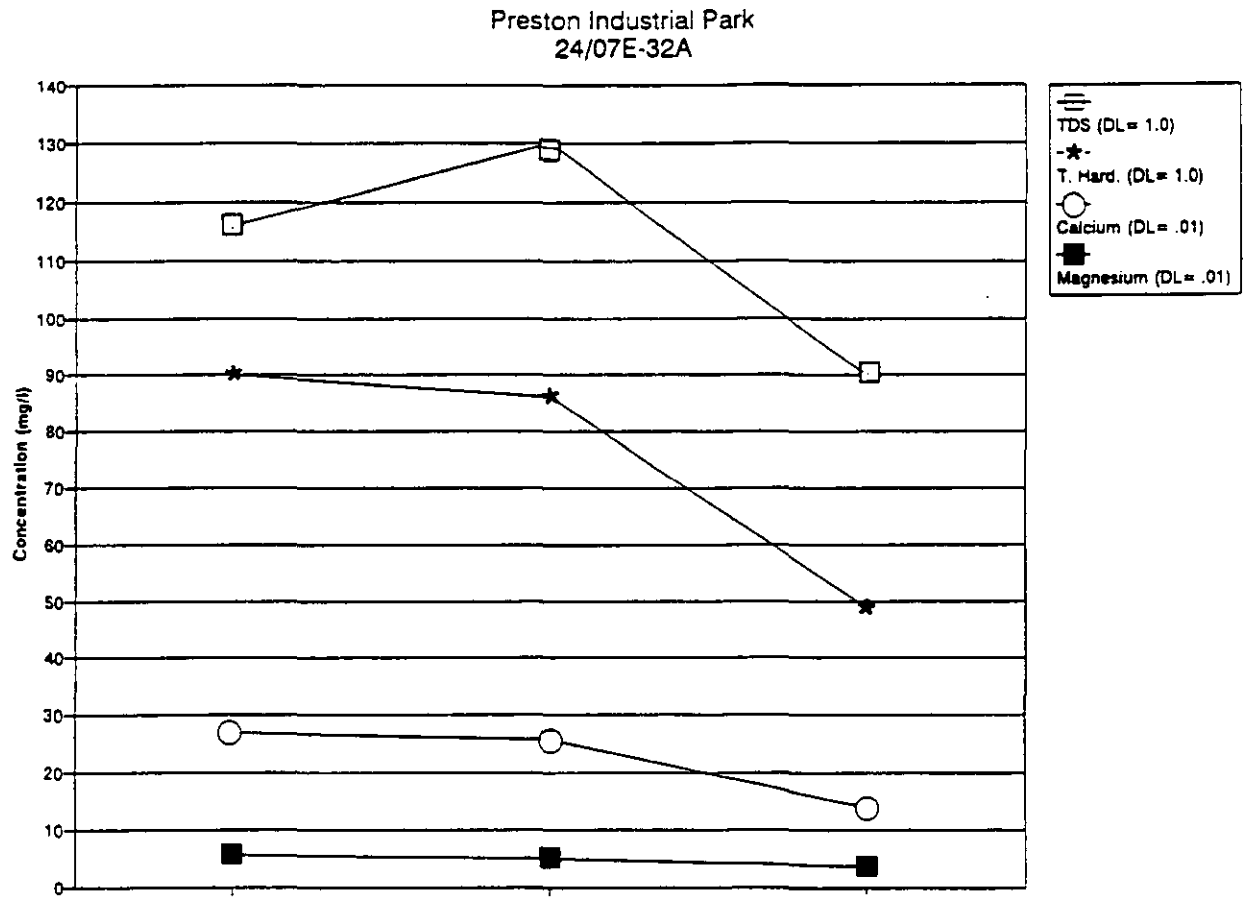

Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

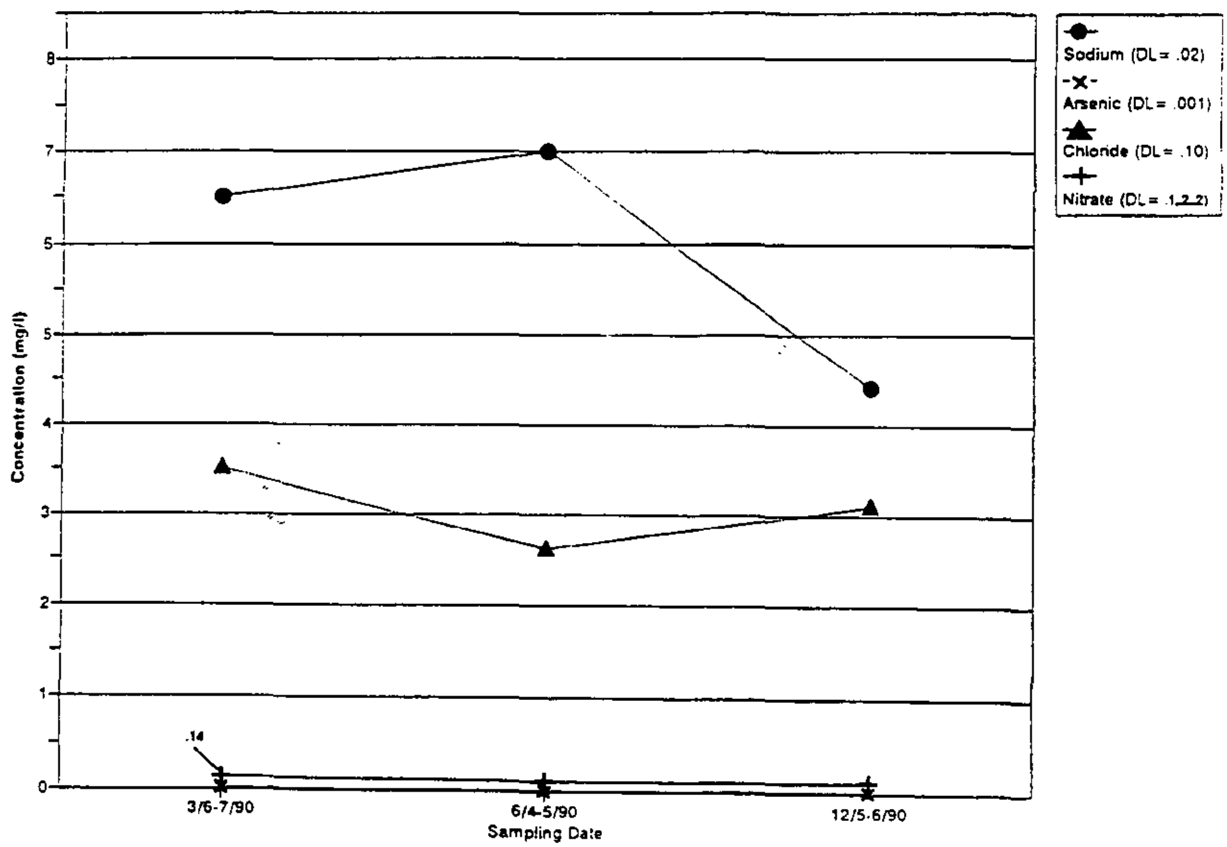
Fig. 7.21. Overdale Well




Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

Fig. 7.22. Pommer Well




Source: Task 5: Hydrogeological Report - Carr/Associates. Sept. 1993

Fig. 7.23. Preston Industrial Park

# Management Strategies

# Discussion & Background

**Draft**

**Issaquah Creek Valley**
**Ground Water Management Plan**

**March, 1996**

## Management Strategies: Background and Discussion

## 1 Introduction

This supplement contains only the background information and discussion for the recommended management strategies. The complete text of the management strategies and implementation is found in the Draft Issaquah Ground Water Management Plan, Chapter 2.

The structure for presentation of each topic is as follows: a summary of the key background information considered by the Issaquah Creek Valley Ground Water Advisory Committee (GWAC); issues and management strategy titles; and the supporting discussion of the decision for the strategies selected. Please note that as the Issaquah Creek Valley GWAC considered each issue, data collection and management, and educational management strategies were adopted for many of the issues. These are compiled into the Data Collection and Management Program and the Education Program, as described in this chapter. The original issue papers are available from the King County Department of Natural Resources, Surface Water Management Division.

## 2 Programs Related To Both Ground Water Quantity and Quality

### 2.1 Special Area Designations to Enhance Ground Water Protection

A number of special federal, state, and local area designations may be used to enhance a Ground Water Management Program. Incorporating them may offer such benefits as a source of funds to implement ground water protection measures, enhanced eligibility for grant funds, or expanded review of development proposals. Increased public recognition of the value of an aquifer may be an important result of a special area designation.

Among the special area designations discussed in this chapter are the following:

- Areas with a critical recharging effect on aquifers used for potable water, according to Chapter 36.70A RCW Growth Management;
- Well Head Protection Areas, according to the 1986 amendments to the federal Safe Drinking Water Act;
- Environmentally Sensitive Areas, according to Chapter 197-11 WAC State Environmental Policy Act Rules;
- Special Protection Areas, according to Chapter 173-200 WAC Water Quality Standards for Ground Waters of the State of Washington;
- Sole Source Aquifers, according to the federal Safe Drinking Water Act of 1974; and
- Aquifer Protection Areas, according to Chapter 36.36 RCW.

### 2.1.1 Areas With a Critical Recharging Effect on Aquifers Used for Potable Water, According to the Growth Management Act (Chapter 36.70A RCW)

The Growth Management Act of 1990 requires all counties and cities in Washington to plan to manage growth. This act, much of which is codified in Chapter 36.70A RCW, requires that the largest and fastest-growing counties (and the cities within them) plan extensively in keeping with the following goals:

- Conservation of important timber, agricultural, and mineral resource lands;
- Protection of critical areas;
- Planning coordination among neighboring jurisdictions;
- Consistency of capital and transportation plans with land use plans;
- Early and continuous public participation in the land use planning process.

Counties and cities must adopt comprehensive plans and regulations to protect designated critical areas and timber, agricultural, and mineral resource lands. The GMA requires the designation and protection of the following "critical areas:" wetlands; areas with a critical recharging effect on aquifers used for potable water; fish and wildlife habitat conservation areas; frequently flooded areas; and geologically hazardous areas. The GMA also requires that the comprehensive plans contain land use controls to protect quality and quantity of ground water used for public water supplies (Chapter 36.70A.070(1) RCW).

The GMA requires that the comprehensive plans of adjacent jurisdictions or those who share related regional issues must be coordinated and an important requirement for effective ground water protection. Meaningful protection of a dynamic resource that is shared by several jurisdictions is impossible without the cooperation among these jurisdictions.

Chapter 365-190 WAC, Minimum Guidelines to Classify Agriculture, Forest, Mineral Lands, and Critical Areas were adopted by the Washington Department of Community Development pursuant to the GMA. The Guidelines, which are advisory in nature, provide a general framework for classification, designation, and regulation of critical areas.

The Guidelines define "areas with a critical recharging effect upon aquifers used for potable water" as "areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water." Although this definition is somewhat circular, it is clear that aquifers used for drinking water are deserving of particular attention. In addition, it is suggested that those aquifers that are vulnerable to significant contamination be targeted.

The Guidelines also refer frequently to "aquifer recharge areas" without defining the term. The term is used very generally but appears to refer to the entire drainage basin in which an aquifer is contained and from which it receives water due to infiltration of precipitation, runoff, and other surface water.

Mapping known critical areas is encouraged as the best way to communicate to developers and regulators the location of the protected lands. It is recognized, however, that mapping wetlands and aquifer recharge areas can be difficult and imprecise. Section 040(2)(g) of the Guidelines recommends that changes in designated areas be allowed as new information is available and errors are found.

The Guidelines suggest that the following be included in local government designation of critical areas that are to receive protection under the GMA:

- Sole Source Aquifer recharge areas designated pursuant to the Federal Safe Drinking Water Act of 1974;
- Special Protection Areas designated pursuant to Chapter 90.54 RCW, Water Resources Act of 1971, and Chapter 90.48 RCW, Water Pollution Control; and
- Well Head Protection Areas designated pursuant to the 1986 amendments to the federal Safe Drinking Water Act.

King County adopted the November 1994 King County Comprehensive Plan to meet Growth Management Act requirements.

### 2.1.2 The Well Head Protection Program Under the Federal Safe Drinking Water Act

The 1986 amendments to the Safe Drinking Water Act established a Well Head Protection Program intended to safeguard ground waters that are tapped by public water supply wells. Each state is required to develop and implement a Well Head Protection Program in accordance with criteria established by the Environmental Protection Agency.

A state Well Head Protection Program must:

- Specify the roles and duties of state agencies, local government entities, and public water suppliers in a well head protection;
- Provide the criteria for delineating the boundaries of Well Head Protection Areas (WHPAs);
- Establish procedures for identifying sources of contamination within each Well Head Protection Area;
- Develop management programs to protect ground water supplies within each Well Head Protection Area from sources of contamination;
- Develop contingency plans for each public water supply system to respond to well contamination;
- Provide siting criteria for new public water system wells to maximize yield and minimize contamination; and
- Ensure public participation.

A Well Head Protection Area is defined in the Safe Drinking Water Act as "the surface and subsurface area around a well or wellfield supplying a public water system through which contaminants are reasonably likely to move toward and reach such water well or wellfield" (42 U.S.C.A. 300h-7(e)). The first step in the implementation of a Well Head Protection Program is to delineate the well head protection area boundaries.

The Washington State Department of Health has been designated by the governor as the lead agency for developing and administering the Well Head Protection Program in this state. Approximately 12,000 public water systems in the state will eventually be included in the Well Head Protection Program. The Drinking Water Regulations (Chapter 246-290 WAC) will be revised to contain the Well Head Protection Program requirements.

Due to the nature of well head protection, much of the actual implementation efforts will be done by public water systems, local governments, and by those agencies with source-specific jurisdictional responsibilities. For example, the Washington Department of Ecology (Ecology) regulates underground storage tanks, while the Washington Department of Agriculture regulates pesticide use. Those agencies would be responsible for emphasizing protection of the Well Head Protection Area within their jurisdictional authority.

The following are highlights of the Well Head Protection Program for Washington:

- Delineation of Well Head Protection Areas primarily based on the area immediately surrounding the well casing and areas describing the 1-, 5-, and 10-year time of ground water travel to the well from the recharge area;
- Inventory of potential sources of ground water contamination within the Well Head Protection Area;
- Development of management strategies to eliminate or minimize the possibility that these potential sources contaminate ground water.

Public water system purveyors are responsible for delineating the Well Head Protection Area and inventorying sources of contamination within the Well Head Protection Area. State agencies are responsible for integrating well head protection measures into their existing programs. In many cases, this will primarily be done by placing a priority on existing activities to emphasize protection within the Well Head Protection Area. Local land use authorities (cities, counties) are responsible for zoning controls and pollution sources outside the authority of the federal or state government. Local governments, where necessary, may also be responsible for developing more stringent programs than federal and state governments currently provide.

It is clear that a Well Head Protection Program will be of particular value to municipal water systems whose Well Head Protection Areas are located completely or primarily within their boundaries. A number of municipalities including the City of Renton and the City of Tacoma have already successfully implemented a form of well head protection. The effectiveness of these programs was largely predicated on the ability of the municipal well owner to directly regulate land use in all or a large portion of the zone of contribution.

However, where public water systems do not control surrounding land use, the success of the Well Head Protection Program will depend on the willingness of other city and county governments to impose necessary land use or other restrictions.

Considering that there are approximately 1,700 large and small public water system wells within King County, individualized land use controls for each public well or wellfield in the county would be unworkable for King County. However, it should be possible to develop a basic Well Head Protection Program under which water purveyors could apply to the county for protection. This type of Well Head Protection Program could be implemented under the auspices of the aquifer recharge area provisions of the Growth Management Act. Development of a basic program would benefit well or wellfield owners that lack sufficient resources to develop an individual Well Head Protection Programs. The state Well Head Protection Program recommends a county-wide approach to well head protection although it is not required at present. While a basic program would not fit every situation, individual public water systems could build upon the basic program at their discretion.

Development of a basic Well Head Protection Program strategies involves an investment of time and money by the county, cities, and public water systems purveyors. It will be technically demanding and politically challenging to develop a program that both provides necessary protection for Well Head Protection Areas and complements the Ground Water Management Plan and other existing ground water protection efforts. The way would be made easier, however, by taking advantage of the recent experience gained in many cities and states around the nation. Many models for well head protection are now available to be studied.

Local jurisdictions in Washington are beginning to develop programs to facilitate the development of individual Well Head Protection Programs. Coordinated approaches have been attempted. For example, the adopted Northern Thurston County Ground Water Management Plan contains a provision for joint development of a countywide Well Head Protection Program by the County and cities. Jurisdictions will establish by interlocal agreement a committee to cooperatively develop the Well Head Protection Program. Clark County is also making headway towards the cooperative development of Well Head Protection Programs. It has been awarded a Centennial Clean Water Fund grant to convene and staff a process to develop a minimum countywide Well Head Protection Program. In this area, the City of Issaquah and the Sammamish Plateau Water and Sewer District have completed the lower Issaquah Valley Well Head Protection Plan (Golder Associates, November, 1993).

### 2.1.3 Environmentally Sensitive Area Designation Under the State Environmental Policy Act

The State Environmental Policy Act (SEPA; Chapter 43.21C RCW) is intended to provide decision makers and the public with sufficient information to evaluate the environmental consequences of proposed land, air, or water use activities when those activities involve an action by a governmental agency. Such an action could range from the issuance of a building permit to undertaking a major construction project such as a dam or a highway. The procedural provisions of SEPA attempt to outline a process for distinguishing between actions that are likely to have a significant adverse environmental impact and those that are not. In cases where significant adverse impacts are anticipated, an environmental impact statement must be prepared.

The State Legislature authorized the Department of Ecology (Ecology) to develop rules for SEPA implementation. The rules that were subsequently developed and adopted by Ecology, Chapter 197-11 WAC, are intended to provide a uniform environmental review process in all political jurisdictions within the state. They are also intended to help define what constitutes a significant adverse environmental impact and to outline the content of environmental documents prepared under SEPA.

The SEPA rules are implemented in unincorporated King County through Chapter 20A.44 of the King County Code, "County Environmental Procedures." The Department of Development and Environmental Services is responsible for environmental review in relation to code requirements and for implementing SEPA compliance for private development proposals in King County. Municipalities within King County have either adopted the SEPA rules by reference or have developed their own regulations that incorporate the SEPA rules. Municipalities conduct environmental review for projects occurring within incorporated boundaries.

In developing the SEPA rules, Ecology determined that some classes or types of activities, because of their size or nature, are not likely to represent a significant environmental impact and should, under ordinary circumstances, be exempt from SEPA requirements. Chapter 197-11-800 WAC of the SEPA rules contains a list of these exempted types of activities, termed categorical exemptions. The categorical exemptions include some activities that could potentially represent a significant adverse environmental impact in areas of unusual ground water sensitivity.

These activities include:

- The installation of underground chemical storage tanks with a capacity of less than 10,000 gallons;
- The construction of commercial buildings of less than 4,000 square feet and associated parking for up to 20 automobiles;
- The construction of parking lots for up to 20 vehicles;
- The construction of agricultural structures of under 10,000 square feet;
- The periodic use of Washington Department of Agriculture approved chemicals to maintain a utility or transportation right-of-way in its design condition; and
- The appropriation of 2,250 gallons per minute of ground water for any purpose.

Local governments have the authority to lower thresholds for requiring environmental review by designating certain portions of their land use jurisdiction as an Environmentally

Sensitive Area. These areas are generally more vulnerable to the adverse effects of land and water-use activities. SEPA rules state that Environmentally Sensitive Areas may include "but [are] not limited to areas with unstable soils, steep slopes, unusual or unique plants or animals, wetlands, or areas that lie within floodplains."

In designating a portion of its jurisdictional area to be an Environmentally Sensitive Area, a county or city can eliminate many of the categorical exemptions found in Chapter 197-11-800 WAC, including all but one of the land and water uses listed above. Categorical exemptions regarding appropriations of ground water cannot be revoked.

King County designated it's sensitive areas maps, adopted under KCC 21A.24.080, as maps of environmentally sensitive areas, and has removed the categorical exemption under Chapter 197-11-800(6)(a) WAC. (KCC 20A.44)

An Environmentally Sensitive Area designation may provide several important benefits for an area that is susceptible to ground water contamination. First, it would assist in raising the level of awareness, of both the public and governmental agencies, regarding the sensitivity of the aquifer system to contamination from overlying land use.

Second, designation would permit the Metropolitan King County Council and city councils to eliminate from environmental review many of the categorical exemptions that are currently allowed under the SEPA rules. As a result, certain exempted land use activities that pose a relatively high risk of contaminating ground water, such as installation of underground chemical storage tanks of under 10,000 gallons, could be required to undergo environmental review.

In determining the categorical exemptions to be eliminated, caution should be taken to revoke only those exemptions that bear a direct and significant relationship to ground water quality. A wholesale elimination of categorical exemptions might result in an unfavorable public reaction since many relatively innocuous activities such as adding a recreation room to an existing house or constructing a garage would require environmental review. Not only would such a broad-brush approach add an unnecessary burden on the public, but it would potentially create a glut of environmental checklists that would significantly add to the workload of agencies that must review or process environmental documents without actually affording better ground water protection.

One significant shortcoming of the SEPA process is that while environmental review assists the public and decision makers in identifying the probable adverse environmental impacts of a proposed activity or action, it does not provide a basis for mitigation of the adverse impacts. Also, individual SEPA review does not consider many projects in an area that may have a cumulative effect on an area. Mitigation measures cannot be imposed unless some legally adopted ordinance, regulation, or policy exists that supports the requirement for mitigation. Adoption of the Ground Water Management Plan provides the County and cities in the Ground Water Management Areas with a legal basis for requiring mitigation because it contains policy for lands within the Ground Water

Management Area. This policy would be in addition to any existing regulations or policies already adopted.

### 2.1.4 Special Protection Areas Established Under Washington Water Quality Standards for Ground Waters

Chapter 173-200-090 WAC outlines procedures for Ecology to designate Special Protection Areas within the state of Washington. The purpose of designating Special Protection Areas is to identify portions of the state with ground waters that require extraordinary consideration or increased protection because of one or more unique characteristics.

Such characteristics include, but are not limited to:

- Recharge areas and well head protection areas that are vulnerable to pollution because of hydrologic characteristics,
- Ground waters that support a beneficial use or ecological system requiring more stringent ground water quality criteria than those based primarily on drinking water standards, and
- Sole source aquifers.

Ecology grants a Special Protection Area designation if an area contains one or more of the three aforementioned characteristics and if such a designation is deemed by Ecology to be in the public interest. Ecology can designate a Special Protection Area at its own discretion or at the request of a federal agency, another state agency, an Indian tribe, or local government. Requests for designation prepared by entities other than Ecology must provide sufficient information in support of the request to demonstrate that the designation would be appropriate under the conditions set forth in Chapter 173-200 WAC. At a minimum the following information is required:

- A rationale for the proposed designation,
- Supporting technical and hydrogeologic data,
- A description of proposed boundaries for the Special Protection Area, and
- Documentation of coordination with affected state and local agencies, tribes, and water users.

Compliance with general procedures for public hearings, public involvement, and notification of affected governments including tribes is required before Ecology renders a decision concerning a request for designation of a Special Protection Area.

Ecology will consider the unique characteristics of a Special Protection Area when developing regulations, guidelines, and policies; when regulating activities; and when prioritizing department resources for ground water quality protection programs. Within Special Protection Areas, Ecology can choose to establish more stringent ground water quality criteria and contaminant enforcement limits.

In addition, Ecology can impose special requirements for permits issued under the authority of Ecology administered programs. Examples would be the State Waste Discharge Permit Program (Chapter 173-216 WAC) and permits for the withdrawal of ground water (water rights) issued pursuant to Chapter 90.44 RCW (Regulation of Public Ground Waters).

### 2.1.5 Sole Source Aquifer Designation Under the Federal Safe Drinking Water Act

The Sole Source Aquifer Program was established under section 1424 (e) of the Safe Drinking Water Act of 1974 and is administered by the Environmental Protection Agency. The primary intent of the program is to prevent projects that receive federal financial assistance from contaminating aquifers representing the sole or principal source of drinking water for an area. Projects that receive a portion, but not 100 percent, of their funding from the federal government are affected. An example would be a highway construction project funded jointly by the federal and state government. By contrast, a military installation is wholly financed by the federal government and thus is not restricted by the provisions of the Sole Source Aquifer Program.

To qualify for Sole Source designation, an aquifer must meet the following basic criteria:

- It must supply 50 percent or more of the drinking water consumed within the area for which the aquifer is supplying water, and
- Alternative sources of drinking water must be of inadequate quantity or not be economically feasible to develop as a replacement for the aquifer.

The Environmental Protection Agency is authorized to declare a ground water system to be a Sole Source Aquifer upon receipt of a satisfactory petition requesting such a designation. A petition can be submitted by any individual, corporation, company, partnership, municipality, state, or federal agency. The petition must contain sufficient technical documentation to demonstrate that the aquifer meets the criteria for Sole Source designation (U.S. Environmental Protection Agency, February 1987).

King County contains two Sole Source Aquifers, Cedar Valley and Vashon Island. A Sole Source Aquifer designation provides a number of positive aspects, the most important of which is its public awareness value. A Sole Source Aquifer designation helps people realize that an aquifer is unique, valuable, and worthy of protection. The designation can serve as a rallying point around which support for ground water protection and management efforts can coalesce. Because of the attention that a Sole Source designation draws to an aquifer, new land development projects that may potentially harm underlying ground water may be more closely scrutinized by the public and by government agencies.

As discussed previously, the primary purpose of the Sole Source Aquifer Program is to prevent contamination of aquifers representing the sole or principal source of drinking water for an area. Once a Sole Source Aquifer has been designated, the Environmental Protection Agency will review all projects in the "project review area" that are partially funded by the federal government. The project review area encompasses the surface area above the aquifer and the basin from which water potentially drains into the aquifer. The Environmental Protection Agency will determine whether projects pose a potential threat of contamination to the aquifer. Should it be determined that a project may contaminate the aquifer, the commitment for federal financial assistance may be withdrawn unless mitigation measures are implemented.

In response to concerns expressed by solid waste utilities and some county governments, Ecology modified its position on the prohibition of new landfills or the expansion of existing landfills located over a Sole Source Aquifer. A variance procedure has now been developed to allow the siting of new landfills or the expansion of existing landfills overlying a Sole Source Aquifer if it can be demonstrated that ground water will not be adversely impacted.

### 2.1.6 Aquifer Protection Areas under Chapter 36.36 RCW

In 1986, the Washington State Legislature passed legislation that provided the authority for creation of local Aquifer Protection Areas. The purpose of an Aquifer Protection Area is to establish a funding base for ground water protection, preservation, and rehabilitation programs. Aquifer Protection Areas are established through an election ballot issue requiring approval from a simple majority of voters within the proposed Aquifer Protection Area. If voters approve the Aquifer Protection Area, the county can collect modest water and septic system user fees. Fees may only be collected from users of water withdrawn from an aquifer as opposed to a surface water source (Chapter 36.36 RCW).

In 1987, voters in a portion of Spokane County established the first Aquifer Protection Area in Washington State. The water user fees established by the voters of Spokane County amount to $1.25 per month per residential equivalent. Septic tank user fees are also $1.25 per month per residential equivalent.

Aquifer Protection Area revenues may be used to fund the following activities in addition to those described above:

1. Ground water protection planning.
2. Ground water treatment facilities.
3. Wastewater treatment facilities.
4. Monitoring of ground water quality and quantity;
5. Ongoing implementation of comprehensive plans to protect, preserve, and rehabilitate ground water, including Ground Water Management Programs;
6. Enforcing compliance with standards and rules relating to the quality and quantity of ground water; and
7. Public education related to protecting, preserving, and enhancing ground water.

Aquifer Protection Area funding can support virtually all activities associated with the implementation of a Ground Water Management Program.

Potential drawbacks to the use of an Aquifer Protection Area to fund the implementation of the Ground Water Management Plan include the following:

1. Lack of flexibility in use of funds. Because proponents must describe the specific use in ballot measure, changes in specific uses require voter approval;
2. Large startup costs to educate the public about ground water protection;
3. Difficulties in adjusting fees over time; changes must be approved by voters; and
4. Inequities in fee assessment, in that:
    a. Assumes that septic users are more significant contributor to potential ground water pollution than other sources such as underground chemical storage and hazardous waste; and
    b. Fee is not related to amount of water used.

**Recommended Management Strategies for Special Areas.**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 General Protection of Aquifers.**

- **SA-1A Elimination of Categorical Exemptions to the State Environmental Policy Act.**
- **SA-1B Designation of Environmentally Sensitive Areas.**
- **SA-1C Adoption of General Aquifer Protection Policies.**
- **SA-1D Enhanced Environmental Review to Protect Aquifers.**
- **SA-1E Define and Map Ground Water Recharge Areas.**

**Discussion:** Action SA-1A through 1E provide broad protection for aquifers. Actions SA-1A and SA-1B will provide protection by bringing projects through State Environmental Policy Act review that are now exempt but that may have significant impacts upon ground water, which are installation of underground chemical storage tanks with a capacity of less than 10,000 gallons; construction of commercial buildings of less than 4,000 square feet and associated parking for up to 20 automobiles; construction of parking lots for up to 20 vehicles; construction of agricultural structures of under 10,000 square feet; and periodic use of Washington Department of Agriculture approved chemicals to maintain a utility or transportation right of way in its design condition (Chapter 197-11-800 WAC). It will be important to determine which categorical exemptions should be eliminated so that minor projects that would have little effect upon ground water will not require State Environmental Policy Act review. A two-tiered approach to categorical exemptions could be considered. For example, more categorical exemptions could be eliminated in the most physically susceptible and recharge areas. Determining which categorical exemption to eliminate would involve analyzing the potential for each category type based on the land use in the GWMA.

Then, each category will be analyzed to determine if there would be a significant impact, and if standard Best Management Practices could prevent ground water impacts. If any categorical exemption are determined to be eliminated, the Management Committee (Department of Natural Resources) will either apply for designation of the GWMA as an Environmentally Sensitive Area, or explore other options for bringing projects in these categories through SEPA review.

Agencies affected by this process, such as King County Department of Transportation Public Works, should be involved in determining which categorical exemptions may be eliminated. Elimination of any categorical exemptions would be by ordinance, which would allow for formal public review and require that a programmatic SEPA review of the proposed changes was performed.

Action SA-1C provides a general policy framework for aquifer protection. This framework includes a commitment to protect public water systems; a provision for addressing the potential for aquifer contamination from the existing and new built environment; and a direction for the Well Head Protection Programs that each public water system purveyor will be required by state regulations to provide specific protection for drinking water sources.

Well Head Protection Programs will consist of a core of water system specific strategies developed by individual purveyors. Strategies to protect water systems may include such measures as education, technical assistance, regulation, monitoring, emergency response, business relocation assistance, and land acquisition. Efficiencies will be achieved by making full use of existing programs and initiating new programs only as needed.

Action SA-1D provides a means for the County and the City of Issaquah to jointly develop guidance documents and informational materials for optimal environmental review. The purpose is to raise the level of understanding about aquifers among environmental reviewers. Maps of aquifers, and the most physically susceptible and high potential recharge areas will be refined and presented in an easy to use format.

Action SA-1E provides for identification of those areas in the Ground Water Management Plan that are particularly important to protect. Maps of these areas will primarily be used to determine priorities for implementation of the Ground Water Management Plan. For example, the GWAC has adopted a policy of monitoring for pesticide and fertilizer contamination in agricultural areas. The maps of physically susceptible and recharge areas will be used to determine where to focus this effort. Maps will also be used to educate and assist the public, elected officials, land use planners, environmental reviewers, and others who make decisions that may affect ground water quality or recharge. These maps will also be valuable to purveyors who are determining well head protection priorities. It is expected that these maps will be updated and refined based upon information from the Wellhead Protection Programs and from other ground water studies.

The maps produced for the GWMP and for the King County Comprehensive Plan 1994 were based on available information. Both the GWMP and the Comprehensive Plan specify that the maps will be refined as new information becomes available. Identification and protection of areas important for ground water quantity and quality is required by the Growth Management Act. King County expects to meet this requirement by starting with the maps currently produced, and working with water utilities and water resource agencies to refine and revise the maps, so that they are useful for planning and ground water protection. This is reflected in King county Comprehensive Plan Policy NE-332, which states: "In unincorporated King County, areas identified as sole source aquifers or as areas with high susceptibility for ground water contamination where aquifers are used for potable water are designated as Critical Aquifer Recharge Areas as shown on the amp, entitled Areas Highly Susceptible to Ground Water Contamination. Since this map focuses primarily on water quality issues, the county shall work in conjunction with cities and ground water purveyors to designate and map recharge areas which address ground water quantity concerns as new information from groundwater and wellhead protection studies adopted by the county or state agencies becomes available. Updating and refining the map shall be an ongoing process."

All of the actions proposed under Issue 1 are joint actions recognizing that aquifer protection cannot be accomplished by one land use jurisdiction alone. Joint action by the County and the City of Issaquah is consistent with Growth Management Act requirements to coordinate protection of aquifers. Coordination with the water purveyors is encouraged. Joint action is practical because costs can be reduced and the regulated community will experience consistent policy towards protected areas. This is particularly important with an area that is large and contains more than one land use jurisdiction.

**Issue 2 Well Head Protection:**

- **SA-2 Basic Well Head Protection Program.**

**Discussion:** In the context of the larger aquifer protection program, well head protection can fill a vital need to focus intense aquifer protection efforts in those areas, usually urban, where there are existing sources of contamination that present very significant risks to public drinking water supplies. This recommendation is supported by King County Comprehensive Plan policy NE-333: "King County should protect the quality and quantity of ground water county-wide by: ... b. Developing a process by which King County will review, and implement, as appropriate adopted Wellhead Protection Programs in conjunction with cities and ground water purveyors: c. Developing with affected jurisdictions, best management practices for new development and of forestry, agriculture, and mining operations recommended in adopted Ground Water Management Plans, and Wellhead Protection Programs as appropriate. The goals of these practices should be to promote aquifer recharge quality and to strive for no net reduction of recharge to ground water quantity...."

Minimum well head protection requirements developed by the Management Committee will build upon the Ground Water Management Plan. The issues considered by the GWAC will probably be considered by the Management Council. A determination should be made as to whether additional protective requirements are needed within a certain zone around the well in relation to these issues. The need for additional protection may be dependent upon the hydrogeology of the zone.

Additional protection may include such measures as education, technical assistance, regulation, monitoring, and emergency response. Business relocation assistance and land acquisition may be considered on a case-by-case basis. Efficiencies will be achieved by making full use of existing programs and initiating new programs only as needed.

Minimum countywide well head protection requirements will not address delineation or contaminant source inventory requirements of the state Well Head Protection Program. The Management Committee effort will focus instead upon steps taken to protect the well once the Well Head Protection Area has been delineated and potential sources of contamination have been inventoried. Cooperative efforts by purveyors in the delineation and source inventory phases are however, encouraged. It is expected that individual purveyors will have system specific needs that they will want to include in individual well head protection programs.

Active participation by the Washington State Department of Health will be sought in developing minimum well head protection strategies. Inclusion of a minimum program that has the support of Washington State Department of Health will speed approval by Washington State Department of Health of well head protection programs of individual purveyors.

It is possible that certain aspects of a minimum well head protection program may be codified in county laws. This will be explored by the Department of Natural Resources, in the course of development of the well head protection strategies.

The Management Committee should address the issue of overlapping Well Head Protection Areas. It will not be unusual for a number of smaller Well Head Protection Areas to be contained within the protection area for a larger system. Also, the protection areas for very large systems may overlap. Protection Zones 1, 2, and 3 will be designated within the well head protection areas. Zone 1 (requiring the highest protection standard) for one system may be located in zone 3 of a second system. The area should be protected to the higher of the two standards. Perhaps management of the area could be the responsibility of the purveyor for whom the area has a higher protection standard. A shared management strategy might also be possible. This, however, is an issue that should be considered by the Management Committee.

**Issue 3 Sole Source Aquifer Petition:**

- **SA-3 Submit Sole Source Aquifer Petition.**

**Discussion:** Sole Source status will require that the federal government consider and prevent adverse impacts upon aquifers from any project that is partially funded by federal dollars. This may be particularly useful in relation to potential freeway construction in the Issaquah area.

Sole Source status has a significant impact upon public perceptions. It also impacts decisions made by regulatory agencies that may affect ground water. Some agencies have written special considerations for Sole Source areas into regulations.

## 2.2 Data Collection and Management Program

Long-term data collection of ground water quality and quantity, precipitation and stream flow is necessary for the continued development of a conceptual characterization of ground water hydrology within the ground water management area. The collected data needs to be entered into a database and analyzed to provide useful information for making resource management decisions.

Data is collected and analyzed so that state and local agencies can:

- determine water resource trends in ground water quality and quantity
- make informed decisions on such issues as land use and water rights
- plan for peak water use and population growth impacts
- develop and refine a water resource model
- respond to data requests from water agencies and other interested parties; and
- respond to incidents such as water level declines.

Long-term data collection by the monitoring of water levels from selected wells will provide trends of groundwater fluctuations related to water use, recharge and land use, and will provide information for managing this resource. Similarly, regular water quality data collection will ensure that the resource is potable and will detect any changes or trends in water quality. Precipitation and stream flow data is necessary for the determination of recharge and runoff quantities.

The ground water management program at the Seattle-King County Health Department established a ground water monitoring network. Data collected within this network has resulted in the establishment of a database containing precipitation, stream discharge, water level and water quality data. Descriptions of rock and soil encountered in the drilling of wells have been obtained from well logs and entered into the database. The resulting data, combined with existing precipitation, stream flow and water level data from other agencies, has only been adequate for initial water balance and ground water flow analysis. The Background Land and Water Use Report, the Background Hydrology

Report, the Data Collection and Analysis Plan and Data Analysis/Area Characterization Report (which are products of the Ground Water Scope of Work) identified where future data collection is needed (see Area Characterization Supplement). Further data collection and analysis is needed along with an expanded network of existing and new wells for the development of a conceptual model of groundwater hydrology.

