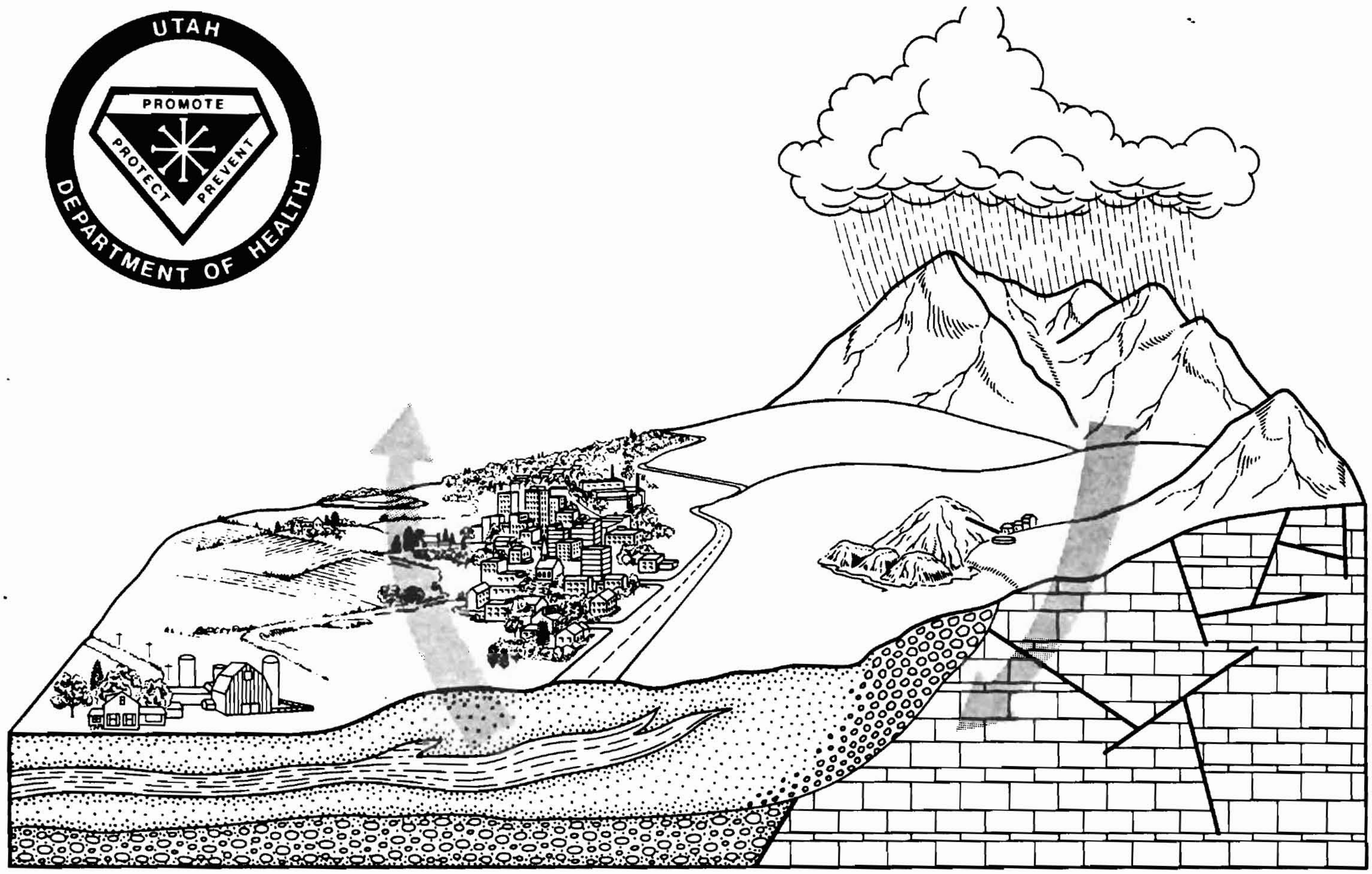
GROUND WATER QUALITY PROTECTION STRATEGY for the STATE OF UTAH



Utah Department of Health
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Ground Water Quality Protection Strategy for the State of Utah

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State of Utah
Salt Lake City, Utah
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GROUND WATER PROTECTION

The ground water resources of Utah are a critical source of water for the public, industry, and agriculture. Almost two-thirds of our public water supplies are furnished by ground water. In the rural areas of the State, ninety percent of the residents are dependent on ground water for their domestic needs. Livestock and wildlife are also heavily dependent on ground water, particularly during the summer months.

Today, this resource is threatened by the careless use, handling and disposal of many of the products we use in our society. Small but significant amounts of organic and inorganic chemicals are being found as contaminants in our ground water. This contamination is difficult and expensive to clean up. Unlike surface water contamination, ground water contamination is, for all practical purposes, permanent. To prevent further pollution of this valuable resource, State government, industry, and the general public must work together to prevent it.

The State government has initiated the development of a program to protect Utah's ground water quality. Under an Executive Order that I have supported, the Utah Department of Health has developed a ground water quality protection strategy. Several State agencies and private industry have contributed to this effort. I am now asking the public for their comments and guidance. In this manner, the citizens of our State can work together to develop Utah answers to the problems that confront our State.

Norman H. Bangerter
Governor

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EXECUTIVE SUMMARY

Ground water is one of the State's most valuable and necessary resources. It furnishes drinking water for two-thirds of the State's residents. About 20 percent of the water used in Utah is obtained from ground water sources. In rural areas of the State, it is commonly the only source of water for man and livestock.

Because of this dependence, a more diligent effort is required to protect Utah's ground water resources. To keep Utah's ground water clean and usable, State and local governments, industry, and the general public must work together to prevent its contamination.

Ground water contamination is not a problem that is readily apparent to the public. Its effects are often local and isolated. Wells in an affected area may be useful indicators; however, there are rarely sufficient wells to define the extent of pollution or to determine the source. Once contaminated, ground water is difficult or impossible to clean up. Even when further contamination is prevented, use of ground water from the polluted area is precluded or severely restricted. Ground water contamination is, in human terms, forever.

The *Ground Water Quality Protection Strategy for the State of Utah* reviews facts about ground water, describes government programs that affect ground water, and discusses potential sources of ground water pollution. The strategy also provides management proposals for public consideration and comment. The purpose of these proposals is to generate discussion and provide a framework for a carefully derived protection program. The public's comments will be used in the development of this ground water protection effort.

The most satisfactory method for protecting the quality of Utah's ground water resources is a management program that emphasizes the prevention of ground water pollution. The *Ground Water Quality Protection Strategy* proposes the following program elements to accomplish this goal:

Management of Ground Water Resources:

- Adopt water quality standards or develop other methods that will protect current and probable future beneficial uses.
- Continue research programs to develop and update regional hydrologic maps of the State.
- Expand programs of detailed mapping and mathematical modeling of aquifers that are currently supplying domestic water to the public.
- Require geophysical logging and filing of the resultant logs with the State for all public supply, irrigation, and industrial water wells that are designed to yield over 50 gallons per minute and are over 200 feet deep.
- Expand programs for detection and tracking of ground water contamination through ambient and site-specific monitoring of ground water.
- Develop a ground water data and well record management program to coordinate the collection, storage, retrieval and transfer of ground water quality and well record data between Federal, State, and local agencies and the private sector.
- Establish an interdepartmental coordinating group for water quality protection in the State. Membership should include senior managers of State agencies involved with water management.

Source Control:

- Continue staff review of construction plans for facilities that discharge directly to ground water.
- Prohibit wastewater discharge in aquifer recharge areas.
- Continue the current Underground Injection Control (UIC) program to regulate disposal and mineral extraction wells.
- Encourage, to the maximum extent possible, the reinjection of water produced with oil and gas.
- Inventory all operating and abandoned landfills in the State.
- Ban construction and operation of landfills in aquifer recharge areas.
- Phase out existing landfills located in aquifer recharge areas and monitor down-gradient areas for ground water contamination.
- Require geologic and hydrologic investigations be made on existing and proposed landfills to determine the possibility for ground water contamination.
- Encourage contamination prevention programs and promote good housekeeping at facilities generating, handling, and storing hazardous chemicals.
- Continue periodic inspection and operations review of those industrial facilities located in areas particularly sensitive to pollution of ground water.
- Work jointly with the Utah Department of Agriculture and the U.S. Soil Conservation Service to

identify agricultural lands that are particularly susceptible to ground water pollution by pesticides, herbicides, and/or fertilizers.

- Provide ground water monitoring programs in areas where pesticides, herbicides, and/or fertilizers are in heavy use, and a significant opportunity exists for ground water contamination.

Recharge Area Protection:

- Develop local ground water protection programs.
- Encourage local governments to exercise control over their watersheds and aquifer recharge areas to protect the public's health.

State Technical Assistance:

- Provide technical assistance to local government units on ground water quality protection.
- Develop ground water information and education programs for the public and elected officials.

Contamination Response:

- Provide funding for development of alternative drinking water supplies where contaminant levels exceed Utah drinking water standards.
- Provide funds for determining the sources of ground water pollution.
- Insure that an adequate emergency response capability exists for the cleanup of spilled hazardous chemicals.

Detailed proposals for management, regulation, staffing, funding, and legislation will be developed following the solicitation of public comment on these proposals.

INTRODUCTION

Purpose

This report is an overview of the current status of protection for ground water in Utah and provides proposals for consideration that would establish a framework for an improved program of ground water quality protection. Hopefully, it will elicit comment and suggestions from interested groups and the general public on what direction the ground water quality protection program should take. Utilizing these suggestions, a proposal for a ground water quality management plan will be developed that reflects the views of the citizens and meets the needs of the State to protect the ground water resources for present and future generations.

Background

On October 4, 1984, Governor Scott M. Matheson issued an Executive Order defining Utah ground water policy. This order directed the Department of Health to develop a ground water quality protection strategy ". . . under existing statutory authority with the coordination of affected agencies and interested parties and with public involvement." The Department of Health's Division of Environmental Health was assigned the responsibility of developing the strategy.

To carry out this assignment, two committees were organized, the Ground Water Steering Committee and the Ground Water Work Group. The directors of the bureaus concerned with water quality in the Department of Health serve on the Ground Water Steering Committee. They provide overall policy guidance on the planning, development, organization, and implementation of the ground water protection strategy. The Ground Water Work Group includes representatives of State and local government agencies, universities, private organizations, and interest groups. Members of the Work Group have worked together to describe the current status of ground water quality in Utah and to define alternative approaches for its protection in the State. Subcommittees of the Work Group have examined numerous potential sources of pollution that may adversely affect the quality of ground water including agriculture; on-site waste treatment systems; solid wastes; hazardous wastes; oil and gas exploration and production; mining; surface impoundments; and urban runoff. Members of the Work Group have also looked at the importance of ground water as a resource and at current laws, regulations, and management alternatives for protecting ground water.

Acknowledgments

Many individuals and groups have contributed to the preparation of this report. In particular, the contributions of the members of the Ground Water Steering Committee and the Ground Water Work Group should be recognized. These individuals contributed their time, talents, and technical expertise. They have added substantially to the content and quality of the report.

The Ground Water Steering Committee functions as a policy making group for the Division of Environmental Health of the Department of Health. In that capacity they offered valued assistance, guidance, and encouragement during the development of this report. Membership consists of the following:

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The authors have drawn from the efforts of other states in developing this study. The *Nebraska Ground Water Quality Protection Strategy* and *The Management of Water Resources in Delaware* were particularly useful as guides and examples of thoughtful, readable reports on their states' programs. Several program summaries and reviews have also been extremely helpful. Included here is the study *Groundwater Strategies for State Action,* prepared by the Environmental Law Institute, *Guide to Ground-Water Standards of the United States,* prepared by the American Petroleum Institute and the *State Ground Water Program Summaries,* volumes 1 & 2, by the U.S. Environmental Protection Agency. Ground water technical data in this report has been derived from various publications of the Utah Department of Natural Resources and the U.S. Geological Survey. Mr. David Severson drafted the illustrations.

Methods and Procedures

As a first step in the development of a program to protect ground water quality in Utah, it was necessary to examine the potential sources of contamination and to evaluate the current programs that provide protection for the resource. Representatives from various State and local agencies, as well as private industry, were requested to serve on six committees as a work group to evaluate different pollution sources. In addition, a review was made of the current laws and regulations that address ground water quality. The information and recommendations developed by these committees is included in the Appendix of this report. The committee's recommendations will form the basis for development of ground water protection regulations.

The second step in the development process is the dissemination of information to the public through available channels in order to develop awareness of the need for protecting ground water quality and to solicit comment and suggestions on ground water problems and alternative management methods. This step will include personal contacts, mailings, news releases, and public meetings. The public's comments will be incorporated in the strategy and utilized in the development of the final ground water quality protection program.

The strategy will establish the framework for building the State ground water program. This program will include proposals for management, regulation, staffing, public information and education, and legislation to develop an effective, comprehensive ground water protection effort. Further public comment may be solicited before the program is completed in its final form.

GROUND WATER CONCEPTS

Ground water is one of the State's most valuable natural resources. It is also one of the least understood by the general population. Full appreciation of the need and the methods for protecting ground water quality requires a basic understanding of the behavior of ground water, a knowledge of the factors affecting that behavior, and an awareness of the dependence of the citizens on the State's ground water resources.

Ground water is a major source of water for public supply, domestic use, agriculture and industry. It provides almost half of the drinking water supply in the United States. It is widely used in many parts of the country because of its high quality, abundance, availability, and relatively low cost. Ground water accounts for over two-thirds of the water used in the United States for irrigation, primarily in the western states. It is also a significant source of water for industrial uses.

The basic source of ground water is precipitation in the form of rain and snow (figure 1). Ground water is an important part of the hydrologic cycle — the circulation of water from the atmosphere to the land surface by precipitation and return to the atmosphere through evaporation and transpiration. When precipitation reaches the land surface, it can evaporate, be taken up by plants, flow as runoff in streams, or infiltrate the surface to become ground water. Some of the water that infiltrates the soil is held by capillarity and replaces the water that has evaporated or been transpired by plants during the preceding dry period. After the soil and plant requirements have been satisfied, the excess water, if any, will seep downward until it reaches the zone of saturation. After that it becomes available as ground water to wells, springs, and base flow for streams. Typically, from 10 to 30 percent of precipitation becomes ground water.

Porosity and permeability are the two properties that determine whether a soil or rock can become saturated with water. Porosity is the open space, or voids, in a soil or rock. All soils and rocks are somewhat porous; the amount of porosity depends on the particle size and shape, how closely the particles are packed together, and the amount of cement binding them together. Permeability is a measure of the capacity of a soil or rock to transmit water; it depends on the size, shape, and interconnection of the openings in the rock. Porosity and permeability determine if a soil or rock can store water and then transmit it to wells to be pumped or to flow to the surface.

Primary porosity is determined by the original grain-size distribution, degree of compaction, and amount of cementation. Secondary porosity results when openings develop along fractures, joints, and bedding planes. When mineral matter is dissolved, it leaves open spaces in rocks, such as limestone, and produces secondary solution porosity. During the cooling of volcanic rock, open fractures and channels may form that provide secondary porosity in these rocks for ground water.

Soils or rocks that are capable of delivering usable quantities of water to wells are called aquifers. In general, the best aquifers are those that are highly permeable and porous. Examples of these aquifers include unconsolidated granular sediments such as sand and gravel deposits, sandstones and conglomerates, and some limestone and volcanic rocks. Rocks that are unable to supply usable quantities of ground water to wells are commonly called confining beds, aquitards, or aquicludes. They generally consist of very fine-grained sedimentary rocks such as clay, shale, and siltstone, or dense, unfractured crystalline rocks that have low porosity and permeability.

Aquifers and confining beds are commonly interlayered (figure 1). When a confining bed overlies an aquifer, the aquifer is confined and is generally recharged in upgradient areas where the confining bed is absent. In unconfined aquifers, also called water table aquifers, water recharges the aquifer directly from the land surface. For both types of aquifers, water in a well will rise to a point where the hydrostatic pressure is equal to atmospheric pressure. For confined aquifers, this water level is referred to as the potentiometric surface. When the elevation of the potentiometric surface is higher than the land surface, water will flow without pumping from a well that penetrates the confined aquifer. This kind of flow is called artesian (figures 1, 7).

In an unconfined aquifer, the top of the zone of saturation is called the water table. The water level stands at the water table in a well that penetrates an unconfined aquifer. The depth of the water table is variable and depends upon local topography, precipitation, and the rock or soil type. The water table generally follows surface contours, although the water table usually has less relief. Seasonal variations in rainfall also affect the depth to the water table. During periods of high rainfall, the water table rises, and during periods of low rainfall, it

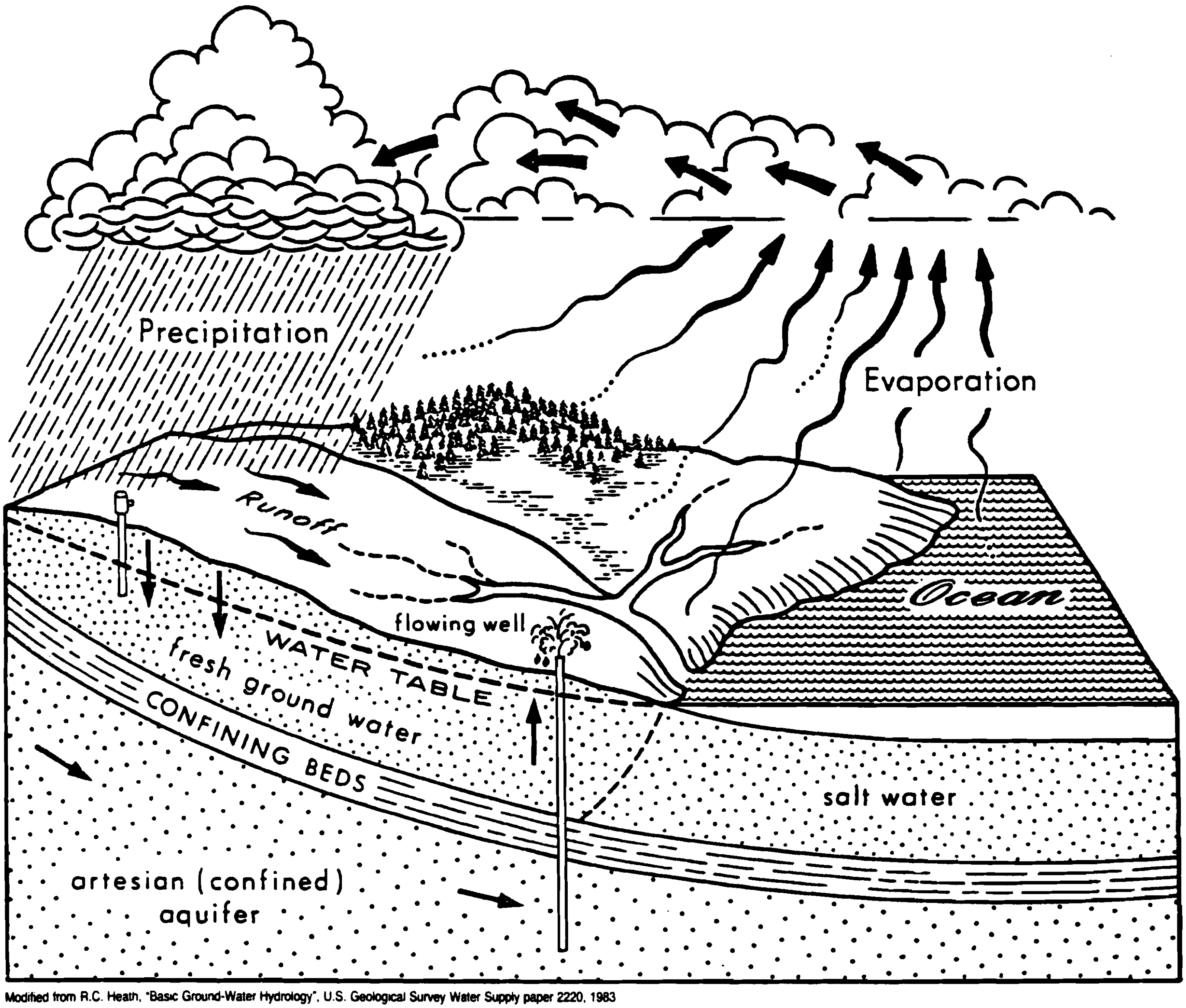
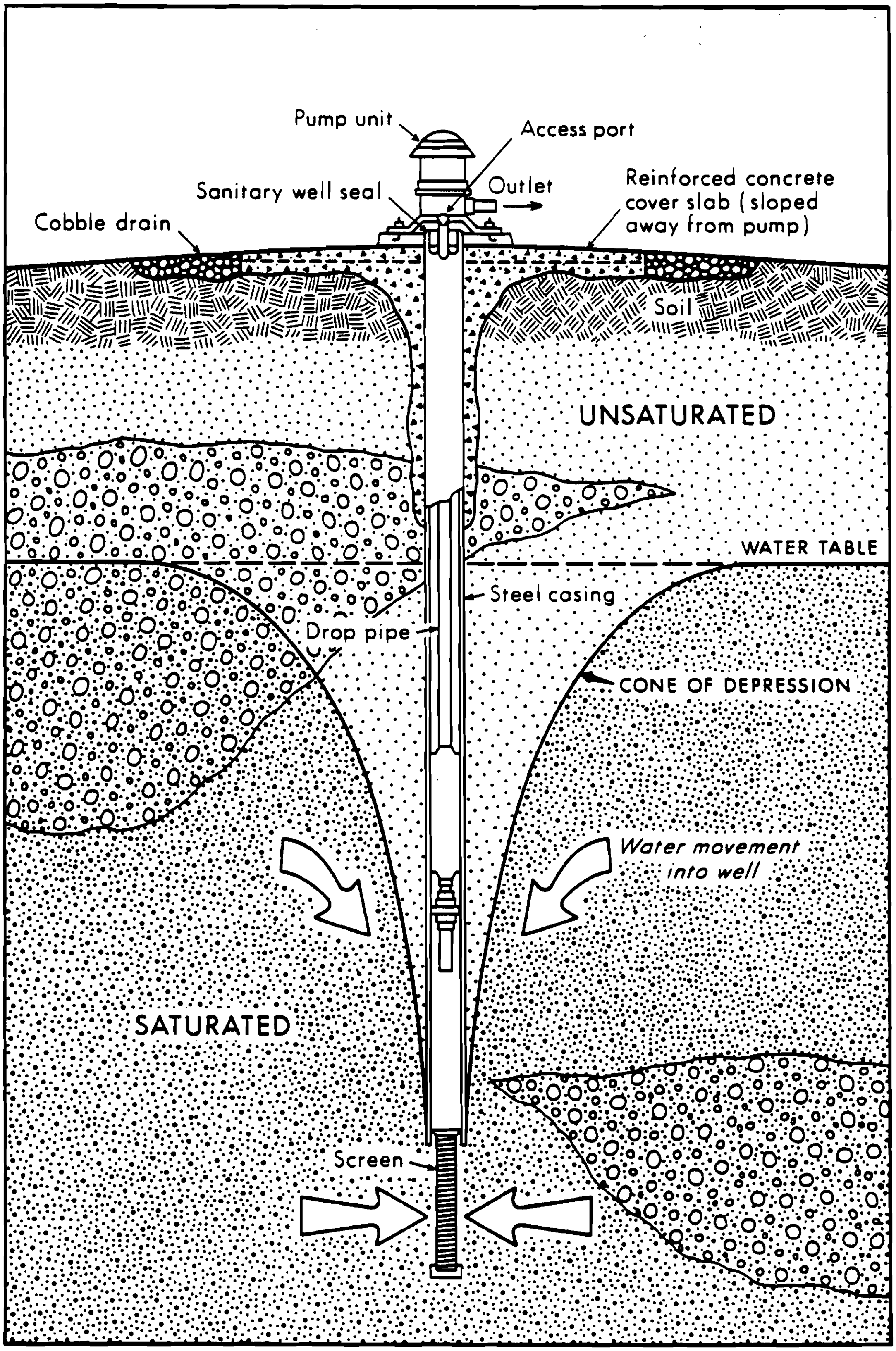


Figure 1. Hydrologic Cycle showing the circulation of water from the atmosphere to the land surface and ground water system.

falls. Ground water levels, however, are much less susceptible than surface water to variation due to rainfall.

In order to pump ground water out of a well (figure 2), it must be able to flow into the well. Under natural conditions, ground water flow is normally slow, ranging from a few feet per day to a few feet per year. Since ground water is moving through pore space or fractures in soils or rocks, the resistance to flow is high. Ground water flow results from gravity and pressure gradients usually caused by elevation differences. In the saturated zone, ground water flows downward and laterally, following changes in elevation and hydrostatic pressure. The direction of flow is away from elevated recharge areas and toward lower discharge areas such as streams, lakes, oceans, springs, or pumping wells. The residence time of ground water from recharge to discharge can be very long. It often ranges from hundreds to even thousands of years.

Despite normally slow ambient velocities, ground water can flow quickly when being pumped. Flow rates in the vicinity of a pumping well can reach 5 feet per minute or more. As pumping begins, water flows quickly into the well because of high suction pressure, and the water table is lowered near the well. The drawdown of the water table is the difference between the static water level and the pumping water level. At the pump, a cone-shaped drainage area called the cone of depression is developed. As pumping continues, the cone of depression enlarges and the water table is lowered over a larger area. The maximum level of pumping that can be maintained without the water table dropping below the pump intake is called the well yield. If the well yield is exceeded, the pump will operate at less than its capacity. Aquifers have different yields, depending on their geologic and hydrologic characteristics.