**Recommended Management Strategies For Data Collection, Analysis and Management**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Data Collection, Analysis and Management:**

- **DCM-1 Data Collection, Analysis and Management Program.**
- **DCM-2 Data Collection, Analysis and Management: Ecology.**

**Discussion:** The Data Collection and Analysis Plan would be adjusted according to the recommendations from consultants and Department of Natural Resources staff following completion of data analysis. A modified monitoring program would include collection of data from existing network sites, plus collection of data from sites added to fill data gaps recognized during initial data analysis. Monitoring stations would be omitted where data was no longer needed. Data collected would include water quality monitoring for pesticide, fertilizer and hazardous waste contamination, the identification of wells and their locations by well identification tagging and the refinement of maps showing areas of high, medium and low recharge. All data collected would be entered into the Department of Natural Resources database and regularly shared with other agencies including the Department of Ecology, Department of Health, the City of Issaquah and utilities.

Data generated from a modified monitoring program would not only result in an increased level of confidence supporting conclusions drawn from the data, but would also serve to fill data gaps and promote an increased conceptual understanding of ground water hydrology useful for future model development.

A ground water flow model includes considerations for surface water linkages to ground water and the impacts to surface waters resulting from increased withdrawal. Model development is necessary to provide the technical information necessary to make informed management decisions relating to ground water and surface water resources.

The Ground Water Management Plan Scope of Work contract with Ecology requires King County to download a database which will provide ground water quantity and quality, precipitation and stream flow data to Ecology. However, there is no mechanism for future data downloads to Ecology upon completion of the study. Ecology, King County and the relevant city and utility data bases all need to be kept current.

## ISSAQUAH GWMP DATA COLLECTION LIST

The following table identifies the elements of the data collection management program in order of priority for implementation. The prioritization was established by the Groundwater Advisory Committee. The rankings are 1 for high priority, 2 for medium priority and 3 for low priority.

| RANKING | ELEMENT | ESTIMATED COST |
|---|---|---|
| 1 | Obtain existing projections of residential, commercial and industrial development in the Issaquah Creek Basin, e.g. information on the specific type and location of existing activities and new development in the Issaquah Creek Valley Ground Water Management Area. | TBD |
| 1 | Obtain existing demographic data for the six forecast and analysis zones in the study area not considered in this report and determine the type and amount of demands to be made on the Issaquah Valley aquifers. | TBD |
| 1 | All the new wells within the monitoring network should be accurately located within one foot for horizontal coordinates and within 1/10 foot for elevation. | TBD |
| 1 | Arsenic test results should be reviewed to determine if a trend or "trigger" level is found. (For example, the testing near the Cedar Hills landfill.) A "trigger" could be when a well with previously low levels shows a test result near the Environmental Protection Agency's Maximum Contaminant Level. A trend could be when a well shows continually increasing levels. If a trend or trigger level is found, then quarterly monitoring should be done on that well and well users informed of the health risk and treatment options. | TBD |
| 1 | To help determine the extent to which storm water runoff represents a threat to ground water quality and quantity, in collaboration with King County Surface Water Management, locate those areas where a significant amount of vehicular oils and greases or other toxins are channeled by storm water systems into physically susceptible and recharge zones. | TBD |
| 1 | Describe the stormwater drainage for major roads in the study area. | TBD |

| RANKING | ELEMENT | ESTIMATED COST |
|---|---|---|
| 1 | Monitor data collected by the Department of Ecology, the Seattle-King County Health Department, and the Local Hazardous Waste Program on hazardous waste generator impacts on ground water quality. | TBD |
| 1 | Identify the type, quantities and locations of chemical applications for rights-of-way maintenance. | TBD |
| 1 | Identify underground storage tanks located in areas where there is significant recharge to aquifers. Identify the extent and type of contamination possible from an underground storage tank leak or accident. | TBD |
| 1 | The existing monitoring network of wells and new wells drilled should be sampled twice yearly (wet and dry seasons) for inorganic, organic and pesticide parameters pertaining to relevant land use activities. | TBD |
| 1 | Evaluate agency procedural methods for herbicides used in roadside and other rights-of-way maintenance. | TBD |
| 1 | Install or locate monitoring wells: in the Tiger Mountain Gap, two to three additional monitoring wells should be located along a north-south line with an existing IGWMA monitoring well to determine the stratigraphy, transmissivity, and hydraulic gradient of the sediments within the Gap. These data are required to assess the potential ground water contribution of the southern portion of the Issaquah Creek Basin to the northern portion. | 30,000. |
| 1 | Continue collecting data from the network set up during plan development for well water levels, well water quality, stream flow and precipitation. | 45,409/yr. |
| 1 | Install or locate monitoring wells along the divide between the Cedar River and Issaquah Creek drainage basins: Two or more additional monitoring wells should be located in sections 17 and 18 (T23N, R6E) and in sections 28 and 33 (T23N, R6E) to determine if ground water is discharging from the Issaquah Creek Basin into the Cedar River Basin. | 20,000 |
| 1 | Install or locate monitoring wells along Tibbets, Fifteen Mile, and Holder Creeks; | 30,000 |

| RANKING | ELEMENT | ESTIMATED COST |
|---|---|---|
| 1 | Determine appropriate location for water level monitoring stations for selected wetlands and lakes, in the southern and northern portions of the basin. | 4,716 to install 220./yr. |
| 1 | Install additional stream gauges in the central lower Issaquah valley to determine the hydraulic continuity between surface and ground water (Lower Issaquah Valley Well Head Protection Plan). | TBD |
| 1 | Continue to collect data from the stream gauging stations within the Issaquah Creek Valley Ground Water Management Area maintained and operated by others. | 7,074 to install 330/yr. |
| 1 | Install three additional stream gauging stations upgradient from, within, and downgradient from the Tiger Mountain Gap. | 3,106/yr. |
| 1 | Continue to collect data from the eight precipitation sites monitored by volunteers for the lead agency. | TBD |
| 1 | Continue to collect data from the meteorological monitoring network provided by the existing Department of Natural Resources and Surface Water Management precipitation stations. | TBD |
| 1 | Obtain additional data from precipitation stations maintained by the water purveyors and the City of Issaquah, King County, and the Washington State Highway Department and others such as schools. | TBD |
| 2 | Information on the number and locations of Group B and individual wells without water rights in the Issaquah Creek Valley needs to be compiled. | TBD |
| 3 | Determine the types and quantities of agricultural fertilizers and pesticides used in the Issaquah Creek Basin. | TBD |
| 3 | Mapping of the location of Group B water systems within the ground water planning area needs to be done. (Group B water systems serve less than 15 connections.) | TBD |
| 3 | Identification of the key private wells in the basin and development of an estimation of the amount of water used by those types of wells in the basin. Key private wells will be those wells within 1, 5 and 10 year time of travel for the | TBD |

| RANKING | ELEMENT | ESTIMATED COST |
|---|---|---|
| | major Group A public water supplies, and those private wells in the most physically susceptible and recharge areas. (Group A water systems serve more than 15 connections.) | |
| 3 | Determine how existing operations of quarries and mines affect ground water quality, e.g. the impacts of industrial contaminants that seep into exposed aquifers at quarries; the potential ground water impacts of an accidental hazardous material spill at a quarry. | TBD |
| 3 | Locate smaller underground storage tanks, especially residential heating oil tanks. | TBD |
| 3 | Continue to evaluate the Solid Waste Division's report findings and proposed future activities concerning ground water quality impacts both off and on the sites (Cedar Hills Landfill and Queen City Farms). | TBD |
| 3 | Refine the description of the direction of ground water flows in the area of the landfills, as well as the depth and range of aquifers exposed to leachate contaminants. | TBD |
| 3 | For each of the major Group A water suppliers, a current breakdown of the type and percent of water customers they serve is needed. Types includes residential, industrial, commercial, agricultural, etc. | TBD |
| 3 | Continue to evaluate ground water quality on and surrounding the Cedar Hills Landfill and Queen City Farms, and enter this information into the King County Department of Natural Resources Ground Water Program database. | TBD |

## 2.3 Ground Water Quality and Quantity Issues Associated with Storm Water Management

Storm water is that water which runs off impervious surfaces when it rains. Past and present storm water management practices account for some ground water quantity and quality problems. Ground water quality may be impacted if storm water containing contaminants is recharged intentionally or inadvertently. The most serious concern over recharge of storm water is, from a public health standpoint, the possible effect(s) on the quality of drinking water. Also, an amount of precipitation is diverted to surface water when, under natural conditions, it would be recharged to ground water. As a result, there is a decrease in the quantity of water recharged to ground water.

The continuity of surface and ground water is an important concept in understanding the effects of surface water contamination on ground water. It is also important when making decisions about the most efficient way to protect both surface and ground water. Ground water and surface water cannot be considered two separate hydrologic systems because they are inextricably linked.

King County has experienced the effects of urbanization and deforestation. Growth of King County's urban area has resulted in more impervious surface, more runoff, stream damage, and a reduction of recharge to ground water. Deforestation, the removal of vegetation and the subsequent compaction of soil, may also be reducing ground water recharge.

Storm water management facilities can be designed to maximize infiltration into the ground thereby increasing recharge to aquifers. However, an obvious concern is the potential to contaminate ground water with pollutants carried in storm water. In the past, storm water management emphasized flood control and was not particularly concerned with water quality. More recently, however, concern has shifted to the quality of storm water and how it can impact receiving waters, including ground water. Storm water management practices include source control and treatment facilities.

Storm water management facilities vary in the degree to which these mechanisms take place. The most common methods used for either flow control and water quality improvement are detention basins, infiltration facilities, wetponds, biofilters, and coalescing plate oil/water separators.

### 2.3.1 Storm Water Management Programs and Regulations

Numerous federal, state, and local programs and regulations govern the management of storm water and the control of point and nonpoint pollution. However, there are no programs and regulations which solely relate to the effects of storm water management upon ground water resources.

**State Programs**

The Puget Sound Water Quality Authority adopted the Puget Sound Water Quality Management Plan. It forms the foundation of the storm water program at Ecology, a program which affects the City of Issaquah, counties, and the Washington State Department of Transportation. The Plan focuses on protection of surface water in its efforts to protect Puget Sound. Little attention is paid to the continuity of surface and ground waters. The protection of ground water afforded by the many activities fostered by the Plan is often noted but is secondary to protection of surface waters.

The Washington State Department of Ecology coordinates surface and ground water management is included in two Ecology programs, the Local Planning and Management of Nonpoint Source Pollution and the Ground Water Management Program. Local Planning and Management of Nonpoint Source Pollution requires affected counties to convene watershed ranking committees to rank watersheds in need of protection. It also encourages coordination and integration of local ground and surface water protection planning efforts by stating that: "To reduce duplication of effort, Ecology shall also be responsible for coordinating the activities of the watershed management committee with other existing water management programs (e.g. ground water)." Coordination and integration of local efforts related to ground and surface water is strongly encouraged. If a joint ground water and watershed management program is established, the county shall be the lead agency for the joint program.

The law creating Ground Water Management Programs (Ground Water Management Plans) contains less specific language but does encourage coordination. However, there are several reasons why this integration at the local level seldom occurs:

- The state treats surface and ground water quality protection programs as separate. The programs are administered by different sections within Ecology. Grants are also managed differently.
- Ground water planning is usually seen as a public health issue, and local public health departments usually serve as lead agency. Watershed planning is usually seen as a surface water issue and is usually addressed by a branch of public works or a planning department.
- Local lead agencies, faced with short timelines and limited resources, are answering to different programs at Ecology and responding to different regulations which guide their planning processes. The magnitude of the problem of trying to coordinate in the face of the confusion generated at the state level proves daunting. Lack of coordination between agencies is often the unfortunate result.

It is possible that budget cuts at Ecology and declines in the amount of money generated by the cigarette tax (Centennial Clean Water Fund) will force a resolution to inefficiencies in water quality planning at the state level. Despite staff recommendations favoring consolidation, there has not yet been concrete progress in this direction.

Ecology is directed by the Stormwater and Combined Sewer Overflow Program to work with the Washington State Department of Transportation on a program to control runoff from state highways in the Puget Sound basin and to develop a technical manual (to assist local governments) that establishes Best Management Practices for storm water management.

Ecology's Stormwater Management Manual for the Puget Sound Basin was developed to assist local governments in meeting the storm water management rules. This manual addresses erosion and sedimentation control, runoff control, and control of pollution from urban land uses. The manual relates to impacts on ground water:

- Infiltration is the preferred method of volume control, and other methods are allowable only after infiltration has been ruled out for technical reasons.

- The Ecology manual requires that a certain volume of runoff be infiltrated or detained. This is of major significance when considering volume of water to be potentially recharged to ground water.

**Local Programs**

The King County Department of Natural Resources, Surface Water Management Division has broad responsibility for storm water management in King County. Surface Water Management conducts routine maintenance of drainage and pollution control facilities, constructs facilities to control runoff and protect natural drainage systems, conducts needed engineering and habitat analyses, and responds to both complaints and emergencies involving flooding, erosion, and water quality. The program's goal is to minimize the personal, financial, and environmental costs associated with flooding and erosion by providing a comprehensive approach to surface water management. King County Surface Water Management has presented the King County Council with the King County Surface Water Management Strategic Plan. The Strategic Plan emphasizes an acceleration of the current program along with new emphasis in water quality and "off road" storm water facilities. King County Surface Water Management also addresses ground water quality and quantity in its planning processes.

The King County Surface Water Design Manual (Design Manual) contains requirements and standards for designing surface and storm water management systems in King County. King County requires that impacts on existing artificial and natural drainage systems be mitigated prior to permit approval for certain developments. The proposed updates to the Design Manual will require water quality treatment comparable to the Ecology Draft Manual, and encourage infiltration where it is feasible. It is generally not allowed in soils that would be considered moderately permeable, however, it is allowed in highly permeable soils with lining to protect ground water. Additionally, the King County manual does not require infiltration or detention of a certain volume of water. It requires that peak runoff not be altered by new development. King County is currently revising its Design Manual to meet the requirements of the Ecology Manual, with a target completion date of October 1996. The section on infiltration was amended and issued in January 1995.

The Department of Development and Environmental Services implements King County Code Title 21 Zoning (the zoning code) which, to some extent, regulates the degree of impervious cover allowed for developments. Proposed changes establish, for the first time, limitations on impervious cover for development. They would prevent extreme cases of lot coverage by impermeable surfaces. The draft code is now being reviewed by a technical review committee established by the Council.

Cities in King County have developed programs varying in their comprehensiveness based on state and local programs.

### 2.3.2 Land Use in Aquifer Recharge Areas

Research has shown that nearly all land uses associated with human activity significantly affect ground water quality due to the effects of nonpoint sources of pollution. It has also been shown that the degree of contamination increases with the intensity of development. It becomes a public policy question as to how to balance land use demands with the need to protect ground water.

Studies demonstrate that certain land uses contribute to contamination of ground water from nonpoint sources. The land uses that were shown to result in the highest concentrations or detection frequencies of a variety of chemical contaminants are generally agriculture, residential (especially high-density), and industrial/commercial. It is difficult to extrapolate the findings of these studies to another geographical area; however, perhaps the most valuable conclusion to the Ground Water Management Plan is the evidence that all land uses compromised ground water quality and that contamination increased with intensity of land use.

To address the land use question in these areas from a water quality basis in relation to storm water management, we would need to increase our understanding of effects on ground water quality of storm water source controls, treatment, and infiltration. We would need to better understand the effectiveness of the best management practice currently supported by experts. Additional study, including modeling and field testing, of these Best Management Practices (lined wet pond - lined bioswale - infiltration basin in series) is needed. Storm water strengths and constituents representative of various land uses should be tested so that, using study results, planners would be able to recommend compatible land uses to elected officials.

**Recommended Management Strategies for Stormwater Management**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Runoff Versus Recharge:**

- **ST-1 Runoff Versus Recharge: Surface Water Design Manual.**

**Discussion:** Impacts from development on ground water can be partially mitigated by infiltrating storm water rather than discharging it to surface water bodies. This practice partially compensates for the loss of natural recharge caused by impermeable surfaces. Some areas of King County with glacial outwash soils are particularly suited to infiltration. In these areas, infiltration should be used to mimic the natural recharge patterns present prior to development as closely as possible. While infiltration is encouraged in King County and, presumably, in some cities, taking a stronger position in its favor should result in greater use of this technique.

This recommendation follows the 1994 King County Comprehensive Plan policy NE-334. "King County should protect ground water recharge quantity in the Urban Growth Area by promoting methods that infiltrate runoff where site conditions permit, except where potential ground water contamination cannot be prevented by pollution source controls and storm water pretreatment." Also, policy NE-302 reflects that position: "Development should occur in a manner that supports continued ecological and hydrologic functioning of water resources. Development should not have a significant adverse impact on water quality or water quantity." Also, policy NE-310 support this action: "Management of storm water runoff should occur through a variety of methods. Storm water runoff caused by development shall be managed to prevent unmitigated significant adverse impacts to water resources caused by flow rates, flow volumes or pollutants to promote ground water recharge, infiltration of storm water when feasible given geological, engineering and water quality constraints. King County's current practice is to pursue nonstructural methods whenever possible. In the Urban Areas, methods which are land consumptive will need to be balanced with the need to protect the supply of developable land."

Storm water infiltration presents a threat to ground water quality; therefore, storm water should not be infiltrated where the risk of ground water pollution cannot be mitigated by pollution source controls and storm water pretreatment. Ecology provides guidance for adequate source control and pretreatment in regard to specific development types in the Stormwater Management Manual for the Puget Sound Basin. Some local jurisdictions are developing similar manuals that are at least as stringent as the Ecology manual. Ground water quality concerns associated with the infiltration of storm water are addressed further in Issue 2.

Infiltration of roof runoff, while allowed in King County, and presumably the City of Issaquah, could be used more extensively or required in appropriate settings including single-family residential development. Consideration should be given to water quality before adopting requirements to infiltrate roof runoff. Certain roofing materials and associated treatments to retard moss growth could result in the introduction of hazardous substances to ground water. In addition, roof runoff may be too contaminated to infiltrate without treatment in highly urbanized areas subject to relatively heavy air pollution. These issues should be more thoroughly explored by King County and the City of Issaquah as they develop specific requirements for infiltration. The King County manual does not presently contain any restrictions on infiltration of untreated roof runoff other than limiting the soils in which infiltration is allowed.

If the Ground Water Advisory Committee decided to take no action, it is probable that King County and the City of Issaquah will gradually increase the use of infiltration technology because of the emphasis placed on it by the Storm Water Management Manual for the Puget Sound Basin (the Ecology Manual).

**Issue 2 Ground Water Quality Concerns:**

- **ST-2A Ground Water Quality Concerns - Facility Requirements.**
- **ST-2B Facility Study.**
- **ST-2 C Facility Monitoring.**

**Discussion:** ST-2A is proposed because of the sensitivity of the most physically susceptible and recharge areas to contamination, the increasing importance of protecting drinking water aquifers, and the difficulty, if not impossibility, of cleaning up contaminated aquifers. Management of storm water, even if done according to Best Management Practices, will not be perfect. Indeed, considerable difficulty has been experienced with storm water infiltration facilities. It should be expected that systems will sometimes fail for structural, maintenance, or weather-related reasons.

King County already requires lined treatment facilities in excessively permeable soils but it does not require conveyance systems that preclude infiltration. It is expected that cities in King County, some of whom have adopted all or part of the King County Manual, have similar requirements. King County Surface Water Management also expects that water quality treatment best management practices will continue to evolve. Effective methods will periodically be incorporated into the Surface Water Design Manual. Water Quality treatment methods should match the risk to ground water quality.

Even as new requirements are instituted, storm water managers do not have adequate information to determine long-term effects of new requirements on ground water quality. Monitoring of the new facilities and additional study will enable us to determine whether long-term effects are acceptable using Best Management Practices.

The Center for Urban Water Resources Management at the University of Washington may coordinate a multi-jurisdictional study. The Center was formed, in part, to address questions about appropriate storm water management. Numerous local jurisdictions are financial contributors to the Center's operations, including King County.

The Center has expressed interest in doing the type of study described in ST-2B and feels it is warranted. The Center serves as a facilitator for local governments interested in solutions to common problems. If, for example, King County were to propose a study, the Center would then contact its members to determine whether they would support it.

A study should be designed and action taken which will benefit all Puget Sound jurisdictions that are both responsible for ground water protection under the Growth Management Act and the Ground Water Quality Standards (Chapter 173-200 WAC) and for requiring infiltration of storm water as directed by the Ecology Manual. The study should determine whether certain land uses make storm water infiltration particularly threatening to ground water quality. For example, the study should compare rural and urban land uses with regard to the potential to safely recharge storm water. Residential and commercial uses of land should also be compared.

The cost of using the best management practice described in ST-2 A will be borne by developers and, ultimately, consumers. Funding for ST-2B should come from identified aquifer protection funds. Alternatively, ST-2B could be funded by a Centennial Clean Water Fund grant, if the aquifer protection fund is not approved by legislative bodies or voters. If that is the case, King County, the City of Issaquah, and the Center for Urban Water Resource Management, should bid for Centennial Clean Water Fund money to carry out a study. Local governments should emphasize in a grant application that local ground water resources may be at risk from the new emphasis by Ecology on infiltration of storm water. Local governments should be supported in their effort to study the effects of state requirements. King County and the City of Issaquah would need to pool financial resources to provide for local match for a grant. Other grant sources besides the Centennial Clean Water Fund could also be considered. If no grant moneys are available, the County and the City of Issaquah would have to pool resources to fund the full cost of the study.

It is anticipated that the monitoring could be done under existing budget, or other fund sources, because King County Surface Water Management's recently adopted Strategic Plan indicates that a certain amount of utility fees are dedicated to monitoring the effectiveness of storm water management facilities.

**Issue 3 Education:**

- **ST-3A Existing Education Programs.**
- **ST-3B Report On Existing Education Programs.**
- **ST-3C Education: Supplemental Educational Program Development.**
- **ST-3D Education Program Coordination.**

**Discussion:** Prevention of pollution is the best approach from the standpoints of cost and environmental impact. Education is the best prevention because it creates a life-long awareness and concern in individuals. This awareness and concern prevents pollution in countless small and large ways as individuals make everyday decisions.

The Department of Natural Resources will seek the cooperation of the parties involved to include ground water information and concerns in the educational programs. Developing an independent educational program to address this issue would probably be largely redundant. It would not likely be supported financially by elected officials in a time of lean budgets. We can use scarce resources more efficiently by reviewing and updating existing programs. Funding for staff at the Department of Natural Resources is necessary to carry out the review, coordination, report, and development of a supplemental program, if needed. It is possible that enhancing existing programs will require that funds be provided to the relevant agency or jurisdiction.

**Funding:** The funding source for this effort will be the aquifer protection funds. If the aquifer protection funds is not approved, grants will be sought in two phases. Phase 1 will involve initial review of educational programs and coordination with other agencies and jurisdictions to address ground water concerns. Phase 1 will also include a report outlining remaining deficiencies. Phase 2 will seek funds to provide enhanced programs at both other agencies and jurisdictions and to develop a supplemental program, if needed. Centennial Clean Water Funds will initially be sought but if that is not successful, all other reasonable sources of grants will be explored.

**Issue 4 Coordination Between Surface and Ground Water Planning Efforts:**

- **ST-4A Coordination Between Surface and Ground Water Planning Efforts - Ecology Programs.**
- **ST-4B Coordination Between Surface and Ground Water Planning Efforts - Puget Sound Water Quality Authority.**
- **ST-4C Coordination Between Surface and Ground Water Planning Efforts - King County.**

**Discussion:** State law encourages coordination of nonpoint and ground water protection plans. In reality, this has been difficult for local governments to achieve. The underlying reasons why this integration at the local level often does not occur include:

- Administration of surface and ground water protection grants by different sections at Ecology;
- Separate state regulations guiding planning processes;
- More favorable funding rules with the Centennial Clean Water Fund for planning processes that do not address water quantity issues, a crucial element of a ground water plan;
- Lack of recognition of the need to protect surface and ground water concurrently as part of a continuous dynamic system;
- Planning processes carried out by different lead agencies at the local level; and
- Lack of a proactive program to coordinate at the local level.

Issue 4 offers the GWAC an opportunity to bring their concerns on this issue to the three major entities involved in multi-jurisdictional surface and ground water planning: Ecology, the Puget Sound Water Quality Authority, and King County. The City of Issaquah is effectively reached by this alternative because the City of Issaquah is a member of the multi-jurisdictional planning efforts. The GWAC will seek a commitment from the City of Issaquah to take steps to evaluate the effectiveness of existing water resource protection planning processes and to make improvements to them where needed.

Legislation is not needed to make administrative changes at Ecology. Relevant regulations addressing ground and surface water planning already encourage coordinated or joint efforts. How the regulations are implemented will be one determining factor in whether water resource protection planning processes continue to evolve on somewhat separate tracks.

The Puget Sound Water Quality Authority's priorities should continue to be those issues which have the greatest impact upon the quality of Puget Sound waters. The Authority should explore, however, the importance of the ground water contribution to Puget Sound. It is encouraging that ground water protection is listed in the Plan's Unfinished Agenda. GWAC input may be enough to cause a shift in perspective at the Authority and thereby move ground water protection up on the scale of priorities.

Changes at the state level would necessitate close cooperation with local governments currently involved in planning activities. Innovation should be encouraged in implementing water resource plans to alleviate redundancies which may exist between surface and ground water planning efforts.

On the local level, coordination will result in more efficient use of scarce resources for environmental protection. Conflicting planning documents that could serve to interfere with the implementation of one or both can be avoided. More importantly, integrated approaches that could result in better protection and more efficient use of resources can be developed.

While a coordinating process will initially be time consuming, it will save resources in the long term. It will also help local lead agencies to meet more closely the coordination provisions of state regulations. This recommendation follows the 1994 King County Comprehensive Plan policy NE-303 which states that "Future watershed plans should integrate surface water, ground water, drinking water and wastewater planning to provide efficient water resource management" and policy F-323 which states that "To reduce flooding, erosion and sedimentation, prevent and mitigate habitat loss, enhance ground water recharge and prevent water quality degradation, the surface waters of King county shall be managed through plans, programs and regulations developed by King County in cooperation with affected jurisdictions whenever possible."

King County agencies responsible for planning could jointly evaluate existing water resource planning efforts to determine how they might be streamlined and made more effective. Agencies involved should include at least the Department of Natural Resources, Seattle-King County Health Department, the Environmental Division, and the Community Planning Section of the Planning and Community Development Division.

**Issue 5 Assessment of Existing Storm Water Facilities:**

- **ST-5 Assessment of Existing Storm Water Facilities in the Most Physically Susceptible and Recharge Areas.**

**Discussion:** Many jurisdictions are preparing for the new storm water management requirements by inventorying their existing storm water facilities. This is an advantageous time to bring to the attention of local authorities the GWAC's concerns about ongoing threats to ground water quality from antiquated storm water management facilities. Dry wells are of particular concern because they are used in very permeable soils, they bypass any treatment afforded by near-surface soils, they are most often used in urban areas subject to significant contamination, and they are often not fitted with water quality controls.

Many jurisdictions will be required to address existing water quality problems. Unless the GWAC brings the matter to the attention of storm water managers that ground water quality is as great a concern as surface water, our concerns may be overlooked in setting priorities for water quality retrofit.

Emphasis on the most physically susceptible and recharge areas is recommended because of aquifer sensitivity. Well Head Protection Areas are emphasized because of the immediacy of the use of the aquifer for public drinking water supplies.

**Issue 6 Roadway Runoff:**

- **ST-6 Roadway Runoff.**

**Discussion:** This action could influence local storm water management jurisdictions within the Issaquah Creek Valley Ground Water Management Area to give a higher priority to the most physically susceptible and recharge areas and Well Head Protection Areas when addressing storm water quality and quantity problems. The benefit of corrective actions would be increased by focusing them in the areas that are most susceptible to ground water contamination or areas that are important because they are located within the zone of contribution to a public water supply well or wellfield.

County and city public works departments have a tremendous task ahead to meet all of the requirements posed by new and upcoming storm water management regulations. Many will be addressing existing water quality problems as a result of new requirements depending on the degree of comprehensiveness of the storm water management program required or opted for. Cities will be establishing storm water utilities and setting priorities for expenditures of fees collected from residents and businesses. It is important at this time to bring to the attention of local jurisdictions concerns for ground water protection and to request that these concerns receive high priority.

**Issue 7 Soil Amendment:**

- **ST-7 Soil Amendment Study**

**Discussion:** Soil amendment may be a valuable means to protect both ground and surface water. Additional information is needed about this topic to determine whether the benefits warrant further action. Soil amendment in this context refers to the process of adding materials to the soil to increase moisture and nutrient retention. Amendments that could be used include composted yard waste, commercial topsoil, and sand. The benefit of soil amendment is that nutrients, pesticides, and other pollutants from generalized sources would be less likely to run off of the site or rapidly move through excessively permeable soils to reach shallow, unprotected aquifers typical of the most physically susceptible and recharge areas.

The City of Redmond has tested various soil amendments for their ability to increase soil moisture and nutrient holding capacity; however, the City was not awarded a Centennial Clean Water Fund grant to field test the findings of the study. A study of this sort might logically be coordinated by the Center for Urban Water Resources Management with the cooperation of King County and the City of Issaquah. Any additional study should build upon work already done by the City of Redmond.

### 2.4 Ground Water Education Program

Providing citizens with information on the ground water resource and protection may be a particularly effective protection method. Understanding, caring, and commitment are needed to protect a finite basic resource which is impacted by a wide variety of activities. Although regulations may help, groups of informed citizens actively caring for ground water under their own communities, may be more effective. Providing technical assistance will not address all the concerns, but it will empower some community members to take individual action.

Currently there are a number of education programs focused on individual sources of contamination. However, no comprehensive ground water education program focuses on the following tasks:

- Help engender understanding and concern to protect the resource.
- Aid in developing resource protection messages that are consistent regardless of the specific education program.
- Coordinate with other resource protection programs that focus on a specific issue, such as solid waste, hazardous waste, surface water and storm water management.
- Develop specific education activities and materials for point and nonpoint sources of contamination that do not have their own individual programs.
- Support research on ground water resource.
- Encourage and promote conservation.

A comprehensive program would coordinate existing environmental education programs to develop consistent messages about the ground water resource and ground water protection. This component would be done by briefing environmental educators about King County's ground water system, and supporting joint programs. The program would respond to local ground water quality and quantity concerns that are not already covered by other programs. This program would provide assistance for local planning efforts and other ground water protection projects.

Providing information to citizens involved in community planning projects would be another program aspect. Increasingly citizens are taking an active part in neighborhood planning and are concerned about resource protection. As they develop these plans, whether addressing school siting, transportation routes, or zoning, the public may need information about the ground water system. This knowledge will assist citizens in addressing ground water protection measures within the context of their planning process.

Educational programs have been shown to be an effective method to protect natural resources. The development of the ground water management program included a public education component. During the GWAC's consideration of the potential threats to ground water, several specific educational program elements were adopted. These elements need to be consolidated into one comprehensive program.

**Recommended Management Strategies for the Educational Program**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Existing Educational Programs:**

- **ED-1 Existing Education.**

**Discussion**: Prevention of pollution is the best approach from the standpoints of cost and environmental impact. Education is the best prevention because it creates an awareness and concern in individuals which influences their decisions and actions. Developing a comprehensive independent educational program to address ground water protection would probably be redundant. Scarce resources can be used efficiently by building upon existing programs.

The Department of Natural Resources will seek the cooperation of the parties involved to include ground water information and concerns in the educational programs. This review will ensure that the Issaquah Ground Water Management Plan goals and policies are reflected. Cooperative Extension and others have several educational efforts underway. They integrate ground water protection information where possible, and are agreeable to including more. Cooperative Extension, Natural Resources Conservation Service, and others could include Ground Water Management Plan concerns in their educational material.

Specific elements will address specific GWAC concerns:

> The Seattle-King County Health Department will coordinate measures to increase public awareness about the potential impacts of discharging household chemical products to an on-site sewage system. Such measures would be an extension of activities scheduled as part of the Local Hazardous Waste Management Plan.
>
> Educational efforts would complement and combine with current efforts of the Department of Natural Resources, Cooperative Extension, and the King Conservation

District. This information could be disseminated through the Master Gardener and other programs of Cooperative Extension. Awareness of the problem of reduced aquifer recharge may increase responsibility and concern for aquifer recharge areas in the community. Educational programs on how landscaping practices can affect aquifer recharge could be coupled with education on the effects of pesticide and herbicide use on ground-water quality. A discussion of proper disposal of household hazardous wastes could be included. Landscaping tips should include a discussion of native vegetation and its role in facilitating moisture infiltration.

Informed and involved well owners and other community members are probably more likely to comply with the well construction and abandonment regulations than they would be otherwise. Ways to inform and involve well owners might include distributing a questionnaire about wells to homes in the community; developing and distributing an educational brochure for homeowners; and supplementing the brochure with community educational programs. The questionnaire should be designed to elicit the number of wells on each property, the construction methods used, and the number of wells that require abandonment. The brochure should include recommended practices and legal requirements for well construction and abandonment. It should also include the reasons why practices such as sealing the well are both advisable and required by law so that homeowners are knowledgeable before they make plans to construct or abandon a well. The education program should cover the same information, and provide the public with an opportunity to ask individual questions.

**Issue 2 New Educational Elements:**

- **ED-2 New Educational Elements.**
- **ED-3 New Education Elements - Volunteer Program.**

**Discussion:** During the development and consideration of the issues that affect ground water quantity and quality, the GWAC found that several issues could be addressed through educational efforts. However, this education was not being conducted by any other agency. Therefore, the adopted actions contained new educational elements. These are:

- The existing public information pamphlet concerning on-site sewage system maintenance and operation will be amended to provide instructions on proper household hazardous waste disposal practices prior to any scheduled reprinting.
- A committed and trained group of volunteers will expand the knowledge of protecting the ground water resource. These volunteers will function in a role similar to that established by the King County Extension Service, Master Gardener and Land Water Steward Volunteer Programs.
- Including home heating oil tanks in the overall Issaquah Ground Water Management Plan Education Program will help address the low level of

compliance with the requirements for home heating oil tank abandonment. Homeowners are unaware of their responsibilities under the Uniform Fire Code, probably because there are no programs on proper maintenance and abandonment. By providing educational material to tank owners, an increase in the community knowledge about the problem, and an increase in the numbers of tank owners that comply with the regulations could result. Also, by increasing community awareness, it is expected that home purchasers would require that information on tank status be disclosed.

- Providing information about recycling, and educating residents about reducing the waste stream, may reduce the amount of waste going into the landfills and the amount of hazardous products that people buy.

Other new program aspects may be developed under direction from the Management Committee. Some possible tasks, especially for the volunteers, are:

- Support schools or individual teachers with an interest in ground water protection. Such support could include providing educational materials, or developing school skits.
- Working with neighborhood groups on neighborhood ground water protection efforts.
- Developing and installing interpretive signs, for example, signs explaining Well Head Protection Areas.
- Development of a video on water resources for cable television and distribution to local video outlets.
- Sponsoring informational booths at local fairs; booth displays at local libraries or bank lobbies.

# 3 Programs To Protect Ground Water Quality

## 3.1 Ground Water Protection Issues Associated with Hazardous Materials Management

Substances that are hazardous to public health and the environment are a by-product of industrialization. As society has become more industrialized, materials that support industrialization have become more prevalent and hazardous. Myriad industrial and commercial processes produce and use these hazardous substances. The use of hazardous materials is not, however, limited to industries and businesses. These materials are widely available and used by almost everyone. The impact of these substances on the environment, particularly ground water, is determined by the management practices of the businesses and individuals who use them.

Ground water contamination can occur when hazardous materials, either liquids or those dissolved in water, migrate through the soil. Ground water contamination can also occur when hazardous materials are spilled into surface water features that are in hydraulic continuity with ground water. Human health threats occur when contaminated ground water reaches aquifers used for drinking water supplies. The cleanup of contaminated aquifers is difficult, costly, time-consuming, and may not be successful.

The threat of ground water contamination by hazardous materials is currently being addressed by a number of federal, state, and local statutes. These laws address particular activities associated with hazardous materials. The remainder of this discussion will be divided into three sections commensurate with the way hazardous materials are regulated. The three sections are:

1. Hazardous waste management
2. Hazardous waste contamination sites
3. Hazardous material spill prevention and emergency response

### 3.1.1 Hazardous Waste Management

Hazardous waste consists of discarded hazardous materials. The Uniform Fire Code of 1988 defines hazardous materials as those chemicals or substances which are physical hazards or health hazards as defined in Article 80 whether the materials are in usable or waste condition. The statutes addressing the protection of ground water from hazardous waste are:

The Resource Conservation and Recovery Act which requires the Environmental Protection Agency to regulate generators that produce hazardous waste.

The Hazardous Waste Management Act (Chapter 70.105 RCW) designates that Ecology as the state agency implement the Resource Conservation and Recovery Act. Chapter

70.105 RCW describes many key features of Ecology's hazardous water management program including:

- Establishing a permit system for land-based treatment, storage, and disposal facilities.
- Developing standards for the safe transportation, treatment, storage, and disposal of hazardous wastes.
- Establishing a manifest system to track hazardous waste.
- Establishing reporting, monitoring, recordkeeping, labeling, and sampling requirements; and
- Inspecting, monitoring and sampling.

The Dangerous Waste Regulations (Chapter 173-303 WAC) were adopted by Ecology as authorized by the Hazardous Waste Management Act for the purpose of implementing its provisions. The purpose of the regulations is to:

- Designate dangerous and extremely hazardous wastes.
- Perform surveillance and monitoring of these wastes.
- Provide forms and rules to establish a system for manifesting, tracking, reporting, monitoring, recordkeeping, sampling, and labeling hazardous wastes.
- Establish siting, design, operation, closure, post-closure, financial, and monitoring requirements for hazardous waste transfer and land-based treatment, storage, and disposal facilities and a permit system.
- Encourage recycling, reuse, reclamation, and recovery to the maximum extent possible.

The Hazardous Waste Management Act requires the development of a statewide Hazardous Waste Plan that is to be updated every 5 years. The plan must include but not be limited to:

- State inventory and assessment of capacity of existing facilities to treat, store, dispose or otherwise manage hazardous waste.
- A forecast of future hazardous waste generation.
- A description of Ecology studies to determine appropriate waste management methods.
- A public information and education plan coordinated with local government efforts.
- Public involvement.

The plan contains seventy separate issues and recommendations. Some of the most important or relevant are:

- Ecology is understaffed to carry out inspection and enforcement activities.
- Staff turnover rates within the permit section was near sixty percent over the last several years, thereby severely limiting Ecology's ability to process applications.