Modified from Montana's Issues in Ground Water Management, January 1985

Figure 2. Typical Water Well

IMPORTANCE OF GROUND WATER TO UTAH

Ground water furnishes a clean, readily available supply of water that is a necessary supplement to surface water supplies for the urban areas of Utah, and it is indispensable in many rural areas where other sources are not available. Almost two-thirds of the State's population is partially dependent on ground water as a source of public supply. About 20 percent of the total water used for all purposes — irrigation, domestic use, stock use, and industry, is obtained from ground water sources. In times of drought, ground water supplements the diminished surface sources that supply our metropolitan areas. In Utah, ground water is vital to the health and well-being of the State's citizens.

The availability and demand for ground water is dependent on the State's climate, population growth, water use, and sources of supply. These factors are discussed in the following sections.

CLIMATE

The climate of Utah is warm and arid in the low desert areas and cool and moist in the mountains above 6000 feet. In the mountains of northern and central Utah most of the precipitation falls as snow in the winter and from thunderstorms in the summer. The deserts of southeastern and western Utah receive their moisture from occasional thunderstorms. Some mountain locations receive annual precipitation amounts of nearly 100 inches, while some desert areas receive as little as 5 inches per year (figure 3).

Precipitation that falls on Utah originates in the Pacific Ocean, the Gulf of California, and the Gulf of Mexico. The northern part of the State receives cyclonic type winter storms from the northern Pacific. These storms typically produce heavy precipitation over wide areas during the winter months with the greatest amounts falling as snow in the mountains. The western deserts, where low rainfall is the norm, are in the rain shadow of the Sierra Nevada Mountains. In southern Utah, moist air moving northward from the Gulf of Mexico and the Gulf of California produces summer thunderstorms that are brief but of high intensity. In southern Utah, the summer months are usually the wettest months of the year.

Temperatures in the State vary, depending on the latitude, altitude, and season. Generally, the higher the elevation and the farther north the location, the cooler the average temperature. High temperatures, which commonly exceed 100°F in the low valley areas during the summer months, cause rapid evaporation of summer rains. Subfreezing temperatures are the norm during the winter months at higher elevations. This preserves the winter snow as an important source of water for streams and aquifer recharge during the spring and early summer.

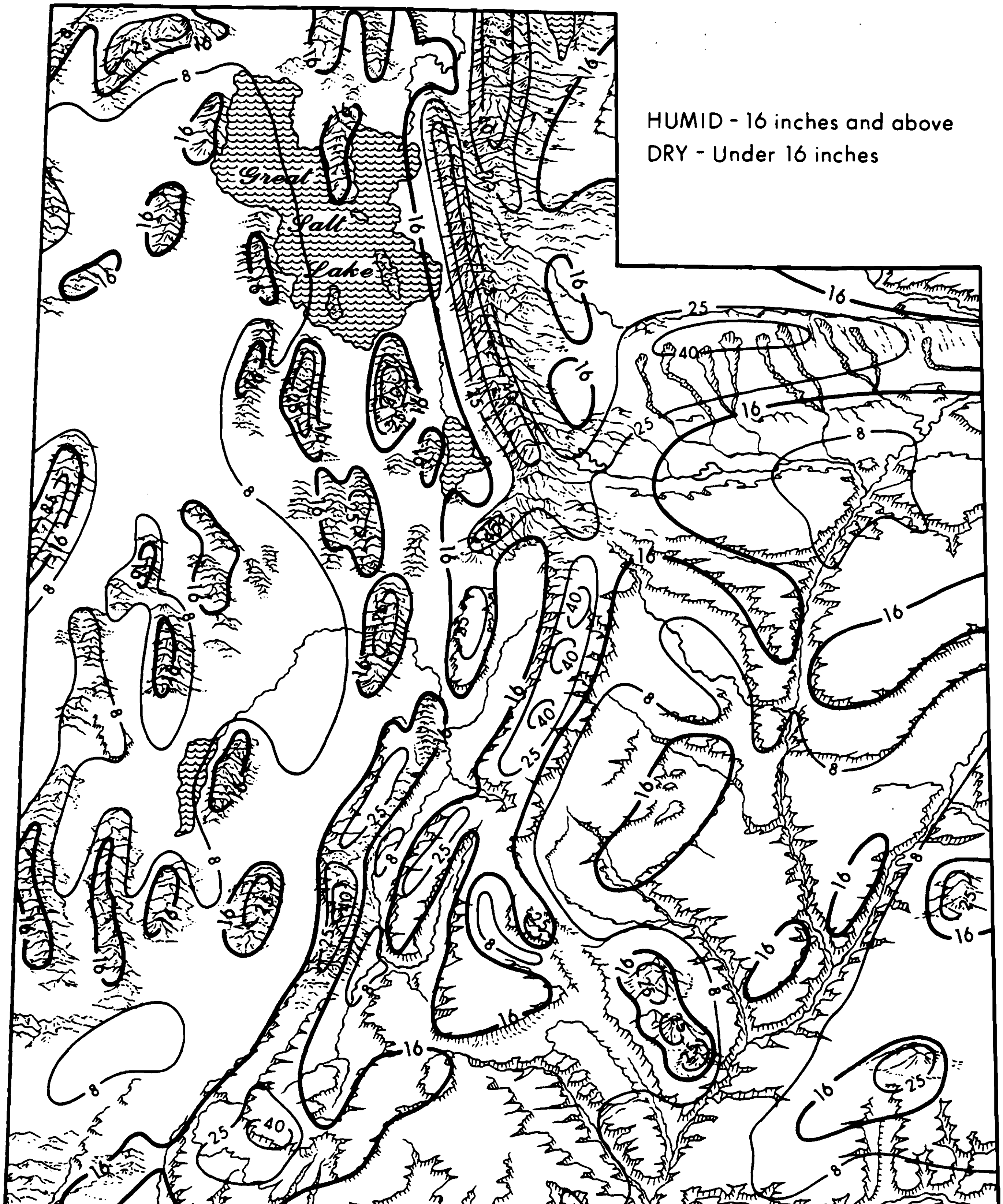
POPULATION DISTRIBUTION AND GROWTH

The 1980 Census reported Utah's population at 1,461,037 people. Based on projections made by the Utah Office of Planning and Budget, the population will increase about 47 percent to 2,148,546 people by the year 2000. The population in the 4-county Wasatch Front will remain at roughly 77 percent of the State's total. This growth in Davis, Salt Lake, Utah and Weber Counties will place increased demands on ground water resources, particularly in periods of drought.

The distribution of the State's population creates an uneven pattern of demand on local ground water resources. The greatest demand for ground water is concentrated along the Wasatch Front in Davis, Salt Lake, Utah, and Weber Counties. In other areas of the State, increased demand has resulted from new industry, expanded irrigation, or rapid population growth.

WATER USE

The trend in ground water usage since the early 1960's generally parallels the trend in growth of the State's population. However, the above-average annual precipitation over much of the State from 1982 through 1985 has resulted in a temporary decline in use of ground water (table 1 and figure 4). In 1983 and 1984, slightly more than 600,000 acre-feet of ground water were pumped. This compares with a peak pumpage of 943,000 acre feet in 1977. Ground water use for public supply increased nearly 300 percent from 1965 (figure 5) to a peak of 162,000 acre feet in 1979. The amount of ground water pumped for public water supply increased from 12 percent of the total pumped in 1965 to 21 percent of the total in 1983. This increase reflects both population growth and the lack of alternative supplies of surface water.



Source: U.S. Dept. of Commerce, Normal Annual Precipitation Map, 1931-1960

Figure 3. Annual Precipitation for Utah

Table 1 — Ground Water Pumpage in Utah, 1965, 1975, and 1983 Data from cooperative investigations by U.S. Geological Survey and Utah Division of Water Resources

Estimated withdrawal from wells (acre-ft) 1965					
Area	Irrigation	Industry	Public supply	Domestic and stock	Total (rounded)
Curlew	—	—	—	—	—
Cache Valley	24,000	3,600	710	—	28,000
East Shore area	40,700	3,800	14,200	—	59,000
Jordan Valley	3,000	39,600	24,900	35,000	102,000
Tooele Valley	17,400	400	1,800	100	20,000
Utah and Goshen Valleys	49,100	7,470	3,940	12,740	73,000
Cedar Valley	1,800	—	—	10	1,800
Juab Valley	17,700	50	—	140	18,000
Sevier Desert	26,000	100	500	800	27,000
Sanpete Valley	7,700	400	400	3,500	12.000
Upper and Central Sevier Valleys	16,000	3	350	1,120	17.600
Pavant Valley	68,300	—	150	350	68.800
Cedar City Valley	15,600	—	500	150	16,000
Parowan Valley	15,000	—	100	150	15,000
Escalante Valley:					
Milford area	43,500	100	200	600	44,000
Beryl-Enterprise area	69,200	—	100	600	70,000
Beaver Valley	4,250	—	100	50	4,400
Other areas	24,600	350	6,600	550	32,000
Totals (rounded)	440,000	56,000	55,000	56,000	610,000

Estimated withdrawal from wells (acre-ft) 1975					
Area	Irrigation	Industry	Public supply	Domestic and stock	Total (rounded)
Curlew	—	—	—	—	—
Cache Valley	10,700	8,700	3,300	2,100	25,000
East Shore area	17,300	6,300	17,600	—	41,000
Jordan Valley	4,600	43,400	43,300	33,500	125,000
Tooele Valley	25,200	1,000	2,500	200	29,000
Utah and Goshen Valleys	54,500	13,800	16,500	12,700	98,000
Cedar Valley	—	—	—	—	—
Juab Valley	24,900	50	0	200	25,000
Sevier Desert	22,700	600	1,500	1,100	26,000
Sanpete Valley	10,800	500	900	3,000	15,000
Upper and Central Sevier Valleys	12,000	100	1,700	6,200	20,000
Pavant Valley	97,300	100	400	300	98,000
Cedar City Valley	25,200	1,000	1,900	200	28,000
Parowan Valley	27,900	0	150	150	28,000
Escalante Valley:					
Milford area	58,800	300	800	100	60,000
Beryl-Enterprise area	84,500	0	100	600	85,000
Beaver Valley	6,500	100	900	100	8,000
Other areas	62,800	1,200	16,000	500	81,000
Totals (rounded)	550,000	77,000	110,000	61,000	800,000

Table 1 (Continued) — Ground Water Pumpage in Utah, 1965, 1975, and 1983

Area	Estimated withdrawal from wells (acre-ft) 1983 Irrigation	Industry	Public supply	Domestic and stock	Total (rounded)
Curlew	17,600	—	50	50	18,000
Cache Valley	9,600	6,800	2,200	1,800	20,000
East Shore area	11,400	7,600	24,300	—	43,000
Jordan Valley	1,300	30,500	55,900	29,000	117,000
Tooele Valley	17,000	500	4,000	150	22,000
Utah and Goshen Valleys	29,100	10,500	14,500	19,900	74,000
Cedar Valley	—	—	—	—	—
Juab Valley	4,300	50	850	300	6,000
Sevier Desert	6,100	1,200	860	300	8,000
Sanpete Valley	—	—	—	—	—
Upper and Central Sevier Valleys	12,000	200	3,500	5,500	21,000
Pavant Valley	41,500	100	440	300	42,000
Cedar City Valley	17,200	900	2,500	400	21,000
Parowan Valley	21,800	300	100	200	22,000
Escalante Valley:					
Milford area	37,600	0	900	300	39,000
Beryl-Enterprise area	66,500	18,200	370	750	86,000
Beaver Valley	—	—	—	—	—
Other areas	41,100	3,200	19,400	4,200	68,000
Totals (rounded)	334,000	80,000	130,000	63,000	607,000

PHYSICAL SETTING

Utah includes within its borders parts of three major physiographic provinces: the Middle Rocky Mountains on the north; the Basin and Range on the west; and the Colorado Plateau on the east. Although the Uinta Basin is considered a part of the Colorado Plateau, it is considered here as a separate physiographic unit (figure 6).

Each of these physiographic provinces is distinguished by different geologic and climatologic characteristics that determine the quality and quantity of the ground water present.

Middle Rocky Mountains

The Middle Rocky Mountains consist of the Uinta, Wasatch, and Bear River Ranges of northern Utah. The terrain is mountainous with alpine lakes, glaciated valleys, and extensive exposures of bedrock.

Most of Utah's precipitation falls over the higher elevations in the Uinta Mountains and the Wasatch Range. Much of this precipitation rapidly infiltrates the thin soil cover and seeps into open fractures and joints in the underlying hard consolidated rocks (figure 7). Ground water in these regions is generally low in total dissolved solids and high in overall quality. It exits the rocks as springs, or flows into streams, ponds, or lakes. A large amount percolates into adjacent alluvial deposits at the base of the ranges.