- Penalties for violations are based on environmental or human health risk. Economic gain by the violator may be sufficient to offset the penalty.
- The issuing of land-based treatment, storage, and disposal facilities permits is extremely resource intensive.
- The existing permit application guidance is very general and non-technical. There is no standardized permit application format.

Under the Hazardous Waste Reduction Act, Ecology adopted the Pollution Prevention Planning Regulations where generators and users of more than threshold quantities of hazardous waste must prepare Pollution Prevention Plans for reducing use of hazardous waste. Annual implementation progress reports must be submitted to Ecology. The Hazardous Waste Management Act declares that local government is the appropriate level for planning and carrying out programs to manage moderate risk waste with Ecology's assistance.

In 1991, jurisdictions in King County developed and adopted the Local Hazardous Waste Management Plan (Plan) with support of a state grant. The goal of the Plan is to protect public health and the environment from the adverse effects of improper handling and disposal of hazardous wastes by small quantity generators and households. Small quantity generators are those businesses that produce moderate risk waste defined as less than 220 pounds of hazardous waste and/or less than 2.2 pounds of extremely hazardous waste per month (or which accumulates on-site no more than these amounts at any time.)

Ground water protection is discussed as a component of educational and enforcement activities during implementation of the plan. Of particular concern is the risk of ground water contamination associated with the disposal of hazardous wastes in on-site sewage disposal systems. The Local Hazardous Waste Management Program in King County intends to emphasize this concern in its educational activities.

**Recommended Management Strategies for Hazardous Waste**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 State Hazardous Waste Plan:**

- **HM-1 State Hazardous Waste Plan - Implementation.**

**Discussion:** The Hazardous Waste Plan identifies problems and recommends solutions for Hazardous Waste Management. The 1994 update of the Plan stated that 40 of the 59 recommendations either have been or are being implemented and that 11 of the 14 not yet implemented were scheduled for implementation during 1994-1998. The GWAC can effectively communicate its concerns for ground water protection from hazardous waste to Ecology and the Legislature by supporting the Plan. The GWAC's resolution will be communicated to Ecology via the Ground Water Management Program review and certification process.

**Issue 2 Dangerous Waste Management Unit:**

- **HM-2 Dangerous Waste Management Unit Setback - Regulation Amendment.**

**Discussion:** Lack of separation by a layer of unsaturated soil increases the chances that hazardous waste leaks could get into ground water before detection and remedial action. Although discussions with Ecology staff indicate that location in ground water would probably not be allowed, nowhere is such a prohibition stated in the Dangerous Waste Regulations. At best, this inconsistency creates a lack of confidence, among concerned citizens, in the siting criteria and confusion upon the part of proponents and reviewers. At worst, a facility could be inappropriately sited, thereby increasing the possibility of ground water contamination.

The GWAC, by requesting an amendment, will bring this matter to the attention of Ecology administrators and will precipitate a change in the regulations if Ecology agrees to it. The GWAC should be aware, however, that Ecology went through an arduous process to adopt these rules over a period of several years. At least fifty-three public hearings and workshops were held. Ecology may be reluctant to open the regulations to change at this time. If that is the case, the GWAC's concerns will at least be registered and may be entered in a list of future changes. In addition, staff will be alerted to the inconsistency.

The request to modify the setback from ground water is communicated to Ecology during the review and certification process for the Issaquah Creek Valley Ground Water Management Plan. No additional action is needed.

**Issue 3 Hazardous Waste Facilities Zones:**

- **HM-3 Hazardous Waste Facilities Zones - Local Designation.**

**Discussion:** The designation of zones will result in better waste management practices. It will recognize and facilitate the state "Close to Home Policy" aimed at encouraging on-site waste management including waste reduction and recycling. This policy also encourages communities who benefit most directly from businesses that generate hazardous wastes to accept some of the associated risk. On-site waste management also reduces the risks associated with transporting wastes. The waste generator may realize reduced costs for waste disposal by pursuing waste reduction and waste management alternatives. The conditions of the Ecology dangerous waste permit will determine which wastes may be stored and for how long.

Given that the state legislature determined that local government land use authority would be preempted to a large degree, it is probably better for King County to designate the zones in which, by its own interpretation, hazardous materials may be treated, stored and disposed rather than have the state do it. It is not yet known whether the City of Issaquah has designated zones. The GWAC can raise this issue with the City of Issaquah during the concurrence process for the Issaquah Ground Water Management Program.

### 3.1.2 Hazardous Waste Contamination Sites

Hazardous waste contamination sites are sites where hazardous waste has been spilled, leaked or disposed of into the ground. The statutes which regulate hazardous waste contamination sites include:

The Comprehensive Environmental Response, Compensation and Liability Act established a trust fund commonly referred to as "Superfund" for the cleanup of abandoned or uncontrolled waste sites. The Environmental Protection Agency has primary responsibility for cleanup and enforcement under Comprehensive Environmental Response, Compensation and Liability Act.

The Comprehensive Environmental Response, Compensation and Liability Act established a new agency within the U.S. Public Health Service (the Agency for Toxic Substances and Disease Registry) to carry out the health-related authorities of Comprehensive Environmental Response, Compensation and Liability Act. The Agency for Toxic Substances and Disease Registry functions as a branch of the U.S. Public Health Service concerned with health effects of toxic substances in the environment. The Agency for Toxic Substances and Disease Registry conducts "human health assessments" at hazardous waste sites listed on the national priority list, the most serious hazardous waste sites in the nation.

The Washington Model Toxics Control Act Chapter 70.105D RCW, passed by Washington voters supplements Comprehensive Environmental Response, Compensation and Liability Act. The stated purpose of Model Toxics Control Act is to raise sufficient funds to clean up all hazardous waste sites and to prevent future hazards due to improper hazardous waste disposal (Chapter 70.105.010. RCW) Toxic Control Accounts, both state and local, are created that may be used to carry out provisions of the Model Toxics Control Act. The Model Toxics Control Act establishes a program for Ecology to identify, investigate, and clean up sites where hazardous substances have been released into the environment. Under the Act, Ecology adopted the Model Toxic Control Act Cleanup Regulations (Chapter 173-340 WAC) to develop a program to carry out the Act.

The Washington State Department of Health, Office of Toxic Substances, has a role in hazardous waste site management that corresponds to the Agency for Toxic Substances and Disease Registry on the federal level. They contract with the Environmental Protection Agency to conduct health assessments for National Priority List sites in Washington for which the responsible parties do not include the federal government.

The Washington State Department of Health, Office of Toxic Substances, is also involved in locating and informing the Environmental Protection Agency and Ecology of sites not on the National Priority List or the Hazardous Site List. The Washington State Department of Health, Office of Toxic Substances, has sought the assistance of local health departments in this task both by letter and newsletter but, to date, has not had much response statewide. The importance of local participation is emphasized by the Washington State Department of Health, Office of Toxic Substances, because there are often sites of possible concern that only local health officials are aware of. Both federal and state officials indicate that more involvement in site discovery and public outreach by local health departments is needed.

Local governments are not subject to any legal requirement to regulate hazardous waste sites. They are involved in hazardous waste site cleanup primarily either as a responsible or affected party. The Seattle-King County Health Department is involved in any aspect of cleanup actions that is subject to its regulatory programs. Landfill closure is the main facet of cleanup actions that the Seattle-King County Health Department regulates.

**Recommended Management Strategies for Hazardous Waste Contamination Sites**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 4 Hazardous Waste Contamination Sites - Site Referral and Public Education:**

- **HM-4 Hazardous Waste Contamination Sites - Site Referral and Public Education by the Seattle-King County Health Department.**

**Discussion:** Although hazardous waste site cleanup programs have a long way to go to remedy existing sites, it does not appear that regulatory involvement is needed on the local level. However, existing programs may not adequately address public health concerns in King County relative to known or as yet undiscovered hazardous waste sites that may involve ground water pollution. Action HM-4 will bring the matter to the attention of King County. If the King County Council agrees with the concern, it may instruct the Seattle-King County Health Department to enter into discussions with the Washington State Department of Health on the appropriate role for the local health department. This would be a role that would complement the federal and state roles, rather than duplicate them. Local knowledge, not available in any written record, would be used in locating possible sites of concern. Local health departments could be of assistance to the Washington State Department of Health in obtaining a site history, given better knowledge and access to local land use records and residents who may have information. The Seattle-King County Health Department could assist the Washington State Department of Health in determining needs for public health information and in disseminating such information to the public at risk.

### 3.1.3 Hazardous Material Spill Prevention and Emergency Response

**Spill Prevention At Facilities**

Fire services in King County play a major role in prevention of hazardous material spills from fixed facilities. This role derives from the fire services' mandate to implement the Uniform Fire Code.

Each city in King County has its own fire department and operates according to its own ordinances. Fire protection in King County is accomplished both by the King County Fire Marshal and fire districts. The County Fire Marshal's Office is the regulatory agency that implements the Uniform Fire Code, including its hazardous materials provisions. Fire districts, on the other hand, have a responsibility for firefighting and other emergency responses including hazardous material spills. Fire districts do not have authority to adopt or enforce fire codes.

The Uniform Fire Code is developed by the International Fire Code Institute. Its intent is to prescribe requirements consistent with nationally recognized good practices for safeguarding life and property from the hazards of fire and explosion associated with various practices. One of these is the storage, handling, and use of hazardous materials.

There is no federally adopted version of the Uniform Fire Code. States are free to adopt a version of the Uniform Fire Code, amend it, or adopt none of it. In practice, most states adopt some version of the Uniform Fire Code. The 1994 version of the Uniform Fire Code became effective July 1995.

Chapter 19.27 RCW, the State Building Code, creates the Washington Building Code Council. This statute gives the Council the authority to adopt and revise the State Building Code, including the Uniform Fire Code.

Article 80 of the Uniform Fire Code provides requirements for the prevention, control, and mitigation of dangerous conditions related to hazardous materials; it also provides information needed by emergency response personnel. The Uniform Fire Code prohibits persons and businesses from using, storing, dispensing, or handling hazardous materials in quantities over a specified amount without a permit. Inspections are performed by fire services to ensure compliance. These inspections are coordinated by the King County Fire Marshal in unincorporated King County. Storage areas must be constructed according to requirements including approved secondary containment facilities for some chemicals. Modifications to and closures of storage facilities must be done under permit. With a few exceptions, such as the appropriate use of pesticides, the Uniform Fire Code prohibits release of any hazardous material to sewers, storm drains, surface waters, the ground, or to the air except under permit from appropriate agencies.

At the discretion of the King County Fire Marshal, Hazardous Materials Management Plans and Hazardous Materials Inventory Statements may be required to obtain an operating permit. These documents are important tools that assist the fire services in implementing Article 80.

The Washington Building Code Council has adopted an amended version of the Uniform Fire Code. Two amendments that weaken the Uniform Fire Code in Washington may be of concern to the Ground Water Advisory Committees (GWAC): (1) Hazardous Materials Management Plans and Hazardous Materials Inventory Statements are not required from businesses regulated under the federal Emergency Planning and Community Right-To-Know Act (Chapter 51-24-80103 WAC); (2) An entire category of hazardous materials has been exempted from storage regulations under the Uniform Fire Code. This category is denoted in the 1991 Uniform Fire Code as "Carcinogens, irritants, sensitizers, and other health hazard solids, liquids and gases" (Chapter 51-24-80315 WAC).

It was concluded by the Building Code Council that the Hazardous Materials Management Plans and Hazardous Materials Inventory Statements duplicate planning requirements under the Emergency Planning and Community Right-To-Know Act. Some hazardous materials experts disagree with the Council and contend that fire services were left with less than adequate information about the facilities that they must respond to in an emergency.

The exemption of a category of hazardous materials from storage regulations is of concern for several reasons. The category exempted contains some of the substances that are of the greatest concern to those who are working to protect ground water quality. The section from which an exemption is granted includes a requirement for secondary containment for both indoor and outdoor storage of the materials included in the hazard class. No agency has the broad authority that the Uniform Fire Code grants to fire services, nor are other agencies on-site for inspections as frequently. The lack of regulation of storage practices for this hazard class at local businesses by the fire services could substantially weaken the effort to prevent the release of these materials to the environment and, ultimately, the ground water.

Local governments may adopt the Uniform Fire Code as adopted by the state, or they may adopt a more stringent version. The version of the Uniform Fire Code adopted by local governments is important to ground water protection in that weaknesses inherent in the state version can be compensated for. King County adopted the Uniform Fire code as written.

While the Uniform Fire Code prescribes the issuance of permits and periodic inspections, local governments establish the level at which the Uniform Fire Code is implemented. Staffing and level of involvement in hazardous materials regulation varies. Some fire departments have not developed expertise in hazardous materials regulation, nor have staff been dedicated to the task. King County has enforced the 1988 expanded version of the Uniform Fire Code.

While there is some overlap in regulatory authority, each of the agencies involved in spill prevention has a different emphasis. In many cases, the agencies can help each other to gain compliance or to maintain contact with businesses. Regulatory requirements added together provide better protection of both the environment and public safety than any regulation standing alone. While fire services have made great strides in implementing Article 80 of the Uniform Fire Code, the programs of local governments are not yet fully developed.

**Hazardous Material Spills During Transport**

The risk of ground water contamination posed by truck or rail transport of hazardous materials is determined by many factors including the nature and quantity of the materials transported, precautions taken in packaging and transport, safety factors including speed limits, congestion, highway or railway design and maintenance, and sensitivity of the area in which a spill occurs.

Many highways and roads in King County that are frequented by trucks carrying hazardous materials bisect areas which are geologically susceptible to ground water contamination or near municipal wells.

Risk assessments for transportation spills have not been done for King County, in general, although individuals may have done such studies to address particular concerns such as SEPA review. Public water system purveyors will, however, in the near future, be developing their well head protection programs as required by federal and state law. Assessment of risk associated with transportation spills will likely be included in contaminant source inventories required under the new law.

Numerous federal and state agencies are responsible for the enforcement of the laws that are designed to prevent spills of hazardous materials from commercial carriers:

- The U.S. Department of Transportation, Washington State Department of Transportation, Federal Highway Administration, Office of Motor Carriers enforces regulations for interstate motor carriers contained in 49 Code of Federal Regulations Parts 100 - 199. Parts 171-180 are commonly referred to as the Hazardous Materials Regulations.

- The Federal Railroad Administration under Washington State Department of Transportation regulates rail construction and safety as well as shipment of hazardous materials by rail.

- The Washington Utilities and Transportation Commission, the Washington State Patrol, the Washington Department of Transportation, and Ecology are all involved on the state level in preventing spills of hazardous materials from commercial motor carriers.

- Ecology has a role in regulating transport of hazardous waste under Chapter 173-303 WAC Dangerous Waste Regulations. These regulations are more stringent than Washington State Department of Transportation hazardous materials rules.

The consensus among persons interviewed for the section on transportation spill prevention is that the system is working well and getting better. Regulations and programs governing packaging and transportation of hazardous materials are generally felt to be good and will become more effective with recent updates.

**Emergency Response To Hazardous Material Spills**

Emergency response to hazardous material spills that threaten the environment is the responsibility of many agencies. This section will discuss spill reporting, spill response, and emergency planning.

Spill reporting is required under the Washington Dangerous Waste Regulations, the federal Emergency Planning and Community Right-to-Know Act, the Department of Transportation's Hazardous Materials Regulations, Washington's Underground Storage Tank Regulations, and the Uniform Fire Code.

Spill response is unique to each spill. First responders to hazardous materials spills threatening life and property are usually the Hazardous Materials Units of local fire services.

The Emergency Planning and Community Right-to-Know Act (42 U.S. Code Section 11045) was enacted by Congress in 1986. It was contained within the Superfund Amendments and Reauthorization Act, Title 3 and its provisions are often referred to informally as "SARA Title 3 requirements" although it is codified separately (not a part of Comprehensive Environmental Response, Compensation and Liability Act). The Emergency Planning and Community Right-To-Know Act requires emergency response planning for federal, state, and local government with the participation of industry. It includes "right-to-know" provisions that provide communities with access to information on facilities in their locales. The Emergency Planning and Community Right-To-Know Act also requires emergency and toxic release reporting.

Emergency planning provisions of the Emergency Planning and Community Right-To-Know Act require states to establish a state Emergency Response Commission, emergency planning districts and local emergency planning committees. Local emergency planning committees must develop and facilitate the implementation of local emergency management plans in cooperation with the facilities that use, produce, or store "extremely hazardous substances."

King County has a basic Local Emergency Management Plan in place. Those industries that are subject to Emergency Planning and Community Right-To-Know Act regulations are required to participate in the preparation of the Local Emergency Management Plan.

One of the ways in which they have participated is to provide emergency response plans for their own facilities. These have been incorporated into the Local Emergency Management Plan. Protection of people and property has been the primary emphasis of the Local Emergency Management Plan to date.

Some problem areas observed with the Local Emergency Management Plan are:

- Most industries subject to Emergency Planning and Community Right-To-Know Act reporting requirements have not provided their emergency response plans to King County for incorporation into the Local Emergency Management Plan; and
- King County should be collecting information from all fire services within the planning area regarding hazardous materials facilities; the County should also be entering information into a database compatible with databases used by other jurisdictions within the county. King County has a database program but it lacks the information needed to enter it into the database system.

A map of areas susceptible to ground water contamination from transportation spills of hazardous materials and the vulnerability assessment could be the basis for the Local Emergency Planning Committees to consider such issues as the routing and timing of extremely hazardous material shipments through the community, particularly in sensitive aquifer recharge areas. Highway design factors and speed limits could also be considered.

Another matter that may be of concern to the GWAC can be addressed by the Local Emergency Management Plan. In other areas of the nation, it has been found that firefighting techniques in sensitive areas should be considered in advance of an emergency.

**Recommended Management Strategies for Hazardous Material Spill Prevention and Emergency Response**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 5 Implementation of the Uniform Fire Code:**

- **HM-5 Implementation of the Uniform Fire Code in Physically Susceptible Areas**.

**Discussion:** The Uniform Fire Code does not prescribe penalties. Rather, it contains an ordinance format that may be used to set penalties. Local jurisdictions may or may not adopt the schedule of penalties. The County has a cumbersome civil penalty procedure that can be used to gain compliance. Only by commitment to an active program to implement Article 80 will its benefits be realized. Some jurisdictions contacted in preparation of this paper have not yet staffed their programs with trained individuals. The Ground Water Advisory Committee, by requesting a commitment to program development, will accomplish two things for ground water protection: (1) They will bring to the attention of local jurisdictions the importance of good hazardous materials management programs on the local level and (2) If successful in obtaining concurrence, will improve existing programs.

Because aquifers cross jurisdictional boundaries, less vigorous spill prevention in one jurisdiction can have a deleterious effect on the aquifer used by an adjacent jurisdiction. It is important, therefore, to seek consensus between all of the jurisdictions in the Ground Water Management Areas on the importance of preventing spills of hazardous materials.

As originally written, Article 80 does not incorporate an enforcement program. Each jurisdiction adopting the Uniform Fire Code must develop and adopt its own enforcement program. Many jurisdictions do not currently have authority to issue citations for violations of the Uniform Fire Code. The GWAC can express both its support for educational approaches and request better enforcement tools in the interest of better hazardous materials management.

Several key sections of Article 80 were altered or deleted by the State Building Code Council. Certain chemicals were exempted from storage requirements, and some businesses were exempted from the requirements for Hazardous Materials Management Plans and Hazardous Materials Inventory Statements. Adoption and enforcement of the original wording, as is done by the King County Fire Marshal's office, is important for ground water protection.

It would be beneficial if fire services could focus attention on physical susceptibility and recharge areas since contamination introduced in these areas presents the greatest risk to drinking water wells.

King County Department of Natural Resources will develop criteria for evaluating the hazardous materials management programs of fire services and include an annual evaluation in its regular reports to the GWAC and Ground Water Management Committees. (Please see Chapter 3 for a discussion of committees involved in Ground Water Management Plan implementation.) The Department of Natural Resources will continue to encourage program development and implementation on an ongoing basis.

The lead agency will discuss funding to implement this action with the King County Fire Marshal and the City of Issaquah's fire department. The goal of this discussion is to determine whether implementation can be funded by hazardous materials permit fees alone or whether aquifer protection fees should be considered to supplement fire service activities.

Some local governments in King County have already instituted a hazardous materials permit fee as a way to fund their program. This is probably the best long-term solution to hazardous materials regulation. Each jurisdiction will need to assess its existing program and determine the best means to fund improvements, if needed.

**Issue 6 Implementation of the Emergency Planning and Community Right-to-Know Act:**

- **HM-6 Implementation of the Emergency Planning and Community Right-to-Know Act in Physically Susceptible and Recharge Areas.**

**Discussion:** All persons consulted for this issue paper agreed that the Local Emergency Management Plan needs significant improvement. The requested improvements noted above reflect the concerns articulated as well as elements of an Local Emergency Management Plan as described by federal guidelines.

The King County Office of Emergency Management coordinates the activities of the Local Emergency Planning Committee. The Local Emergency Planning Committee contains representatives of cities and fire districts in King County. This committee determines what is in the Local Emergency Management Plan, and how each agency will coordinate with the others.

Maps of Physically susceptible and recharge areas will provide emergency planners with the necessary information to plan for appropriate response to spills in these areas. Firefighting and emergency response techniques that are as protective of ground water as possible should be considered.

Referral of facilities that fail to meet Emergency Planning and Community Right-To-Know Act requirements to the Environmental Protection Agency for enforcement will provide the last resort measure to obtain compliance from facilities that have been uncooperative with educational approaches. This is needed because local emergency response officials do not have enforcement authority under the Emergency Planning and Community Right-To-Know Act.

The Local Emergency Management Plan must be constantly updated and tested if it is to be effective. Community outreach is needed so that new businesses are brought into the system. The database should be dynamic and rapidly incorporate information taken from routine inspections done by local fire services. In this way, emergency planners, elected officials, and resource protection planners can assess on an ongoing basis, the threat to the environment and public health from hazardous materials in the community.

King County Department of Natural Resources will:

- Provide maps of physical by susceptible and recharge areas and well location to the King County Office of Emergency Management.
- Provide information about the emergency response techniques necessary to protect aquifers and wells. for Local Emergency Planning Committee consideration, and incorporation into the Local Emergency Management Plan.
- Review existing literature and determine the need to contract for a consultant with expertise in this area.

- Develop recommendations for the Office of Emergency Management, as coordinator of the Local Emergency Planning Committee. It is recommended that the lead agency work through the Local Emergency Management Plan process.

The Department of Natural Resources will discuss funding to implement this action with the King County Office of Emergency Management. Manager and the City of Issaquah's fire department. The goal of this discussion is to determine whether implementation can be funded by an industry-supported program. Perhaps a portion of hazardous materials permit fees referred to in Action HM-5 could be dedicated to supporting the Local Emergency Management Plan. The possibility of supplementing hazardous materials permit fees with aquifer protection fees will be considered.

**Issue 7 Prevention of Aquifer Contamination Associated With Transportation-Related Hazardous Material Spills:**

- **HM-7A Transportation-Related Hazardous Materials Spills - Purveyor Assessment in Well Head Protection Programs.**
- **HM-7B Transportation-Related Hazardous Material Spills - Management Committee Evaluation:**

**Discussion:** The state Well Head Protection Program will require public water system purveyors to assess contamination risks in well head protection areas. It is likely that assessing risks of transportation-related hazardous material spills will be one of the components. The GWAC can ensure that this matter is considered by bringing it up with the Issaquah Creek Valley Ground Water Management Plan. In their well head protection program, public water system purveyors should address problems unique to their well head protection area.

The Washington State Department of Health has developed a process to identify ways in which transportation hazardous material spills could be more effectively prevented and responded to; it also plans to pursue changes on a state level if appropriate. Participants will include the Washington State Department of Health, Ecology, Transportation, federal highway, federal railroad, and chemical and transportation industries. The GWAC could take advantage of this existing process and defer the matter to the Management Committee for further resolution.

## 3.2 Ground Water Concerns Associated with Underground Storage Tank Management

Commercial underground petroleum and chemical storage tanks represent perhaps the most significant potential threat to ground water quality in King County. Leakage from underground storage tanks and associated piping often occurs without detection and even relatively small amounts of certain compounds can have serious adverse impacts on ground water quality. Once released from an underground storage tank, some volatile organic compounds and petroleum products can rapidly migrate to ground water.

The precise number of underground storage tanks that are located in King County is not known. However, Ecology estimates that at least 6,550 such tanks are currently in operation, not including home heating oil tanks.

Underground storage tanks are regulated by federal, state, and local governments. Private sector pressures from insurance and lending institutions also bring increasing pressure to bear upon owners and operators of underground storage tanks to install and maintain systems in a manner which reduces liability risks by avoiding spills. A summary of each level of governmental regulation is provided below.

**Federal Program**

Federal regulations (Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks, 40 CFR 290 Part 280) have been developed by the Environmental Protection Agency under Subtitle I of the Resource Conservation and Recovery Act. The Environmental Protection Agency regulations contain provisions for delegation of the federal Underground Storage Tank Program to the states.

**State Program**

Chapter 90.76 RCW (1989) directs Ecology to develop an Underground Storage Tank Program designed, operated, and enforced in a manner that meets the requirements for delegation of the federal Underground Storage Tanks Program. Chapter 90.76 RCW provided Ecology with authority to adopt rules for management of all underground storage tanks that are governed by Environmental Protection Agency regulations. Accordingly, Ecology adopted the state Underground Storage Tank Regulations (Chapter 173-360 WAC) in November 1990. These comprehensive regulations incorporate the minimum requirements of the federal Underground Storage Tanks Program. Certain classes of underground storage tanks are exempt from regulation under both the Ecology and Environmental Protection Agency Underground Storage Tank Programs. These classes include tanks of less than 1,100 gallons that store heating oil and farm and residential motor fuel tanks of up to 1,100 gallons.

**Local Programs Under Chapter 90.76 RCW**

Under Chapter 90.76 RCW, Ecology is encouraged to delegate portions or all of the state Underground Storage Tank Program responsibilities to cities, towns, or counties. The annual fees collected by Ecology will be apportioned between Ecology and the City, town, or county assuming responsibility for the program or a portion of the program. However, local governments seeking delegation of the entire program would be undertaking a heavy commitment considering the funding options available.

Local jurisdictions may establish underground storage tanks programs more strict than the state program if they do so to protect an "Environmentally Sensitive Area." Under

Chapter 90.76 RCW, local underground storage tank regulations that are more stringent than those contained in Chapter 173-360 WAC can be implemented, subject to approval by Ecology, in an Environmentally Sensitive Area. Environmentally Sensitive Areas are geographic areas that possess physical characteristics that make them especially vulnerable to releases from underground storage tanks. A city, town, or county can request Ecology to designate an area within its jurisdiction as an Environmentally Sensitive Area. If a single Environmentally Sensitive Area is located within more than one political jurisdiction (for example, two different cities or one city and a county), the jurisdictions can jointly request that Ecology designate the area as sensitive.

An area can qualify as an Environmentally Sensitive Area in one of two ways: (1) if the area has already been granted special environmental status under another state or federal statute or regulation for the purpose of protecting ground water or surface water from pollution, or (2) the local jurisdiction must demonstrate that ground water is vulnerable to pollution because of site-specific hydrogeological characteristics (Chapter 173-360-520 WAC).

An Environmentally Sensitive Area designation under authority of Chapter 90.76 RCW is not synonymous with an Environmentally Sensitive Area designation under Chapter 197-11-908 WAC of the State Environmental Policy Act; although, a single area could be designated as an Environmentally Sensitive Area under both Chapter 90.76 RCW and SEPA. Designation under Chapter 90.76 RCW affects only the construction and operation of underground storage tanks while designation under SEPA can affect a much broader range of land-use activities.

**Local Programs Under Uniform Fire Code**

Local fire protection agencies must regulate underground storage tanks under the provisions of the Uniform Fire Code (Article 79 Uniform Fire Code). Chapter 51-16 WAC, State Building Code, adopts the Uniform Fire Code by reference. Local governments must enforce the provisions of the Uniform Fire Code as adopted and modified by the state. Local jurisdictions may adopt more stringent requirements.

Some cities in King County do not believe that the Uniform Fire Code authorizes them to regulate heating oil tanks. The King County Fire Marshal's Office does, however, regulate heating oil tanks under Article 79 of the Uniform Fire Code. The July 1995 version of the Uniform Fire Code included regulations for heating oil tanks. The King County Fire Marshal's office annually inspects all known hazardous material storage, use or handling facilities, including underground storage tanks.

King County is legally responsible for permitting and inspecting the installation and removal of underground tanks within unincorporated areas regardless of whether that area is in a Fire District. Fire Districts are responsible for the firefighting function while the King County Fire Marshal's office is responsible for technical tasks such as construction plan review for compliance with fire safety codes and hazardous materials storage including plan review for new underground storage tanks. The Fire Marshal's office is a section of the Department of Development and Environmental Services. City fire departments carry out both the firefighting and permitting tasks.

Underground storage tanks of 10,000-gallon, or larger, size must undergo environmental review under the State Environmental Policy Act. The SEPA section of the King County Environmental Division, Department of Development and Environmental Services, routinely requires secondary containment for underground storage tanks of this size in Ground Water Management Areas upon review of permit applications referred by the Fire Marshal's office. It is not known whether city SEPA reviewers are requiring secondary containment.

**Leaking Underground Storage Tank Management**

Section 205 of the Superfund Amendments and Reauthorization Act of 1986 created an Underground Storage Tank Trust Fund intended to pay for the cleanup of releases of hazardous substances, including petroleum products, from underground storage tanks. The fund, which is administered by the Environmental Protection Agency Office of Underground Storage Tanks, is intended to support cleanup of leaking underground storage tanks in cases where no financially solvent owner/operator can be identified, where the owner/operator refuses or is unable to promptly respond to the problem, or where an imminent hazard to public health or the environment exists. The fund also provides financial assistance to state governments for development of state leaking underground storage tank response programs. Ecology developed this state's Leaking Underground Storage Tank Program through this fund. Releases of hazardous substances from underground storage tanks in this state are currently addressed by Ecology through oversight of voluntary cleanup actions by tank owners or through enforcement actions.

Leaking underground home heating oil tanks may present a threat to ground water quality. Both federal and state regulations adopt a less aggressive approach to regulation of heating oil tanks, however, because of differences in the constituency and migration of fuel oils in the soil.

Potential problems associated with home heating oil tanks include leakage from operating tanks and releases from improperly abandoned tanks containing residual product. Many of the existing home heating oil tanks within King County are likely to be bare steel tanks without cathodic protection and, as such, a large percentage may be leaking or will leak in the future.

The number of underground home heating oil tanks in operation within King County is unknown, primarily because the number and locations of such tanks is considered proprietary information by the heating oil industry. The King County Department of Assessments has information regarding the heat source for residences excluding mobile homes. The information is not necessarily accurate, however, because it is often not updated when oil to gas conversions occur. The frequency of underground home heating oil tank abandonment has been estimated at 20 percent over the last decade.

The Uniform Fire Code requires that tanks which have remained unused for a period of one year must be abandoned in a manner prescribed by Article 79, which generally involves removal and proper disposal of the tank. The tank may be abandoned in place at the discretion of the fire chief (or in the case of King County) by the Fire Marshal. Whether removed or abandoned in place, the remaining product must be removed and disposed of properly. The tank must be filled with concrete or some other approved substance if abandoned in place.

Compliance with Uniform Fire Code requirements has historically been very low according to the King County Fire Marshal's Office. Many home heating oil tank owners are apparently unaware of their responsibilities under the Uniform Fire Code. Tank owners that are aware of their responsibilities are often reluctant to undertake proper tank abandonment because of the relatively high cost, about $2,000 per tank. This cost could double or go higher, if soil sampling and removal of contaminated soil are required. Part of the expense in unincorporated King County includes the cost of a permit. The fee in 1995 is 190.90.

**Recommended Management Strategies for Underground Storage Tank Management**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Augment State Underground Storage Tanks Program**:

- **UST-1A Augment State Underground Storage Tanks Program - Designation As Environmentally Sensitive Area Under Chapter 90.76 RCW.**
- **UST-1B Augment State Underground Storage Tanks Program - Inspection.**

**Discussion:** Ecology's designation of Environmentally Sensitive Areas in King County will give local jurisdictions an opportunity to build upon the Ecology program. Ecology has already indicated that their program will not involve field inspections of each individual underground storage tank. Many of the compliance activities associated with the Ecology rules will be conducted through the mail. Ecology anticipates that their underground storage tank program will stress a self-policing approach. Preventing contamination of some of the more highly vulnerable aquifers in King County from the operation of underground storage tanks may require a more comprehensive management program than that currently envisioned by Ecology. An enhanced program may be developed and implemented commensurate with the importance of the physically susceptible areas contributing recharge to important public water supplies.

Designation of the entire Issaquah Creek Valley Ground Water Management Area would create workable boundaries for administrative purposes and is supportable from a protection standpoint since Ground Water Management Area boundaries are based on ground water divides. Chapter 173-360-510 WAC provides that Ground Water Management Areas may be readily designated as Environmentally Sensitive Areas.

Funding sources for state and local activities are connected. Ecology charges an annual tank fee to all underground storage tank owners. If an Environmentally Sensitive Area is established, Ecology may charge a supplemental fee for tanks in the area. Ecology may pass through some of this supplemental fee to local programs; however, Ecology must retain a sufficient portion of the fees necessary for operation of the state program. This may be the entire fee, since the fee set by the legislature is very low. Local jurisdictions are prohibited by Chapter 90.76 RCW from assessing additional annual tank fees. Local programs may assess a permit fee in Environmentally Sensitive Areas to support local program activities.

State and local governments are therefore limited in their ability to assess industry for program costs. Local governments that are interested in developing enhanced underground storage tank programs should determine which aspects of the state program most need enhancement and offer possibilities for adequate funding, given the prohibitions against increased annual tank fees contained in Chapter 90.76 RCW.

Tank installation and removal are critical steps in the management of underground storage tanks. Removal is particularly important because of the opportunity to detect and clean up previous spills. These are activities that are already inspected for compliance with the Uniform Fire Code. This action offers the possibility of expanding the existing inspection program to include relevant requirements of the Underground Storage Tank Regulations. Increased permit fees to offset inspection costs would not violate the prohibition against raising the annual tank fee. Staff training is an aspect of the program that could be funded by pass-through moneys collected by Ecology, based upon status of the Ground Water Management Areas as Environmentally Sensitive Areas.

The feasibility of an enhanced inspection program requires resolution of the following issues by state and local governments:

- Each of the existing Ground Water Management Areas, except Vashon Island, includes one or more incorporated communities. Decisions about the nature of an enhanced local program must be jointly made by all of the affected jurisdictions.
- Local governments will need to develop a proposal and submit it to Ecology. Ecology will determine whether the proposal meets the requirements of laws and regulations governing designation of Environmentally Sensitive Areas and provisions for stricter local programs. The amount of money collected by Ecology and available for passing through to the local program will have to be negotiated.
- A key local decision involves delegation of the new responsibility. Both fire protection agencies and the Seattle-King County Health Department could

logically carry out the program. Fire protection agencies offer the advantage of current involvement in an existing inspection program. On the other hand, the Seattle-King County Health Department may be the most appropriate agency to implement the program because it has legal standing in all incorporated and unincorporated communities in King County. It may be much simpler (and offer consistency) if a King County Board of Health rule were to establish a countywide program such as that in existence for on-site sewage disposal. It is not known whether a King County Board of Health rule could be implemented by the fire protection agencies, but that possibility should be explored. At least one neighboring county has a dual program for tank removal inspection. The Tacoma-Pierce County Health Department inspects for environmental concerns, while the fire protection agencies continue to inspect for fire code requirements. This arrangement is reported to be working well with good cooperation between the two entities involved. The dual program offers the benefit that fewer personnel must be trained to do inspections.

- Staff must be trained in the installation and removal requirements sections of the Underground Storage Tank Requirements, and funds are needed to pay for this activity. A possible source is the supplementary annual tank fee that Ecology collects in Environmentally Sensitive Areas. It is planned that this money will be turned over to local governments for the purpose of carrying out enhanced local programs in Environmentally Sensitive Areas.
- A fee for the installation and eventual removal of new underground storage tanks will be needed to offset the costs incurred by the agency responsible for plan review and on-site inspections associated with the design and installation of new underground storage tanks. Plan review and on-site inspection costs can be quite high. Experiences in a neighboring county suggest that, on a time and material basis, an average of about $300 to $350 is expended by an agency responsible for plan review and on-site inspection of each new underground storage tank. King County Fire Marshal's Office currently charges $125 for the first tank and $39 for each additional tank for plan review and inspection under the Uniform Fire Code. For aggregate storage at one site of over 10,000 gallons, the proposal is referred to the Environmental Protection Agency Section which requires an additional $600 fee. (These fees were current as of 1991.)
- Expansion of the enhanced program to other cities or unincorporated areas of the County should be considered. However, supplemental annual tank fees would not be available to train staff. It is possible that training could be provided to all jurisdictions in the County for the same cost as to those in Ground Water Management Areas. This possibility should be considered.

- **UST-1C Augment State Underground Storage Tanks Program - Disclosure and Secondary Containment.**

**Discussion:** Requiring disclosure of any tanks located on a piece of property would provide a source of information for the database on tank location. This would enable King County to provide information on a specific property to anyone in need of the information.

This would also provide the Fire Marshal's Office with information on heating oil tanks. The education program could include these properties for direct mail or other educational activities.

Requiring secondary containment for new tanks would close a gap in the current federal and state regulations, because federal and state regulations do not require secondary containment of underground storage tanks. This measure would help prevent ground water from becoming contaminated. Current regulations only require leak detection, which may not alert tank operators until after ground water is contaminated. Secondary containment requires that the primary tank be enclosed within a second impermeable barrier, with some provision for all or partial containment of the tank volume. Combining secondary containment with interstitial monitoring can detect leaks before they escape into the environment.

**Issue 2 Exempt Tanks**:

- **UST-2A Exempt Tanks - Secondary Containment**.

**Discussion:** Current state regulations focus on monitoring and post-leak detection, rather than prevention of leaks. They provide for leak detection methods which may not alert tank operators until ground water is already contaminated. Requiring secondary containment would enhance current regulations by providing a method to prevent leaks. Secondary containment offers the best protection from contamination of the environment from leaks from underground storage tanks. It is both economically and technically feasible. (Secondary containment refers to the practice of enclosing the primary tank with a second impermeable barrier. The secondary vessel may be a separate container or it may be an integral component of the primary tank. Leak detection monitoring is provided in the space between the tanks.)

The primary reason to consider secondary containment is because it offers the best prevention of leaks that contaminate soil and ground water. It is the only method that detects the potential for spill before the spill is introduced into the environment.

The Metropolitan King County Council could impact the possibility of future contamination of ground water in a major way by requiring that this precaution be taken. The industry widely recognizes the advisability of secondary containment and most commercial installations now incorporate it.

The smaller, exempt tanks could also benefit from secondary containment. Most existing exempt tanks lack corrosion protection and many are probably leaking. Exempt tanks are home and farm tanks of 1100 gallons or less that store motor fuel for consumptive use on the premises and heating oil tanks of 1100 gallons or less; Also, heating oil tanks over 1100 gallons in size are exempt from some of the requirements of federal and state regulations. Secondary containment equipment is available for small tanks, as well as large, and is economically feasible.

Fire protection agencies already have programs to review plans for aboveground and underground tanks that are fee-supported. A requirement for secondary containment or aboveground storage would have a major impact on the existing inspection programs.

- **UST-2B Exempt Tanks - Tested for Integrity**.

**Discussion:** Requiring that exempt tanks are tested and tagged would ensure that leaking tanks receive no more product. This would also address the question about whether ground water is being contaminated from these tanks. Tank locations could be added to the database for analysis. This is a stringent requirement that would provide needed information. A future problem that needs to be addressed is what would be done with the information, and if there would be any follow-up.

**Issue 3 Home Heating Oil Tanks:**

- **UST-3 Home Heating Oil Tanks - Education**.

**Discussion**: Including home heating oil tanks in the overall Issaquah Creek Valley Ground Water Management Plan Education Program will help address the low level of compliance with the requirements for home heating oil tank abandonment. Homeowners are unaware of their responsibilities under the Uniform Fire Code, probably because there are no programs on proper maintenance and abandonment. Providing educational material to tank owners should increase community understanding about the problem; this in turn may increase the number of tank owners that comply with the regulations.' Also, by increasing community awareness, it is expected that home purchasers would require that information on tank status be disclosed.

## 3.3 Ground Water Quality Issues Related to On-Site Sewage Treatment and Disposal System Use

Ground water contamination associated with domestic on-site sewage system effluent can involve a number of contaminants including nitrate, bacteria, viruses, and trace organic chemical compounds. Nitrate is often considered the most significant contaminant associated with domestic wastewater since it is highly resistant to removal from treatment mechanisms present in the soil profile. Bacteria and viruses can be attenuated during migration through a few feet of fine to medium textured soils provided that unsaturated flow conditions can be maintained. However, coarse-textured, excessively permeable soils are ineffective in removing bacteria and viruses. Also, domestic effluent often contains volatile and semi-volatile organic compounds at very low levels. These organic chemicals are generally residues from household cleaning and paint products, and are known as household hazardous wastes. If on-site sewage systems are improperly designed or constructed, installed in inadequate soils, used at too high of a development density, or used to dispose of non-domestic wastewater, they can adversely impact surface and ground water quality as well as public health.

There is an extensive regulatory system currently in place at the state and local level to prevent adverse public health and environmental impacts from the use of on-site sewage treatment and disposal systems. The state regulations were recently modified and implemented on January 1, 1995 which served to strengthen the ground water protection provisions of applicable on-site sewage system regulations and standards.

Improved design criteria in the revised regulations appear to have further reduced the threat to ground water quality posed by new individual residential on-site systems. However, within the various Ground Water Management Areas, there may be existing high density developments served by conventional on-site sewage systems. To date, water quality problems associated with such developments have been not been documented. Also, extensive ground water monitoring efforts to identify problems associated with on-site sewage systems have not been undertaken.

**Recommended Management Strategies for On-Site Sewage Treatment and Disposal System Use**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Nitrate Concerns:**

- **OS-1 Nitrate Concerns in Well Head Protection Programs.**

**Discussion:** Public water system purveyors are required to delineate Well Head Protection Areas and develop Well Head Protection Programs. Well Head Protection Areas include the surface and subsurface area surrounding a well or wellfield that supplies a public water system through which contaminants are likely to pass and eventually reach the well(s). Well head protection areas must be managed by a community to protect ground water-based drinking water supplies. Research has shown that, when median nitrogen levels are 6 mg/L or greater, 10 percent of nitrate samples will be greater than the 10 mg/L maximum contaminant level. Other communities in the nation have set a limit of 5 mg/L to provide a margin of error and safety.

An analysis of current and future loading will enable planners and public officials to make informed decisions on land use and water use. Where current nitrate levels threaten public water supplies, decisions on future water supplies will need to be made. Such alternatives as a new drinking water source or the extension of public sewers to the community can be considered. The nitrate loading analysis will also enable planners and public officials to make decisions on future land use in the Well Head Protection Area.

It was expected that considerable difficulties would occur in implementing a program geared towards seeking replacement of existing on-site sewage systems with sewers or alternative on-site technology. Strong opposition to sewer expansion may be encountered in some communities because sewer availability may promote or facilitate additional growth and development. In addition, public opposition may result from costs to individual property owners associated with substituting existing systems with either alternative on-site technology or public sewers.

However, if this activity is associated with the Well Head Protection Program, a focused and defined area where a drinking water system is located, this type of resistance can be minimized.

**Issue 2 Hazardous Materials:**

- **OS-2A Commercial Hazardous Materials - Inventory, Education, Monitoring.**

**Discussion:** A number of important programs are being implemented as a result of the Local Hazardous Waste Management Plan for King County. However, those activities are not currently designed to emphasize the unique risks associated with hazardous materials introduced into on-site sewage systems.

Once released to the soil column, hazardous materials or hazardous wastes can potentially migrate to underlying ground water. Since low levels of some hazardous materials in drinking water can pose a high level of risk to human health, even releases of small quantities of hazardous materials to an on-site sewage system can have a profound impact on underlying ground water quality.

The inventory proposed here could enable the Seattle-King County Health Department's Wastewater Section to identify those facilities that are likely have the types and quantities of hazardous substances on the premises that suggest a relatively high risk should there be a release of those substances to the on-site sewage system. Those high-risk facilities should be targeted for earliest possible on-site educational activities under the Local Hazardous Waste Management Plan. The educational activities could provide facility owners and operators with information on alternative products, proper hazardous substance storage, handling, recycling, disposal, and spill containment. Should the on-site educational activities reveal any facilities where wastewater other than that of residential/domestic quality is being generated, the owner/operator would be asked to make changes in their operation. If the changes are not made, then they would be referred to Ecology for possible regulation under the State Waste Discharge Program.

Changes in occupancy of commercial, industrial, and institutional facilities could be carefully monitored by Seattle-King County Health Department and the inventory periodically updated. The Seattle-King County Health Department would develop and implement this program within the context of the Local Hazardous Waste Management Plan.

This action should prove moderately effective in limiting the release of hazardous substances to on-site sewage systems serving commercial, (including food service establishments) industrial, and institutional facilities.

- **OS-2B Hazardous Materials: Prohibit Non-Domestic Sewage.**

**Discussion:** Under this action, the Seattle-King County Health Department would be requested to prepare amendments to Title 13 to prohibit the discharge of non-domestic wastewater to on-site sewage systems. Chapter 246-272-03001 WAC allows the health officer to regulate "residential sewage." The primary intent of the alternative is to emphasize the Seattle-King County Health Department's existing authority under the revised WAC to prevent the discharge of non-domestic wastes to on-site sewage systems, particularly wastes containing hazardous materials.

Enforcement of this provision will require careful review of site applications for on-site sewage treatment and disposal by Seattle-King County Health Department staff. The Seattle-King County Health Department should consider requiring discharge monitoring reports from operators of commercial or institutional establishments. Strengthening the regulatory authority to prevent discharges of non-domestic wastewater may assist in enforcement actions.

**Issue 3 Household Hazardous Wastes:**

- **OS-3A Household Hazardous Wastes: Education in the Local Hazardous Waste Program in King County.**

**Discussion:** The Seattle-King County Health Department will undertake measures to increase public awareness concerning the potential impacts of discharging household chemical products to an on-site sewage system. Such measures will be an extension of activities scheduled as part of the Local Hazardous Waste Management Plan.

- **OS-3B Household Hazardous Wastes: Public Education.**

**Discussion:** This program will be included in the overall Ground Water Management Plan education program, which includes the following elements:

- King County Department of Natural Resources and the Seattle King County Health Department will develop a supplemental educational program to address deficiencies identified above, if necessary, and present to the Management Committee for review and adoption.
- King County Department of Natural Resources will coordinate implementation of the program which may involve actions by the Seattle-King County Health Department and other agencies and jurisdictions.

One item that has been identified to be done for this action is that prior to any scheduled reprinting, the existing public information pamphlet concerning on-site sewage system maintenance and operation will be amended to provide instructions concerning proper household hazardous waste disposal practices.

**Issue 4 Operation and Maintenance of On-Site Sewage Treatment and Disposal Systems**:

- **OS-4A Operation and Maintenance: Plan Recorded With Property Deed.**

**Discussion:** Under this action, Seattle-King County Health Department will prepare amendments to Title 13, about recording as-built plans, and submit the amendments to the King County Board of Health for approval. This action is supported by King County Comprehensive Plan policy F-316: "King County should monitor on-site systems that have shown evidence of failure or potential for failure. This data should be used to correct existing problems and prevent future problems. King County should analyze public funding options for correcting on-site wastewater system failures which may include, where feasible and otherwise consistent with this Plan, conversion to community sewage systems or installation of public sewers." An as-built plan is a scale drawing of an on-site sewage treatment and disposal system as it is actually installed at a construction site. It is submitted to the Seattle-King County Health Department by the designer after construction is completed.

The as-built plan serves the important function of demonstrating the location and configuration of the on-site sewage system at a site. The standard as-built form of the Seattle-King County Health Department also provides information on general maintenance and operation of the system such as recommended frequency of septic tank pumping. That information could be expanded to include information on household hazardous waste disposal practices. Currently, there is no requirement for the home or business builder or first owner to provide the as-built plan to subsequent owners of a home or business. By requiring the as-built to be recorded with the deed, the as-built will be provided automatically to subsequent owners with the title report.

This action should be highly effective in ensuring that critical information on the location and configuration of the on-site sewage system is transferred to a home or business purchaser. It also affords an opportunity to transmit information on proper on-site sewage system maintenance and operation. Recording of the as-built will result in nominal cost to the initial home or business owner. No significant obstacles to implementation are anticipated.

- **OS-4B Operation and Maintenance: Management Program.**

**Discussion:** The Seattle-King County Health Department will conduct a feasibility assessment on the effectiveness of an on-site sewage system management program on ground water quality. The purpose of an on-site sewage system management program is to help ensure proper operation and maintenance of on-site sewage systems. Historically, an on-site sewage treatment and disposal system was considered to have failed if sewage backed up into the house, or sewage surfaced on the ground. These types of failures usually affected human health (by direct contact) and surface water quality. Systems that affect ground water quality do so by subsurface discharge to ground water. This type of impact should be minimized by the on-site sewage regulations that require enhanced treatment in those soils that do not provide adequate contaminant attenuation (Type 1 soils). It is unclear how an on-site system management program could help prevent or remedy subsurface failures, and this is what needs to be addressed.

### 3.3.4 Ground Water Quality Issues Related to the Use of Pesticide and Fertilizer

Pesticides and fertilizers are used for the control of plant and animal pests and promotion of plant growth. Pesticides are a large and varied group of substances that are specifically designed to kill biological organisms including weeds, insects and rodents. Fertilizer is used to promote plant growth. Pesticides and fertilizers are in everyday use all around us. The major categories of use are agriculture, home, forestry and rights-of-way maintenance. Pesticides and fertilizer have the potential to contaminate ground water even when they are used according to the label instructions.

With pesticides there is a concern about long-term or chronic exposure from low concentrations in drinking water. Our knowledge of chronic health effects for humans is incomplete, but lab studies with animals and various studies looking at human exposure to pesticides suggest that cancers and other malignant tumors, birth defects or other chronic illness are related to exposure to certain pesticides. Until the Environmental Protection Agency completes its re-registration program, actions need to be on the conservative side.

Both commercial fertilizers and animal manure can leach nitrate into ground water. While certain foods can also be a source of nitrate in the diet, in some areas drinking water may increase the intake of nitrate considerably, adding to the potential for adverse health reactions. Concern over nitrate has generally centered around its role in methemoglobinemia, a blood disorder that can result in death for very young babies. As nitrate levels rise in water supplies, the potential for serious illness for babies also rises. Babies under three months old who have diarrhea are even more sensitive to nitrate-caused methemoglobinemia; the current Maximum Contaminant Level for nitrate in drinking water does not protect them.

Recent research suggests that older children and adults also may suffer health effects from long-term exposure to nitrate. A small fraction of ingested nitrate is converted to nitrite by oral bacteria. Nitrite can react in the stomach with certain amines found in other food and drugs to form nitrosamines, a class of chemicals known to cause cancer in many different organs of many species.

Home use accounts for approximately 20 percent of pesticide use in the Puget Sound region. Unlike licensed pesticide users, home or business owners are not trained in proper application procedures or in diagnosing whether a particular pesticide is needed, and may use them improperly. The use of fertilizer and pesticides by non-agricultural users will likely increase as King County population continues to grow. In rural areas, agricultural activities are likely to present the greatest threat to ground water quality. Current agricultural practices may not adequately protect ground water.

A variety of entities use herbicides (plant pesticides) for rights-of-way maintenance. These include city and county public works, electric companies, state Department of Natural Resources, railroads, state and federal highways, natural gas companies and oil pipeline companies. Ground water contamination related to pesticide and fertilizer use in King County may not have been reported because, no one looked for the right chemical in the right place, the expense for this analysis has been prohibitive, and laboratories did not have the capability to analyze for many pesticides. Monitoring and research programs are difficult to design because there is little accurate information about the types of pesticides used in the region and the patterns of use. The Ground Water Management Program included some pesticide and fertilizer components in the ground water quality sampling program to characterize the aquifer(s).

**Programs and Regulations**

Small farms may need help to ensure that their practices do not contaminate ground water. The King Conservation District works with landowners to train and instruct them on Best Management Practices to improve water quality and to increase productivity; provides technical assistance to landowners who are developing farm management plans on their own initiative or who have been referred by Ecology prior to taking enforcement action; and develops local education and information programs on soil and water conservation. Farm plans integrate Best Management Practices to protect ground water quality into a comprehensive resource protection plan designed for the individual farm. The landowner makes all of the implementation decisions. Currently used Best Management Practices do not include consideration of the health hazards of specific pesticides. King County established, by ordinance, policies requiring livestock owners to implement Conservation District plans or implement best management practices specified in the ordinance.

In the Puget Sound Water Quality Management Plan, Non-Point Source Pollution Program (see below), the Authority states that the use of farm conservation plans is the preferred approach to controlling pollution from both commercial and noncommercial farms (the King Cónservation District's farm conservation planning and practices documents for farm conservation plans are the recommended standard).

The Environmental Protection Agency, under provisions of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the distribution, use and sale of pesticides in the United States. Over 50,000 pesticide products have been registered since FIFRA was enacted in 1947. Most of these pesticides were registered before their long-term health and environmental effects were known. In 1972, Congress amended FIFRA to require the Environmental Protection Agency to re-evaluate registered pesticides under more current scientific and regulatory criteria. In 1988, Congress again amended FIFRA to accelerate the Environmental Protection Agency's re-registration review process by imposing time frames that would result in completion by 1997. As of September 1993, the Environmental Protection Agency had reached final decisions on only 250 of the 20,000 older products (containing 676 active pesticide ingredients) subject to re-registration. Most are lower-priority pesticides such as garlic, dried blood and putrescent egg solids.

After the Environmental Protection Agency reviews the data available on a specific pesticide active ingredient, the agency compiles a publicly available fact sheet listing use patterns and formulations, science findings, and a summary of major data gaps which must be filled before re-registration can be considered. These can be used to compare potential risks of pesticides with similar uses and leaching characteristics.

The California Environmental Protection Agency has also compiled fact sheets on pesticides used in California, after reviewing test data submitted by the manufacturers. Most of these fact sheets are available from the Washington Toxics Coalition in Seattle.
The Washington State Department of Agriculture is the state agency with primary authority over pesticide and fertilizer sale and use through the following regulations:

- Chapter 15.54 RCW Fertilizers, Agricultural Minerals, and Limes, requires that commercial fertilizer distributors must report twice a year, to the Washington State Department of Agriculture, the net tons of fertilizer they distribute in Washington.
- Chapter 15.58 RCW Washington Pesticide Control Act requires that pesticide dealers and private and public pest control applicators must be licensed. Licensees must demonstrate knowledge of pesticide laws, labels, and the legal distribution, use and disposal of pesticides. Further, they may be required to keep records, including quantity of pesticide, date of shipment and receipt, name of consignor and consignee, and any other information requested by Washington State Department of Agriculture
- Chapter 17.21 RCW, the Washington Pesticide Application Act, authorizes the Department of Agriculture to regulate pesticide applicators. This law provides authority for licensing and record keeping for pesticide applicants including farmers.
- Chapter 16-228 WAC Rules Relating to General Pesticide Use require record keeping by pesticide dealers on the sale of restricted-use pesticides, on the distribution of pesticides, except those labeled for home and garden use only, and on distribution of state restricted-use pesticides. Certified applicators must keep records about application sites. These records must be given to the Director of the Department of Agriculture upon request.

The Washington State Department of Agriculture conducted the Record Database Pilot Project to explore the feasibility of using pesticide application records in a state geographic information database. This approximated requesting and cataloguing the information that commercial pesticide dealers and certified applicators are required to keep. Because the data request was voluntary, the data received were not a complete summary of all pesticides applied in the areas for the year. Several major applicators, such as railroads, rights-of-way, and a few commercial farms did not submit records. Most homeowner use in urban areas also was not part of the database, because recordkeeping is not required of these individuals. In general, the Washington State Department of Agriculture found that a general application data request was very expensive and time-consuming. Those individuals and businesses that have had record-keeping requirements for some time were able to complete the information required fairly accurately. Small hobby farms and individuals who have not been required to keep records in the past had difficulty. Most records submitted needed staff time to analyze before the data could be entered. Approximately six or seven records per hour could be entered into the computer geographic information system. Since major record requests can involve thousands of applications, present staffing could not effectively handle the data. The geographic information system and database was shown to be feasible if the initial data request is limited to specific sites or specific pesticides.

The Washington State University Cooperative Extension Service as a part of the state educational system, develops and implements a broad range of educational programs and resource materials. Specific programs are developed that relate to pest and nutrient management for homeowners, recreational areas, and crop and livestock production. They provide technical assistance in selecting and implementing Best Management Practices and integrated pest management systems for specific sites and circumstances. They also provide training to private and commercial pesticide applicators to prepare for licensing and recertification exams.

The Pesticide Reduction Program is a grant project of the Washington State University Cooperative Extension Service. This prevention program emphasizes proper diagnosis of plant problems and advocates alternatives and reduced pesticide use. The Program will target residents and businesses in the Green-Duwamish and Cedar River watersheds during January 1992 to December 1994. This project could be applied to the Issaquah Creek Valley Ground Water Management Area, if it is found to be effective in reducing pesticide and fertilizer impacts on ground water.

Ecology has coordinated a multi-jurisdictional effort to address the impact upon ground water of pesticide and fertilizer use. This effort has produced *Protecting Ground Water: A Strategy for Managing Agricultural Pesticides and Nutrients* (April 1992), which is referred to as the "State Strategy." The Strategy is intended to provide support and direction to agencies and the agricultural community in their efforts to protect and preserve ground water quality in rural areas. The focus of the Strategy is on protection of ground water, rather than remediation. It identifies and supports activities and programs to prevent contamination, and will allow both the agricultural community and involved agencies to make best use of resources.

The Puget Sound Water Quality Authority has adopted the comprehensive Puget Sound Water Quality Management Plan. The 1991 Plan update includes: the addition of monitoring for pesticides in Puget Sound; additions to the household hazardous waste program to incorporate educational opportunities for urban and suburban residents about pest management alternatives and the proper application of pesticides; and two new elements in the non-point source pollution section addressing water quality impacts from pesticides. These additions are reflected in the following policies:

- Non-point Source Pollution Program NP-16 Pesticide Usage Surveys in Selected Watersheds. The Cooperative Extension will be the lead to design a pilot pesticide usage survey for selected watersheds in the Puget Sound Basin. The Cooperative Extension will include appropriate agencies, scientists and local governments in designing and conducting the surveys. The surveys should define spatial and temporal use patterns; focus specifically on pesticides of concern in the watershed; include information from all major users, including homeowners; and identify storage and disposal practices.
- Non-point Source Pollution Program NP-17 Puget Sound Pest Management Information Program. The Cooperative Extension will be the lead to establish this Program by designing and implementing program activities with an advisory group. The program will work through existing programs and groups to conduct research and education on integrated and targeted pest management, promoting conservative use of pesticides particularly by local governments and homeowners.

Educational activities, although currently extensive, may not correctly reflect the threat to ground water from the use of pesticide and fertilizer and the ways to reduce that threat. A variety of educational programs are currently underway that could be evaluated and augmented with information on the relationship between pesticide and fertilizer use and ground water. The Washington State University's Cooperative Extension Service provides significant educational activities. The Puget Sound Water Quality Authority Plan contains two policies for The Cooperative Extension Service:

- Household Hazardous Waste Program HHW-2 Information and Education on Less-Toxic Alternatives for Household Products. The Cooperative Extension Service will work with others to make information and training available to promote targeted and proper use and disposal of pesticides as part of the implementation of the local hazardous waste plans. The Cooperative Extension Service will consult with other groups on the type of information and program needed.
- Non-point Source Pollution Program NP-17 Puget Sound Pest Management Information Program. The Cooperative Extension Service will act as the lead to establish a Puget Sound Pest Management Information Program. The Cooperative Extension Service will design and implement program activities with an advisory group. The program will work through existing programs and groups, including the King County Roads Division program, on integrated pest management, to conduct research and education on integrated and targeted pest management, promoting conservative use of pesticides particularly by local governments and homeowners.

More control of pesticide and fertilizer impacts on ground water is possible. This would involve using current technology to target the areas that could benefit most from increased education or regulation. Current technology is available in King County to determine ground water susceptibility and vulnerability to pollution. Susceptibility depends upon the overlying soil characteristics. Vulnerability depends on the presence of contaminants at the surface. It is also possible to match the chemical characteristics of pesticide and fertilizer to the soils' capability to absorb and break them down, thereby identifying possible ground water contamination sources. Ground water monitoring parameters could then be designed to include the predicted pesticide and fertilizer components. The various educational efforts could be augmented with information on the impact on ground water from the use of pesticide and fertilizer.

**Recommended Management Strategies for Pesticide and Fertilizer**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Pesticide and Fertilizer - Past Use:**

- **PF-1A Pesticide and Fertilizer - Past Use: Mapping of Vulnerable Aquifer Areas.**

**Discussion:** This will identify areas where pesticide/fertilizer contamination of ground water may be a concern. There is no additional cost associated with this action. Also, other aspects of the Ground Water Management Plan may use this information, such as the ground water monitoring program.

- **PF-1B Pesticide and Fertilizer - Past Use: Monitoring.**

**Discussion:** The ground water monitoring program will be designed to include the expected components when monitoring in physically susceptible and recharge areas which have had land uses associated with pesticide and fertilizer use. This action would be included in the Data Collection and Management Program.

**Issue 2 Pesticide and Fertilizer Use:**

- **PF-2A Pesticide and Fertilizer Use: Farm Plans.**

**Discussion:** The cumulative impact from large numbers of small farms can be substantial. As more land is developed on the border between urban and rural zones, more small or hobby farms are created. Various agencies provide training on Best Management Practices and integrated pest management, but hobby farm owners are not required to attend. Often they do not have the time to attend or do not know about learning opportunities. Farm plans include Best Management Practices and integrated pest management for a variety of farm practices, including pesticide and fertilizer use. This would provide a mechanism for direct education of the hard-to-reach pesticide and fertilizer users.

After the physically susceptible and recharge areas are identified, King Conservation District would follow up by identifying and contacting all of the small farms that would be affected, and working with them to develop their Plans. King Conservation District has the administrative framework in place for Farm Plans.

- **PF-2B Pesticide and Fertilizer Use: Cooperative Extension Pesticide Reduction Program.**

**Discussion:** The Cooperative Extension Pesticide Reduction Program emphasizes proper diagnosis of plant problems and advocates alternatives and reduced pesticide use. It targets homeowners, commercial pesticide applicators, and nursery operators in the Green-Duwamish and Cedar River watersheds (January 1992 to December 1994). King County and the City of Issaquah (the Management Committee) would evaluate its effectiveness and possible applicability for implementation in other areas in the county to determine whether this program would be useful for ground water protection. This evaluation would be done with Cooperative Extension at the end of the Program. The Management Committee must also determine funding needs and sources. A potential funding source could be development fees as a mitigation for non-point source pollution.

- **PF-2C Pesticide and Fertilizer Use: Roads and Utility Rights-Of-Way Maintenance.**

**Discussion:** The use of leaching vegetation management chemicals could have a detrimental effect on ground water. Some public and private agencies are decreasing or eliminating use of leaching chemicals and are actively researching alternative methods. For example, the County Roads Division developed and implemented an integrated pest management program. However, some agencies have not followed this trend. These agencies are not easily reached through existing educational programs. This would be a preventative, not remedial, action, as there has been no documented case of ground water pollution from these practices.

This action is supported by King County Comprehensive Plan policy, NE-502 which states that King County should actively encourage the use of environmentally safe methods of vegetation control and that herbicide use should be minimized.

Research into alternatives to chemical use would involve a variety of agencies and utilities, including the State Department of Transportation, the State Parks and Recreation Commission, Burlington Northern, Weyerhaeuser and other forest owners, and public and private utilities.

**Issue 3 Education and Proposed Programs:**

- **PF-3A Education and Proposed Programs: Small Farmers and Homeowners.**

**Discussion:** The State Strategy and the Puget Sound Water Quality Authority Plan address statewide pesticide and fertilizer use. As statewide strategies, they are not specific to King County, but they attempt to attain similar ground water protection goals. They provide an overall backdrop to development of local programs, guidance to developers of local non-point plans, well head protection strategies, and ground water management plans. These strategies would benefit from recognition and support in the Issaquah Creek Valley Ground Water Management Plan.

- **PF-3B Education and Proposed Programs: Education Section.**

**Discussion:** Pollution prevention is the best approach from the standpoints of cost and environmental impact. Education is the best prevention because it creates an awareness and concern in individuals which influences their decisions.

The Department of Natural Resources will seek the cooperation of the parties involved to include ground water information and concerns in the educational programs. This review will ensure that the Issaquah Ground Water Management Plan goals and policies are reflected. The Cooperative Extension Service and others have several educational efforts underway which integrate ground water protection information where possible; they are agreeable to including more information. The Cooperative Extension Service, the King Conservation District and others could include the Issaquah Ground Water Management Plan concerns in their educational material.

Developing an independent educational program to address this issue would probably be largely redundant. It would not likely be supported financially by elected officials in a time of lean budgets. Scarce resources are more efficiently used by reviewing and updating existing programs. Funding for staff at the Department of Natural Resources is necessary to carry out the review, coordination, report, and development of a supplemental program, if needed. It is possible that enhancing existing programs will require that funds be provided to the relevant agency or jurisdiction.

### 3.5 Ground Water Quality Issues Related to Well Construction and Decommissioning

Wells provide a link between an aquifer and the earth's surface. Modern wells consist of a well casing that extends downward from the ground surface to the aquifer within a cylindrical bore hole. Chapter 173-160 Washington Administrative Code (WAC), Minimum Standards for Construction and Maintenance of Wells, requires that the space between the casing and the wall of the bore hole be sealed to prevent vertical movement of water along the outside of the casing. If this space is not adequately sealed, it may serve as a conduit by which contaminated surface or subsurface water may travel into an aquifer.

Under Chapter 173-160 WAC, any well that is unusable, whose use has been permanently discontinued, which is in such disrepair that its continued use is impractical, or is an environmental, safety, or public health hazard, must be decommissioned. The principal objective of proper decommissioning procedures is to restore, as far as possible, the original hydrogeologic conditions at the well site. Proper decommissioning procedures entail sealing the well in such a way that water is excluded from the well and no vertical movement of water is possible. An improperly decommissioned well may serve as a conduit for contaminated ground or surface water, permit continued flow of water to the surface from an artesian aquifer, alter the pressure conditions within a confined aquifer, or present a physical hazard at the surface.

Resolving the issue of potential aquifer contamination by improper well construction and decommissioning involves ensuring that existing regulations pertaining to construction and decommissioning are followed. Ecology is the agency responsible for regulating well construction and decommissioning by administering the State standards. However, Ecology has sufficient work force and budget to inspect only a fraction of the wells constructed and decommissioned each year. Because of Ecology's budgetary limitations, well construction and decommissioning are largely self-policed by well owners and contractors. Also, prior to 1973, Ecology did not require well contractors or owners to submit well logs. As a result, an unknown number of wells exist in the state without any record; therefore, they cannot be evaluated for compliance with regulations.

In response to these and other concerns, in 1992 the State Legislature passed SHB 2792 authorizing Ecology to delegate to local health districts or counties the authority to administer and enforce the well sealing and decommissioning portions of the water well construction program. Using the expertise and work force of the local health jurisdictions may help to ensure that wells are properly constructed and decommissioned.

**Recommended Management Strategies for Well Construction and Decommissioning**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 State Regulations and Program:**

- **WC-1A State Program: Adequate Funding**.

**Discussion:** Ecology is not focusing on well construction and has been operating the program at a minimal level due to lack of funding. Ecology tried to obtain the needed funding by proposing legislation to provide funding from increased fees for licensing, start cards, water right applications and enforcement penalties. This proposed legislation was not approved.

Ecology would continue its efforts to increase funding for these programs, including presenting legislation. Ecology will call upon the GWAC, including King County and the City of Issaquah, for support for the legislation. This could include phone calls, letters and/or testimony to the state legislators. If legislation is passed, Ecology could then hire staff to adequately implement the well program.

- **WC-1B State Program Delegation to King County.**

**Discussion**: Delegation of part of a program to the local health department has been demonstrated to be a dynamic method of ensuring that public health concerns are safe-guarded, as shown by the local health department/Washington State Department of Health programs for on-site sewage disposal and small public water systems. A partnership between local and state government could provide a greater degree of protection for the public health than is currently in effect, because local health departments are closer to the public and see more day-to-day problems than does Ecology.

The Seattle-King County Health Department would work with Ecology to develop a program. This will include showing how King County meets the requirements and adding the program to the Seattle-King County Health Department budget. The local program would include identification tagging as part of the program. Ecology would continue to perform the administrative aspects of the program, such as well driller licensing and instruction; well log review and record-keeping; providing technical information and training to the local health department; and completing enforcement procedures, when necessary.

**Issue 2 Well Identification:**

- **WC-2A Well Identification at Sale of Property.**

**Discussion:** King County Planning estimates that, on the average, a residence is sold every five years. Under this program, buyers would be notified using a coordinated disclosure form which could encompass other environmental, health and safety concerns in addition to well decommissioning and identification. The form would notify buyers that unused or unusable wells, and wells presenting an environmental safety or public health hazard, are required to be decommissioned according to procedures outlined in Chapter 173-160 WAC. It will also state that wells are legally required to be tagged with a well identification number. The disclosure form would indicate whether decommissioning has been performed according to requirements. Identification numbers for wells on the property, if available, will be provided on the form. The cost for this evaluation would be borne by the parties to the transaction.

This would result in Ecology, the Washington State Department of Health, and the Seattle-King County Health Department responding to the reported wells. This response could be slow, given the current funding. Ecology would oversee the decommissioning of wells or delegate this to the Seattle-King County Health Department. The Washington

State Department of Health and the Seattle-King County Health Department would enforce existing regulations on any unapproved public water supplies that were found.

- **WC-2B Well Identification During SEPA Review, Rezone and Land Use Permit Applications.**

**Discussion**: A major reason for well identification is to determine whether a well should be decommissioned. Proper decommissioning procedures entail sealing the well in such a way that water is excluded from the well and no vertical movement of water is possible. By having applicants provide information on status, more wells could be evaluated. Well status includes information about whether the well is currently in use, what it is used for, and its apparent construction method.

King County involvement in identifying wells in need of proper decommissioning already exists on an informal basis. This alternative would formalize the involvement while also encouraging community involvement and education. The discovery of unused wells during land development is fairly common. Granting of the rezone or permit would be contingent upon unused wells being properly decommissioned and active wells being tagged with an identification number and entered into Ecology's well inventory. By requiring that applicants for rezones and land use permits demonstrate that the property has been examined for wells and that existing wells are in compliance with the standards specified in Chapter 173-160 WAC, King County and cities could help narrow a regulatory gap. The cost of these requirements would be passed on to the applicants for rezones and permits. Follow-up on the status report would be through the Seattle-King County Health Department delegation program.

**Issue 3 Decommissioning Cost:**

- **WC-3A Decommissioning Cost: Funding Source.**

**Discussion:** The Management Committee will decide whether an aquifer protection fund could support this and if so, whether or not to include this option in the overall program. The Department of Natural Resources will report to the Management Committee on the feasibility and costs based on the disclosure information collected through other actions.

- **WC-3B Decommissioning Cost: Alternative Procedures.**

**Discussion:** There is interest at Ecology in considering alternatives to the current regulations for well decommissioning. Ecology may consider alternatives during revision of Chapter 173-160 WAC, which details the required decommissioning methods.

**Issue 4 Education:**

- **WC-4 Education: Coordinate With Ecology.**

**Discussion**: Informed and involved well owners and other community members are more likely to comply with well construction and decommissioning regulations. Some ways to inform and involve well owners could include: distributing a questionnaire about wells to homes in the community; developing and distributing an educational brochure for homeowners; and supplementing the brochure with community educational programs. The questionnaire should be designed to elicit information on the number of wells on each property, the construction methods used, and the number of wells requiring decommissioning. The brochure should include recommended practices and legal requirements for well construction and decommissioning. It should also include the reasons why practices such as sealing the well are both advisable and required by law so that homeowners are knowledgeable before they make plans to construct or abandon a well. The education program should cover the same information, and provide the public with an opportunity to ask individual questions.

### 3.6 Ground Water Concerns Associated with Sewer Pipes

Sewage collection and treatment in King County is provided by the King County Department of Natural Resources, Water Filtration Control cities, and water and sewer districts. Wastewater is carried from homes and businesses through a system of side sewers, which are connected to a system of tributary sewers (or "sewer mains") within the drainage area. Sewer mains are connected to interceptors which transport the wastewater to treatment plants. In King County, there are approximately 3,000 miles of sewer pipe with approximately 150 million gallons of wastewater received at wastewater plants throughout the county each day.

Currently, all sewer pipes in King County are fabricated from polyvinyl chloride (PVC), a strong, durable material that is virtually leak-free. However, prior to the use of PVC, sewer pipes were made from materials such as concrete, brick, clay and ductile iron. Joints were more susceptible to leaking with the use of these materials. Many of these older pipes are still in use.

Infiltration, in the context of sewer pipes, is defined as ground water entering sewer pipes through leaking joints or defects, both as runoff during storm events or as base flow from other sources. Inflow refers to direct flows of storm water into sewer pipes through hookups such as roof and footing drains. Because sources of infiltration and inflow (I and I) are not easily distinguished by sewer authorities, they are commonly considered under the single heading, "I and I."

In the area characterization report for the Issaquah Groundwater Management Area, infiltration into sewer systems servicing the City of Issaquah and the Sammamish Plateau also represents potential export losses of ground water. Export loss means that ground water is transported out of the basin by sanitary sewer, thereby reducing the total available ground water.

If ground water infiltrates into sewer pipes during periods when the water table is high, then it is conceivable that waste water is discharged into the ground when the water table is lowered. Exfiltration (waste water leaking from sewer pipes) is not considered a problem by the utilities contacted in King County.

Numerous utility officials consider side sewers on private property more of a threat to ground water quality than the sewer mains themselves. For example, in a Kent study, in an older neighborhood, side sewers were determined to contribute 75 percent of the infiltration to Kent sewers. Department of Natural Resources, Water Pollution Control Division (at that time, Metro) detected the problem by using a smoke test. The Water Pollution Control Division and the City of Kent bore the cost of replacing the leaking side sewers.

In 1987, the Water Pollution Control Division formally completed an infiltration study for the Renton Treatment Plant. The conclusion of the study was that it was cheaper to treat the waste water at the plant than to repair the leaking pipes. However, with new technologies for pipe repair, it now appears less costly to correct infiltration and inflow problems than to enlarge the plant. The Renton plant treats approximately 60 million gallons of wastewater per day in summer. From a study conducted at this plant in 1989/90, it was determined that approximately 20 million gallons per day of infiltration was occurring.

To date, data on the extent and magnitude of this potential problem is unavailable. There have been no studies conducted on exfiltration of wastes from sewer lines in King County and the possible impacts on ground water quality.

### Recommended Management Strategies for Sewer Pipes

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

### Issue 1 Infiltration and Exfiltration

- **SP-1A Infiltration and Exfiltration: Determine Problem.**

**Discussion:** Existing programs by Water Pollution Control Division and the sewer utilities are replacing leaking sewer pipes where necessary to prevent overloading of waste treatment plant facilities. This is reducing exfiltration from sewer pipes and infiltration of ground water into sewer pipes. This long-term project is only in effect in some parts of the ground water management areas.

Side sewers in some of the older, established, high-density residential areas are leaking. In the Issaquah Creek Valley Ground Water Management Area, these areas, as well as those areas where piping has been replaced need to be mapped. Older high-density residential areas need to be given priority for sewer and side sewer maintenance.

- **SP-1B Sewer Maintenance Programs.**

**Discussion:** The Department of Natural Resource Water Pollution Control Division (formerly Metro) and the utilities are conducting maintenance and pilot programs in King County to replace leaking sewer pipes for reduction of infiltration and inflow at waste treatment plants. This is reducing exfiltration from sewer pipes and infiltration of ground water into sewer pipes. For ground water protection from contamination and depletion, Water Pollution Control Division and the utilities should be encouraged to replace leaking sewer pipes in the Issaquah Creek Valley Ground Water Management Area and to educate homeowners in properly maintaining their side sewers. Projects such as the Water Pollution Control Division replacement of side sewers in Kent should be encouraged.