Basin and Range

In Utah, the Basin and Range Province is the warm arid area generally west of the Wasatch and Hurricane faults. The geologic structure consists of a series of up-faulted north-south trending mountain ranges separated by down-faulted valleys filled with thick deposits of alluvium.

About 98 percent of the wells in Utah draw water from unconsolidated deposits of sand and gravel, mainly in the Basin and Range Province (figure 8). Wells in these deposits commonly have large yields. The largest amount of ground water pumpage is in Davis, Salt Lake, Utah and Weber Counties, the counties with the largest populations. The ground water pumpage in these counties is primarily for public supply, industrial, domestic, and stock use. In 1983, 83 percent of the pumpage was used for these purposes (table 1), while 17 percent of the pumpage was used for irrigation.

Significant ground water development has also

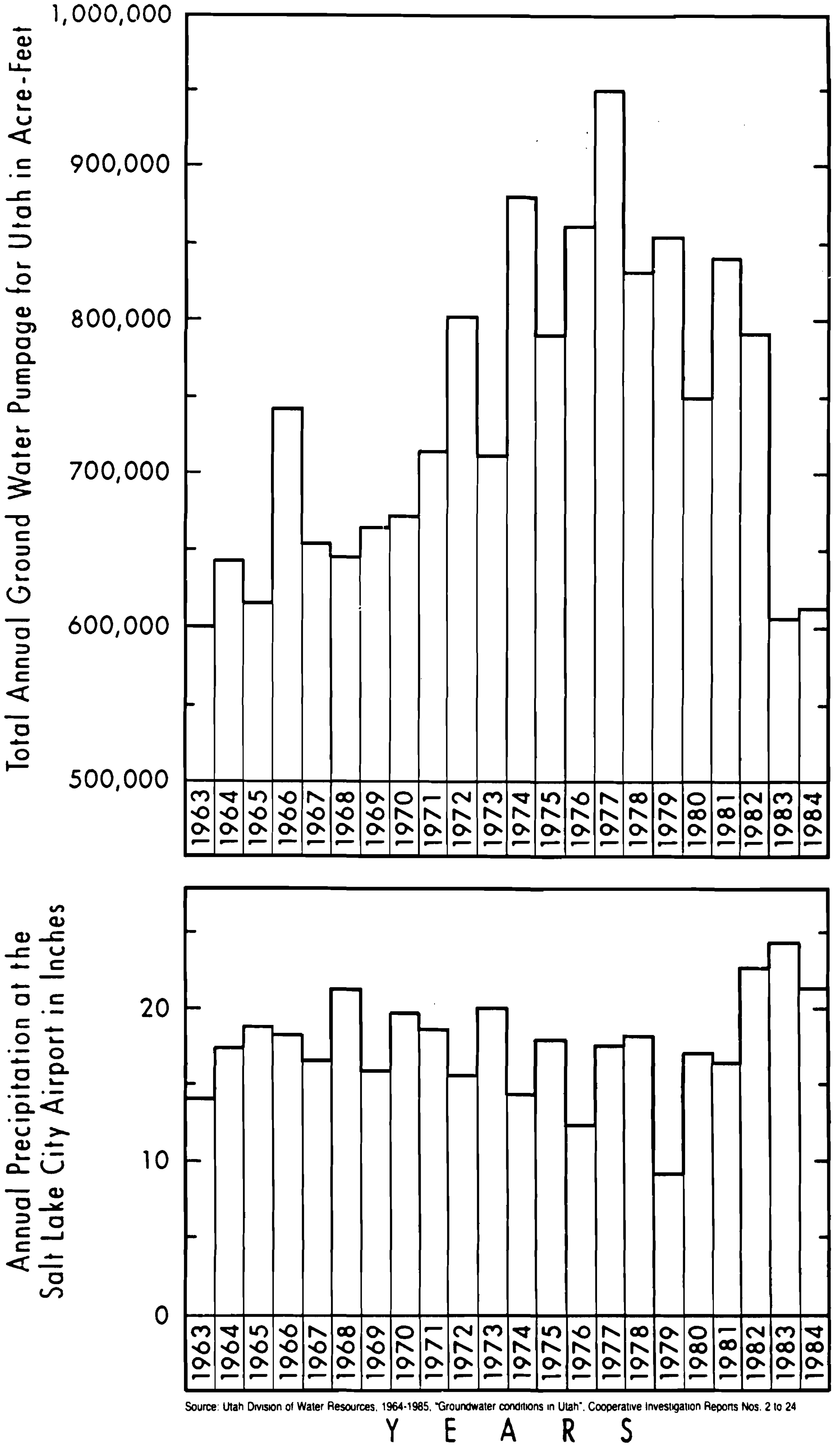
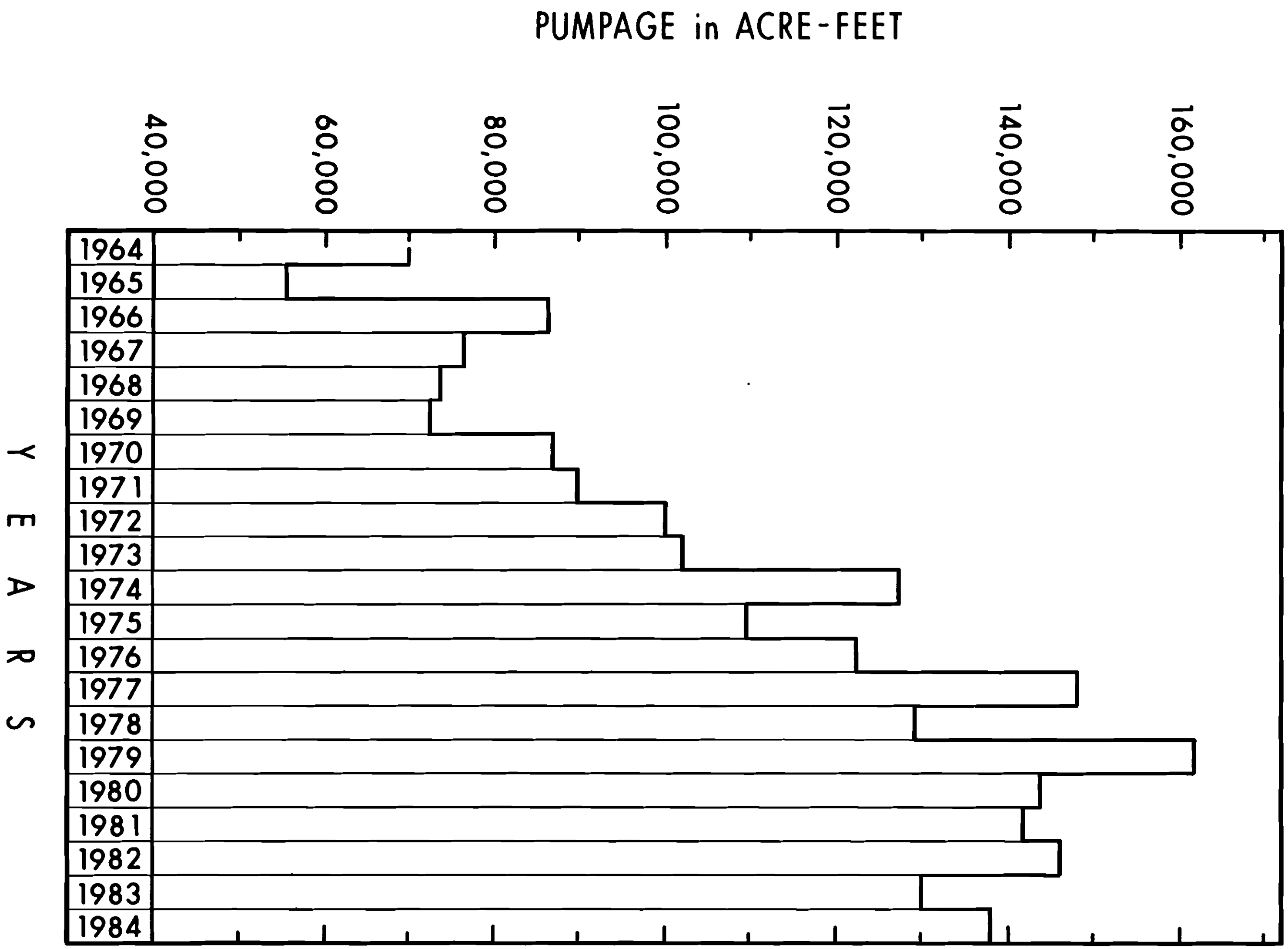


Figure 4. Annual Precipitation and Ground Water Pumpage showing relationship of precipitation to ground water demand.



Source: Utah Division of Water Resources, 1964-1985, "Groundwater conditions in Utah", Cooperative Investigation Reports Nos. 2 to 24

Figure 5. Well Pumpage for public water supply in Utah 1964–1984.

occurred in Curlew Valley, Cache Valley, Tooele Valley, Juab Valley, Sevier and Fremont River Valleys, Pavant Valley, Sevier Desert, the Milford area, Beaver Valley, Cedar City and Parowan Valleys, and the Beryl-Enterprise area. Only 22 percent of the ground water pumpage was used for public supply, industrial, domestic and stock use in these areas, while 78 percent of the pumpage was used for irrigation (table 1).

Along the Wasatch Front, most of the ground water pumpage is from a sand and gravel conglomerate that is overlain by a confining bed of lake silt and clay (figure 7). The conglomerate, of pre-Bonneville Lake age, is the principle aquifer. It is exposed around much of the basin margins and is overlain by wave-cut lake terraces and benches that are composed of sand and gravel. The exposed gravel deposits of the pre-Bonneville conglomerate and the lake terraces are a highly permeable recharge zone that flanks the valley (figure 9). Ground water enters this recharge zone, flows laterally and downward through the conglomerate, and discharges upward in the low areas of the valleys. The quality of water in the pre-Bonneville conglomerate is generally good. However, the water table aquifer present in the overlying Lake Bonneville and post-Lake Bonneville deposits usually contains poor quality ground water.

Ground water velocities are high in the coarse pre-Bonneville conglomerate material. Northern Utah Valley tests show that in many areas the deposits have a hydraulic conductivity of 500 feet/day. The hydraulic gradient, particularly in the recharge area, is as steep as 14 feet per mile. Assuming a porosity of 35 percent, the velocity would be about 3.7 feet/day or 1355 feet per year. Other studies indicate that the typical velocity for ground water is 2.6 feet/day in the Salt Lake Valley. The calculated values for velocity indicate that ground water contaminants would spread rapidly down-gradient.

The confining beds of the Lake Bonneville Group are moderately impermeable. Values for vertical hydraulic conductivity have been estimated at 0.001 feet/day to 0.05 feet/day for the northern valleys of Utah. Using these values, and assuming a head difference of 100 ft. between a confined aquifer and the overlying water table aquifer, contaminated ground water would move downward through the confining bed at a rate of 0.4 to 18 feet per year. Under these conditions, contaminants in the upper aquifer would move through a 100-foot thick confining bed in 6 to 250 years. Therefore, in order to protect the deeper artesian aquifer from contaminants in the overlying water table aquifer, the potentiometric head in the deeper aquifers must be managed by regulating ground water withdrawals.

Uinta Basin

The Uinta Basin is a warm, arid region in northeastern Utah where the rocks are down-folded into a broad bowl-shaped depositional basin. The population density is low. Ground water is an important asset to the area and is available from semi-consolidated rocks of late-Cretaceous and Tertiary age and from shallow unconsolidated glacial outwash and alluvium of Quaternary age.