- **SP-1C Leakproof Piping.**

**Discussion:** The King County Comprehensive Plan was updated in 1994. By amending the Comprehensive Plan, King County can require leak-proof piping for new installations or replacement of leaking sewer pipes in the most physically susceptible and recharge areas when reviewing sewer utility plans. King County Code 13.24 states that utility plans must be consistent with King County Comprehensive Plans. By requiring leak-proof sewer piping in the most physically susceptible areas, ground water in those areas will be protected from depletion and contamination.

**Issue 2 Ground Water Depletion:**

- **SP-2 Ground Water Depletion - Backfill Materials and Seals.**

**Discussion:** The use of granular sand as backfill for pipe support in new sewer construction or repair allows for the transmission of ground water along the pipe alignments. This may cause a depletion in ground water levels or a depletion in the quantity of ground water available for drinking water purposes in a specific area. Backfill materials used in pipe construction and repair need to be constructed of materials that do not permit this ground water transmission. Ecology needs to develop Best Management Practices for sewer trenches on sloping ground for gravel based bedding or similar materials, or the use of impermeable seals at appropriate intervals to stop ground water transmission and loss.

## 3.7 Ground Water Quality Issues Related to Solid Waste Landfills

A landfill is a disposal facility at which solid waste is permanently placed in or on land. A mixed municipal landfill can accept all waste except hazardous wastes as defined in federal and state regulations. Other landfills are used for limited purposes, such as construction/demolition waste, inert waste, and wood waste. The environmental impacts associated with landfills include leachate and gas production. Leachate is water or other liquid that has been contaminated by dissolved or suspended materials due to contact with solid waste or gases from the solid waste. Landfills may pose a threat to ground water quality due to leachate production. Ground water that has been contaminated by leachate may affect public health. Ground water that is not currently being used for drinking water also needs to be protected from leachate contamination, as it may become a drinking water source in the future.

Many regulations affect landfill operations. The significant state and local regulations are:

- Water Quality Standards for Ground Water of the State of Washington (Chapter 173-200 WAC) establishes ground water quality standards which provide for the protection of the environment and human health and protection of existing and future beneficial uses of ground water. These regulations are administered by Ecology.

- The Criteria for Municipal Solid Waste Landfills (Chapter 173-351 WAC) (referred to here as the Criteria) establishes minimum statewide standards for municipal solid waste landfills so that jurisdictional health departments can enact ordinances equally as or more stringent than the WAC and to have jurisdictional health departments implement such ordinances through a permit system. The Criteria applies to new municipal solid waste landfills, existing municipal solid waste landfills and later expansions. It does not apply to inert and demolition waste, wood waste, industrial solid wastes, other types of solid waste disposed of in limited purpose landfills, which are regulated under the Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC).

  The Criteria includes restrictions on municipal solid waste landfill location relating to flood plains, wetlands, seismic impact zones and unstable areas (Chapter 173-351-130 WAC). This section also notes that Well Head Protection Programs, Ground Water Management Programs and Special Protection Areas may impose additional location restrictions. It also restricts new municipal solid waste landfills or lateral expansions from being located over a designated sole source aquifer, unless it can be demonstrated that the sole source aquifer is not vulnerable to potential ground water contamination from the active area. (Chapter 173-351-140 WAC).

  The Criteria also includes restrictions on the separation between ground water and the liner for a new municipal; solid waste landfill or lateral expansion. The Criteria states that the bottom of the lowest liner must be ten feet above the seasonal high level of ground water in any water bearing unit which is horizontally and vertically extensive, hydraulically recharged and volumetrically significant. An exception can be made if a demonstration, during the permit process, is made that a hydraulic gradient control system or the equivalent can be installed to control ground water fluctuations and maintain a five foot separation between the controlled seasonal high level of ground water in the identified water bearing unit and the bottom of the lowest liner.

Chapter 173-351-300 WAC contains design criteria for new municipal solid waste landfills and lateral expansions. It states that these shall have a composite liner and leachate collection system. The Criteria also includes requirements for ground water monitoring systems and corrective action, for ground water monitoring system design, for ground water sampling and analysis, for ground water reporting, for statistical methods for ground water monitoring, and for a detection monitoring program. (Chapter 173-351-400, -405, 410, -415, 420 and -430 WAC) Chapters 173-351-480 and 173-351-490 WAC contain requirements for ground water modeling and the hydrogeologic report contents.

Chapter 173-351-200 WAC also contains municipal solid waste landfill operating criteria, including procedures for excluding the receipt of dangerous waste. It states that the owner or operator must implement a program at the facility for detecting and preventing the disposal of regulated dangerous wastes.

- The Code of the King County Board of Health, Title 10, "King County Solid Waste Regulations" adopts Minimum Functional Standards as the local regulation for governing design, construction, operation, and closure of solid waste facilities in King County. The Seattle-King County Department of Public Health enforces Title 10. In 1992, the Seattle-King County Department of Public Health revised Title 10. Among other changes, demolition disposal sites now must meet siting criteria for mixed waste landfills.

These regulations on design, operation, maintenance and closure contain many standards that help to ensure that ground water will not be contaminated by leachate. Some gaps in the current regulations can be closed by ensuring consistency with the state ground water standards and by revising state and local regulations. These changes will help ensure that existing landfills are operated to the best ground water protection methods.

In addition to these regulations, the 1994 King County Comprehensive Plan contains this policy: "F-319 solid waste should be handled and disposed of in environmentally sound ways that protect the quality of air, water and public health."

Abandoned landfills may pose a threat to ground water quality. An abandoned landfill is any site completed before a closure permit was required. A permit allows solid waste activities to be performed at a specific location. A permit also includes specific conditions for facility operations, including closure requirements. Not enough is known about abandoned landfills to determine their possible impact on ground water quality. King County has identified a number of abandoned landfills and is investigating these sites. No abandoned landfill sites exist in the Issaquah Ground Water Management Area.

**Recommended Management Strategies for Solid Waste Landfills**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Standards:**

- **SW-1A King County Board of Health Standards.**

**Discussion:** : The Seattle-King County Health Department will prepare amendments to Title 10 to adopt Chapter 173-351 WAC by reference. Adoption, by reference, would complete the intent of Chapter 173-251 WAC, which is to enable the local health jurisdiction to enact ordinances as, or more stringent than the WAC, through a permit system. Adoption by reference would ensure that the ground water protection measures required in Chapter 173-351 WAC will be implemented in King County.

**Issue 2 Education:**

- **SW-2 Education Program.**

**Discussion:** Providing information about recycling and educating residents about reducing the waste stream may reduce the waste going into the landfills and the hazardous products that people buy.

## 3.8 Ground Water Concerns Associated with Burial of Human Remains

Cemeteries are found throughout King County, and it is possible that, under certain hydrogeologic conditions, burial practices have affected or are affecting local ground water quality. About 40 percent of King County residents rely on ground water for their potable water source. Currently, there are 70 cemeteries in King County ranging in size from 20 burial sites to 140,000 burial sites. Nothing is known about the existing or potential effect of decomposing corpses and caskets on ground water within King County.

The threat to ground water from decomposing corpses and caskets includes chemicals, bacteria, viruses and metals. The embalming process uses formalin, (formaldehyde, methanol, glycerin, borax, and water). Approximately ½ gallon of formalin is used to embalm each body. Bacteria are not a concern since nutrients and oxygen are not present for the bacteria to survive and multiply. Viruses in both embalmed and non-embalmed bodies will eventually die out because they require a living host to reproduce.

Similar to body decomposition, the rate of a casket's decomposition depends on materials used and soil conditions. Materials used include hardwood, softwood, metals and a magnesium bar placed along the middle of the casket to prevent hydrolysis of the metals. It is unknown if these metals have leached into and are contaminating ground water.

Ground water may be in contact with corpses and caskets. Concrete burial liners and vaults are not waterproof. Embalming fluids and other materials may infiltrate ground water depending on such factors as soil type, topography, the geology encountered as water travels to an aquifer and the depth to the water table. Soils and geologic materials vary in their ability to attenuate or remove contamination by chemical, biological and physical processes. Generally, the deeper the water table, the greater opportunity exists for contaminant removal by soil and geologic deposits.

In King County, there are ample circumstances for cemetery graves to come in contact with water. Many cemeteries are located in areas where the water table is believed to be very shallow, within 10 feet of land surface. Rainfall ranges from 20 to 50 inches per year throughout the Puget Sound lowlands, with an average value of approximately 35 inches per year. Additionally, the grounds of most operational cemeteries are heavily irrigated in the summer months. In instances where vaults are not used, or do not keep water out, either ground water or recharge water could come into contact with the grave, increasing decomposition and transporting decomposition and embalming products to the ground water system.

Attempts to gather information pertaining to ground water contamination have produced no useful citations. Considerable information does exist on the transitional and end products of decomposing human bodies, residual body wastes and chemicals that are used in the process of embalming bodies. Data are also available on the composition of residues of disintegrating caskets and associated material. However, little is known about the effects of these products on ground water.

**Recommended Management Strategies for Burial of Human Remains**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Lack of Information:**

- **C-1 Information - Studies.**

**Discussion:** A thorough search, to date, of both national and international databases concluded that there was no information available on cemetery waste impacts on ground water. The results of the Woodlawn Cemetery study should provide some information on impacts to ground water. However, this study may not meet our needs, given the unique geology of this region. The goals and objectives of the Woodlawn study, and various factors (such as depth of ground water sources) may be quite different. Correspondence dated August 18, 1992 from the president of the Woodlawn Cemetery, New York indicated that the original company contracted to do the study had canceled and as yet a suitable replacement had not been found.

A study of the potential for cemeteries to contaminate ground water aquifers would make an important contribution to the assessment of ground water quality. This study could provide King County with regionally specific answers to this issue and allow the county to determine whether further action is warranted. A local study will have significant costs, but would provide specific information on local ground water impacts.

## 3.9 Ground Water Quality Issues Related to Sand and Gravel Mining in King County

It is not unusual for productive sand and gravel mines to be located over vulnerable aquifers. Mining activities in these areas can increase ground water vulnerability to contamination from both the extraction process and site reclamation.

The primary "effluent" discharged at a gravel site is turbid rinse water. Generally, operators are required to collect the wastewater on-site in retention and settling ponds where the fine sediment settles out. The collected water is then allowed to infiltrate back to the water table.

Often the excavation pit is also a component of the treatment system. Any chemical contaminants that are allowed to enter the excavation pit via the wash water or spills in the area would have increased access to the aquifer. Possible contaminants found at a mining site include lubricants and fuels which may be from the site or from road and work area runoff.

Beyond the risks associated with active mining, one of the largest threats to ground water appears to be the excavation pit itself. Excavation pits have been used both legally and illegally as dump sites for a variety of wastes. In many cases the material historically used to fill the pits would today be classified as a dangerous waste.

Sand and gravel mining operations are currently subject to permitting at both the local and state level. One of two land use permits must be obtained in King County to mine sand and gravel: (1) A conditional use permit is required to mine in a mining zone. As implied by the title, conditions are attached to the permit. The conditions are established during environmental review under Chapter 43.21 RCW State Environmental Policy Act; (2) An unclassified use permit is required to mine in areas not zoned for mining. This is a temporary permit lasting for five years and is also subject to conditions established during environmental review.

Applications for the above permits incorporate the reclamation plan for the site and provide information showing how provisions of King County Code Chapter 21.42 Q-M, Quarrying and Mining classifications, will be met.

King County also requires a grading permit for sand and gravel excavations with a volume exceeding 500 cubic yards. The applicant must demonstrate that the conditions governing operation and reclamation of the site are met. Grading permits are renewed annually, thus allowing the Department of Development and Environmental Services to institute new conditions as regulations change. Ground water protection is one condition of the permit. This section is very general and does not address ground water concerns. The source of fill being used in reclamation is specified in the initial permit and upon annual updates. Applicants must provide fill approved by Ecology if the fill comes from a previously developed site. Soil must be tested for contamination in order to obtain Ecology approval. Certification is not required if the fill comes from an undeveloped site.

The King County Comprehensive Plan, adopted November, 1994, contains these policies related to minimal resources:

RL-410 The periodic review process for M (Mining) zoned sites and those sites operating in the Forest Production District and as legal nonconforming uses shall include sufficient public notice and comment opportunities. The purpose of the periodic review process is to provide opportunities for public review and comment on the internal resource facility's fulfillment of state and county regulations and implementation of industry-standard best management practices, and for King County to modify, add or remove conditions to address new circumstances and/or unanticipated project-generated impacts. The periodic review process is not intended to reexamine the appropriateness of the mineral resource use, or to consider expansion of operations beyond the scope of existing permitted operations since that review would be accomplished through the County's permitting process. The periodic review is intended to be part of King County's ongoing enforcement and inspections of mineral resource sites, and not to be a part of the County's permitting process.

RL-411 Conditions and mitigations for significant adverse environmental impacts associated with mining operations should be required especially in the following areas: .... b. Environmentally sensitive and critical areas, such as surface and ground water quality and quantity, wetlands, fisheries and wildlife habitats.

R -412 King County should work with the state and federal governments to ensure that proposals for underground mining, oil and gas extraction, and surface coal mining are reviewed with consideration of local land use and environmental requirements.

R-413 King County should work with the State Department of Natural Resources to ensure that mining areas are reclaimed in a timely and appropriate manner. Where mining is completed in phases, reclamation also should be completed in phases as the resource is depleted.

State permits for sand and gravel mining are required both from the State Department of Natural Resources and Ecology. Applicants generally apply for the Washington State of Natural Resources permit concurrently with the King County grading permit. The

Department of Natural Resources permits sand and gravel mines over three acres in size. King County works closely with the Washington State Department of Natural Resources to ensure that each is approving the same operating plans.

Chapter 78.44 RCW, as amended in 1993 and 1994, places a high priority on ground water protection. Specific contents of the bill include that the Washington State Department of Natural Resources will regulate mine reclamation with the county reviewing applications with the Washington State Department of Natural Resources considering the county comments. The Washington State Department of Natural Resources cannot approve fill for reclamation of site without county health department approval of fill first. This does not correlate with Ecology's general permit requirements where Ecology approves of fill material. The minimum reclamation standards discuss how the Washington State Department of Natural Resources will protect ground water and surface water by working with the operator to ensure that the reclaimed mine provides for water quality protection in the future.

In 1991, Ecology, the Department of Natural Resources, and several local authorities identified Best Management Practices for sand and gravel operations. Originally, Ecology planned to adopt Best Management Practices as either guidelines or formal rules for industry to follow in order to comply with the requirements of Chapter 173-200 WAC, Water Quality Standards for Ground Waters of Washington State. After further evaluation, Ecology determined to protect both surface and ground water quality through a general permit titled: "General Permit for Processed Water and Storm Water Associated with Sand and Gravel Operations, Rock Quarries, and similar mining operations, including Stockpiles of Mined Materials, Concrete Batch Operations and Asphalt Batch Operations (July, 1994)." This general permit issued by Ecology supersedes surface and ground water permits that Ecology requires.

The goal of the General Permit is to enforce state and federal standards that apply to the quality of water discharged to either surface water or ground water from certain types of mines. All discharges from sand and gravel mines must meet the Groundwater Quality Standards (Chapter 173-200) and the Surface Water Standards (173-201A). For this permit, the discharge of water includes both surface water discharge (National Pollutant Discharge Elimination System) and discharge to ground (State Waste discharge) such as through infiltration ponds.

The method of compliance with the general permit may include the implementation of recently developed Best Management Practices and wastewater treatment facilities. Permittees will be required to monitor discharges to both surface water and ground water. All facilities covered under the general permit will annually collect and report their monitoring data to Ecology. Ecology will use the monitoring data obtained in the first three years to determine permit effluent limits for potential contaminants and the scope of monitoring required in the re-issued general permit (after 5 years).

## Recommended Management Strategies for Sand and Gravel Mining

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

### Issue 1 Regulatory Modifications:

- **SG-1 Regulatory Modifications: National Pollutant Discharge Elimination System Permit Program and Ecology's "General Permit" Requirements.**

**Discussion:** For the general permit drafted by Ecology, sand and gravel facilities are required to manage, treat and discharge their wastewater in a manner consistent with the Ground Water Quality Standards and National Pollutant Discharge Elimination System Permit Program. This general permit includes the implementation of best management practices and monitoring of discharges to ground water with annual reporting of the monitoring data to Ecology. The General Permit provides positive controls to protect both surface water and ground water from contamination. King County should work with both state and federal governments to ensure that mining operations are not having an adverse impact on ground water quality and quantity.

### Issue 2 Aquifer Impacts and Regulation:

- **SG-2A Ground Water Protection: Support Changes.**
- **SG-2B Aquifer Impacts and Regulation: SEPA Guidance.**

**Discussion:** By supporting these changes, the GWAC gains attention for the ground water management program and helps to remind regulators and legislative bodies of the importance of ground water protection. Letters of support and emphasis could be sent to agencies preparing regulatory changes. Support could also be provided by the GWAC as key issues come before legislative bodies. This support could be in the form of a letter from the GWAC or could consist of many letters and phone calls for individual GWAC members or both. This support would need to be given as circumstances dictate. This alternative is cost-effective, feasible, timely, and is consistent with the goal.

The goal of SEPA should be to assure that: 1) There is no net loss of recharge due to sand and gravel operations, that is, the pre- and post-development recharge rates should remain the same, and 2) the net recharge of the site is increased in order to enhance the beneficial uses of ground water.

This action provides a means for the County to develop guidance documents and informational materials for optimal environmental review. The purpose is to raise the level of understanding of aquifers among environmental reviews.

**Issue 3 Land Use of Inactive or Reclaimed Mines:**

- **SG-3A Land Use of Inactive or Reclaimed Mines: Comprehensive Plan Policy.**

**Discussion:** Comprehensive Plans provide overall guidance for land use decisions. It would be appropriate for Plans to address subsequent land use of reclaimed sand and gravel sites. This issue would thereby influence subsequent policy decisions, regulation revisions, and day-to-day decisions. The Metropolitan King County Council would probably be receptive to this recommendation because it does not preclude particular land uses but rather it requires special consideration for gravel mining sites. This option is consistent with the above goal in that it would help encourage regulatory agencies to adequately protect ground water quality. The approach is also timely and requires no funding. Concurrence with the Ground Water Management Plan by the Metropolitan King County Council and the City of Issaquah would constitute agreement to implementation. For the King County Plans, a separate petition could be prepared by the Department of Natural Resources, on behalf of the GWAC, if the need for input precedes the concurrence process. The Department of Natural Resources will keep aware of the progress of the Plan revisions to ensure timely input by the GWAC.

- **SG-3B Zoning Code - Reclamation Plans**.

**Discussion:** King County Code Chapter 21.A.22, Development Standards Mineral Extraction, Section 446 Reclamation requires that a reclamation plan shall be submitted for each rezone application that addresses the subsequent land uses of the reclaimed lands anticipating reclassification of zones; and a time schedule indicating how and when reclamation will occur during and after extractive operations. This section is general and does not address ground water quality and quantity impacts from land uses proposed in the reclamation plan. These sites consist of gravel-type soil and there is ready access to ground water from the excavation pit prior to site reclamation.

## 3.10 Ground Water Concerns Associated with Biosolids and Sewage Effluent

**Biosolids** are the treated and primarily organic sewage solids generated from wastewater treatment plants. Biosolids were formerly referred to as sewage sludge. Biosolids may be utilized for various beneficial uses including: compost and fertilizer production, agricultural and silvicultural land application, land reclamation, and the manufacture of various construction materials. The biosolids generated in King County are low in pollutants, rich in nutrients and organic matter, and are highly suitable for recycling as a result of extensive pretreatment efforts. Research results and operating experiences over the past 25 years have greatly expanded our understanding of the risks and benefits of using or disposing of biosolids.

Currently, nearly all of the biosolids generated in King County are utilized for silviculture, composting, soil improvement, or other agricultural and landscaping purposes. Properly managed uses of biosolids pose little threat to health or the environment. The rate of biosolids application at land application sites is matched to the agronomic rate of the sites vegetation to avoid off site nitrogen mobilization and eliminate risks to underlying ground water resources.

As required by the Clean Water Act Amendments of 1987, the U.S. Environmental Protection Agency (EPA) developed a new regulation to protect public health and the environment from any reasonably anticipated adverse effects of certain pollutants that might be present in biosolids. This regulation became effective in 1993 and is titled *The Standards for the Use or Disposal of Sewage Sludge,* Title 40 of the Code of Federal Regulations, Part 503. Many of the requirements of the Part 503 rule are based on the results of an extensive multimedia risk assessment. This risk assessment for the Part 503 rule was more comprehensive than for any previous Federal biosolids rulemaking effort. Development of the Part 503 rule began in 1984. During this extensive effort and risk assessment, EPA addressed pathogens and 25 pollutants using 14 exposure pathways. The EPA's multimedia risk assessment was reviewed and approved by the EPA's Science Advisory Board. Detailed information describing the risk assessment and technical basis of the Part 503 standards is contained in the Preamble to the Part 503 rule published in the Federal Register on March 22, 1993.

The Part 503 rule includes five subparts: general provisions, land application, surface disposal, pathogen and vector attraction reduction, and incineration. The regulations also include pollutant limits, management practices, operational standards, and requirements for the frequency of biosolids monitoring, recording keeping, and reporting of results. For the most part, the requirements of the Part 503 regulations are self-implementing and must be followed even without the issuance of a permit.

The Part 503 rule includes several options for land applying biosolids all of which are equally protective of human health and the environment. These options include:

- Exceptional Quality Biosolids: Biosolids that meet limits for pollutants and vector attraction potential, and Class A pathogen reduction (virtual absence of pathogens) are considered a product that is virtually a fertilizer and is unregulated for use, whether used in bulk or distributed in bags or other containers.

- Pollutant Concentration Biosolids: These biosolids meet the same low pollutant concentrations as an Exceptional Quality biosolids, but only meet Class B pathogen reduction criteria. Unlike Exceptional Quality biosolids, Pollutant Concentration biosolids may only be applied in bulk and are subject to additional requirements and management practices such as public access restrictions and environmental monitoring.

All biosolids currently distributed or land applied in King County meet the Exceptional Quality Biosolids or Pollutant Concentration Biosolids criteria.

The Washington State Department of Ecology is currently drafting regulations to allow them to be delegated enforcement authority from the EPA for the Part 503 regulations. In 1993, the Department of Ecology issued the draft *Biosolids Management Guidelines for Washington State*. The Seattle-King County Health Department currently enforces existing state regulations through Title 10 of the King County Board of Health, Solid Waste Regulations. Currently, the Seattle-King County Health Department requires permits for biosolids treatment facilities and land application sites. The permitting process includes: review of biosolids quality, site specific project design and operations, inspections, and environmental monitoring. The Seattle-King County Health Department does not require permits for sites that utilize biosolids meeting the Part 503 rule criteria for an Exceptional Quality Class A biosolids such as composts and dried biosolids fertilizers. The Seattle-King County Health Department has approximately 1/4 full-time equivalent (FTE) assigned to the permitting and monitoring of biosolids land application projects. The Seattle-King County Health Department has found that this level of staffing is adequate to allow for sufficient regulation of current and future expected projects.

The GWAC determined that no additional action was needed for this issue.

**Sewage effluent** is the liquid waste left after sewage has settled. This liquid may be untreated, or it may be further settled, filtered, and disinfected, depending on final use. Reuse of effluent is regulated by the State Water Pollution Control Act (Chapter 90.48 RCW) administered by Ecology and by the "Guidelines for Land Disposal of Treated Domestic Sewage Effluent in Washington State, dated February, 1976" that were prepared jointly by Ecology and the Department of Social and Health Services (now Department of Health). These guidelines are considered to be outdated and have been replaced with the Wastewater Reclamation and Reuse Interim Standards.

Currently, reuse of sewage effluent by land application is not widely practiced in King County because of precipitation which limits the application period. However, interest in effluent reuse increased during the 1992 drought period. During that time, Metro, the Seattle Water Department, Ecology, the Washington State Department of Health and the Seattle-King County Health Department discussed possible uses for treated sewage effluent. The City of Seattle, with concurrence from Washington State's Department of Health, used treated effluent for a variety of non-public contact uses, such as street washing and sewer line flushing. Also, other utilities and industries are proposing projects such as irrigation and energy recovery.

In response to the concern about outdated guidelines, and to the increased interest in effluent reuse, Ecology adopted standards, procedures, and guidelines for industrial and commercial use of reclaimed water on August 1, 1993. Ecology, the State Department of Health, and the State Department of Agriculture provided technical assistance in the development of the standards, procedures, and guidelines. The standards include provisions for permits, fees, monitoring, and inspections. In February 1993, the Washington State Department of Health, in conjunction with the Department of Ecology, released the Wastewater Reclamation and Reuse Interim Standards. These standards are intended to implement the requirements of SHB 2833.

**Recommended Management Strategy for Sewage Effluent**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 State Guideline Revision:**

- **BSE-1 Ecology Guideline Revision.**

**Discussion:** The potential for effluent reuse by a variety of organizations appears to be increasing. Some effluent reuse applications sites may be in the most physically susceptible and recharge areas. The revision to the guidelines should anticipate this, and address this potential problem.

## 3.4 Ground Water Quantity Issues

Ground water quantity is important because ground water is used for drinking water, irrigation, industrial processes, and provides flow to streams, which support fish and other wildlife. Fortunately, some of the soil in King County can hold and release water. Soils that contain in a useable amount are called aquifers. Also, rainfall in this area is fairly dependable. Rain is the primary source of recharge for ground water. Aquifers, and related surface water levels, are maintained by preserving recharge.

The two main threats to preserving recharge and ground water levels, is reducing recharge by increasing permeable surfaces, and by overuse. Recharge occurs only through relatively undisturbed, permeable soils. Population growth, with it's related building of homes, roads and businesses, causes an increase in impermeable surfaces. Population growth also increases the demand for ground water.

The state of Washington has attempted to balance the needs of its citizens with maintaining the water resource. Ecology administers laws dealing with water appropriations and allocations. Allocations to new users must not conflict with existing use; however, the information needed to make allocation decisions is faulty. Some areas have experienced the effects of unwise use of aquifers, such as water level decline and sea water intrusion. Parties involved in water use are developing and using innovative techniques, such as conservation and artificial recharge, to decrease water use and increase water availability. Recent interest in maintaining surface water resources has spotlighted the interaction of ground water and surface water. Future ground water resource management must consider this interaction.

## 4.1 State

Ecology must make decisions on water rights, water level declines, ground water reservations, sea water intrusion and artificial recharge. These decisions are difficult, because of the lack of adequate data upon which to make decisions.

### 4.1.1 Water Rights

To evaluate water right applications, Ecology must determine how much water an aquifer system is capable of yielding on a sustained basis. This is difficult to do because of the lack of accurate pumpage figures. Ecology has issued water rights in the past using standard, but informal, water usage rates for various land uses when precise information was not available. Technically and legally, water use should approximate water right totals. This is seldom the case due, in part, to the lack of a statewide systematic water usage data management program and outdated water rights records. Staffing limitations and inefficient reporting frequently restrict staff efforts to priority areas experiencing significant problems. Consequently, estimates based on field inventory, random sampling, or personal contacts are frequently the best available figures. Ecology does have the statutory authority to require an actual use accounting from the various appropriators of ground water.

### 4.1.2 Water Table

It has been Ecology's position that aquifer systems could be fully used to the capacity of the aquifer to yield water on a sustained basis as long as the water table did not decline below a reasonable or feasible pumping lift, known as a decline limit. In order for Ecology to determine if a water table is declining, a long record of water level data is required. Most of King County does not have sufficient water level data to make confident statements about the regional response to ground water withdrawal.

### 4.1.3 Water Reservation

Ecology also evaluates ground water reservation petitions. As part of an acceptable petition, Ecology must make a finding of general availability of unappropriated water to reserve. This finding depends upon known appropriation, which may not reflect actual use.

### 4.1.4 Seawater Intrusion

The threat to ground water from seawater intrusion (migration of salt water into fresh water aquifers due to pumping of ground water) is an emerging concern along the coast. When ground water is pumped from aquifers that are in hydraulic connection with Puget Sound, the gradients that are set up may induce a flow of salt water from Puget Sound toward the well. The lack of information on the extent of ground water resources and ground water use compounds the problem of determining where seawater intrusion could exist. In response to these concerns, Ecology and the Washington State Department of Health produced the Seawater Intrusion Policy. The goal of the policy is to prevent seawater intrusion in areas where it has not occurred and to control seawater intrusion where the problem already exists.

### 4.1.5 Artificial Recharge

Artificial recharge is an innovative method to augment the ground water resource. The main function of artificial recharge is to replenish aquifers during winter months when stream flows exceed minimum instream flow requirements. Replenished aquifers could be pumped during summer periods to meet local peak demands. This would reduce seasonal demands placed on the system during the summer and late fall months.

Currently, Ecology does not have the comprehensive ground water information needed to evaluate water right applications, water level decline, and sea water intrusion. The Washington State Department of Health and Ecology are responsible for water usage and water rights data.

The problem of lack of accurate data is being addressed by the Water Resource Data Management Task Force in the Five Year Water Resource Water Management Plan. The Plan is to provide the information necessary for effective statewide and regional planning and management of the State's water resources. The Plan will use data developed through the Ground Water Management Plan and other sources.

The Washington State Department of Health requires conservation plans from larger water purveyors and has guidelines for these plans (Water Use Efficiency Act of Chapter 43.20.230 RCW and Interim Guidelines for Public Water Systems Regarding Water Use Reporting, Demand Forecasting Methodology, and Conservation Programs). In addition to these requirements, the adopted coordinated water supply plans include specific conservation program elements. Source and service meters, common conservation methods, are routinely installed for the larger public water systems. However, the smaller water systems with 2 - 9 connections do not currently have this requirement. These systems are regulated by the King County Board of Health Title 12 and administered by the Seattle-King County Health Department.

Drought, aquifer depletion, and population growth are renewing attention on water reuse. Sewage effluent may be "re-used" for a variety of purposes, including water for toilet flushing, industrial use, irrigation, and aquifer recharge. The 1992 legislative session passed SHB 2833, which provided for the use of "reclaimed water." This bill set out the procedure for Ecology, the Washington State Department of Agriculture, and the Washington State Department of Health to follow to update the guidelines for sewage effluent reuse. By August 1, 1993, the Washington State Department of Health was to adopt a single set of standards, procedures, and guidelines for the industrial and commercial use of reclaimed water.

## 4.2 King County

In King County, most physically susceptible and recharge areas are protected primarily through policies in the King County Comprehensive Plan, individual community plans, and ordinances in the Zoning Code. Basin plans may also direct how development occurs to protect recharge. King County relies on community plans to implement and augment, through zoning the aquifer protection policies outlined in the King County Comprehensive Plan. The Comprehensive Plan was adopted on November 18, 1994 by the Metropolitan King County Council. The Comprehensive Plan contains several policies that relate to ground water recharge:

U-206 Environmental standards for urban development should emphasize ways to allow maximum permitted densities and uses of urban land. Mitigating measures should be encouraged to serve multiple purposes, such as drainage control, ground water recharge, stream protection, open space, cultural and historic resource protection and landscaping. When technically feasible standards should be simple and measurable, so they can be implemented without lengthy review process.

NE-302 Development should occur in a manner that supports continued ecological and hydrologic functioning of water resources. Development should not have a significant adverse impact on water quality or water quantity. On Vashon Island, development should maintain base flows, natural water level fluctuations, ground water recharge in Critical Aquifer Recharge Areas and fish and wildlife habitat.

NE-333 King County should protect the quality and quantity of ground water county wide by:

a. Placing a priority on implementation of adopted Ground Water Management Plans:
b. Developing a process by which King County will review, and implement, as appropriate, adopted Wellhead Protection Programs in conjunction with cities and groundwater purveyors;
c. Developing with affected jurisdictions, best management practices for new development and for forestry, agriculture, and mining operations recommended in adopted Ground Water Management Plans and Wellhead Protection Programs as appropriate. The goals of these practices should be to promote aquifer recharge quality and to strive for no net reduction of recharge to ground water quality; and
d. Refining regulations as appropriate to protect critical aquifer recharge areas where information is evaluated and adopted by King County.

NE-334 King County should protect ground water recharge quantity in the Urban Growth Area by promoting methods that infiltrate runoff where site conditions permit, except where potential ground water contamination cannot be prevented by pollution source controls and storm water pretreatment.

NE-335 In making future zoning and land use decisions which are subject to environmental review, King County shall evaluate and monitor ground water policies, their implementation costs, and the impacts upon the quantity and quality of ground water. The depletion or degradation of aquifers needed for potable water supplies should be avoided or mitigated, and the need to plan and develop feasible and equivalent replacement sources to compensate for the potential loss of water supplies should be considered.

NE-336 King County should protect ground water in the Rural Area by:

a. Preferring land uses that retain a high ratio of permeable to impermeable surface area and that maintain or augment the infiltration capacity of the natural soils; and
b. Requiring standards for maximum vegetation clearing limits, impervious surface limit, and where appropriate, infiltration of surface water. These standards should be designed to provide appropriate exceptions consistent with Policy R-216.

NE-216 Rural development standards should be designed to protect the natural environment by addressing seasonal and maximum clearing limits, impervious surface limits, surface water management standards that emphasize preservation of natural drainage systems and water quality, ground water protection, and best management practices for resource-based activities. These standards should be designed to provide appropriate exceptions for lands that are to be developed for K-12 public schools and school facilities, provided that the school project shall comply at a minimum with the requirements and the King County Surface Water Drainage Manual or revisions thereto.

The existing community plans shall remain in effect and continue as official county policy until reviewed and revised to be consistent with the 1994 Comprehensive Plan and adopted as elements of the Comprehensive Plan, or until repealed or replaced. In the case of conflict or inconsistency between applicable policies in existing community plans and the 1994 Comprehensive Plan, the Comprehensive Plan shall govern.

The Comprehensive Plan policies are implemented specifically in community plans. The Tahoma-Raven Heights Community Plan states that "the demand from surrounding land uses and densities should not exceed the capacity of the area's ground water resources nor otherwise cause deterioration of its quality" and "critical ground water recharge areas and watersheds should be identified and maintained in low density residential or similar non-intensive uses."

Recently, several policies were proposed that would enhance recharge in the county for community plans, and basin plans, and implement changes to the zoning code. The Northshore Community Plan included policies for land clearing which may benefit aquifer recharge:

- "King County should adopt a county wide clearing ordinance with guidelines for clearing on lands outside of sensitive areas and specific performance standards including phasing and seasonality of clearing activities, retention requirements, and coverage. The ordinance should include the clarification of a clearing permit process."

- "Until such time that a county wide clearing ordinance is adopted, interim development standards should be implemented whereby clearing is limited on subdivision, short subdivision, and new residential and commercial building projects to protect water quality, limit surface water runoff and erosion, and maintain wildlife habitat and visual buffers."

Another proposed policy that may benefit ground water recharge is in the Executive Proposed Basin Plan for Hylebos Creek and Lower Puget Sound. This vegetation retention policy states that significant trees should be identified during the platting process and retained, that significant natural vegetation should be retained, and the retained vegetation areas should be clearly and permanently marked on the site and identified on all maps, and have legally binding restrictions. It also states that long-term monitoring for water quality trends should be performed to assess trends associated with increased urbanization.

King County Code Title 21 Zoning regulates the degree of impervious cover allowed for developments and therefore affects the amount of recharge. The existing code contains maximum lot coverage by building. For the first time, proposed changes establish limitations on impervious cover for development. These limitations were established to provide for accurate sizing of storm water facilities to manage future runoff. They also would prevent extreme cases of lot coverage by impermeable surfaces. They are considered a clarification of the existing code and are representative of existing coverage with impermeable surfaces in King County. It should not be interpreted that these revisions to the zoning code provide a significant reduction in the amount of impermeable surfaces allowed.

Another method to protect ground water recharge is through the evaluation required by the State Environmental Policy Act (SEPA). A number of proposed land uses require completion of a checklist that indicates potential environmental impacts prior to permitting by King County. If the proposed activities are judged to represent a significant environmental impact, an environmental impact statement is completed. The review process is implemented by King County Environmental Division, SEPA Section. The SEPA checklist includes sections on surface, ground, and runoff water, but does not ask specifically whether the proposed activities will be conducted in an physically susceptible and recharge areas, whether they are likely to affect the quantity of recharge on-site, or to what degree the quantity of recharge is likely to be affected. In recharge-related questions, however, the applicant is asked how much dredging or filling of wetlands is planned, whether water will be discharged to ground water, and how runoff will be generated and handled. Additional information may be requested by the SEPA Section if the reviewers decide that the information provided in the checklist is not sufficient or if another agency or group has indicated that the proposed site of the land use is an area that requires extra attention. The state law exempts certain activities from SEPA review. The SEPA ordinance at the county level may be amended to include these activities if it is found that they could contribute environmental effects.

**Recommended Management Strategies for Ground Water Quantity**

The following section lists the issue, and the title(s) of the recommended management strategies for each issue. (The full text of the recommended management strategies and the implementation are in the Draft Issaquah Ground Water Management Plan.)

**Issue 1 Policies and Ordinances:**

- **WQ-1 Policies and Ordinances: SEPA Checklist**

**Discussion:** Revising the SEPA questionnaire would reflect a growing concern for protection of ground-water resources in general and critical recharge areas in particular. The cost of addressing the expanded SEPA questionnaire would be carried primarily by the developers. Additional costs could arise from the increased work load for the SEPA questionnaire reviewers at King County and the City of Issaquah, possibly necessitating addition of staff, which would be offset by related review fees.

**Issue 2 Data Needs:**

- **WQ-2 Data Needs: Information for Water Resource Decisions.**

**Discussion**: The Issaquah Creek Valley Ground Water Management Plan started the data development necessary for characterizing ground water resources, including resource capability. However, a 2- to 3-year study is not long enough to collect all of the data necessary to make good decisions. Ecology, King County, and utilities need this information for a variety of ground water resource management purposes. If this information is not obtained, then decisions will be based on incomplete or inaccurate data. Specific information about the data needed will be in the Data Collection and Management Program, and will be based upon the needs identified by the state Data Management Task Force.

**Issue 3 Water Rights:**

- **WQ-3 Water Rights Records.**

**Discussion**: Water right records could be a much better tool in ground water management if the individual water rights more clearly reflected actual use and if unused rights were voluntarily or involuntarily relinquished to be eliminated from the records. Utility records of water rights need to be updated and reported to Ecology to influence policy decision. The Five Year Water Resource Data Management Plan's "Activity 10.2 Standardize Water Use Reporting" will provide for a standard method to use for those organizations which report water use. This Activity will specify the data to be collected, acceptable methods of data collection, and frequency of collection. This Plan is designed to address the needs of Ecology, King County and the utilities for a variety of ground water resource management purposes. If this information is not obtained, then decisions will be based on incomplete or inaccurate data.