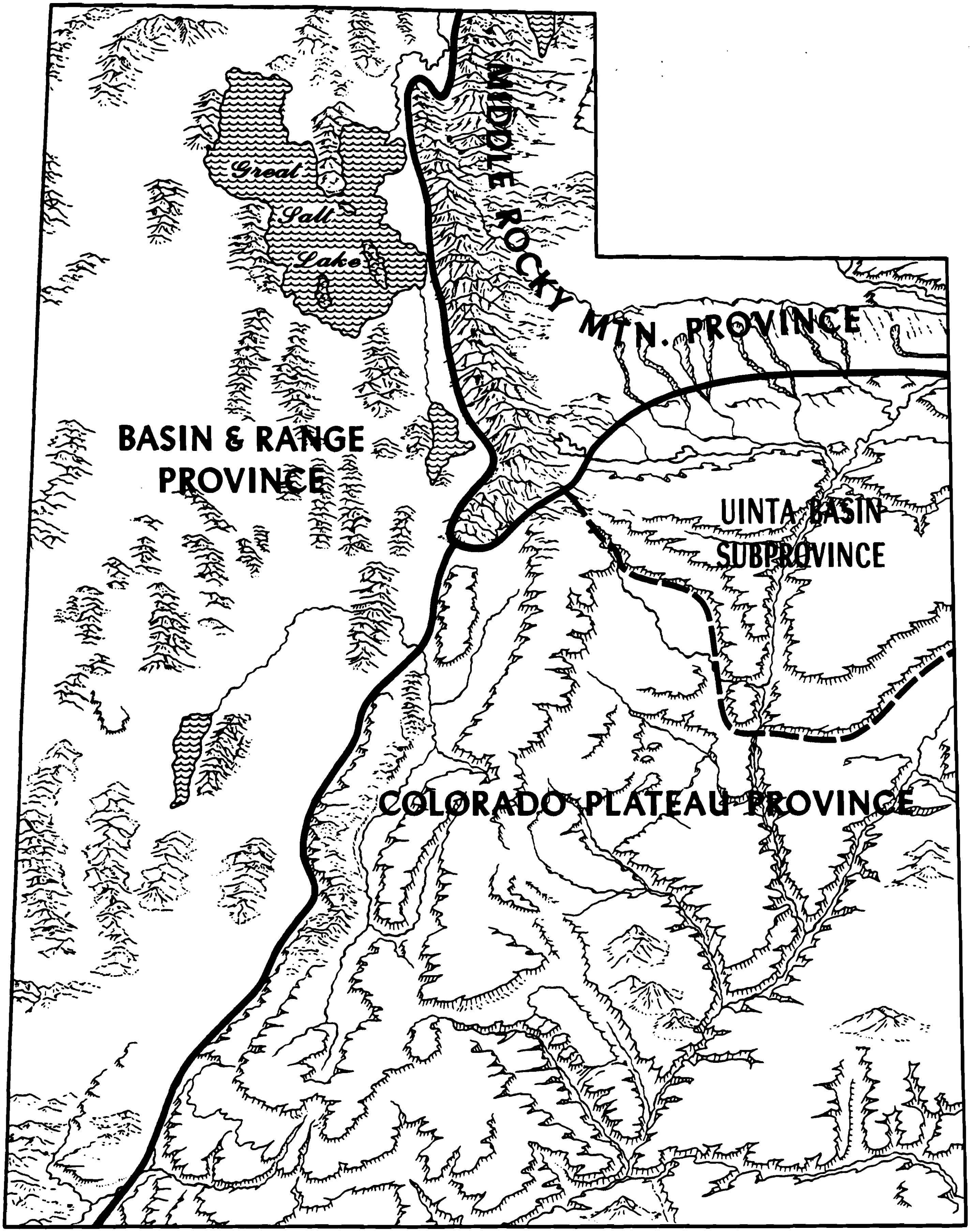
The Tertiary-age Duchesne River and Uinta Formations (figure 8) contain important aquifers that yield much of the water used for domestic and stock purposes in the central part of the basin. The sandstone beds in these two formations have low permeabilities, but commonly the permeability is enhanced by fracturing. The water is under artesian pressure and many wells flow. Other aquifers, including the Weber Quartzite, the Current Creek Formation, the Glen Canyon Group, and the Nugget Sandstone, are additional sources of fresh water but are not widely utilized. The Uinta Basin aquifers are generally overlain and underlain by relatively impermeable confining beds that protect the water from contamination.

Shallow, highly permeable glacial outwash and alluvial deposits present along the upper Duchesne and Ashley Creek Valleys form water table aquifers. Much of the water in these deposits is of high quality with less than 1000 milligrams per liter (mg/l) total dissolved solids. However, it could easily be polluted because of the lack of protection from contaminants seeping downward from the surface.

Colorado Plateau

The Colorado Plateau is a scenic, warm, arid region in southeastern Utah where the rocks are deeply eroded, faulted, and folded into broad synclines and anticlines. The population density is low. Ground water is important to the region and is available from consolidated rocks of Paleozoic and Mesozoic age (figure 8). Alluvial deposits are generally thin and supply little water.

Water suitable for domestic and livestock use can be obtained from wells and springs from many thick sandstone deposits and from some limestones in the region. However, formations that in some areas yield water of suitable quality, may in other parts of the region contain saline or brackish water. The ground water flow system and the geochemistry is only partially understood for the Navajo Sandstone in the Green River, Colorado and Virgin River areas, and for the Ferron Sandstone in some coal mining



Source: Dept. of Geography, University of Utah

Figure 6. Physiographic Provinces of Utah

areas. Data for other aquifers is either not available or insufficient to define the flow system.

The Navajo Sandstone encompasses the most highly developed aquifer in the region and some data is available concerning the ability of this formation to transmit water. The rock consists of thick, massive, red and white crossbedded, wind-blown sand that is extensively exposed in many areas of southern Utah, including Zion National Park. The sandstone is only moderately permeable, but the pore-space permeability is generally enhanced by fracturing. In many areas, the water is of good quality. Along major fracture systems, the rate of ground water movement can be very rapid.

Major aquifers in the region also occur in other eolian or marine sandstones such as the Wingate, Kayenta, and Entrada Sandstones, and the Mesa Verde Formation. These aquifers are overlain and underlain by confining beds which protect the contained water from contamination.

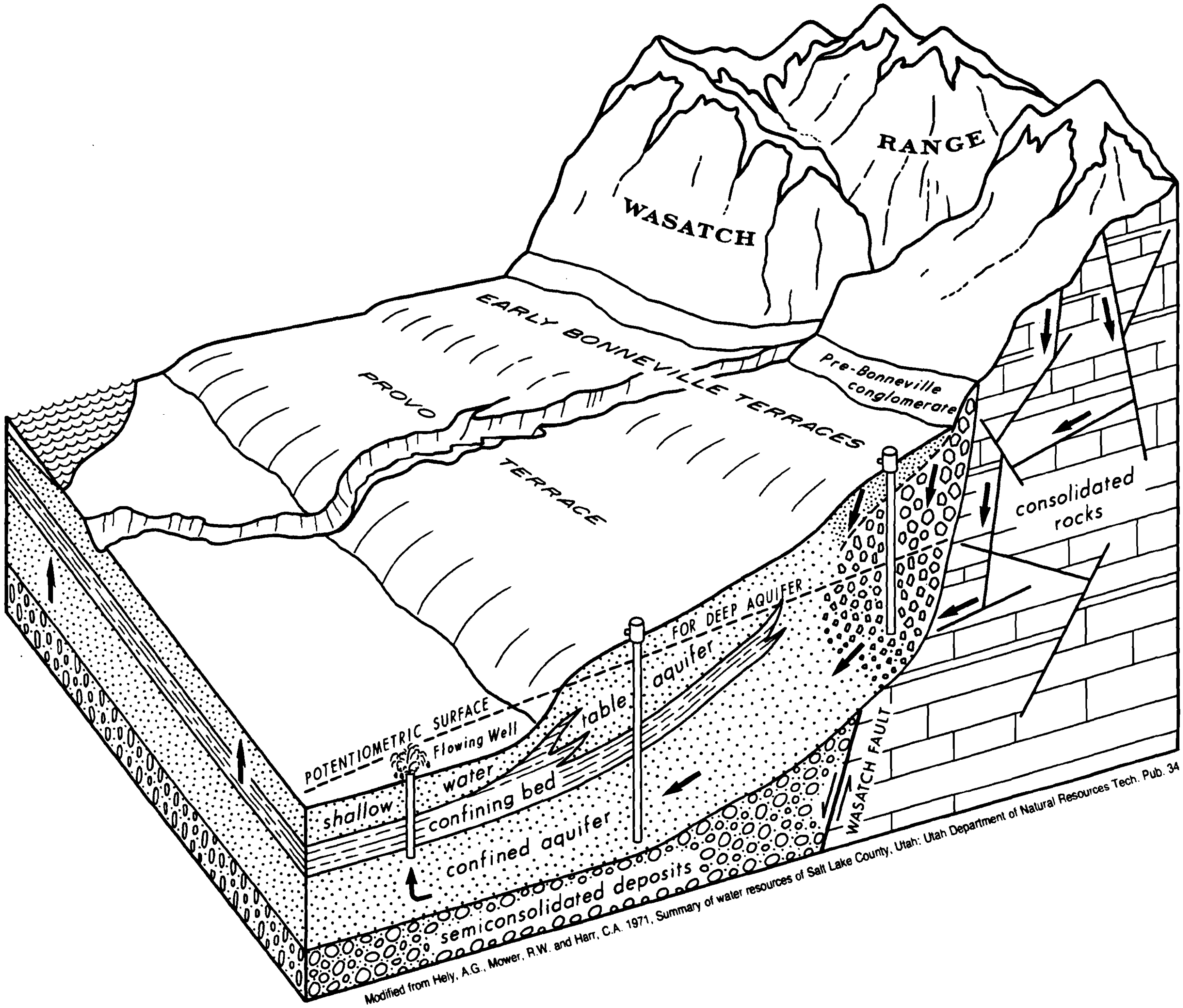


Figure 7. Block Diogram showing major aquifer systems in Salt Lake and Utah Counties.

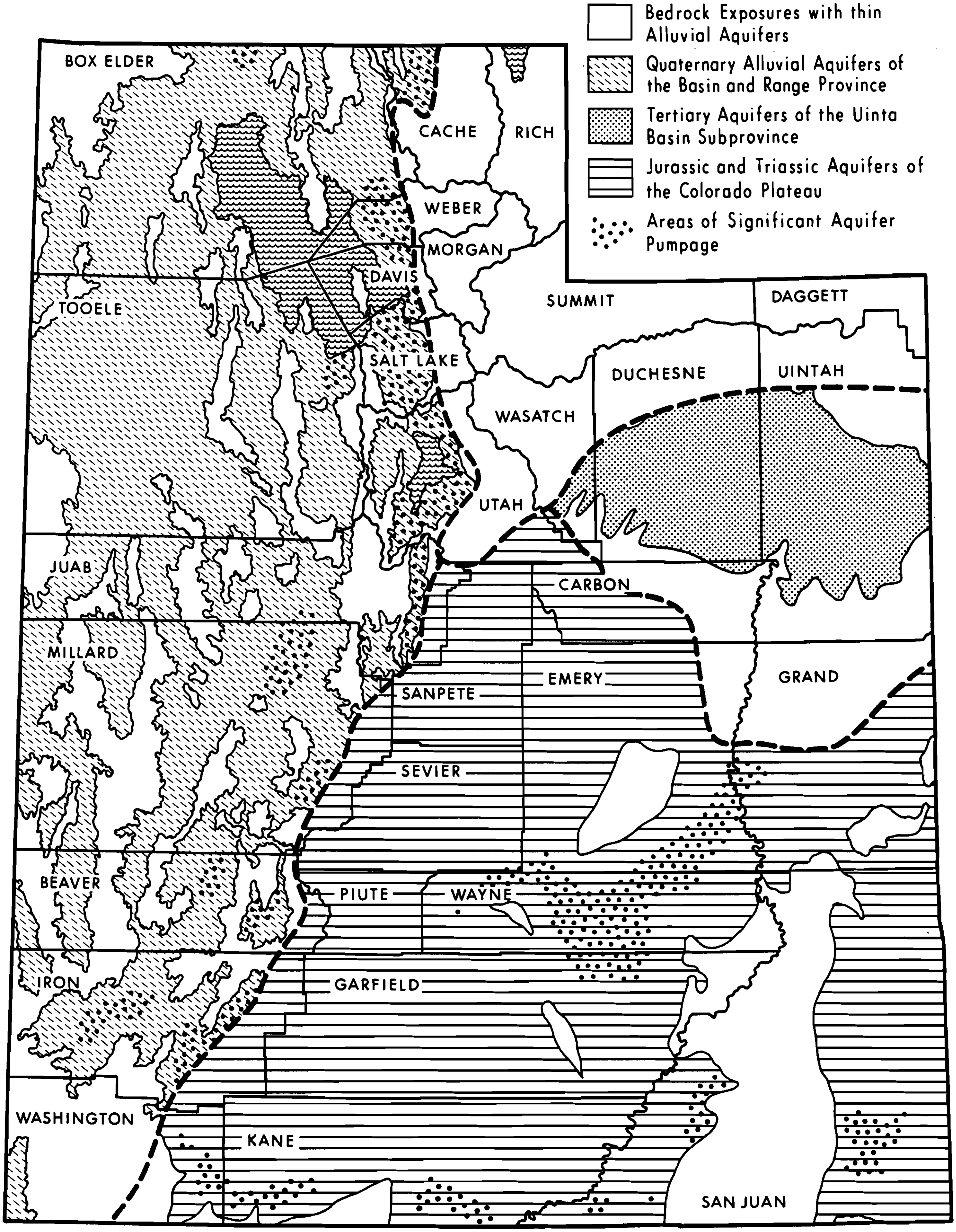


Figure 8. State of Utah showing major aquifers by physiographic province.