**Issue 4 Conservation:**

- **WQ-4A Conservation: Landscaping Ordinances.**
- **WQ-4B Conservation: Group B Small Public Water Systems.**
- **WQ-4C Conservation: Individual Wells.**

**Discussion:** Ground water may be conserved through implementation of effective demand reduction techniques. Conservation of water supplies is essential to the proper management of ground water resources. Including conservation measures in the landscaping ordinance will ensure that water conservation is considered during the planning of a development. Otherwise, subsequent owners may have to retrofit conservation measures (WQ-4A).

The proposed regulations would address a gap in the requirement of conservation plans. A system that is not in a Coordinated Water Supply Plan, Critical Water Supply Area, with less than 1000 connections, and not under Utilities Technical Review Committee review does not have to prepare a conservation element in a comprehensive plan. The proposed regulations would address this type of system.

Revising the Small Public Water System Regulations would include requiring water source meters, individual meters, and other items listed under the Interim Guidelines for Public Water Systems Regarding Water Use Reporting, Demand Forecasting Methodology and Conservation Programs. Existing Group B Small Public Water Systems could be required to retrofit with meters (Source and Individual) within 5 years of regulation adoption. New and Expanding Group B systems could have to comply with requirements upon creation, or completion of expansion (WQ-4B).

New regulations for individual wells would incorporate conservation measures. These would include requiring these wells to retrofit with a source meter at the time of property sale and title transfer. New individual wells will have a source meter installed at time of initial well completion and approval. Meters provide a record and a method to monitor water use (WQ-4C).

**Issue 5 Education:**

- **WQ-5A Education: Xeriscaping.**
- **WQ-5B Education: Schools.**
- **WQ-5C Education: Cooperative Extension Service.**

**Discussion:** Educational efforts would complement and combine with current efforts of Seattle-King County Health Department Cooperative Extension and the King Conservation District. This information could be disseminated through the Master Gardener and other programs of Cooperative Extension. Awareness of the problem of reduced aquifer recharge may increase responsibility and concern for aquifer recharge areas in the community. Education programs on how landscaping practices can affect aquifer recharge could be coupled with education on the effects of pesticide and herbicide use on ground-water quality. A discussion of proper disposal of household hazardous wastes could be included. Landscaping tips should include a discussion of native vegetation and its role in facilitating infiltration of moisture.

**Issue 6 Artificial Recharge:**.

- **WQ-6 Artificial Recharge: Investigate**.

**Discussion:** The main function of artificial recharge is to replenish aquifers during winter months when stream flows exceed minimum instream flow requirements. Replenished aquifers could be pumped during summer periods to meet local peak demands. This would reduce seasonal demands placed on the system during the summer and late fall months. Site-specific investigations are required before suitability is established. The Seattle Water Department's Highline Project may serve as a model for other programs.

**Issue 7 Reservation:**

- **WQ-7 Reservation**.

**Discussion:** The unallocated ground water that can be safely withdrawn without depleting the resource is limited. Reservation for future needs will protect the resource and promote its best use. Prudent ground water management includes planning for the future. The Reservation process provides a mechanism to do this. A Reservation petition may be prepared at any time. By including this action in the Issaquah Ground Water Management Plan, the GWAC informs the readers of the Plan that it intends to petition for Reservation in the future and that it supports Reservation as a ground water management tool. However, reserving ground water without understanding the available resource may be pointless. A Reservation should reflect both future needs and an approximation of the unallocated, usable ground water resource. Future needs may be projected based on population projections.

### 3.5 UNFINISHED AGENDA

There is no additional background information for the Unfinished Agenda.

# Bibliography

Draft

Issaquah Creek Valley
Ground Water Management Plan

March, 1996

## Management Strategies Bibliography

### Special Area Designations to Enhance Ground Water Protection

An Annotated Bibliography on Wellhead Protection Programs. U.S. Environmental Protection Agency. Office of Ground-Water Protection. EPA 440/6-87-104. August 1987.

An Annotated Bibliography on Wellhead Protection Programs. U.S. Environmental Protection Agency. January 1990.

Bailey, Jim. Sweet-Edwards/EMCON, Inc., Bellevue, Washington. June-August, 1991. Personal communication.

City of Federal Way Comprehensive Plan, city of Federal Way, Washington, 1992.

Clayton, Geoff. RH2 Engineering, Kirkland, Washington. August 1991. Personal communication.

Cohen, Phil, Public Works Department, City of Redmond, Redmond, WA, Personal communication on wellhead protection areas, 1991.

Draft South King County Ground Water Management Plan. Grant 1. Volume 1. South King County Ground Water Advisory Committee. 1989.

Driscoll, Fletcher G. 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota.

Freeze, R. Allan and John A. Cherry. 1979. Groundwater. Prentice-Hall, Englewood Cliffs, N.J. pp. 193-211.

Guidelines for Delineation of Wellhead Protection Areas. U.S. Environmental Protection Agency. Office of Ground-Water Protection. EPA 440/6-87-010. June 1987.

Jennings, David. Washington Department of Health. April 1992. Personal communication.

Keith, Susan. Geraghty and Miller, Inc., Bellevue, Washington. May, 1991. Personal communication.

King County Comprehensive Plan. King County. 1985.

Lasby, Bill. Seattle-King County Health Department. December 1992. Personal communication.

Maxwell, John. Economic and Engineering Services, Inc. August 1991. Personal communication.

Miller, Stan. Spokane County Public Works Department. Aquifer Protection Area

Office. February 1990. Personal communication.

On Tap - Drinking Water News for America's Small Communities. National Drinking Water Clearinghouse. Volume 1, Issue 4. November 1992.

Rowe, Alan; Personal Communication on wellhead protection areas, Washington State Department of Health, Olympia, WA., February 1990.

Safety of Public Water Systems (Safe Drinking Water Act). 42 U.S.C.A. § 300f et seq.

Safioles, Sally. Washington Department of Ecology. Northwest Regional Office. December 1992. Personal communication.

Saunders, Heather. Thurston County Health Department. Remarks at Workshop on Management Options for Wellhead Protection Areas, Tacoma, WA. Sponsored by Washington Department of Health and U.S. E.P.A. September 9, 1992.

Soil Survey - King County Area - Washington. United States Department of Agriculture, Soil Conservation Service. 1973.

Sole Source Aquifer Designation, Petitioners Guidance. U.S. Environmental Protection Agency. Office of Ground-Water Protection. February 1987.

Sole Source Aquifer Program Overview. US Environmental Protection Agency, January 1990.

State of Washington Ground Water Quality Management Strategy. Washington Department of Ecology. 1987.

Swanson, Rod. Clark County Department of Community Development. November 1992. Personal communication.

Turney, Gary. United States Geological Survey, Tacoma, Washington. April and August, 1991. Personal communication.

Vashon Community Plan and Area Zoning. King County. 1986.

Washington State Wellhead Protection Program - Proposed Program. Washington Department of Health. November 1992.

Wellhead Protection Programs: Tools for Local Governments. U.S. Environmental Protection Agency. Office of Water. EPA 440/6-89-002. April 1989.

Williams, Jonathan. EPA Office of Ground Water Region 10, Seattle. Personal communication. 1990 and 1991.

Winters, Nancy, Washington Department of Ecology, Personal communication on special area designation, February 1991.

**Laws and Regulations**

City of Redmond, WA. Ordinance No. 1693, June 23, 1992.

Code of the City of Federal Way, Title 20. City of Federal Way.

King County Code, Chapter 21.54. Special Control Areas and Flood Hazard Areas

King County Code, Chapter 20.44. County Environmental Procedure 1989

King County Council. Motion No. 8496, October 1, 1991.

Revised Code of Washington Chapter 36.36. Aquifer Protection Areas.

Revised Code of Washington Chapter 36.70A. Growth Management - Planning by Selected Counties and Cities.

Revised Code of Washington Chapter 43.21C. State Environmental Policy Act.

Revised Code of Washington Chapter 90.44. Regulation of Public Ground Waters.

Substitute House Bill 2724; 1990 Legislative Session.

Substitute House Bill 1116; 1986 Legislative Session, Title 36 RCW.

Substitute House Bill 1019; 1991 Legislative Session, amendments to Title 36 RCW.

Washington Administrative Code Chapter 173-200. Water Quality Standards for Ground Waters of the State of Washington, 1990.

Washington Administrative Code Chapter 173-216. State Waste Discharge Permit Program.

Washington Administrative Code Chapter 173-304. Minimum Functional Standards for Solid Waste Handling.

Washington Administrative Code Chapter 197-11. State Environmental Policy Act Rules. April, 1984.

Washington Administrative Code Chapter 246-290. Drinking Water Regulations.

Washington Administrative Code Chapter 365-190. Minimum Guidelines to Classify Agriculture, Forest, Mineral Lands and Critical Areas.

**Data Collection and Management**

Consultants Recommendations and GWAC Adopted Actions.

**Ground Water Quality and Quantity Issues Associated with Stormwater Management**

Arima, Debbie. King County Surface Water Management Division. Personal communication. October 1991.

Balcom, Jerry. King County Division of Building and Land Development. Personal communication. May and October 1991.

Barton, Cynthia, E.F. Vowinkel, and J.P. Nawyn. "Preliminary assessment of water quality and its relation to hydrogeology and land use, Potomac-Raritan-Magothy aquifer system, New Jersey. Water-Resources Investigations Report 87-4023. U.S. Geological Survey. 1987.

Booth, Derek. King County Surface Water Management Division.. Remarks at a GWMP forum entitled Stormwater Infiltration. September 1990.

Bowen, Bert. Washington Department of Ecology. Personal communication. October 1991.

Bresler, Helen. Washington Department of Ecology. Personal communication. May 1992.

Burlingame, Mark. City of Milton. Personal communication. May 1992.

Cain, Doug, Dennis Helsel, and Stephen Ragone. "Preliminary Evaluations of Regional Ground-Water Quality in Relation to Land Use." Volume 27, #2. *Ground Water.* March, 1989

Carla, Kim. City of Auburn. Personal communication. August 1991.

Carpita, John. City of Issaquah. Personal communication. May 1992.

Chase, Richard. City of Kent. Personal communication. May 1992.

Cohen, Phil. City of Redmond. Personal communication. October 1990.

*Covington Master Drainage Plan, Volume I.* Prepared by R.W. Beck and Associates. King County Surface Water Management Division. May 1991.

*Draft Clover/Chambers Creek Basin Ground Water Management Program and Environmental Impact Statement. Technical Appendices.* Prepared by Brown and Caldwell Consultants. Tacoma-Pierce County Health Department. 1990.

*Draft Stormwater Management Manual for the Puget Sound Basin.* Washington Department of Ecology. 1991.

Driscoll, Fletcher. *Groundwater and Wells, Second Edition.* Johnson Division, St. Paul, Minnesota, 1986.

Eckhardt, David, William Flipse, and Edward Oaksford. 1989. "Relation between land use and ground-water quality in the upper glacial aquifer in Nassau and Suffolk Counties, Long Island, New York." Water-Resources Investigations Report 86-4142. U.S. Geological Survey.

*Focus - Improving Stormwater Runoff.* Washington Department of Ecology. July 1991.

*Fresno, CA Nationwide Urban Runoff Program Project: Final Report.* Prepared by Brown and Caldwell consultants. U.S. Environmental Protection Agency. 1984.

Galvin, David G. and Richard K. Moore. *Toxicants in Urban Runoff,* Municipality of Metropolitan Seattle. 1984.

Goldberg, Jennie. City of Seattle. Personal communication. May 1992.

Grady, Stephen."Statistical Comparison of Ground-Water Quality in Four Land-Use Areas of Stratified-Drift Aquifers in Connecticut" in *Proceedings of Technical Meeting in Phoenix Arizona, September 26-30, 1988.* Editors G.E. Mallard and S.E. Ragone. United States Geological Survey Water Resources Investigation Report #88-4220. 1989.

Gredler, Dale. City of Normandy Park. August 1991. Personal communication.

Hansen, James and Mark Sizing. *Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Volume III.* U.S. Environmental Protection Agency. Chicago, Illinois. 1982.

Holman, Ned. City of Pacific. Personal communication. August 1991.

Horner, Richard. *Biofiltration Systems for Storm Runoff Water Quality Control.* Prepared for Washington Department of Ecology, Metro, King County, and the cities of Bellevue, Mountlake Terrace, and Redmond. December 1988.

Horner, Richard. University of Washington Center for Urban Water Resource Management. Personal communication. April 1992.

Hubbard, Tom and David Galvin. *Stormwater Quality Management in the Seattle-King County Region: An Issue Paper*. Municipality of Metropolitan Seattle. 1989.

*Hylebos Creek and Lower Puget Sound Current and Future Conditions Report.* King County Surface Water Management Division and the City of Federal Way. 1990.

*King County Basin Reconnaissance Program.* King County Surface Water Management Division. Program Summary. 1987.

*King County Surface Water Design Manual.* King County Surface Water Management Division. 1990.

*King County Surface Water Management Strategic Plan.* King County Surface Water Management Division. January 1991.

Kruger, Gary. Washington State Department of Ecology. Personal communication. May 1991.

*Long Island Segment of the Nationwide Urban Runoff Program.* NTIS Report PB84-120633. U.S. Environmental Protection Agency. 1982.

Matthews, Wayne. City of Des Moines. Personal communication. August 1991.

Memo to reviewers of *Draft Stormwater Management Manual for the Puget Sound Basin.* Washington Department of Ecology. June 10, 1991.

Miller, Stan. "The Impact of Stormwater Runoff on Groundwater Quality and Potential Mitigation." Paper presented at a conference on the "Protection and Management of Aquifers with an Emphasis on the Spokane-Rathdrum Aquifer," Pullman, Washington on October 10, 1984. 1985

Monaghan, Don. City of Seatac. Personal communication. August 1991.

*Nationwide Urban Runoff Program Priority Pollutant Monitoring Project: Summary of Findings.* NTIS Report PB 84-175686. Washington, D.C. , U.S. Environmental Protection Agency. 1983.

Nussbaum, Jayne. *Urban Storm Water Runoff and Ground-Water Quality.* Report prepared for the EPA under a National Network for Environmental Management Studies fellowship. 1990.

Olsen, Keith. City of Black Diamond. Personal communication. August 1991.

Pierce County. Chapter 21.16 Aquifer Recharge Area. 1991.

Pressley, Helen. Washington Department of Ecology. Personal communication. 1990 and 1991.

*Proposed Soos Creek Basin Plan and Final Environmental Impact Statement.* King County Surface Water Management Division. 1990.

*1991 Puget Sound Water Quality Management Plan.* Puget Sound Water Quality Authority.

Pullar, Ray. City of Algona. Personal communication. August 1991.

*Results of the Nationwide Urban Runoff Program. Volume I. Final Report.* NTIS Report PB 84-185552. Washington, D.C. U.S. Environmental Protection Agency. 1983

Roe, Cary. City of Federal Way. Personal communication. August 1991.

Schwartz, Bob. Municipality of Metropolitan Seattle. Personal communication. November 1991.

Stark, Dave. King County Surface Water Management Division. Personal communication. April 1992.

"Stormwater Quality Management Bibliography." Municipality of Metropolitan Seattle. November 1991.

Stratton, Dayle Ann."The Two Worlds of Surface and Ground Water Planning," *Proceedings From the Technical Sessions of the Regional Conference Nonpoint Source Pollution: The Unfinished Agenda for the Protection of Our Water Quality.* March 20-21 1991. Tacoma, Washington. Presented by the State of Washington Water Research Center and others. Sponsored by the United States Geological Survey and others. 1991.

Thomas, Susan. King County Surface Water Management Division. July 1991. Personal communication.

Turney, G.L. *Quality of Ground Water in the Puget Sound Region, Washington.* United States Geological Survey. Tacoma, Washington. 1986.

**Ground Water Education Program**

Compilation of education elements from other issue topics.

**Ground Water Protection Issues Associated with Hazardous Materials Management**

*A Report on Underground Storage Tanks.* Prepared by Thom Lufkin, WA State Department of Ecology. February 1987.

Barreca, Jeanette, Department of Ecology LUST Program. Personal communication. September 1991.

Bolender, Wendy. Washington Department of Ecology. Personal communication. Numerous occasions in 1990 and 1991.

*Draft Local Program Delegation Guidelines.* WA State Department of Ecology. May 16, 1990.

Environ, Inc., *Analysis of the Potential Hazards Posed By No. 2 Fuel Oil Contained in Underground Storage Tanks,* Prepared for Oil Heat Task Force, September 1987.

Gonzales, Peter. Washington State Energy Office, Oil Help Program, Olympia, WA. Personal communication. January 1990.

Grant, Jeff. Oil Heat Institute of Washington, Seattle, WA. Personal communication. January 1990.

Groundwater Technology, Inc., *Fuel Oil Storage Tank Static Tank Testing Program, Prepared for Oil Heat Task Force.* December 1988.

Hart, Fred C., and Associates, *Structural and Engineering Differences Between Fuel Oil and Gasoline Underground Storage Tank Systems.* Prepared for Oil Heat Task Force. August 1988.

Hickey, Joe. Department of Ecology, Northwest Regional Office, Redmond, WA. Personal communication. January 1990.

Higgins, Leo. King County Fire Marshal's Office. Personal communication. Numerous occasions 1990 and 1991.

Klopfenstein, John. King County Fire Marshal's Office. Personal communication. December 1991.

McKain, Ellen. Washington Department of Ecology. Personal communication. October 1991.

Moe, Don. Ace Tank and Equipment. Seattle, WA. Personal communication. December 1991.

Saunders, Heather. Thurston County Health Department. Personal communication. December 1991.

Svec, John. Florida Department of Environmental Regulation. Personal communication. December 1991.

**Laws and Regulations**

City of Renton, Washington. Ordinance #4147. April 4, 1988.

Resource Conservation and Recovery Act (RCRA) Subtitle I, 40 CFR 290 Part 280, *Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks*, Environmental Protection Agency (EPA).

Revised Code of Washington Chapter 70.105, *Model Toxics Control Act*. November 1988.

Revised Code of Washington Chapter 90.76, *Underground Storage Tanks*, 1989.

Superfund Amendments and Reauthorization Act of 1986, Section 205.

Uniform Fire Code, Article 79, International Conference of Building Officials and Western Fire Chiefs Association, Wittier California.

Washington Administrative Code Chapter 173-360 *Underground Storage Tank Regulations*. November 1990.

Washington Administrative Code Chapter 197-11 *State Environmental Policy Act Rules*. April 1984.

**Ground Water Concerns Associated with Underground Storage Tank Management**

Barreca, Jeanette, WA State Department of Ecology, LUST Program, Personal communication. September 1991.

Bolender, Wendy. WA State Department of Ecology. Personal communication. Numerous occasions in 1990 and 1991.

Environ, Inc. *Analysis of the Potential Hazards Posed By No. 2 Fuel Oil Contained in Underground Storage Tanks*. Prepared for Oil Heat Task Force. September 1987.

Gonzales, Peter. Washington State Energy Office, Oil Help Program, Olympia, WA. Personal communication. January 1990.

Grant, Jeff. Oil Heat Institute of Washington, Seattle, WA. Personal Communication. January 1990.

Groundwater Technology, Inc., *Fuel Oil Storage Tank Static Tank Testing Program,* Prepared for Oil Heat Task Force, December 1988.

Hickey, Joe. Department of Ecology, Northwest Regional Office, Redmond, WA. Personal communication. January 1990.

Higgins, Leo. King County Fire Marshal's Office. Personal communication. Numerous occasions 1990 - 1992.

Klopfenstein, John. King County Fire Marshal's Office. Personal communication. December 1991.

McKain, Ellen. Washington Department of Ecology. Personal communication. October 1991.

Moe, Don. Ace Tank and Equipment. Seattle, WA. Personal communication. December 1991.

Saunders, Heather. Thurston County Health Department. Personal communication. December 1991.

*Structural and Engineering Differences Between Fuel Oil and Gasoline Underground Storage Tank Systems.* Hart, Fred C., and Associates. Prepared for Oil Heat Task Force, August 1988.

Svec, John. Florida Department of Environmental Regulation. Personal communication. December 1991.

Washington Department of Ecology. *A Report on Underground Storage Tanks.* Prepared by Thom Lufkin. February 1987.

Washington Department of Ecology. Draft Local Program Delegation Guidelines. May 16, 1990.

**Laws and Regulations**

City of Renton, Washington. Ordinance #4147. April 4, 1988.

Resource Conservation and Recovery Act (RCRA) Subtitle I, 40 CFR 290 Part 280, *Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks*, Environmental Protection Agency (EPA).

Revised Code of Washington Chapter 70.105, *Model Toxics Control Act*. November 1988.

Revised Code of Washington Chapter 90.76, *Underground Storage Tanks*, 1989.

Superfund Amendments and Reauthorization Act of 1986, Section 205.

Uniform Fire Code, Article 79, International Conference of Building Officials and Western Fire Chiefs Association, Wittier California.

Washington Administrative Code Chapter 173-360 *Underground Storage Tank Regulations*. November 1990.

Washington Administrative Code Chapter 197-11 *State Environmental Policy Act Rules*. April 1984.

**Ground Water Quality Issues Related to On-Site Sewage**

Anderson, J.L., Machmeier, R.E., Hansel, M.J., "Long Term Application Rates for Soils," *Proceedings of the Third National Symposium on Individual and Small Community Sewage Treatment*, American Society of Agricultural Engineers, 1981.

Boatsman, Carolyn, Personal Communication, Seattle-King County Health Department, May 1990.

Brown K.W., Slowey, J.F., Wolf, H.W., *The Movement of Salts, Nutrients, Fecal Coliform, and Virus Below Septic Leach Fields in Three Soils*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

Converse, J.C., Anderson, J.L., Ziebel, W., Bouma, J., *Pressure Distribution to Improve Soil Absorption Systems*, Proceedings of the National Home Sewage Disposal Symposium, American Society of Agricultural Engineers, 1974.

Crosby, James W., Johnstone, Donald L., Drake, Charles H., Fenton, Robert L., *Migration of Pollutants in a Glacial Outwash Environment*, Water Resources Research-WSU, Vol. 4, No. 5, October 1968.

Department of Health, Wellhead Protection Program (informational flyer), 1992.

Department of Health and Department of Ecology, *Design Guidelines for Larger On-Site Sewage Systems with Design Flows of Greater than 3,500 Gallons Per Day*, 1987.

De Walle, Foppe B., Kalman, David, Norman, Donald, Sung, John, Plews, Gary, *Trace Organics Removal in a Large Septic Tank*, Proceedings of the 4th Northwest On-site Wastewater Disposal Short Course, University of Washington, September 1982.

Environmental Protection Agency (EPA), *Alternatives for Small Wastewater Treatment Systems*, Vol. 1, EPA Technology Transfer Seminar Publication, October 1977.

Environmental Protection Agency (EPA), *Design Manual for On-site Wastewater Treatment and Disposal Systems*, Cincinnati, OH, 1980.

Environmental Protection Agency (EPA), *Protection of Public Water Supplies from Ground Water Contamination*, EPA/625/4-85/016, September 1985.

Flipse, William J., Brian G. Katz, Juli B. Linder, Richard Markel, *Sources of Nitrate in Ground Water in a Sewered Housing Development, Central Long Island, New York*, Groundwater, Vol. 22, No. 4, July-August 1984.

Franks, Alvin L., *Geology for Individual Sewage Disposal Systems*, California Geology, Vol. 25, No. 9, September 1972.

Green, K.M., Cliver, D.O., *Removal of Virus from Septic Tank Effluent by Sand Columns*, Proceedings of the National Home Sewage Disposal Symposium, American Society of Agricultural Engineers, 1974.

Hargett, D.L., Tyler, E.J., Siegrist, R.L., *Soil Infiltration Capacity as Affected Septic Tank Effluent Application Strategies*, Proceedings of the Third National Symposium on Individual and Small Community Sewage Treatment, American Society of Agricultural Engineers, 1981.

Harkin, J.M., Fitzgerald, C.J., Duffy C.P., Kroll, D.G., *Evaluation of Mound Systems for Purification of Septic Tank Effluent*, University of Wisconsin-Madison, Technical Report 79-05, 1979.

Haynes, Chris, Personal Communication, Department of Ecology, Olympia, March 1990.

Henriksen, James, Personal Communication, Seattle-King County Health Department, Seattle, March 1990.

Hill, Robert C., *Final Environmental Impact Statement (EIS) on Mound Systems For Private Waste Disposal*, Wisconsin Department of Health and Social Services, October 1979.

Hausenbuiller, R.I., *Soil Science*, William C. Brown Company, Dubuque, IA, 1978.

King County, *King County Comprehensive Plan*, April 1985.

King County, *King County Sewerage General Plan*, 1979.

King County, City of Seattle, Metro, Seattle-King County Health Department, *Local Hazardous Waste Management Plan for Seattle-King County*, August 1989.

Kimsey, Melanie, Personal Communication, Department of Ecology, August 1991.

Kropf, F.W., Laak, R., Healy, K.A., *Equilibrium Operation of Subsurface Absorption Systems*, Journal of the Water Pollution Control Federation, 1977.

Lance, Clarence, *Fate of Nitrogen in Sewage Effluent Applied to Soil*, Proceedings of the American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 101, No. IR3, September 1975.

Lenning, David, Personal Communication, Department of Health, Olympia, January 1990.

Littler, J.D., Aden, J.T., Johnson, A.F., *Survey of Ground Water and Surface Water Quality for the Chambers Creek/Clover Creek Drainage Basin*, Pierce County, Washington Department of Social and Health Services, 1981.

Machmeier, R.E., *Design Criteria for Soil Treatment Systems*, American Society of Agricultural Engineers Paper No. 75-2577, 1975.

Mc Gauhey, P.H., Winneberger, John, *Causes and Prevention of Failures of Septic Tank Percolation Systems*, prepared for the Federal Housing Administration, FHA No. 533, 1964.

Mc Gauhey, P.H., Krone, R.B., *Soil Mantle as a Wastewater Treatment System*, School of Public Health, University of California, Berkley, 1967.

Nelson, M.E., S.W. Horsley, T.C. Cambareri, M.D. Giggey, J.R. Pinnette, *Predicting Nitrogen Concentrations in Ground Water - An Analytical Model*, Wellhead

Protection Program: Tools for Local Government, U.S. Environmental Protection Agency and the Washington Department of Health, 1992.

Otis, R.J., Plews, G.D., Patterson, D. H., *Design of Conventional Soil Absorption System Trenches and Beds*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, December 1977.

Peavy, H.S., Groves, K.S., *The Influence of Septic Tank Drainfields on Groundwater Quality in Areas of High Groundwater*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

Salvato, Joseph A., *Environmental Engineering and Sanitation*, John Wiley and Sons, New York, 1972.

Schlender, George, Personal Communication, Department of Health, Spokane, March 1990.

Seattle-King County Health Department (SKCHD), Tacoma-Pierce County Health Department (TPCHD), Thurston County Health Department (TCHD), and Seattle Engineering Department, *A Survey of Small Quantity Hazardous Waste Generators, The Puget Sound Experience*, 1986.

Siegrist, R.L., Woltanski, T., Waldorf L.E., *Water Conservation and Wastewater Disposal*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

Tacoma-Pierce County Health Department (TPCHD), *Clover/Chambers Creek Basin Geohydrologic Study*, Prepared by Brown and Caldwell, 1985.

Tacoma-Pierce County Health Department (TPCHD), *Clover/Chambers Creek Basin Ground Water Management Program*, Prepared by Brown and Caldwell, Adolfson Associates, and Sweet-Edwards/EMCON, 1990.

Tyler, E.J., Laak, R., Mc Coy, E., Sandhu, S.S., *The Soil as a Treatment System*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

U.S. Department of Agriculture (USDA), *Soil Survey, King County Area, Washington*, Soil Conservation Service, November 1973.

Wilson, J.T., et al., *Transport and Fate of Selected Organic Pollutants in a Sandy Soil*, Journal of Environmental Quality, Vol. 10, No. 4, 1981.

Yates, Marylynn V., *Septic Tank Density and Ground-Water Contamination*, Groundwater, Vol. 23, No. 5, September-October 1985.

Ziebell, W.A., Anderson, J.L., Bouma, J., Mc Coy, E., *Fecal Bacteria: Removal from Sewage By Soils*, American Society of Agricultural Engineers Paper No. 75-2579, December 1975.

**Laws and Regulations**

Code of the King County Board of Health, Title 13.

Washington Administrative Code 173-200, *Water Quality Standards for Ground Waters of the State of Washington*, October 1990.

Washington Administrative Code 173-216, *State Waste Discharge Permit Program*, November 18, 1983.

Washington Administrative Code 173-240, *Submission of Plans and Reports for Construction of Wastewater Facilities*, November 16, 1983.

Washington Administrative Code 248-96 (Recodified as WAC 246-272), *On-site Sewage Disposal System Rules and Regulations of the State Board of Health*, Department of Health (DOH), September 1989.

**Ground Water Quality Issues Related to Pesticide and Fertilizer**

Agriculture, Washington Department of. *Pesticide Laws and Rules*. Olympia, WA, May 1990.

Agricultural Law and Policy Institute. *Farming and Groundwater: an Introduction*. University of Minnesota Law School, Minneapolis, MN 55455, 1988.

American Farm Bureau Federation. *Revised Water Quality Self-Help Checklist*. Natural & Environmental Resources Division, Park Ridge, IL, 60068, 1989.

Anderson, Dan. Personal communication. Branch Manager, Orkin Pest Control.

Batie, Sandra S., William E. Cox, and Penelope L. Diebel. *Managing Agricultural Contamination of Ground Water: State Strategies*. National Governors Association, 1989.

Brunner, Jay F., and David R. Penman, editors. *Agricultural Pesticides: Issues and Options for Washington State*. Proceedings of the November 1990 Workshop held in Wenatchee, WA. College of Agriculture and Home Economics, Washington State University, Pullman, WA. May 1991.

Drost, Brian. March 1990. Personal communication. United States Geological Survey, Tacoma. Project chief, Franklin/Benton Groundwater Study.

Ecology, Department of. *Ground Water Quality Management Strategy*. Water Quality Program, Olympia, WA. Principal author, Tony Barrett. January 1987.

Ecology, Department of. *Ground Water Quality Monitoring Strategy, vol. I-V*. Olympia, WA. Water Quality Investigations Section, Olympia WA. 1987-1989.

Ecology, Department of. *Guidelines for Development of Ground Water Management Areas and Programs*. Water Resources Program, Olympia, WA. Revised October 1986.

Ecology, Department of. *Ground Water Resource Protection, a Handbook for Local Planners and Decision Makers in Washington State*. Prepared by King County Resource Planning. December 1986.

Ecology, Department of. *Nonpoint Source Pollution Assessment and Management Program*. Water Quality Program, Olympia, WA. October, 1989.

Ecology, Department of. *Protecting Ground Water: A Strategy for Managing Agricultural Pesticides and Nutrients*. Referred to as "State Strategy." Draft, July 1991.

Ecology, Department of. *Washington State Agricultural Chemicals Pilot Study, Final Report*. Environmental Investigations and Laboratory Services Program, Olympia, WA. Authors: Denis Erickson and Dale Norton. November 1990.

Ecology, Department of. *Water Quality Laws and Regulations*. Olympia, WA. 1987, updated 1990.

Fay, Larry. Personal communication. Director, Jefferson County Department of Environmental Health. September, 1991.

Fisher, John. Personal communication. Washington State Department of Natural Resources.

Freshwater Foundation. *Groundwater and Agrichemicals: Suggested Policy Directions for 1990*. Proceedings of a conference held October 1989. St. Paul, Minnesota. 1990.

Goss, D. *Resources for the Future/Use*. ARS, SCS/USDA/Potentials.

Hall, Greg. Personal communication. Grounds Superintendent, Inglewood Golf and Country Club.

Hallmark, Steve. Personal communication. Corporate Forester, Division Operations, Puget Power. September, 1991.

Harlowe, Bill. Personal communication. Manager, Eastside Spray Service.

Health, Department of. *Pesticide Incident Reporting and Tracking Review Panel, Annual Report 1990*. Environmental Health Programs, Pesticide Division, Olympia, WA. January 1991.

Health, Department of. *Pesticide Incident Reporting and Tracking Review Panel, Annual Report 1991*. Environmental Health Programs, Pesticide Division, Olympia, WA. February 1992.

Health, Department of. *Toxic Substances Fact Sheet: Nitrates in Drinking Water*. Office of Environmental Health Programs, Olympia, WA. 1990.

Health, Washington State Board of. *Washington State Health Report*. Olympia, WA. 1990.

Holden, Patrick. *Pesticides and Groundwater Quality: Issues and Problems in Four States*. National Academy Press, Washington, D.C. 1986.

Iowa, State of. *Iowa Groundwater Protection Strategy*. Environmental Protection Commission and Iowa Department of Natural Resources. 1987.

Jenkins, Tom, *"Farming and Agrichemicals: Seeking a Balance Between the Economy and the Environment,"* Journal of Environmental Health, Vol. 54, No. 2, p. 17. September/October 1991.

King County., Draft Memorandum of Understanding between King County and DNR for administering and coordinating forest practices and land development clearing operations in King County. October 1990.

Kuga, Henry. Personal communication. Division of Roads, King County Public Works. June 1991.

Matoon, Doug, Personal communication. Division of Roads, King County Public Works. June 1991.

Minnesota, State of. *Protecting Minnesota's Waters: A Strategy for the Wise Use of Pesticides and Nutrients.* Environmental Quality Board, Water Resources Committee. December 1988.

Moulton, Curt. Personal communication. King County Cooperative Extension. August, 1991.

Office of Technology Assessment. *Beneath The Bottom Line - Agricultural Approaches to Reduce Agrichemical Contamination of Groundwater.* Congress of the United States. Vol.II, Part D, Pest and Pesticide Management, Integrated Pest Management. Nov. 1990.

Padgitt, Steven, "Farmers' Views on Ground Water Quality: Concerns, Practices and Policy Preferences," prepared for the US Congress, Office of Technology Assessment, *Beneath the Bottom Line: Agricultural Approaches to Reduce Agrichemical Contamination of Ground Water*, OTA-F-418 Washington DC: US Government Printing Office. November 1990.

Parsons, Douglas and James Witt. *Pesticides in Groundwater in the United States of America.* Oregon State University Extension Service, Corvallis, Oregon. June 1988.

Price, Pete. *The Leaching Fields: A Nonpoint Threat to Groundwater.* California Assembly Office of Research, Sacramento, CA. March 1985.

Puget Sound Water Quality Authority. *Issue Paper: Pesticides in Puget Sound.* Seattle, WA. March 1990.

Puget Sound Water Quality Authority. *1991 Puget Sound Water Quality Management Plan.* Seattle, WA. November 1990.

Rosenthal, Russell N., Ph.D. Personal communication. Horticulturist, Washington State Department of Transportation, Olympia.

Sacha, Leslie, et al. *Survey of Pesticides used in Selected Areas Having Vulnerable Groundwaters in Washington State.* Environmental Protection Agency, Region 10, Seattle, WA. August 1986, revised July 1987.

Seattle-King County, *Local Hazardous Waste Management Plan for Seattle-King County.* August, 1989.

Scott, Bruce. Personal communication. Regional Safety Manager, ChemLawn-Services Corporation.

Silk, Larry. Personal communication. Farm Manager, Barron Turf Farm.

Social and Health Services, Department of. February, *Results and Implications of the Investigation of Ethylene Dibromide in Ground Water in Western Washington.* Water Supply and Waste Section, Olympia WA. 1985.

Soil Conservation Service. *Annual Progress Report,* Code 108, 1983-89. Spokane, WA. 1990.

Swofford, Wally. August, 1989. Personal communication. Supervisor, Seattle-King County Health Department, Solid Waste Program.

Towery, Audie. Personal communication. Farm Manager, J & B Sod.

U.S. Congress. *Summary of Beneath the Bottom Line: Agricultural Approaches to Reduce Agrichemical Contamination of Groundwater.* Office of Technology Assessment, Washington, D.C. Available from U.S. Government Printing Office. 1990.

U.S. Environmental Protection Agency. *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy.* Office of Pesticides and Toxic Substances, Washington, D.C. December 1987.

U.S. Environmental Protection Agency. *National Pesticide Survey, Summary Results of EPA's National Survey of Pesticides in Drinking Water Wells.* Office of Water and Office of Pesticides and Toxic Substances, Washington, D.C. Fall 1990.

U.S. Environmental Protection Agency. *Protecting Ground Water: Pesticides and Agricultural Practices.* February 1988.

Vashon Island Community Forest Planning Project, Minutes of Reforestation and Land Rehabilitation Working Group. October 7, 1989. Community Forestry Plan Workshop. Bill and Susan Tobin, organizers.

Walton, Graham. *Survey of Literature Relating to Methemoglobinemia,* American Journal of Public Health. Vol. 41, pp. 986-996. August, 1951.

Ware, George W. *The Pesticide Book - Alternatives to Pesticides: Where Do We Go From Here?* University of Arizona. p. 153.

Washington, State of. *Environment 2010: The State of the Environment.* Department of Ecology, Olympia, WA. November, 1989.

Western Fertilizer Handbook.

Wick, Ann. Personal Communication. Program Manager, Program Development Branch, Pesticide Management Division, Washington State Department of Agriculture, Olympia. November, 1991.

**Laws and Regulations**

7 USC Section 136 *Federal Insecticide, Fungicide and Rodenticide Act*. November, 1991.

42 USC Section 6901 *Resource Conservation and Recovery Act*

42 USC Section 9601 *Comprehensive Environmental Response, Compensation, and Liability Act*

Aquifer Protection Ordinance. Draft May 7, 1991. Section 6

Federal Farm Bill of 1990

Revised Code of Washington Chapter 15.09 *Horticultural Pest and Disease Board*

Revised Code of Washington Chapter 15.54 *Fertilizers, Agricultural Minerals and Limes*

Revised Code of Washington Chapter 15.58 *Washington Pesticide Control Act*

Revised Code of Washington Chapter 70.105D *Model Toxics Control Act*

Washington Administrative Code Chapter 16-228 *Rules Relating to General Pesticide Use*

Washington Administrative Code Chapter 173-200 *Water Quality Standards for Ground Water of the State of Washington*

Washington Administrative Code Chapter 222 *Forest Practices Act*

**Ground Water Quality Issues Related to Well Construction and Decommissioning**

Batra, Mo. Washington State Department of Health. Personal communication.