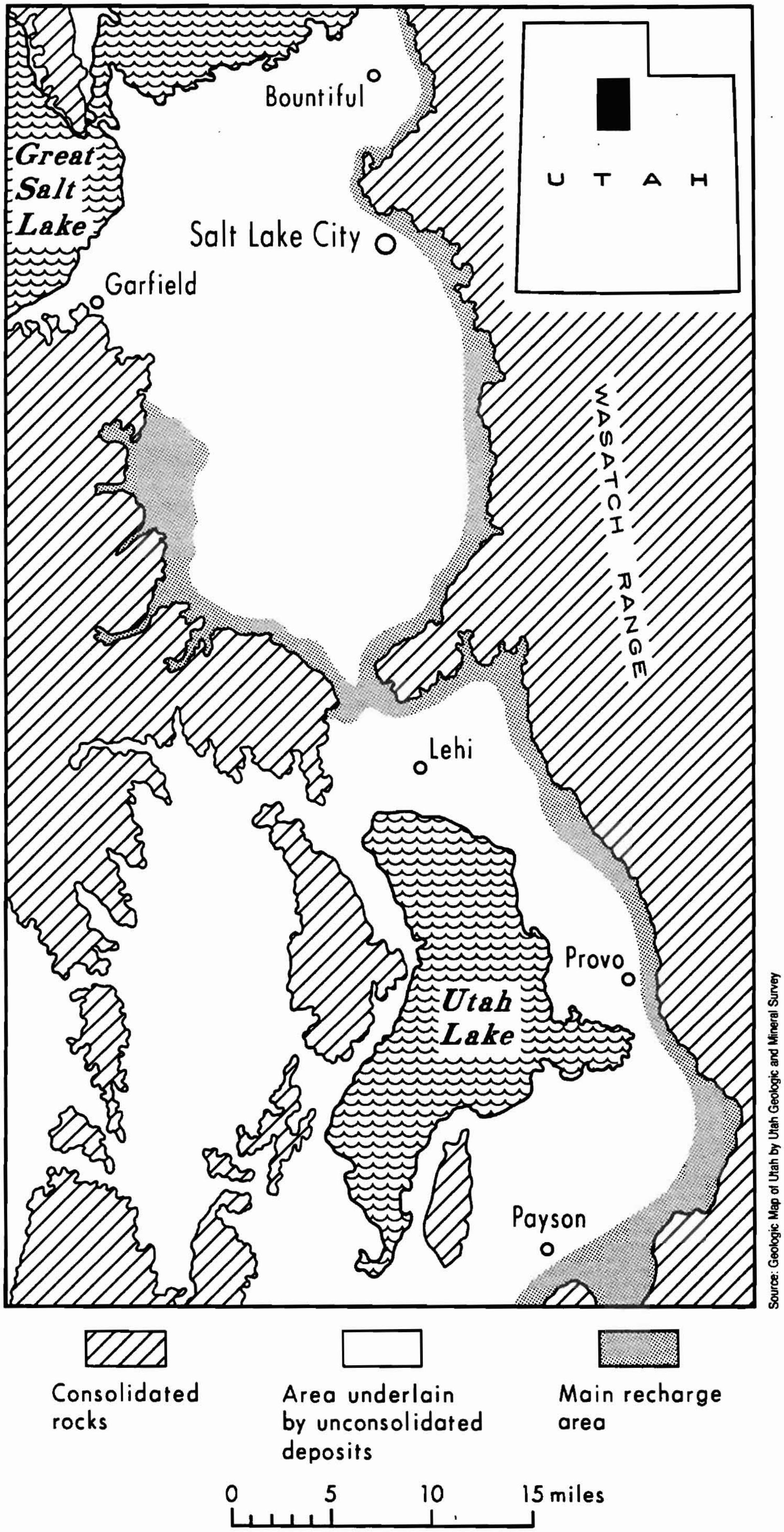


Figure 9. Geologic Map Provo–Salt Lake area showing aquifer recharge areas.

CONTAMINATION OF GROUND WATER

Water usually contains various impurities. Some of these impurities result from natural processes and others result from man's activities. The amount of natural and man-induced contaminants together determine what uses can be made of the water. While natural contaminants can be removed by treatment when necessary, man-made contamination can usually be prevented.

Organic and radioactive compounds are not usually present as natural impurities in water. If present, they are usually a result of man's activities. The only exception is the natural occurrence of some radioactive substances near uranium deposits.

The type and degree of man's contamination of ground water is determined by many factors. They include the kind of activity occurring on the surface; the permeability of the soil; the presence of confining beds that restrict the vertical movement of contaminants; and the rate, direction of movement, and pressure gradient of ground water in the underlying aquifer. If the surface is used for a residential area or for range land, the potential for ground water contamination from the surface is lower than if heavy industrial facilities are located on the land. Shallow clay or shale beds may prevent surface contaminants from reaching underlying aquifers.

Ground water moves in response to pressure gradients caused by elevation differences and generally moves from higher mountain fronts to lower valley areas. In the valley areas, the direction of ground water movement is upward toward the surface of the valley floors. This upward movement produces springs in the valleys and helps to prevent contaminants from migrating from the shallow to the deeper aquifers.

The suitability of ground water for specific uses usually depends on the amount of dissolved mineral matter in the water. Rainfall begins to dissolve minerals upon contact with the land surface, and continues to dissolve them as the water infiltrates through the soil. The amount and kind of dissolved minerals in the water depends upon the solubility and types of rocks encountered, the amount of carbon dioxide and soil acids in the water, the length of time the water is in contact with the rocks, various ion-exchange reactions, and bacterial processes. Table 2 lists some of the more common chemical constituents, their effects, and the limits they place on usability of drinking water.

Maximum allowable limits have been established in regulations promulgated under the Safe Drinking Water Act for six chlorinated hydrocarbons used as pesticides and herbicides. These standards were adopted by the Utah Safe Drinking Water Committee, along with limits on natural and man-made radionuclides, to establish maximum contaminant levels (MCL's) for these substances. The U.S. Environmental Protection Agency (EPA) has recently proposed MCL's for eight other volatile organic compounds. Table 3 lists the proposed limits for these organic compounds together with the MCL's for organics and radionuclides adopted by the Utah Safe Drinking Water Committee. Under the provisions of the Safe Drinking Water Act Amendments of 1986, 83 other chemicals are to be reviewed in the next three years by EPA and limits established for contaminant levels in drinking water.

Table 2. Major chemical constituents in water — their sources, effects upon usability, and recommended concentration limits.

(Modified from Durfor and Becker, 1964, table 2; Hem. 1970, U.S. Public Health Service, 1962 and Utah Dept. of Health, 1981)

Constituents	*Major source*	*Effects upon usability*	*Nat. Academy of Sciences, Nat. Academy of Engineering (1973), recommended limits for drinking water.**
Nitrate (NO_3)	Nitrogenous fertilizers, human and animal excrement,legumes, and plant debris.	More than 100 mg/l may cause a bitter taste and/or physiological distress. Concentrations greatly in excess of 45 mg/l have been reported to cause methemoglobinemia in infants.	45 mg/l nitrate or 10 mg/l nitrate nitrogen.
Arsenic (As)	Byproducts of industrial		0.1 mg/l(.05 mg/l)*
Barium (Ba)	processes, weathering of		1.0 mg/l
Cadmium (Cd)	coal, mineral deposits,		0.01 mg/l
Chromium (hexavalent, as Cr)	and tailings		0.05 mg/l
Copper (Cu)			1.0 mg/l
Lead (Pb)			.05 mg/l
Lead (Pb)			.05 mg/l
Mercury (Hg)			0.002 mg/l
Zinc (Zn)			5.0 mg/l
Zinc (Zn)			5.0 mg/l
Iron (Fe)	Natural sources: amphiboles, ferromagnesian minerals, ferrous and ferric sulfides, oxides, carbonates, and clay minerals. Manmade sources: well casings, pump parts, and storage tanks.	If more than 100 ug/l (micrograms per liter) iron is present, it will precipitate when exposed to air, causing turbidity; staining plumbing fixtures, laundry, and cooking utensils; and imparting tastes and colors to food and drinks. More than 200 ug/l iron is objectionable for most industrial uses.	300 ug/l
Manganese (Mn)		High concentrations of manganese cause difficulty in water-quality control.	50 ug/l
Boron (B)	Tourmaline, biotite, and amphiboles.	Many plants are damaged by concentrations of 2,000 ug/l.	
Dissolved solids (TDS)	Anything that is soluble.	Less than 300 mg/l is desirable for some manufacturing processes. Excessive dissolved solids restrict the use of water for irrigation.	Because of the wide range of mineralization, it is not possible to establish a limiting value.

Table 2. Major chemical constituents in water — their sources, effects upon usability, and recommended concentration limits. (Continued)

Constituents	*Major source*	*Effects upon usability*	*Nat. Academy of Sciences, Nat. Academy of Engineering (1973), recommended limits for drinking water.**
Silica (SiO2)	Feldspars, ferromagnesian, and clay minerals.	In presence of calcium and magnesium, silica forms a scale that retards heat transfer in boilers and on steam turbines.	
Calcium (Ca)	Amphiboles, feldspars, gypsum, pyroxenes, calcite, aragonite, dolomite magnesite, and clay minerals.	Calcium and magnesium combine with bicarbonate, carbonate, sulfate, and silica to form scale in heating equipment.	
Magnesium (Mg)	Amphiboles, olivine, pyroxenes, dolomite, magnesite, and clay minerals.	Calcium and magnesium retard the suds-forming action of soap. High concentrations of magnesium have laxative effect.	
Sodium (Na)	Feldspars, clay minerals evaporites, and cation exchange with calcium and magnesium on clay minerals.	More than 50 mg/l (milligrams per liter) sodium and potassium with suspended matter causes foaming, which accelerates scale formation and corrosion in boilers.	
Potassium (K)	Feldspars, feldspathoids, some micas, and minerals		
Bicarbonate (HCO3) / Carbonate (CO3)	Limestone, dolomite, and anaerobic processes.	Upon heating of water to the boiling point, bicarbonate is changed to steam, carbonate, and carbon dioxide. Carbonate combines with alkaline earths (principally calcium and magnesium) to form scale.	
Sulfate (SO_4)	Gypsum, anhydrite, and oxidation or weathering of sulfide minerals.	Combines with calcium to form scale. More than 500 mg/l tastes bitter and may be a laxative.	250 mg/l (500)*
Chloride (Cl)	Halite and sylvite.	In excess of 250 mg/l, may impart salty taste, greatly in excess may cause physiological distress. Food processing industries usually require less than 250 mg/l.	250 mg/l

Table 2. Major chemical constituents in water — their sources, effects upon usability, and recommended concentration limits. (Continued)

Constituents	*Major source*	*Effects upon usability*	*Nat. Academy of Sciences, Nat. Academy of Engineering (1973), recommended limits for drinking water.**
Fluoride (F)	Amphiboles, apatite, fluorite, and mica.	Optimum concentration in drinking water has a beneficial effect on the structure and resistance to decay of children's teeth. Concentrations in excess of optimum may cause mottling of children's teeth.	Recommended maximum limits depend on average of maximum daily temperatures. Maximum limits range from 1.4 mg/l at 32°C to 2.4 mg/l at 10°C.

* *Value in brackets is the value defined by the State of Utah, Dept. of Health (1981).*

Table 3. Drinking water limits for selected organic compounds and radionuclides adopted by Utah Safe Drinking Water Committee and EPA proposed limits for volatile organic compounds.

Constituent	*Limit (micrograms/liter)*
Chlorinated Hydrocarbons	
Endrin	0.2 ug/l
Lindane	4 ug/l
Methoxychlor	100 ug/l
Toxaphene	5 ug/l
Chlorophenoxys	
2, 4-D	100 ug/l
2, 4, 5-TP Silvex	10 ug/l
Radionuclides	*Limit (picocurie/liter)*
Gross alpha	15 pCi/l
Gross beta	50 pCi/l
Radium 226,228 combined	5 pCi/l
*Strontium 90	8 pCi/l
*Tritium	20,000 pCi/l

**Amounts necessary to yield maximum allowable annual radiation exposure*

Volatile organic compounds — EPA proposed drinking water limits

Trichloroethylene	5 ug/l
Carbon Tetrachloride	5 ug/l
Vinyl Chloride	1 ug/l
1, 2 – Dichloroethane	5 ug/l
Benzene	5 ug/l
1, 1 – Dichloroethylene	7 ug/l
1, 1, 1–Trichloroethane	200 ug/l
p-Dichlorobenzene	750 ug/l

CURRENT FEDERAL, STATE, AND LOCAL PROGRAMS FOR GROUND WATER QUALITY PROTECTION

Much of the impetus for today's water quality protection program is the result of a national concern in the 1960's over the declining quality of the water in our streams and lakes. During the last fifteen years, the Federal and state governments responded to this concern with passage of legislation that addresses many of these pollution problems. Passage of these laws reflects a fundamental change in the public perception of the health and environmental effects of the improper use, handling, and disposal of products and wastes from our society. Their implementation has resulted in the development of a major joint effort on the part of government, industry and the public to identify and correct current and past contamination problems.

Although these laws emphasize surface water quality protection, they also affect ground water quality. Authority for enforcing many of these laws has been delegated to the states, including Utah, by incorporation of Federal statutory language, or its equivalent, into state laws and through agreements between the states and the EPA.

In order to develop a comprehensive strategy to protect Utah's ground water, an understanding of the Federal programs that are part of Utah's current programs and statutes is necessary. Following is a summary of Federal, State, and local programs that are in effect in Utah.

FEDERAL LEGISLATION AND PROGRAMS

The Federal government oversees a broad range of ground water programs through the EPA, Department of Interior, Department of Agriculture, Nuclear Regulatory Commission and other Federal agencies. These programs provide research, technical assistance, funding, and regulation for ground water problems. Although these Federal programs do not provide a consistent, coherent, or complete approach to ground water protection, they do make a variety of resources available to the states that can strengthen state protection programs. Utah can build on this foundation of Federal programs to construct a comprehensive program of protection for its ground water.

Six national pollution control laws administered by the EPA provide some protection for ground water. They are the Safe Drinking Water Act (SDWA); Resource Conservation and Recovery Act (RCRA); Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, usually called Superfund); Clean Water Act (CWA); Toxic Substance Control Act (TSCA); and Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). These laws provide the basis for current Federal ground water protection programs and many state programs.

Safe Drinking Water Act (SDWA)

The Safe Drinking Water Act (SWDA) was passed in 1974 to assure that drinking water from public water systems is safe for human consumption. The Act provides for adoption and enforcement of a set of national quality standards. Included are interim primary standards for contaminants affecting health, and secondary standards affecting aesthetics such as taste, smell, and appearance. These standards apply to ground water when it is used as a source of drinking water in public water systems serving 25 or more people, or 15 service connections. In Utah, the Safe Drinking Water Committee and the Bureau of Public Water Supplies are responsibile for enforcing the safe drinking water regulations.

Provisions of the SDWA also provide for regulation of wells used for injection of contaminated water or other hazardous wastes that pose a potential threat to underground supplies of drinking water. Under the Underground Injection Control (UIC) program, wells are divided into five classes depending on their purpose. Wells used for waste disposal, solution mining of mineral deposits, and oil and gas production must meet certain design, performance, and monitoring guidelines. At the conclusion of their use, wells must be properly plugged to prevent fluids moving through the well bore between aquifers. Federal funds are provided to the Utah Division of Oil, Gas, and Mining for regulation of injection wells associated with oil and gas production, and to the Utah Department of Health's Bureau of Water Pollution Control for regulation of all other types of injection wells.

The SDWA can furnish protection for aquifers when they are designated as a principle or sole source of drinking water. Local, regional or state agencies can petition EPA for a sole or principle source designation for an aquifer. When so designated, Federal funding assistance is prohibited to projects which may contaminate these drinking water supplies. Also, injection wells can be prohibited in a sole or principle source aquifer area. The

EPA has not designated any aquifers as sole or principle source aquifers in the State of Utah.

Resource Conservation and Recovery Act (RCRA)

The EPA regulates hazardous wastes and other solid wastes through the authority provided by the Resource Conservation and Recovery Act (RCRA). Separate regulations address "hazardous wastes" and "other solid wastes." Subtitle C of RCRA establishes regulations for the generation, transportation, treatment, storage, and disposal of materials identified by EPA as hazardous wastes. Subtitle D addresses the regulation of landfills, dumps and ponds handling "other solid wastes," including both solid and liquid wastes from industry and other sources. Wastes from the mining industry are currently exempt from regulation under RCRA.

Authority for enforcement of RCRA regulations has been delegated to Utah through a formal agreement between the State and EPA. The Solid and Hazardous Waste Committee, consisting of members appointed by the Governor, provides policy guidance. The regulatory program is administered by the Bureau of Solid and Hazardous Wastes Management of the Department of Health. Funding for administration is provided by EPA and the State.

The purpose of the hazardous waste management program is the management of hazardous wastes from current industrial operations not otherwise subject to regulation. EPA has developed a list of hazardous wastes that is subject to continued revision. Hazardous wastes are tracked through a manifest system from their creation to final disposal.

Design and operating standards have been developed to regulate hazardous waste storage, treatment, and disposal facilities. These facilities must obtain an operating permit that requires compliance with the performance standards. Design standards include requirements for landfill liners, leachate collection systems, run-off controls, weekly leakage inspection, and post-closure monitoring. Under the performance standards, the uppermost aquifer under the site must be monitored to detect changes in background ground water quality. Failure to comply with these regulations can result in civil and criminal penalities.

The regulations for "other solid wastes" cover operations of nonhazardous solid waste facilities such as municipal landfills. While landfills do not usually handle hazardous materials, they may contain wastes that contaminate ground water. Therefore, landfills are prohibited from contaminating ground water beyond their site boundaries.

In 1984, RCRA was amended to provide for regulation of underground storage tanks. Leaks from buried storage tanks such as bulk gasoline tanks have resulted in serious ground water contamination problems. Because tanks are partially or totally buried, leaks have gone undetected for years, only to be discovered when the contamination reaches water wells. The Underground Storage Tank (UST) program bans installation of tanks that are not cathodically protected or constructed of noncorrosive material. It also requires registration of existing tanks, sets performance standards for new tanks and establishes inspection procedures, including site monitoring of air, surface, and ground water. States can assume responsibility for enforcement after May of 1987.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Comprehensive Environmental Response Compensation and Liability Act (CERCLA, commonly called Superfund) authorizes EPA to respond to spills, releases, or threatened releases of hazardous substances, and to cleanup orphan hazardous waste sites. Funding for the cleanup is derived from taxes on petroleum products and petrochemical feedstocks and, to a limited extent, general revenues.

CERCLA contains provisions to hold parties liable for costs incurred by the government for cleanup or to require parties to undertake cleanup at their own expense. Cleanup expenses can include containment or removal of contaminated materials; monitoring; equipment and supply costs; compensation for damages to government-owned natural resources; health-effect studies; providing alternate drinking water supplies; and relocation of residents potentially affected by releases of hazardous substances.

Through the notification provisions of CERCLA, spills of hazardous materials over prescribed amounts must be reported to the EPA. Also, companies or individuals presently or previously owning facilities that handle hazardous substances are required to inform EPA of their location.

Ground water protection is a major concern in the regulations established under CERCLA. Sites where ground water pollution is a major problem are predominate on the site cleanup list. Protection of ground water quality, public drinking water supplies, and public health were clearly the goals of Congress when it passed CERCLA. Through formal agreement with EPA, Utah directs the Superfund program in the State. The Bureau of Solid and Hazardous Waste Management administers the program.

Clean Water Act (CWA)

The Clean Water Act (CWA) was passed in 1972, primarily to protect surface water quality. CWA includes provisions for Federal grants for construction of sewage treatment plants. Point source discharges of pollution into waterways from industrial facilities and municipal sewage treatment plants are regulated by the National Pollutant Discharge Elimination System (NPDES) of the CWA. Wastewater pretreatment standards for discharges to municipal treatment plants by industry are also set by CWA. The Pretreatment Standards specify limits on concentration and amounts for various types of discharges. Under regulations of the CWA, spills of petroleum products or other pollutants into waterways must be reported. Owners of facilities where petroleum is stored are required to prepare Spill Prevention and Countermeasure Plans for preventing or responding to inadvertent discharges of oil.

The CWA also laid a substantial foundation for the current efforts to protect ground water quality. CWA empowers EPA to foster the development of a comprehensive program for ground water pollution control, monitor ground water quality, develop water quality standards, develop Best Management Practices for control of non-point sources of pollution, and fund development of state and local ground water protection management plans. To encourage the development of state ground water programs, EPA has supported the development of Federal and state ground water protection strategies. Funding under Section 106 of CWA is supporting the development of Utah's ground water protection strategy.

Toxic Substances Control Act (TSCA)

The Toxic Substances Control Act (TSCA) seeks to regulate or prevent manufacture and distribution of toxic chemicals that have adverse effects on human health and the environment. Regulations under TSCA can require pre-manufacture testing, limit use of toxic chemicals, provide warning labels on containers, require users to take pollution control measures, and follow authorized disposal procedures.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) gives EPA the means to regulate a variety of agricultural chemicals that, through their normal use, may result in ground water contamination. EPA can control use of pesticides through regulations that require registration and testing for potential ground water problems from leaching. In Utah, the State Department of Agriculture oversees enforcement of FIFRA.

Hazardous Materials Transport Act (HMTA) and Motor Carrier Act (MCA)

The Federal government has superceded state regulation of the transportation of hazardous materials. The Hazardous Materials Transport Act (HMTA) establishes regulations for controlling the transportation of hazardous materials. It also contains provisions for handling spills.

The Motor Carrier Act (MCA) includes provisions to cover both public and private liability, including environmental damage. Both the HMTA and MCA are administered by the Federal Department of Transportation.

Other Federal Programs

Several other Federal programs regulate or supply technical information about ground water. Regulation of contaminants leached from uranium tailings is administered by the Nuclear Regulatory Commission (NRC). The Utah Department of Natural Resources, in cooperation with the Water Resources Division of the U.S. Geological Survey, has studied various aspects of Utah's ground water resources. Many of these projects also include other State and local agencies. This information provides a substantial technical base for administering programs to protect Utah's ground water quality.

NEEDED FEDERAL PROGRAM IMPROVEMENTS

The present efforts to protect ground water quality are spread throughout a large number of programs administered separately and jointly by many State and Federal agencies. EPA's authority, for example, is spread over six statutes and several subsequent amendments. In addition, some activities with potential for ground water contamination, such as mine tailings disposal, may be exempt from regulation. The net result is an overall lack of coordinated effort, different statutory requirements and differential application of regulations, and a varying program of protection. Individually, the six major environmental statutes have deficiencies that detract from their overall effectiveness. The specifics of these deficiencies are described in more detail in the following sections.

Safe Drinking Water Act (SDWA)

The SDWA of 1974 was passed to establish a national standard for drinking water. To a large extent, the health effects of microbiological and inorganic contaminants and the subsequent contaminant levels established by EPA are based on the 1977 findings of the National Academy of Sciences. However, sufficient new data has become available to justify standards for many other contaminants, especially organic compounds. Only recently has EPA set maximum contaminant levels for eight volatile organic chemicals. Because of EPA's slow pace in setting such standards, some states, such as New Mexico, have opted to establish their own limits for contaminants not covered by Federal standards.

Medical research has often linked long-term low-level exposure to toxic substances to increased incidences of cancer, birth defects, and certain chronic debilitating diseases. This is exactly the kind of exposure expected from contaminated ground water. Still, humans have a tolerance for most contaminants up to certain concentration levels with no resultant short or long-term adverse health effects. The need is to establish threshold levels that separate the no-adverse-effects concentration from the higher concentrations that would adversely affect the health of some individuals.

The inadequacies of the SDWA to protect ground water stems from the fact that it covers only those supplies used for public drinking water. The standards are designed to provide "end of pipe" protection for the consumers and not so much for the resource. Monitoring regulations emphasize detection of existing contamination, whereas more attention needs to be focused on establishing the ambient water quality and prevention of ground water degradation.

Resource Conservation and Recovery Act (RCRA)

RCRA places a heavy reliance on the designation of hazardous substances in this program of regulation. Without such designation, many substances remain outside regulatory control under the provisions of RCRA. Yet the program of testing and listing of hazardous substances is years behind in their review. The net result has been an increased opportunity for ground water pollution.

Mine tailings and other wastes connected with the extraction, beneficiation, and processing of ores and minerals are presently exempt from Federal regulation under RCRA. Wastewater discharge to surface waters from coal mining operations is currently regulated by the Surface Mining Control and Reclamation Act (SMCRA) administered by the Federal Department of Interior. Other mining wastewater discharges are regulated by the NPDES regulations of the CWA.

Many other shortcomings of RCRA have been remedied by recent amendments. Included are new regulations for small hazardous waste generators, review of the effects of discharges of hazardous wastes into public wastewater treatment facilities, prohibitions on the use of contaminated oils for dust suppressants, and regulation of underground storage tanks.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

CERCLA has received extensive criticism for delays in the cleanup efforts at abandoned hazardous waste sites and for underfunding of the program considering the task at hand. To be eligible, a site must first be placed on EPA's National Priorities List for the cleanup to be funded by the Trust Fund. The cleanup plan must also meet guidelines in EPA's National Contingency Plan. Even in states where the state administers the CERCLA program through EPA-state cooperative agreements, EPA has retained control over the selection of the cleanup alternatives.

CERCLA is currently before the Congress for reauthorization and should be acted upon in the summer of 1986. Funding and other deficiencies in the program should be addressed in the revised legislation.

Clean Water Act (CWA)

The CWA stresses protection of surface water. A better balance needs to be established between the need for protection of surface water and ground water. For example, land spreading of sludges is an easy means of disposal yet this method can contribute to ground water contamination. The provisions of the NPDES do not cover permitting of discharges to ground water.