Bishop, Roy. Washington Department of Ecology, NW Regional Office, Redmond, WA. Personal communication.

Fueste, Louis. Information Officer, U.S. Geological Survey, Water Resources Division. Personal communication.

Huggins, Herman. Washington Department of Ecology, NW Regional Office, Redmond, WA. Personal communication.

Liszak, Jerry. Washington Department of Ecology, NW Regional Office, Redmond. Personal communication.

Moseng, Ethan. Drinking Water Operations, Supervisor, Washington Department of Health. Personal communication.

Scott, Randy. Washington State Association of Counties. Personal communication

Thompson, Gordon. King County BALD. Personal communication.

Walsh, Brian. Water Resources and Planning. Well Identification Task Force, Washington Department of Ecology, Olympia. Personal communication.

Well Identification Task Force, *Proposed Well Identification Program for Washington State: A Draft Proposal for inclusion in the Five Year Data Management Plan of the Water Resource Data Management Task Force*. Washington Department of Ecology. April 8, 1992.

Woods, Mike. Association of Washington Cities. Personal communication.

**Laws and Regulations**

Revised Code of Washington, Chapter 18.104, *Water Well Construction Act*, 1971.

S.H.B. 2796 Chapter 67, Laws of 1992 "An Act relating to delegation of water well construction enforcement authority."

Code of the King County Board of Health, Title 12, Rules and Regulations No. 53, *King County Public Water System Rules and Regulations*

Washington Administrative Code, Chapter 173-160, *Minimum Standards for Construction and Maintenance of Wells.*

Washington Administrative Code, Chapter 173-162, *Rules and Regulations Governing the Regulation and Licensing of Well Contractors and Operators.*

Washington Administrative Code, Chapter 246-290, *Drinking Water Regulations - State Board of Health.*

**Ground Water Concerns Associated with Sewer Pipes**

American Public Works Association, Washington State Chapter, *1991 Standard Specifications for Road, Bridge and Municipal Construction*. Washington State Department of Transportation.

Ames, Rick. Vashon Sewer District. Personal communication.

Carr, Jim. Carr & Associates. Personal communication.

Christensen, Dave. Personal communication. City of Renton.

Cox, Edward. Municipality of Metropolitan Seattle. Personal communication.

Dight, Ruth and Applied Geotechnology, Inc. *Groundwater Resource Protection. A Handbook for Local Planners, and Decision Makers in Washington State.* Hall & Associates, King County Resource Planning and Washington State Department of Ecology. 1986.

Gelb, Steve B. and Mary P. Anderson. *Sources of Chloride and Sulfate in Groundwater Beneath an Urbanized Area in Southeastern Wisconsin.* 1981.

Heydon, Tim. City of Kent. Personal communication.

Hornsby, L. City of Renton. Personal communication.

*Issaquah Groundwater Management Plan Area Characterization Report.* Parametrix and Carr and Associates. 1990.

Kimmel, Grant E. *Geological Survey Professional Paper 800-D*. Geological Survey Research. 1972.

McCormick, Bud. Sewage and Drainage Utility, Seattle Engineering Department. Personal communication.

Newman, Allen. Department of Ecology, Olympia, WA. Personal communication.

Sylvester, Bob. Department of Ecology, NWRO. Personal communication.

Velasquez, Angelica. King County Parks, Planning and Resources, Seattle, WA. Personal communication.

Weineke, Steve. Federal Way Water and Sewer. Personal communication.

Yate, Eugene B., Scott N. Hamin, and Lisa Horowitz McCann. *Geohydrology, Water Quality and Water Budgets of Golden Gate Park and the Lake Merced Area in the Western Part of San Francisco, California.* 1984.

**Laws and Regulations**

King County Council Ordinance 4035, *King County Sewerage General Plan.*

Revised Code of Washington, Chapter 36.94, *Sewerage General Plan adopted by Counties.*

Revised Code of Washington, Chapter 35.67, *Plan for a System of Sewerage Adopted by Cities.*

Revised Code of Washington, Chapter 53.08, *Plan for Sewer Systems Adopted by Port Districts.*

Revised Code of Washington, Chapter 54.16, *Plan for Sewer Systems adopted by Public Utility Districts.*

Revised Code of Washington, Chapter 56.08, *Comprehensive Plan for a System of Sewers Adopted by Sewer Districts.*

Revised Code of Washington, Chapter 57.08, *Comprehensive Plan for a System of Sewers Adopted by Water Districts.*

Washington Administrative Code, Chapter 173-240, *Submission of Plans and Reports for Construction of Waste Facilities.*

**Ground Water Quality Issues Related to Solid Waste Landfills**

*Abandoned Landfill Study in King County*, Seattle-King County Department of Public Health, April, 1985.

Brunner, Dirk R., Daniel J. Keller, *Sanitary Landfill Design and Operation*, US EPA. Report SW-65ts. 1972.

Burke, Steve, Senior Environmental Health Specialist, Chemical/Physical Hazards Section, Seattle-King County Health Department, personal communication, May 1991.

*Cedar Hills Regional Landfill Refuse Area 4*, Preliminary Design Report, CH2M Hill. September, 1989.

*Clovers/Chambers Creek GWMP Draft Solid Waste Disposal*, unpublished paper, Tacoma-Pierce County Health Department, 1989.

The Conservation Foundation, *Groundwater Protection*, 1987.

D'Itri and Wolfson, *Rural Groundwater Contamination*, Lewis Publishers, 1988.

*Draft Solid Waste Disposal and Ground Water Management, unpublished paper,* Parametrix, February 1990.

Ellefson, Mark, Special Waste Supervisor, Engineering Services, King County Solid Waste Division, personal communication, June 1991.

Glysson, Eugene A., James R. Packard, Cyril H. Barnes, *The Problem of Solid Waste Disposal*, College of Engineering, University of Michigan, Ann Arbor, 1972.

*Issaquah GWMP Area Characterization Report*, Seattle-King County Health Department, February 1990.

Jorgensen, Eric P., Editor, *The Poisoned Well*, Island Press, 1989.

Jurgensen, Shirley, Supervising Engineer, Engineering Services, King County Solid Waste Division, personal communication, April 1991.

Kiernan, Kevin, Acting Manager, Engineering Services, King County Solid Waste Division, personal communication, May 1991.

Knox, Canter, Kincannon, Stover, and Ward, *Aquifer Restoration*, Noyes Publications, 1986.

Lewis, Jeff, *Demolition Landfill Leachate Analysis*, unpublished, October, 1989.

Moran, Dan, Senior Environmental Health Specialist, Solid Waste Section, SKCHD, personal communication, June 1991.

*Proposed Comprehensive Solid Waste Management Plan*, King County Solid Waste Division, 1989.

*Proposed Comprehensive Solid Waste Management Plan*, King County Solid Waste Division, Vol. 2, Appendix A, 1989.

*Protection of Public Water Supplies From Ground-Water Contamination*, EPA. 1985.

Rathje, William L., *Once and Future Landfills*, The National Geographic, Vol. 179, No. 5, May 1991.

*Redmond-Bear Creek GWMA Background Land and Water Use Report*, Seattle-King County Health Department, unpublished, July 1991.

Safioles, Sally, Hydrogeologist, DOE NWRO Solid Waste Unit, personal communication, September 1991.

*South King County GWMA Phase I Report*, Economic and Engineering Services, Inc., Seattle-King County Health Department and South King County RWA, June 1989.

Sweet-Edwards/EMCON and Adolfson Associates, Inc., *Description of Federal and State Programs that Potentially Relate to the Ground Water Management Programs in King County*, unpublished, March 1990.

Swofford, Wally, Supervisor, Solid Waste Section, SKCHD, personal communication, April 1991.

*Thurston County GWAC Draft Solid Waste Disposal Issue Section*, unpublished paper, Thurston County Health Department, 1989.

*Vashon Island Landfill Leachate Control Facilities*, King County Solid Waste Division, Engineering Report, December, 1987.

*Vashon Island Landfill Monitoring Results*, King County Solid Waste Division, unpublished, 1990.

*Vashon Island Landfill Plan of Operation*, King County Solid Waste Division, December 1987.

**Laws and Regulations**

Code of the King County Board of Health, Title 10, "King County Solid Waste Regulations."

King County Code, Title 10, "King County Solid Waste Handling Code."

King County Ordinance 8771.

Revised Code of Washington 70.65 *Waste Not Washington Act.*

Revised Code of Washington 70.95 *Solid Waste Management Act.*

Revised Code of Washington 70.105D *Model Toxics Control Act.*

Washington Administrative Code 173-200 *Water Quality Standards for the Ground Waters of the State of Washington.*

Revised Code of Washington 173-304 *Minimum Functional Standards for Solid Waste Handling.*

**Ground Water Concerns Associated with Burial of Human Remains**

Cox, Ed, Municipality of Metropolitan Seattle, Personal communication

Davidson, Karl, Cemetery Board, State of Washington Department of Licensing. Personal communication.

*Design Manual for Sludge Treatment and Disposal.* EPA-625/1-79-011. U.S. Environmental Protection Agency. 1979.

*Directory of Cemeteries and Funeral Homes in Washington State.* Washington Internment Association and Washington State Funeral Directors Association. 1989.

Donnellan, John, Director, Cemetery Board, State of Washington Department of Licensing. Personal communication.

Earwin, Dadds, Department of Health, Missouri. Personal communication.

Elvig, Paul. Evergreen-Washelli Funeral Home, Seattle. Personal communication.

Glover, Tim. Department of Environmental Resources, State of Florida. Personal communication.

Grasser, Bob. Department of Economic and Community Affairs, State of Alabama. Personal communication.

Hogan, Jim. Epidemiology Unit, Seattle-King County Department of Public Health. Personal communication.

Horn, Charles, Department of Environmental Management, Alabama. Personal communication.

Laux, Ed, Woodlawn Cemetery, Bronx, New York. Personal communication.

McFarlane, Dr. Louise, Department of Health and Hospitals, Louisiana. Personal communication.

Palmquist, Robert. *Critical Aquifer Recharge Areas: The DRASTIC Approach.* State of Washington Department of Community Development. 1991.

Price, Dave, Health & Rehabilitive Services, South Carolina. Personal communication.

Prior, Bob, Department of Environmental Resources, Florida. Personal communication.

Roberts, Mary Jane, Evergreen Washelli. Personal communication.

Strub, Clarence G. and L.G. Frederick. *Principles and Practices of Embalming*. 1967.

Turney, Gary. *Cemetery Study Proposal*. U.S. Geological Survey, Tacoma, WA. 1991.

Wells, Dr. Wanda, Department of State, NY. Personal communication.

Wermcrantz, Sally. Seattle Public Library Government Research Assistance Library, Personal and written communication.

Wilcoxen, Tim, Vashon Funeral Home, Director. Personal communication.

Winek, Charles, Wagdy W. Wahba, Leon Rozin, and Charles L. Winek, Jr., "Determination of Ethchlorvynol in body tissues and fluids after embalmment," *Forensic Science International*, 37 (1988) Elsevier Scientific Publishers, Ireland, Ltd.

**Laws and Regulations**

King County Board of Health, § 12, Rules and Regulations No. 53, *King County Public Water System Rules and Regulations*.

Revised Code of Washington 16.38, 18.130, *Embalmers and Funeral Directors*.

Revised Code of Washington, § 68, *Cemeteries, Morgues and Human Remains*.

Washington Administrative Code, § 98, *Cemetery Board*.

Washington Administrative Code, § 248, *DSHS - Health, Board and Division of (Vital Statistics)*

**Ground Water Quality Issues Related to Sand and Gravel Mining**

Aller, Linda, Truman Bennett, Jay H. Lehr, and Rebecca J. Petty. *DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings*. U.S. Environmental Protection Agency Publication EPA/600/2-85/018. U.S. Government Printing Office, Washington D.C. 1985.

*A Review of Sources of Ground Water Contamination From Light Industry*. Technical Assistance Document, EPA, 440/6-90-005. Office of Ground Water, U.S. Environmental Protection Agency, Washington, D.C. 1990.

Barrett, Tony. *State of Washington Ground Water Quality Management Strategy*. Publication Number 87-6. Washington State Department of Ecology, Olympia, Washington. 1987.

Cooke, R.U., and J.C. Doornkamp. *Geomorphology in Environmental Management*. Clarendon Press, Oxford, England. 1974.

Creahan, Kathy, DDES, King County, Resource Planning. Personal communication on zoning designations of sand and gravel operation. July 6, 1994.

*Ground Water Resource Protection - A Handbook For Local Planners.* King County Planning Division/Washington Department of Ecology. Olympia, Washington. 1986.

King County Comprehensive Plan, Public Review Draft, April 1994.

Le Grande, H.E., *System for Evaluation of Contaminant Potential of Some Waste Disposal Sites.* Journal American Water Works Association, Vol. 56, pp 959-974. 1964.

Lingley, Phil, DNR, Geology and Earth Resources, author of *The Direct and Cumulative Effects Of Gravel Mining On Ground Water Within Thurston County, Washington*, Groundwater Management Program, Environmental Health Division, Thurston County Public Health and Social Services Department. Personal communication on the changes taking place in the water balance as a result of sand and gravel operations. June 24, 1994.

Lingley, William. Manager of Regulatory Programs, Washington State Division of Natural Resources, personal communication, August, 1990.

Molenaar, Dee, Grimstead, Peder, and Kenneth L. Walters. *Principal Aquifers and Well Yields In Washington.* Geohydrologic Monograph 5. Washington Department of Ecology. Olympia, Washington. 1980.

Molenaar, Dee. *The Spokane Aquifer, Washington: Its Geologic Origin and Water-Bearing and Water-Quality Characteristics.* U.S. Geologic Survey Water Supply Paper 2265. U.S. Government Printing Office, Washington, D.C. 1988.

Norman, David. District Geologist SW Regional Office, Division of Natural Resources. Personal communication, August 1990.

The Planning Association of Washington. *A Short Course On Local Planning, 2nd Edition.* Washington State Department of Community Development, Olympia, Washington. 1987.

Rayforth, Bob, DOE, Yakima, General Permit for sand and gravel operations. Personal communication on the changes taking place in the new General Permit process and compliance with State and Federal regulation regarding stormwater discharges. May 31, 1994.

*Sand and Gravel Mining: Effectiveness of Regulatory Programs In Protecting Ground Water*. Seattle-King County Health Department Issue Paper (Unpublished) for the Issaquah Creek Valley Ground Water Advisory Committee. Seattle, Washington. 1990.

Sandin, Randy, DDES, King County, Personal communication on the Grading Permit, and adequacies of the SEPA and EIS review processes associated with sand and gravel operations. June 21, 1994.

Stirland, Meade A. *Changing Water Quality Regulations: Impact on Mining*. Editor, Alexander Zaporozec, Proceedings of the Conference On Minimizing Risk to the Hydrologic Environment, American Institute of Hydrology, pp. 169-173. Kendall/Hunt Publishing, Dubuque, Iowa. 1990.

Washington Ground Water Vulnerability Task Force. *Draft Proposals for Projects to Assess Ground Water Vulnerability In Washington State*. (Unpublished project proposals). Washington Department of Ecology, Olympia, Washington. 1990.

*Wellhead Protection: Tools for Local Government.* Office of Ground Water Publication EPA 440/6-89-002. U.S. Government Printing Office, Washington, D.C. 1989.

*Wellhead Protection - A Decision-Makers' Guide.* Office of Ground Water Publication EPA 440/6-87-009. U.S. Government Printing Agency, Washington, D.C. 1987.

**Laws and Regulations**

King County Zoning Code, Title 21 A, Adopted June 7, 1994..

Revised Code of Washington, Chapter 78.44, *Surface Mining.*

Washington Administrative Code, Chapter 173-303, *Dangerous Wastes Regulation.*

Washington Administrative Code, Chapter 173-304, *Minimum Functional Standards for Solid Waste Handling.*

Washington Administrative Code, Chapter 332-18, *Surface Mined Land Reclamation.*

**Ground Water Concerns Associated with Biosolids and Sewage Effluent**

*Best Management for Use of Municipal Sewage Sludge, WDOE 82-12,* Washington Department of Ecology, September, 1982.

*EPA Activities Related to Sources of Groundwater Contamination*, USEPA, October, 1977.

*Estimating Sludge Management Costs Handbook*, USEPA, October, 1985.

*Guidelines for Land Disposal of Treated Domestic Sewage Effluent in Washington State*, Washington Department of Ecology and Department of Social and Health Services (now Department of Health), February 25, 1976.

Hanson, Al. Washington State Department of Ecology (No longer with this Program). Personal communication.

Kiuchi, Atsushi. Senate Environment and Natural Resources.

*Land Utilization of Sludge Permit Application*, Seattle-King County Department of Public Health.

Moran, Dan. Seattle-King County Department of Health. Personal communication.

*Municipal and Domestic Sludge Utilization Guidelines*, WDOE 82-11, Washington Department of Ecology, October, 1982.

*Nisqually Valley News*, Thursday, January 11, 1990

O'Brien, Edward. Ecology. Personal communication.

*Process Design Manual, Land Treatment of Municipal Wastewater*, USEPA, October, 1977.

*Process Design Manual, Municipal Sludge Landfills*, USEPA, October, 1978.

*Process Design Manual, Sludge Treatment and Disposal*, U.S. Environmental Protection Agency, September, 1979.

Regional Sludge Management Committee, Meeting Summary, Handouts, (Sludge) Survey Update. March, 1990.

Selleck, Julie. Ecology, N.W. Regional Office. Personal communication.

*State Waste Discharge Permit Program*, Washington Department of Ecology, Washington Administrative Code, Chapter 173-216.

Stephenson, Cullen. Northwest Regional Office, Department of Ecology. Personal communication. April, 1992.

Stephenson, Julie. Regional Sludge Management Committee. Personal communication.

Swofford, Wally. Seattle-King County Department of Health. Personal communication.

Tacoma-Pierce County Health Department, Sludge Utilization Policy, Adopted January, 1985.

*Use versus Disposal, Sludge Management, A Legislative Report*. Senate Environment and Natural Resources Committee. January, 1990.

Wieneke, Steve. Federal Way Water and Sewer. Personal communication.

**Laws and Regulations**

Seattle-King County Department of Public Health, King County Board of Health, *Rules and Regulations No.8 ("King County Solid Waste Regulations")*, Effective January 1, 1987.

Washington Administrative Code, Chapter 173-304, *Minimum Functional Standards for Solid Waste Handling*, Washington Department of Ecology,

**Ground Water Quantity**

Atkins, Riley. Personal communication. September, 1991.

Balcom, Jerry. Personal communication. October, 1991.

*Before the Well Runs Dry. A Handbook for Designing a Local Water Conservation Plan.* Vol. 1. American Water Works Association (AWWA). December 1984

Bigger, Dan. Washington Department of Natural Resources. Forest Practices, Regulations. Timber/Fish/Wildlife Committee, Personal communication.

Boatsman, Carolyn. Seattle-King County Health Department. Environmental Health Division. Personal communication.

Bowen, Bert. Washington Department of Ecology. Water Quality Program, Ground Water Division. Personal communication.

Carr, J. R. and Associates. *Vashon/Maury Island Water Resources Study.* King County Department of Planning and Community Development. 1983

CH2M Hill. *Project Development Plan. US Bureau of Reclamation. Ground Water Recharge Demonstration Project. Highline Well Field.* Prepared for Seattle Water Department. August, 1989.

Clark, Steve. City of Issaquah Planning Department. December, 1991. Personal communication.

Clovers/Chamber Creek Ground Water Management Plan. Tacoma-Pierce County Health Department.

*Complaints Swirl About Low-Water-Use Toilets.* ENR. page 19. May 18, 1989.

Conservation Foundation. *Groundwater Protection. National Groundwater Policy Forum.* Washington, D.C. 1987.

Davidson, Nancy. Seattle Water Department. As reported in the South King County GWMA Minutes March 27, 1991.

Dion and Sumioka. *Seawater Intrusion*. Water Supply Bulletin No. 56. U.S. Geological Survey/Ecology. 1984.

*Draft Hydraulic Continuity Policy*. Water Resources Forum. July 6, 1992.

*Draft Water Allocation Issue Paper*. Subcommittee Work Product. Water Resources Forum. April 24, 1992.

*Draft Water Resource Data Management Five Year Plan. Water Resource Data Management Program. Data Management Task Force*. Washington State Department of Ecology. July, 1992

*Draft Water Use Issue Paper*. Subcommittee Work Product. Water Resources Forum. April 24, 1992.

*Draft WDOE Sea Water Intrusion Policy*. Washington State Department of Ecology. December 3, 1991.

Driscoll, Fletcher G. *Groundwater and Wells*. Johnson Division. St. Paul, Minnesota. 1986.

Dunne, T., and Leopold, L.B. *Water in Environmental Planning*. W.H. Freeman and Company. San Francisco, California. 818 pp. 1978.

Economic and Engineering Services, Inc. Hart-Crowser, Pacific Ground Water Group, and Robinson and Noble. *South King County Ground Water Management Program. Grant No. 1. Background Data Collection and Management Issues*. Draft 1989 and revised April, 1991.

Economic and Engineering Services, Inc. and CH2M Hill, URS Consultants. *South King County Coordinated Water Supply Plan. Regional Supplement*. Prepared for the South King County Water Utility Coordinating Committee. October, 1989

*Essentials of Ground-Water Hydrology Pertinent to Water-Resources Planning*. Bulletin 16 revised. U.S. Water Resources Council. Hydrology Committee. 1980.

*Establishing a Public Benefit Rating System*. King County Department of Parks, Planning and Resources. Office of Open Space. July 1992.

*Executive Proposed Basin Plan for Hylebos Creek and Lower Puget Sound*. King County Surface Water Management. 1991.

Fewins, Greg. City of Federal Way Planning Department. Personal communication. December, 1991.

Garrigues, Robert S., Robin Shoal, Arthur G. Larson, Kenneth O. Slattery and Doug McChesney. *Hydraulic Continuity, Ground Water in Continuity with Surface Water, an Issue Paper*. Draft October 1991. Department of Ecology

Geraghty and Miller, Inc. *Hydrogeology Background Data and Water Use in the Vashon Ground Water Management Area*. May 1991.

Geraghty and Miller, Inc. *Vashon-Maury Island Land Use Background Data*. August 1990.

Grace, Barbara. City of Bothell Planning Department. Personal communication. August, 1992.

Grant, Lori. King County Community Planning. Personal communication. 1990

*Groundwater Resources Protection: A Handbook for Local Planners and Decision Makers in Washington State*. Washington, State of. Department of Ecology. December, 1989.

Heavey, Barbara. King County Comprehensive Planning. Personal communication. 1990

Henriksen, Jim. Seattle-King County Health Department. Personal communication. August 1992.

HDR Engineering, Inc., NLK, Inc., Howard Edde, Inc. *Reclaimed Wastewater Feasibility Study*. For the City of Tacoma Public Utilities and Simpson Tacoma Kraft Mill. April 1991.

Horton Dennis and Associates, Inc. and CH2M Hill. *Skyway Coordinated Water System Plan*. November, 1988

Horton Dennis and Associates, Inc. and CH2M Hill. *Vashon Coordinated Water System Plan Regional Supplement*. June 1, 1990.

Huggins, Herm. Department of Ecology. Personal communication. 1990.

*Interim Guidelines for Public Water Systems Regarding Water Use Reporting, Demand Forecasting Methodology, and Conservation Program*. Washington State Department of Health, July 1989.

Island County Coordinated Water System Plan. July 1990.

*Issaquah Creek Basin. Current/Future Conditions and Source Identification Report.* King County Surface Water Management. October 1991.

Jones, Larry. Personal communication. November, 1991.

Marsh, W.M. and Dozier, J. *Landscape - an introduction to physical geography.* Addison-Wesley Publishing Company, Inc. Reading, Massachusetts. 1981.

McFadden, Michelle. King County Sensitive Areas Ordinance. Personal communication.

Miller, Jim. General manager, Federal Way Water and Sewer District. Personal communication. December, 1991.

Mutsafa, Salihu and N. A. Rafindad. "Nonlinear Steady State Seepage into Drains," *Journal of Irrigation and Drainage Engineering.* Vol. 115. No. 3. page 358. June 1989.

North Thurston Draft Ground Water Management Plan. Tacoma-Pierce County Health Department, March 26, 1991.

Parametrix, Inc. and Carr and Associates. *Issaquah Ground Water Management Program Area Characterization Report.* Draft, July, 1990

Phillips, John. Union Hill Water Association. Personal communication. 1991.

Questad, Barbara. King County SEPA. Personal communication. 1990.

Robinson & Noble. *Description of the Aquifer Systems in the Federal Way Area. Private report for the Federal Way Water and Sewer District.* 1987.

*Salt Water Intrusion Policy for Public Water Systems.* Washington State Department of Health and Island County Health Department. July 19, 1989.

*Sea Water Intrusion Team Final Plan.* Washington State Department of Ecology. June 1990.

Selby, M.J. 1982. *Hillslope Materials and Processes.* Oxford University Press. Oxford.

Skorr. P. "Reusing Water." *Civil Engineering.* pp 69-71. August 1988.

Smith, Craig. King County Building and Land Development and Environmental Services, Code Development Section. Personal communication. August 1992.

Smith, Jackie. *Natural Aquifer Recharge. Draft # 2.* Unpublished. Geraghty & Miller, Inc. July 20, 1990.

Swartz, Bob. Seattle Water Department. Personal communication. October, 1991 and August 1992.

Sweet Edwards/EMCON, Adolfson and Associates, and CWC-HDR. *Redmond Ground Water Management Area Background Land and Water Use Report.* July 1991.

Tiemann, Dave. Office of Open Space. King County. Personal communication. July 1992.

Wallace, Gene. Personal communication. March 1992.

Wallace, Gene, and Matlock, Dan, of the Pacific Groundwater Group and Krautkramer, Mike, of Robinson and Noble. *Groundwater Resource Management Issue Paper, Draft #1.* Unpublished. Economic and Engineering Services, Inc. September, 1990.

Walsh, Brian. Water Resources Program, Ground Water Policy, Washington State Department of Ecology. Personal communication. December, 1991.

Walters. *Reconnaissance of Sea-Water Intrusion.* Water Supply Bulletin No. 32. U.S. Geological Survey/Ecology. 1971.

Watanabe, Ann. City of Kent Planning Department. Personal communication. August 1992.

*Water Conservation Alternatives Inventory.* Arizona Department of Water Resources. Tucson Active Management Area.

*Water Conservation Plan.* Economic and Engineering Services. Inc. For the Tacoma Water Division. January 1991.

*Water Conservation Progress. Water Saving Devices.* Seattle Water Department. January 1991.

Williams, Jonathan. EPA. Personal communication. August, 1991.

Yelton, Tiffany. Department of Ecology. Comments on Draft King County Groundwater Management Area Conservation Issue Paper. March 1991.

**Laws and Regulations**


Engrossed Substitute House Bill No. 1594 as Amended by Free Conference Committee. State of Washington. 50th Legislature. 1988 Regular Session.

Revised Code of Washington, Chapter 90.03, *Water Code 1917 Act.*

Revised Code of Washington, Chapter 90.14, *Water Rights, Registration, Waiver and Relinquishment, Etc.*

Revised Code of Washington, Chapter 90.22, *Minimum Water Flows and Levels.*

Revised Code of Washington, Chapter 90.42.005 - 900. Pilot project for water conservation programs and water right trust program.

Revised Code of Washington, Chapter 90.44, *Regulation of Public Ground Waters.*

Revised Code of Washington, Chapter 90.54, *Water Resources Act of 1971.*

Washington Administrative Code, Chapter 5-18. *Washington State Conservation Performance Standards.* WA State Building Code Council. July 1990

Washington Administrative Code, Chapter 173-136. The establishment of a system of authorizing the withdrawal of artificially stored ground water embodied in an approved declaration under Revised Code of Washington 90.44.130, which are commingled with public groundwater in ground water area, subarea, and zones established under Revised Code of Washington 90.44.130.

Washington Administrative Code, Chapter 173-500. *Water Resources Management Program Established Pursuant to the Water Resources Act of 1971.*

Washington Administrative Code, Chapter 173-508, *Instream Resource Protection Program, Cedar-Sammamish Basin, WRIA 8.* 1979

Washington Administrative Code, Chapter 173-509. Instream Resources Protection Program, Green-Duwamish River Basin, WRIA 9.

Washington Administrative Code, Chapter 173-590. *Procedures Relating to the Reservation of Water for Future Public Water Supply.*

Washington Administrative Code, Chapter 508-12. *Administration of Surface and Ground Water Codes.*

# Appendices

Draft

# Issaquah Creek Valley Ground Water Management Plan

March, 1996

## APPENDIX A

## SOIL ASSOCIATION DESCRIPTIONS

ALDERWOOD ASSOCIATION

The Alderwood association blankets over one-fourth of the Issaquah Ground Water Management Area. It is found in upland areas, including the southeast portion of the Sammamish Plateau, and Cedar Hills and Hobart Plateau in their entirety. It is composed of 85 percent Alderwood soils, 8 percent Everett and 7 percent less extensive soils. In general they are moderately well drained, variably sloped soils underlain by very low permeability glacial till at a depth of 20 to 40 inches.

The Alderwood series is one of the most commonly found soils throughout the Issaquah Ground Water Management Area. These soils are gravelly sandy loams and are typically found on slopes ranging from 6 to 35 percent. A 75 percent Alderwood and 25 percent Kitsap soil unit is found on steep (25 to 75 percent) slopes. This Alderwood and Kitsap mix also contains pockets of deep, moderate to coarse textured soils.

Runoff is slow to medium on 6 to 15 percent slopes, and medium to very rapid on steeper slopes.. Permeability is moderately high in the surface layer. During saturated winter conditions, infiltrated water encounters the dense substratum and moves laterally downgradient.

These soils are severely limiting to septic tank filter fields. Water quality degradation could result where site conditions are inappropriate for septic tank systems. Vertical recharge is probably slow, except along fractures in the till. Lateral subsurface movement to more permeable zones or windows in the substratum could contribute substantially to recharge. The extent and location of these more permeable zones in largely unknown.

BEAUSITE-ALDERWOOD ASSOCIATION

The Beausite-Alderwood association is the most extensive association in the Issaquah Ground Water Management Area, covering primarily the mountainous area (Cougar and Squak Mountains, Grand Ridge, and likely the mostly unmapped Tiger Mountain peak complex). Major soils represented include approximately 55 percent Beausite soils, 30 percent Alderwood soils, 10 percent Ovall soils, and 5 percent miscellaneous soils. These soils are found on rolling to very steep surfaces underlain at 20 to 40 inches depth by sandstone, shale, or dense glacial till. In general, these soils are moderate to well drained.

## BEAUSITE SOILS

Beausite soils are gravelly, sandy loams formed in glacial materials. These soils are underlain by fractured sandstone at a depth of about 20 to 40 inches. Rock outcrops are exposed at many locations.

Beausite soils are situated on rolling to very steep slopes (6 to 75 percent). On the east side of Squak Mountain, and north side of Tiger Mountain, slopes greater than 50 percent are common. On 6 to 15 percent slopes, runoff is moderate. On greater slopes, runoff is rapid to very rapid. Permeability is moderately high. Sandstone is not considered a primary aquifer material, so recharge is probably not significant. However, lateral movement of water in saturated soils might play a significant role in adjacent recharge zones.

Due to the thinness of the soils over bedrock, and steep slope conditions, these soils are severely limiting to on-site sewage disposal. Contaminants introduced to the soil surface could enter bedrock fractures and affect local domestic wells. Large contaminant releases would be rapidly transported by shallow subsurface flow and streams, and could impact water quality downgradient.

## OVALL SOILS

Ovall soils are gravelly loams formed in thin glacial deposits. They are underlain by weathered, andesite breccia at a depth of 20 to 40 inches. The soils are found on rolling to very steep hills with 15 to 75 percent slopes within the Issaquah Ground Water Managment Area. Runoff ranges from moderately rapid to very rapid. Permeability is moderate. Recharge is likely insignificant. Subsurface flow and surface runoff could contribute recharge to more permeable areas downgradient. Due to the shallow presence of bedrock and the steepness of slopes, the soils are severely limiting to on-site waste disposal. Rapid runoff of surface contaminants is likely.

## EVERETT ASSOCIATION

Everett association soils are found on northern upland units in the vicinity of Tradition Lake Terrace, lower Grand Ridge, and an adjacent portion of the Sammamish Plateau. A substantial portion the city of Issaquah and the upstream valleys also consists of Everett soils. The association typically consists of 70 percent Everett soils, 15 percent Neilton soils, 7 percent Alderwood soils and 8 percent less extensive soils. The dominant soils are found on both gently undulating surfaces, and steep terrace faces. They are underlain by sand and gravel, and are exceedingly well drained.

## EVERETT SOILS

Everett soils are composed of gravelly, sandy loam, underlain by gravelly sand at a depth of 18 to 36 inches. The soils were formed on glacial outwash, and are found on terraces and terrace fronts. At depth, there are unpredictably distributed lenses of low permeability silt. Slopes vary from 0 to 30 percent. Runoff is slow to medium on 0 to 15 percent slopes, medium to rapid on 15 to 30 percent slopes. Permeability is rapid and recharge is likely significant.

Everett soils offer very little protection to ground water quality. This is due to the highly permeable nature of the soils and substrata. The presence of silt lenses or low permeability strata could result in unpredictable lateral movement of ground water.

NEILTON SOILS

Neilton soils are composed of gravelly, loamy sand, and are underlain by stratified glacial outwash. This outwash contain layers of materials that vary greatly in permeability. The soils are found on rolling, undulating terrace slopes of 2 to 15 percent. Runoff is slow to medium. Permeability is very high. Recharge is likely significant. As in the case of Everett soils, Neilton soils offer limited protection to ground water quality.

VALLEY SOILS

There are a number of soils represented in the valleys. A partial listing of these soils includes: Sammamish, Bellingham, Briscot, Puyallup, Puget, Oridia and Sultan. Most of these soils are found in developing areas of the lower Issaquah Creek Valley.

Although not extensively distributed elsewhere in the Issaquah Ground Water Managment Area, these soils are significant due to the industrial, urban, and residential development that has occurred or is planned in their vicinity. Large-scale development is likely to include drainage rerouting or enhancement, and substantial earth moving or placement of fill. Such activities greatly disrupt the natural drainage and permeability properties of native soils. The number of potential contaminant sources also increases with intensive land use activities.

SAMMAMISH SOILS

Sammamish soils consist of silt loams stratified with fine sand and clay. The soils exist in alluvium and are found in stream valleys on level 0 to 2 percent slopes. Runoff is slow. Permeability is moderately slow. There is a seasonal high water table at 1 to 2 feet depth. Flooding is a hazard. Recharge is probably slow, but could be significant in those areas underlain by shallow aquifers.

These soils offer limited protection to underlying shallow aquifers. Flooding and the seasonal high water table prevent operation of effective septic tank drainfields. It is logical to assume underground storage tanks or holding pits would face similar high water table constraints.

Appendixes B - F are Available From the King County Department of Natural Resources, Surface Water Management Division:

APPENDIX B HYDROSTRATIGRAPHY

APPENDIX C WELL WATER LEVEL MEASUREMENTS, 1989-1992

APPENDIX D SUMMARY OF PRECIPITATION DATA

APPENDIX E WATER QUALITY

APPENDIX F RELATED DOCUMENTS:

- Data Collection and Analysis Plan
- Data Management Plan
- Quality Assurance Project Plan
- Public Involvement Plan
- Area Characterization Plan
- Data Analysis Report

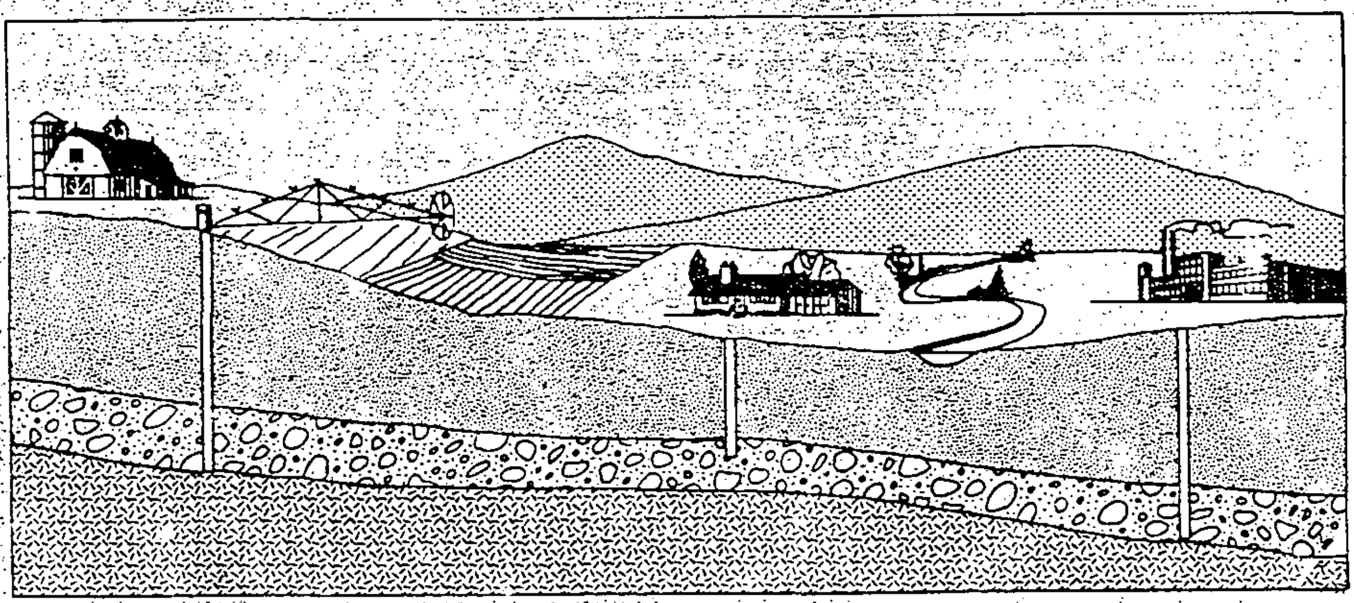
## APPENDIX G

## GUIDELINES FOR THE DEVELOPMENT OF GROUND WATER MANAGEMENT AREAS AND PROGRAMS (Chapter 173-100 WAC)

State of Washington Department of Ecology

# GUIDELINES FOR DEVELOPMENT OF GROUND WATER MANAGEMENT AREAS AND PROGRAMS (CHAPTER 173-100 WAC)

DOE 86-2



WATER RESOURCES PLANNING AND MANAGEMENT SECTION

WASHINGTON STATE DEPARTMENT OF ECOLOGY

APRIL 1986

REVISED OCTOBER 1986

Development
of
Ground Water Management Areas and Programs

In response to growing concern about Washington State's ground water resources, the 1985 legislature passed landmark legislation to assist state and local governments in effectively managing the public's ground water. Substitute House Bill 232 directed the Department of Ecology to establish a process for the identification and designation of ground water management areas and for the development of comprehensive ground water management programs. This process is described in *Chapter 173-100 WAC* of the state administrative code, entitled *"Ground Water Management Areas and Programs."* A copy of these regulations, which became effective on January 17, 1986, are included in this booklet.

There are several advantages to local agencies and user groups in using the process described in Ground Water Management Areas and Programs. The process is designed so that a ground water management program can be initiated and developed on the local level while at the same time be supported by state legislation and regulations. Development of these ground water management programs is intended to be a team planning effort utilizing resources from interested user groups and various local and state agencies. Chapter 173-100 WAC establishes a well defined process which allows for issues, concerns and opportunities from all interested groups and agencies to be incorporated into the planning process in an effective and efficient manner. This coordination should facilitate a wider acceptance of the program and also provide a broader authority to implement and enforce the program. In addition, passage of the Clean Water Bill (ESSB 4519) by the 1986 Legislature will allow Ecology to contribute up to 50 percent in matching funds for the development of ground water management programs which follow this process.

This booklet is intended to assist local governments and water user groups in understanding Chapter 173-100 WAC and to serve as a guide for those who are interested in developing ground water management programs in their area. This booklet is designed to answer general questions about the process. For more detailed requirements and procedures leading to designation of ground water management areas and development of ground water management programs, Chapter 173-100 WAC should be reviewed.

The following questions and answers will provide information for developing a ground water management program.

*What is a "ground water management area?"*

A ground water management area is a specific geographic area which encloses one or more aquifers and in which there exists a justifiable concern for the quality and/or quantity of the ground water. The purposes of designating a ground water management area are to:

1. Protect the quality and quantity of ground water.
2. Meet future water needs while recognizing existing water rights.
3. Provide for effective and coordinated management of the ground water resource.

The regulation states that an area must first be designated by Ecology as a ground water management area before an advisory committee can be established to develop a ground water program.

Reference: <u>WAC 173-100-050</u>

*What does Ecology consider a "justifiable concern?"*

A list of concerns to help guide in the identification of probable ground water management areas is included in WAC 173-100-050 of the regulations. The following is a summary of that list:

1. Geographic areas where ground water quality is threatened or is susceptible to contamination. This includes contamination from land use activities and seawater intrusion.

2. Aquifers that are declining due to restricted recharge or over use. This includes aquifers which have the potential for over use based on projected future demands.

3. Aquifers that have been over appropriated and adjudications of water rights have not been completed.

4. Aquifers designated as "sole source aquifers" by the Environmental Protection Agency. Only three aquifers in the state have been designated as sole source. They are Whidbey, Camano and the Spokane-Rathdrum aquifers.

5. Aquifers identified as the primary source of a public water supply.

6. Aquifers where an approved coordinated water system plan has identified a need for a ground water management program.

*What is a "ground water management program?"*

A ground water management program is a comprehensive program designed to protect ground water quality and assure ground water quantity for current and future uses.

*A water user group or local government agency is interested in developing a ground water management program in their area. What is their first step?*

The first step is to develop a request for designation of the proposed area as a probable ground water management area. Development of a request requires several steps in itself, the most important one being coordination with local agencies and water user groups. Early involvement of all interested agencies and groups will help avoid problems later in the process. Coordination with the local county or counties is required so that written concurrence by the county or counties for appointment of a lead agency can be included in the request for designation.

Probable ground water management areas may be proposed for designation at any time by Ecology upon its own motion or at the request of other state agencies, local governments or ground water user groups.

*What is involved in developing a request for designation of a ground water management area?*

Developing a request for area designation will involve agency and user group coordination, information gathering and a minimum of one public meeting for public comment and review. The request should be in the form of a concise, factual report and contain the following:

1. A general description of and rationale for the proposed ground water management area boundary.

2. A list of concerns along with supporting documentation to substantiate those concerns. Utilizing available data from federal, state and local sources may help justify your concerns. Information from completed ground water studies, land use and water use records, local soils, geology and hydrology conditions and local expertise would be valuable as supporting documentation. Reference should be made as to how the information justifies your particular concern.

3. Goals and objectives for the proposed ground water management area.

4. An estimated cost of developing the ground water management program and potential funding sources.

5. Recommendations for agencies, organizations and groups to be represented on the advisory committee. The advisory committee will oversee and review the development of the ground water program. Membership of the advisory committee should represent

a broad spectrum of the public. A list of potential committee members and the responsibilities of the committee is described in WAC 173-100-090.

6. A recommendation for the lead agency, taking into consideration the responsibilities contained in WAC 173-100-080. Either Ecology or a local government agency may be the lead agency. The recommendation for lead agency shall first be submitted to the county or counties with jurisdiction over the proposed ground water management area. Written concurrence by the county or counties for lead agency should be submitted along with the request for designation. If the proposed area is entirely within one county, that county has the option to be lead agency if it so desires.

7. A list of those who have participated in the development of the request through public meetings, mailing lists and other interaction. The request should specifically address the extent of coordination and involvement by government agencies and user groups.

The request should then be submitted to Ecology, Water Resources Planning and Management, and also to other interested agencies and groups for their review and comments. These groups should be instructed to submit comments directly to Ecology. A list of those to whom copies of the request have been mailed should be sent to Ecology.

Reference: WAC 173-100-050

*What happens after a request is submitted to Ecology?*

When a request is received by Ecology it will be reviewed to make sure it complies with the intent and requirements of Chapter 173-100 WAC. Ecology will review the request on the following basis:

1. Do the proposed area boundaries constitute a logical groundwater management area based on the local hydrogeology?

2. Does the request contain all of the required components including justifiable concerns, goals and objectives, cost estimates and funding sources and a general description and rationale for the proposed area?

3. Have other interested agencies and groups been involved in formulation of the request? What level of coordination has gone into the development of this request?

4. Has at least one public meeting been held for review and comments? Was a broad spectrum of the public represented at this meeting?

5. Has a recommendation for the lead agency and advisory committee members been made? Has written concurrence for lead agency from the appropriate county or counties been included?

6. Has local government shown a willingness to cooperatively develop a comprehensive ground water management program?

If Ecology determines that the request meets the intent and criteria of WAC 173-100-050, Ecology will identify the proposed area as a probable ground water management area, establish the general planning boundaries and appoint a lead agency. Ecology will also begin to seek nominations for the advisory committee and evaluate the request for ranking on the General Schedule.

*How does the General Schedule work?*

Ecology intends to designate a ground water management area as soon as possible after a request is received and it is placed on the General Schedule. The General Schedule guides Ecology in the order of designation of ground water management areas and also in the allocation of Ecology's available funding and staffing. The schedule will rank the relative priority of each probable ground water area based on:

1. The urgency of the problems or potential problems as described in the request for identification. Highest priority will be given to those areas where water quality is imminently threatened.

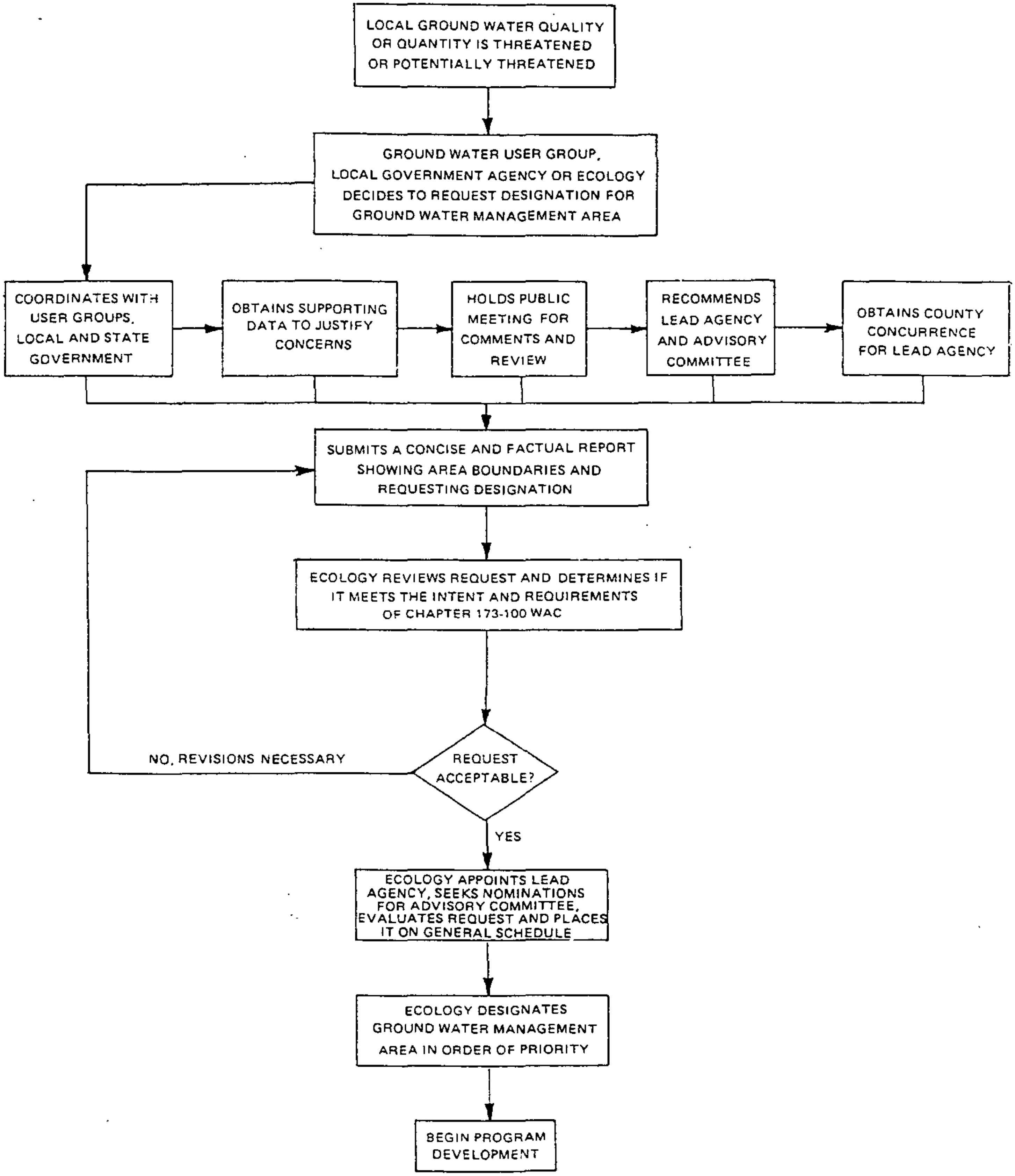
2. The availability of funding and staff on a local or state level to develop and implement a ground water management program.

As stated above, passage of the Clean Water Bill (ESSB 4519) will allow Ecology to contribute up to 50 percent in matching funds to public bodies for the development of ground water management programs. The ability and willingness at the local level to fund their share of the program will be a significant factor in determining priority.

Although Ecology will make every effort to avoid a delay in designation, a situation may arise where the number of requests for designation is so great that Ecology does not have the funding or staffing to handle all requests. In this case the higher priority areas will be designated first and the lower priority areas later. All requests which are put on the General Schedule will be designated as soon as state resources are available to do so.

Ecology may update and revise the General Schedule at anytime as needed. Ecology will notify the public of revisions through the news media and the Washington State Register. A public hearing will be held during June of each year for public comment on the General Schedule. Although requests may be submitted at any time, Ecology recommends that requests be submitted by April 1 of each year. This will allow time for Ecology to review the requests and place them on the General Schedule prior to the annual public hearing.

## REQUEST FOR GROUND WATER MANAGEMENT AREA DESIGNATION



Prior to designation of a ground water management area, Ecology will hold a public hearing within the local area for comments and review of the proposal. Upon designation, Ecology will issue an order which contains a general description of the planning boundary and documents the intent to develop a ground water management program for that area. It should be noted that the proposed boundary is only a planning boundary at this stage and may be modified as data is collected during program development.

Reference: WAC 173-100-060 and WAC 173-100-070

*Once the area is designated as a ground water management area, what is the next step?*

After the area is designated the lead agency will be eligible to apply for grant funding and program development can begin. Ecology will appoint the ground water advisory committee in cooperation with the local governments and interested user groups. The lead agency shall hold the first meeting of the ground water advisory committee within 60 days of the appointment of the committee.

The lead agency shall be responsible for coordination and undertaking the activities necessary for development of the ground water management program. This includes preparation of a work plan, coordinating data collection and scheduling advisory committee meetings. The lead agency may delegate the development of various elements of the ground water management program to other committee members or it may choose to hire a consultant to complete some tasks.

The advisory committee is responsible for overseeing the development of the ground water management program and assuring it is both technically and functionally sound. The committee will give final approval to the program before it is submitted to Ecology for certification. Ecology will participate on the advisory committee along with other state and local government agencies and ground water user group members.

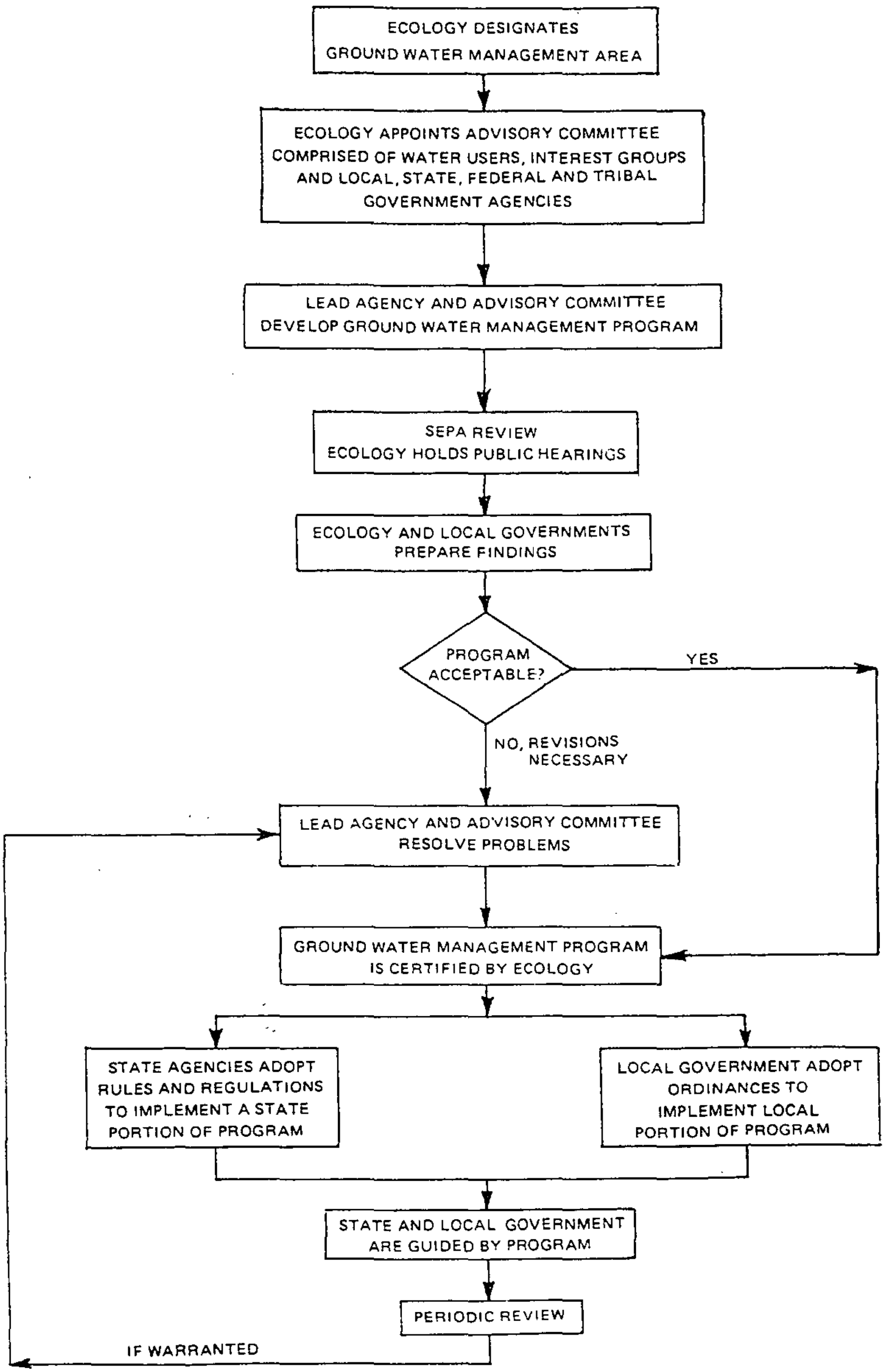
Reference: WAC 173-100-080 and WAC 173-100-090

*What should be included in a "ground water management program?"*

The program for each management area will be tailored to the specific conditions of that area. Each ground water management program should include the following:

1. A section describing the collection and analysis of data, the area's hydrogeological characteristics, historical and projected ground water usage and jurisdictional boundaries and responsibilities.

## GROUND WATER MANAGEMENT PROGRAM DEVELOPMENT



2. A discussion of the type and extent of land use activities potentially affecting ground water quality and quantity.

3. Identification of water quantity and quality goals and objectives.

4. An alternatives section which outlines and evaluates various land and water use management strategies.

5. A section recommending specific management strategies for implementation.

6. An implementation plan including a detailed work plan, model ordinances and a monitoring plan and system for program review to assure goals and objectives are being met.

The time frame for program development will depend on each areas complexity both geologically and politically. Ecology feels an average of two to three years for program completion is a reasonable estimate at this time.

Reference: WAC 173-100-100

*What is Ecology's role after the ground water management program is completed?*

Upon completion, the proposed ground water management program shall be subject to review pursuant to the State Environmental Policy Act (SEPA). Ecology will hold a local public hearing for comment and review of the program. Following the hearing, the department and each local agency and user group will have 90 days to evaluate the program and submit their findings containing their concurrence or nonconcurrence with the program. Statements of nonconcurrence shall be resolved by the advisory committee, using mediation techniques if necessary. If the program is found to be consistent with the intent of Chapter 173-100 WAC, Ecology will certify the program. Following certification, affected state agencies and local governments shall adopt or amend regulations and policies for implementation of the ground water management program.

Reference: WAC 173-100-120

All correspondence involving ground water management area designation or ground water management program development should be sent to:

Department of Ecology
Water Resources Planning and Management
Mail Stop PV-11
Olympia, Washington 98504-8711

(206) 459-6000

## SUMMARY OF RESPONSIBILITIES

| | | |
|---|---|---|
| INITIATOR OF REQUEST (user group, Ecology or local government) | ----------- | Coordination with local government, user groups with state government<br>Develop request for designation<br>Recommend lead agency and GWAC<br>Hold public meeting on request for area designation<br>Submit request to Ecology |
| Provide written concurrence on lead agency recommendation<br>Member of GWAC | -------------- | COUNTY GOVERNMENT |
| LEAD AGENCY | -------------------- | Coordinate development of GWMP<br>Prepares workplan, schedule, budget for GWMP<br>Schedule GWAC meetings<br>Delegate activities to GWAC<br>Coordinate SEPA review |
| Oversees development of GWMP<br>reviews workplan, schedule and budget for GWMP<br>Final review of GWMP before submittal to Ecology<br>Coordinates public review | -------------- | ADVISORY COMMITTEE |
| ECOLOGY | ----------------------- | Places request for area designation on general schedule<br>Holds public hearing on request for area designation<br>Designates GWMA<br>Appoints lead agency and GWAC<br>Participates on GWAC<br>Holds public meeting upon plan completion<br>Certifies GWMP |

GWMA - Ground Water Management Area
GWMP - Ground Water Management Program
GWAC - Ground Water Advisory Committee

# Chapter 173–100 WAC
# GROUND WATER MANAGEMENT AREAS AND PROGRAMS

WAC



**WAC 173–100–010 Purpose.** The purpose of this chapter is to establish guidelines, criteria, and procedures for the designation of ground water management areas, subareas or zones and to set forth a process for the development of ground water management programs for such areas, subareas, or zones, in order to protect ground water quality, to assure ground water quantity, and to provide for efficient management of water resources for meeting future needs while recognizing existing water rights. The intent of this chapter is to forge a partnership between a diversity of local, state, tribal and federal interests in cooperatively protecting the state's ground water resources. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-010, filed 12/20/85.]

**WAC 173–100–020 Authority.** This chapter is promulgated by the department of ecology pursuant to RCW 90.44.400, 90.44.410, 90.44.420, 90.44.430 and 90.44.440. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-020, filed 12/20/85.]

**WAC 173–100–030 Overview.** This regulation establishes a process for the identification and designation of ground water management areas and for the development of comprehensive ground water management programs. From a general schedule of probable ground water management areas, the department of ecology in cooperation with local government will designate specific ground water management areas, subareas, or depth zones within such areas and will appoint a lead agency to develop a ground water management program and an advisory committee to oversee the development of the program for each designated area. Following completion of the program and a public hearing to be held by the department of ecology, the program must be certified to be consistent with the intent of this chapter. The program will then be implemented through state regulations and local ordinances. The programs must thereafter be periodically reviewed. [Statutory Authority: RCW 90-.44.400. 86-02-004 (Order DE 85-24), § 173-100-030, filed 12/20/85.]

**WAC 173–100–040 Definitions.** For the purposes of this chapter the following definitions shall apply:

(1) "Aquifer" means a geologic formation, group of formations or part of a formation capable of yielding a significant amount of ground water to wells or springs.

(2) "Department" means the Washington State department of ecology.

(3) "Ground water" means all waters that exist beneath the land surface or beneath the bed of any stream, lake or reservoir, or other body of surface water, whatever may be the geological formation or structure in which such water stands or flows, percolates or otherwise moves.

(4) "Ground water advisory committee" means a committee appointed by the department to assist in the development of a ground water management program.

(5) "Ground water area or subarea" means a geographic area designated pursuant to RCW 90.44.130.

(6) "Ground water management area" means a specific geographic area or subarea designated pursuant to this chapter for which a ground water management program is required.

(7) "Ground water management program" means a comprehensive program designed to protect ground water quality, to assure ground water quantity and to provide for efficient management of water resources while recognizing existing ground water rights and meeting future needs consistent with local and state objectives, policies and authorities within a designated ground water management area or subarea and developed pursuant to this chapter.

(8) "Ground water management zone" means any depth or stratigraphic zone separately designated by the department in cooperation with local government for ground water management purposes within a ground water management area. Ground water management zones may consist of a specific geologic formation or formations or other reasonable bounds determined by the department consistent with the purposes of this chapter.

(9) "Ground water right" means an authorization to use ground water established pursuant to chapter 90.44 RCW, state common or statutory law existing prior to the enactment of chapter 90.44 RCW, or federal law.

(10) "Ground water user group" means an established association of holders of ground water rights located within a proposed or designated ground water management area.

(11) "Lead agency" means the agency appointed by the department to coordinate and undertake the activities necessary for the development of a ground water management program. Either the department or an agency of local government may be the lead agency.

(12) "Local government" means any county, city, town, or any other entity having its own incorporated government for local affairs including, but not limited to, a metropolitan municipal corporation, public utility district, water district, irrigation district, and/or sewer district.

(13) "Local government legislative authority" means the city or town council, board of county commissioners, special district commission, or that body assigned such duties by a city, county or district charter as enacting ordinances, passing resolutions, and appropriating funds for expenditure.

(14) "Probable ground water management area" means a specific geographic area identified by the department, in cooperation with other state agencies, local government and ground water user groups, as a candidate area for designation as a ground water management area pursuant to this chapter. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-040, filed 12/20/85.]

**WAC 173-100-050 Probable ground water management areas.** The department in cooperation with local government and ground water user groups shall identify probable ground water management areas.

(1) Probable ground water management areas may be proposed for identification at any time by the department upon its own motion or at the request of other state agencies, local government or ground water user groups.

(2) Probable ground water management area boundaries shall be delineated so as to enclose one or more distinct bodies of public ground water as nearly as known facts permit. Probable ground water management subareas shall be delineated so as to enclose all or any part of a distinct body of public ground. Boundaries shall be based on hydrogeologic properties such as limits to lateral extent of aquifers, major perennial rivers, and regional ground water divides or as deemed appropriate by the department to most effectively accomplish the purposes of this chapter.

(3) The criteria to guide identification of probable ground water management areas shall include, but not be limited to, the following:

(a) Geographic areas where ground water quality is threatened;

(b) Aquifers that are declining due to restricted recharge or over-utilization;

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

(d) Aquifers reserved or being considered for water supply reservation under chapter 90.54 RCW for future beneficial uses;

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

(f) Aquifers underlying a critical water supply service area where the coordinated water system plan established pursuant to chapter 70.116 RCW has identified a need for a ground water management program;

(g) Aquifers designated as sole source aquifers by the federal Environmental Protection Agency;

(h) Geographic areas where the ground water is susceptible to contamination or degradation resulting from land use activities;

(i) Aquifers threatened by seawater intrusion; or

(j) Aquifers from which major ground water withdrawals have been proposed or appear imminent.

(4) The state agency, local government or ground water user group requesting probable ground water management area identification shall provide sufficient information for the department to determine if the area should be so identified. The department and other affected state and local governments and user groups may cooperate in preparing the request for identification.

(a) The request for identification shall be presented in a concise, factual report form and shall consider the guidelines and criteria set forth in subsections (2) and (3) of this section as they relate to the proposed area. It shall also contain: (i) Supporting data as to the need for such identification; (ii) a general description of and rationale for the proposed ground water management area boundary; (iii) goals and objectives for the proposed ground water management area; (iv) an estimated cost of developing the ground water management program and potential funding sources; (v) recommendations for agencies, organizations and groups to be represented on the ground water management area advisory committee; and (vi) a recommendation for the lead agency, taking into consideration the responsibilities contained in WAC 173-100-080.

(b) The recommendation for lead agency shall first be submitted to the county or counties with jurisdiction for written concurrence. Such written concurrence shall be included with the information required in (a) of this subsection. If such concurrence cannot be obtained, the department shall attempt to mediate an agreement between the parties.

(c) The agency or ground water user group initiating the request for identification shall hold at least one public meeting for the purpose of receiving comments from the public, affected local, state and tribal agencies and ground water user groups.

(d) Upon completion, the request for identification shall be submitted to the department and other affected state and local agencies and ground water user groups for their review and comment. Comments shall be submitted to the department.

(5) If the department is proposing an area for identification, the department shall prepare a report containing the information in subsection (4)(a) of this section, hold a public meeting, and submit the report to affected

state and local agencies and ground water user groups for their review and comment.

(6) Based upon review of the request for identification together with any comments received and a finding that the proposed area meets the guidelines and criteria of subsections (2) and (3) of this section, the department shall identify the proposed area as a probable ground water management area, establish the general planning boundaries and appoint a lead agency. When a probable ground water management area is included within only one county and that county indicates its desire to assume lead agency status, the department shall appoint the county as lead agency. The department shall notify affected state and local agencies, ground water user groups, tribal governments and local news media of such identification. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-050, filed 12/20/85.]

**WAC 173-100-060 General schedule.** The department shall establish a general schedule for the designation of specific ground water management areas. The general schedule shall guide the department in the designation of specific ground water management areas and in the allocation of the department's available water resources funding and staffing.

(1) The general schedule for designation of ground water management areas shall identify the relative priority of each of the probable ground water management areas. The relative priority of the probable ground water management areas shall be based upon:

(a) The availability of local or state agency resources to develop and implement a ground water management program;

(b) The significance, severity or urgency of the problems or potential problems described in the request for identification submitted for each area, with the highest priority given to areas where the water quality is imminently threatened;

(2) The department shall revise the general schedule as needed to comply with the intent of this chapter. After each revision the general schedule shall be published in the news media and the Washington State Register. A public hearing will be held in June of each year to receive public comment on the general schedule. [Statutory Authority: RCW 90.44:400. 86-02-004 (Order DE 85-24), § 173-100-060, filed 12/20/85.]

**WAC 173-100-070 Designation of ground water management areas for program planning purposes.** The department shall designate ground water management areas by order of the department in accordance with the general schedule. The department shall hold a public hearing within the county or counties containing the probable ground water management area prior to such designation. The order shall be issued to the lead agency as well as the agency or ground water user group originally requesting identification of the areas, with copies sent to other affected state agencies, local governments, tribal governments and those parties recommended for ground water advisory committee membership. Copies of the order shall be published by the department in newspapers of general circulation within the area. The order shall contain a general description of the planning boundary for the ground water management area and shall state that the department, in cooperation with the lead agency and local government, intends to appoint a ground water advisory committee to oversee the development of a ground water management program for the area. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-070, filed 12/20/85.]

**WAC 173-100-080 Lead agency responsibilities.** The lead agency shall be responsible for coordinating and undertaking the activities necessary for development of the ground water management program. These activities shall include collecting data and conducting studies related to hydrogeology, water quality, water use, land use, and population projections; scheduling and coordinating advisory committee meetings; presenting draft materials to the committee for review; responding to comments from the committee; coordinating SEPA review; executing inter-local agreements or other contracts; and other duties as may be necessary. The lead agency shall also prepare a work plan, schedule, and budget for the development of the program that shows the responsibilities and roles of each of the advisory committee members as agreed upon by the committee. Data collection, data analysis and other elements of the program development may be delegated by the lead agency to other advisory committee members. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-080, filed 12/20/85.]

**WAC 173-100-090 Ground water advisory committee.** (1) The ground water advisory committee shall be responsible for overseeing the development of the ground water management program: reviewing the work plan, schedule and budget for the development of the program; assuring that the program is technically and functionally sound; verifying that the program is consistent with this chapter and with the respective authorities of the affected agencies; and formulating and implementing a public involvement plan.

(2) The membership of each ground water advisory committee shall represent a broad spectrum of the public in order to ensure that the ground water is protected and utilized for the greatest benefit to the people of the state. The committee shall include, but not be limited to, representation from the following groups:

(a) Local government legislative authorities within the designated area;

(b) Planning agencies having jurisdiction within the designated area;

(c) Health agencies having jurisdiction within the designated area;

(d) Ground water user groups within the designated area, including domestic well owners;

(e) The department;

(f) Department of social and health services;

(g) Other local, state, and federal agencies as determined to be appropriate by the department;

(h) Tribal governments, where a ground water management program may affect tribal waters;

(i) Public and special interest groups such as agricultural, well drilling, forestry, environmental, business and/or industrial groups within the area, as determined to be appropriate by the department.

(3) The department shall appoint, by letter, members and alternates to the ground water advisory committee after seeking nominations from the groups listed above. Members and alternates shall serve until the ground water management program for the area is certified. The department may appoint replacement members or alternates upon request of the appointee or the ground water advisory committee.

(4) The lead agency shall hold the first meeting of the ground water advisory committee within sixty days of the appointment of the committee. Public notice shall be given for each meeting. The lead agency shall chair the first meeting, during which the advisory committee shall determine, by general agreement, rules for conducting business, including voting procedures, and the chairperson of the advisory committee. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-090, filed 12/20/85.]

**WAC 173-100-100 Ground water management program content.** The program for each ground water management area will be tailored to the specific conditions of the area. The following guidelines on program content are intended to serve as a general framework for the program, to be adapted to the particular needs of each area. Each program shall include, as appropriate, the following:

(1) An area characterization section comprised of:

(a) A delineation of the ground water area, subarea or depth zone boundaries and the rationale for those boundaries;

(b) A map showing the jurisdictional boundaries of all state, local, tribal, and federal governments within the ground water management area;

(c) Land and water use management authorities, policies, goals and responsibilities of state, local, tribal, and federal governments that may affect the area's ground water quality and quantity;

(d) A general description of the locale, including a brief description of the topography, geology, climate, population, land use, water use and water resources;

(e) A description of the area's hydrogeology, including the delineation of aquifers, aquitards, hydrogeologic cross-sections, porosity and horizontal and vertical permeability estimates, direction and quantity of ground water flow, water-table contour and potentiometric maps by aquifer, locations of wells, perennial streams and springs, the locations of aquifer recharge and discharge areas, and the distribution and quantity of natural and man-induced aquifer recharge and discharge;

(f) Characterization of the historical and existing ground water quality;

(g) Estimates of the historical and current rates of ground water use and purposes of such use within the area;

(h) Projections of ground water supply needs and rates of withdrawal based upon alternative population and land use projections;

(i) References including sources of data, methods and accuracy of measurements, quality control used in data collection and measurement programs, and documentation for and construction details of any computer models used.

(2) A problem definition section that discusses land and water use activities potentially affecting the ground water quality or quantity of the area. These activities may include but are not limited to:

-Commercial, municipal, and industrial discharges
-Underground or surface storage of harmful materials in containers susceptible to leakage
-Accidental spills
-Waste disposal, including liquid, solid, and hazardous waste
-Storm water disposal
-Mining activities
-Application and storage of roadway deicing chemicals
-Agricultural activities
-Artificial recharge of the aquifer by injection wells, seepage ponds, land spreading, or irrigation
-Aquifer over-utilization causing seawater intrusion, other contamination, water table declines or depletion of surface waters
-Improperly constructed or abandoned wells
-Confined animal feeding activities

The discussion should define the extent of the ground water problems caused or potentially caused by each activity, including effects which may extend across ground water management area boundaries, supported by as much documentation as possible. The section should analyze historical trends in water quality in terms of their likely causes, document declining water table levels and other water use conflicts, establish the relationship between water withdrawal distribution and rates and water level changes within each aquifer or zone, and predict the likelihood of future problems and conflicts if no action is taken. The discussion should also identify land and water use management policies that affect ground water quality and quantity in the area. Areas where insufficient data exists to define the nature and extent of existing or potential ground water problems shall be documented.

(3) A section identifying water quantity and quality goals and objectives for the area which (a) recognize existing and future uses of the aquifer, (b) are in accordance with water quality standards of the department, the department of social and health services, and the federal environmental protection agency, and (c) recognize annual variations in aquifer recharge and other significant hydrogeologic factors;

(4) An alternatives section outlining various land and water use management strategies for reaching the program's goals and objectives that address each of the ground water problems discussed in the problem definition section. If necessary, alternative data collection and

analysis programs shall be defined to enable better characterization of the ground water and potential quality and quantity problems. Each of the alternative strategies shall be evaluated in terms of feasibility, effectiveness, cost, time and difficulty to implement, and degree of consistency with local comprehensive plans and water management programs such as the coordinated water system plan, the water supply reservation program, and others. The alternative management strategies shall address water conservation, conflicts with existing water rights and minimum instream flow requirements, programs to resolve such conflicts, and long-term policies and construction practices necessary to protect existing water rights and subsequent facilities installed in accordance with the ground water management area program and/or other water right procedures.

(5) A recommendations section containing those management strategies chosen from the alternatives section that are recommended for implementation. The rationale for choosing these strategies as opposed to the other alternatives identified shall be given;

(6) An implementation section comprised of:

(a) A detailed work plan for implementing each aspect of the ground water management strategies as presented in the recommendations section. For each recommended management action, the parties responsible for initiating the action and a schedule for implementation shall be identified. Where possible, the implementation plan should include specifically worded statements such as model ordinances, recommended governmental policy statements, interagency agreements, proposed legislative changes, and proposed amendments to local comprehensive plans, coordinated water system plans, basin management programs, and others as appropriate;

(b) A monitoring system for evaluating the effectiveness of the program;

(c) A process for the periodic review and revision of the ground water management program. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-100, filed 12/20/85.]

**WAC 173-100-110 SEPA review.** The proposed ground water management program shall be subject to review pursuant to the State Environmental Policy Act, chapter 43.21C RCW, as required under the applicable implementing regulations. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-110, filed 12/20/85.]

**WAC 173-100-120 Hearings and implementation.** (1) Upon completion of the ground water area management program, the department shall hold a public hearing within the designated ground water management area for the purpose of taking public testimony on the proposed program. Local governments are encouraged to hold joint hearings with the department to hear testimony on the proposed management program. Following the public hearing, the department and each affected local government shall prepare findings on the ground water management program within ninety days. This period may be extended by the department for an additional ninety days. The findings shall evaluate the program's technical soundness, economic feasibility, and consistency with the intent of this chapter and other federal, state and local laws. The findings shall identify any revisions necessary before the program can be certified and shall contain a statement of the agency's concurrence, indicating its intent to adopt implementing policies, ordinances and programs if required, or a statement of nonconcurrence with the program if such be the case.

(2) The lead agency will consolidate the findings and present them to the advisory committee. Statements of nonconcurrence shall be resolved by the committee and the program revised if necessary.

(3) The program shall then be submitted by the ground water advisory committee to the department which shall certify that the program is consistent with the intent of this chapter.

(4) Following such certification, state agencies and affected local governments shall adopt or amend regulations, ordinances, and/or programs for implementing those provisions of the ground water management program which are within their respective jurisdictional authorities.

(5) The department, 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 ground water management program. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-120, filed 12/20/85.]

**WAC 173-100-130 Designation of ground water areas.** The procedures provided in RCW 90.44.130 may be utilized by the department to designate ground water areas, subareas, or zones for the purposes described therein either in conjunction with the procedures of this chapter or independently thereof. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-130, filed 12/20/85.]

**WAC 173-100-140 Inter-governmental agreements.** In order to fully implement this chapter, the department may negotiate and enter into cooperative agreements with Indian tribal governments, adjacent states and Canadian governmental agencies when a ground water management area is contiguous with or affects lands under their jurisdiction. Such cooperative agreements shall not affect the jurisdiction over any civil or criminal matters that may be exercised by any party to such an agreement. Inter-governmental agreements shall further the purposes of this chapter, and shall serve to establish a framework for inter governmental coordination, minimize duplication, and efficiently utilize program resources to protect ground water resources. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-140, filed 12/20/85.]

**WAC 173-100-150 Appeals.** All final written decisions of the department pertaining to designation of ground water management areas, certification of ground water management programs, permits, regulatory orders, and related decisions pursuant to this chapter shall be subject to review by the pollution control hearings board under chapter 43.21B RCW. [Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-150, filed 12/20/85.]