Toxic Substance Control Act (TSCA)

The TSCA has been limited in its effectiveness in controlling the production of toxic substances. Generally, the burden of proof lies with EPA to substantiate that a product represents an unreasonable risk and is a significant health hazard. Information supplied by manufacturers on the toxicity and environmental fate of toxic substances under TSCA's manufacturers notification requirement has generally not met the need to evaluate the risk involved with widespread usage.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The recent problem in California with aldicarb contaminated watermelons has again focused attention on the problems within the Federal pesticide program. The intent of FIFRA is to provide an effective screening of pesticides and controls on their use so that adverse environmental effects can be avoided. However, the testing, evaluation, and classification procedures have not been adequate to meet the task. The volume of pesticide products is substantial, determination of their long-term environmental fate and health effects is difficult, and the classification procedures lengthy. Controls on use are usually hard to enforce. Applicators of highly toxic pesticides are now certified and controls are presently in effect for pesticide processors or formulators for the disposal or storage of pesticide containers and unused pesticides.

State and Local Legislation and Programs

Congress has passed the six major pollution control laws discussed in the last section; however, their enforcement responsibilities have largely been assumed by the states. In Utah, statutory committees or boards, created by the State Legislature and appointed by the Governor, develop and enforce regulations, and set policy for many State administrative agencies. Committees or boards concerned with ground water quality management include the Water Pollution Control Committee; Solid and Hazardous Waste Committee; Safe Drinking Water Committee; Board of Oil, Gas and Mining; Board of Water Resources; and the Board of the Utah Geological and Mineral Survey. Where Federal legislation has been enacted, the committees have adopted equivalent regulations as part of the agreement with EPA to administer these programs. For example, regulations essentially equivalent to the Federal RCRA regulations have been adopted by the State's Solid and Hazardous Waste Committee.

Administrative agencies that regulate ground water in Utah are located in the Departments of Health and Natural Resources. The Division of Environmental Health of the Department of Health is primarily concerned with protecting the quality of surface and ground water. Four bureaus in the Division have responsibility for a variety of ground water protection programs. These include the Bureau of Water Pollution Control, Bureau of Solid and Hazardous Waste Management, Bureau of Public Water Supply, and Bureau of General Sanitation. The Department of Natural Resources includes in its organization agencies that allocate ground water to users, provide technical and financial assistance in the development of surface and ground water resources, regulate the exploration and production of oil and gas through the useable ground water zone, and study the geologic setting of the State's ground water resources. These agencies are, respectively, the Division of Water Rights; Division of Water Resources; Division of Oil, Gas, and Mining; and the Utah Geological and Mineral Survey.

The Utah Department of Agriculture does not have direct involvement in the regulation of ground water; however, they do regulate some agricultural activities that affect ground water quality.

Following is a more detailed discussion of the major State agencies within the Departments of Health and Natural Resources that are concerned with ground water quality.

Bureau of Water Pollution Control (BWPC)

The Utah Water Pollution Control Act, UCA 26-11-01 et seq., created the present Utah Water Pollution Control Committee and defined its powers and duties. The Act delegates to the Committee broad authority to develop programs for the prevention, control, and abatement of new or existing pollution of the waters of the State. "Waters of the State" are defined by law to include all surface and underground waters. The authority includes provisions for conducting investigations, establishing quality standards, classifying waters, regulating dischargers, reviewing plans and issuing construction permits for treatment plants, and adopting rules for governing underground injection.

While the Committee determines water pollution control policy for the State, the Bureau of Water Pollution Control (BWPC) is delegated the administrative duties necessary to accomplishing the Committee's goals. The Bureau is organized into four sections: Planning, Engineering and Construction Grants, Monitoring, and Permits and Compliance.

The Planning Section administers water quality management planning for the State. Its responsibilities include establishing and reviewing water quality standards for surface water, reviewing water quality management plans, coordinating salinity control activities, determining wastewater load allocations, and setting effluent limitations. Working with other State and Federal agencies such as the EPA, Forest Service, Bureau of Land Management, and Soil Conservation Service, it reviews natural resource plans with emphasis on non-point source pollution control and consistency with State water policy for the protection of Utah's lakes and streams.

The Engineering and Construction Grants Section reviews plans and specifications and issues construction permits for municipal, industrial, and agricultural wastewater disposal facilities in the State. It also administers EPA and State funds that assist in financing the construction of publicly owned wastewater treatment facilities. In addition, it provides assistance to local agencies for planning, financing, managing, and operating treatment facilities.

The Monitoring Section is responsible for planning and carrying out programs to track municipal and industrial effluent discharges, and monitoring ambient water quality in surface water of the State. It also conducts quality assurance programs and maintains data bases on water quality.

The Permits and Compliance Section is responsible for a varied group of programs that protect water quality. This Section administers programs for discharge permits, dredge and fill permits, hazardous spill response, underground injection of fluids other than produced waters, surface disposal of produced brines, and investigation and enforcement of violations of discharge regulations. Recently two members have been added to the staff of this Section to initiate the development of a ground water protection strategy.

The Permits and Compliance Section has the most direct involvement in programs that protect ground water quality. In addition to the current effort to develop a ground water quality protection strategy for Utah, personnel of the Section manage the Underground Injection Control (UIC) program, surface disposal of produced brines from oil and gas wells,and the National Pollutant Discharge Elimination System (NPDES). Also, plans for facilities that will discharge to ground water are reviewed by the Permits and Compliance staff. The State UIC program is based on Federal regulations developed by EPA; partial funding is provided through a Federal grant. Under UIC, wells that are used for disposal of water or wastes, and wells used for mineral extraction are regulated. Wells used for production of oil and gas or reinjection of produced water are regulated by the Division of Oil, Gas and Mining.

Regulations adopted by the Utah Water Pollution Control Committee set standards for the construction and operation of produced water disposal ponds. These regulations establish requirements for containment with natural soil, clay or artificial liners, and for monitoring of ground water adjacent to the disposal pits.

When a proposed facility facility expects to discharge to ground water, plans are reviewed prior to issuance of construction permits by the Bureau. Examples of regulated ground water discharges include sewage lagoons and mine tailings ponds.

The NPDES program is currently in transition, with responsibility for the program being shifted from the EPA to the State. The State must adopt regulations equivalent to the Federal NPDES regulations and hire additional staff to administer the program before the transfer will be completed.

Bureau of Solid and Hazardous Waste Management (BSHWM)

The Utah Solid and Hazardous Waste Act, UCA 26-14-1 et. seq., placed the authority to regulate the disposal of solid and hazardous wastes with the Solid and Hazardous Waste Committee. The Committee is authorized to promulgate rules to control the collection, transport, storage, treatment, and disposal of solid and hazardous wastes for the protection of the public health. The Act grants the Committee broad authority to develop information through hearings, testimony of witnesses under oath, and production of documents, and to enforce regulations through the issuance of orders and instigation of judicial proceedings. As part of its rule making authority, the Committee has adopted regulations essentially equivalent to those of the Resource Conservation and Recovery Act (RCRA). However, recent amendments to RCRA, passed by Congress in 1984, have not yet been adopted in an equivalent form by the State of Utah.

Administration of regulations adopted by the Committee is delegated to the Bureau of Solid and Hazardous Waste Management (BSHWM). The Bureau is currently divided into four sections: Enforcement Compliance, Plan Review and Permitting, Planning and Program Development, and CERCLA. Both the Enforcement Compliance, and Plan Review and Permitting Sections are primarily concerned with administration and enforcement of the Utah Hazardous Waste Management Regulations. These regulations address hazardous wastes and "other solid wastes." The hazardous wastes provisions provide for "cradle to grave" management of materials identified as hazardous waste. The "other solid wastes" provisions address the handling and disposal of wastes in surface impoundments, landfills, and by land spreading. The Planning and Program Development Section is responsible for implementation of new regulations and programs, while the CERCLA Section is responsible for the investigation of potential Superfund sites.

Legislation, UCA 26-14b-20, was passed by the Utah Legislature in 1983 enabling the Department of Health to enter into a contractual agreement with EPA to administer the CERCLA program in Utah. The CERCLA Section in the Bureau of Solid and Hazardous Waste Management administers this Federal program. Management of the program does not involve the Statutory Committee in a policy making or other role. Policy is established by the Department of Health management in consultation with EPA officials. The regulations are spelled out in the *Federal Register*.

The current CERCLA program is scheduled for reauthorization this year (1986). Both the U.S. House and Senate versions of the bill provide for increased funding, and mandate standards and time-tables for cleanup.

Bureau of Public Water Supplies (BPWS)

The Utah Safe Drinking Water Act, UCA 26-12-1 et seq., authorizes the creation of the Utah Safe

Drinking Water Committee, and empowers it to adopt and enforce rules for public drinking water systems. The Committee membership is appointed by the Governor from individuals representing local governments, municipalities, water districts, industry, professional groups, and the public.

The Committee has promulgated rules and regulations governing water quality standards equivalent to those of the Federal Safe Drinking Water Act. This has qualified the State to have primary enforcement responsibility for the Federal program in Utah. In addition, these rules also incorporate construction standards for public water supply systems. Their administration is carried out by the Bureau of Public Water Supplies (BPWS).

The Bureau functions through the Compliance and Engineering Sections. The Compliance Section handles the inspection, monitoring, and preparation of periodic reports to assure Utah's public water systems are in compliance with the drinking water standards. The Engineering Section administers a construction loan program and the construction standards for the development of public water supply facilities including such ground water supplies as wells and springs. The standards contain rigid provisions for construction, including provisions that provide for required isolation from concentrated sources of contamination.

While the primary focus of the Utah Safe Drinking Water Act has been on the public drinking water systems and their management, the Act also allows for the adoption of rules to protect watersheds and water sources used in public systems. The Safe Drinking Water Committee is currently evaluating the appropriate use of this provision.

Bureau of General Sanitation (BGS)

The Bureau of General Sanitation (BGS), established by the Utah Legislature (UCA 26-15-2 et seq.), has the authority to establish and enforce rules for individual wastewater disposal systems (UCA 26-15-2). The Bureau has developed minimum standards for these systems that are enforced by local health departments. The standards include limits on wastewater quantity, location, and elevation above the ground water table that are designed to provide protection for the ground water resource.

Division of Water Rights (DWR)

The Division of Water Rights (DWR) was established by Utah Legislature Act UCA 73-1-1.1 et seq. The State Engineer (UCA 73-2-1) is appointed by the Governor and is Director of the Division. The Division is responsible for allocation, distribution, development, adjudication, and protection of the waters of the State. Under the Geothermal Resource Conservation Act, UCA 73-22-1 et seq., the DWR was granted authority to regulate geothermal exploration and development.

Under Utah law, the waters of the State are public property. The right to use the water is based on the date of application; later applicants may not interfere with prior water rights. Proof that the water has been developed and placed in beneficial use according to the application must be furnished to perfect the water right.

DWR exercises its authority to prevent pollution of the State's ground water through the regulation and licensure of the well drillers, prevention of pumping in excess of recharge of ground water basins, and regulation of geothermal exploration and development.

Division rules for water well drillers provide for licensing of drillers, operator registration, and minimum well construction standards. To receive a license, an individual must pass an examination on the applicant's knowledge of ground water and water well development practice and post a bond of $500.00. Company operators are required to register with the State and pass an examination similar to that for a license. The construction standards set minimum requirements for development, completion, and abandonment of water wells.

The Division is paying increased attention to the interrelationship between water pumpage and ground water quality. Pumping of ground water basins in excess of their recharge can result in gradual deterioration of the quality of the water as the ground water is mined. Future growth in water demand will result in increased pressure to mine ground water.

In 1981, the Legislature assigned regulatory authority for the exploration and development of geothermal resources to the Division of Water Rights. Geothermal resources are defined as waters with temperatures higher than 120°C. Ownership is based on land ownership in a manner similar to mineral or hydrocarbon ownership.

Through cooperative agreements with the U.S. Geological Survey, the Division funds joint studies of surface and ground water in the State. These studies include the collection of data on both ground water and surface water to maintain long-term records for use by Federal and State agencies involved with water resource management.

The Division has developed regulations for permitting, drilling, and development of geothermal resources. Exploration wells such as temperature gradient wells, observation wells, and wells drilled for geologic information, as well as field development wells, are included under the regulations. The regulations include requirements for casing and abandonment that are intended to protect ground water quality.

"All wells shall be cased . . . in such a manner as to protect or minimize damage to the environment, usable ground waters and surface waters." (Rule 2-7-1, *Rules and Regulations of the Division of Water Rights for Wells Used for the Discovery and Production of Geothermal Energy in the State of Utah.*) Wells must have conductor pipes and surface casing cemented to the surface. Intermediate and production casing may also be cemented to the surface or sealed by other means. In abandoning a geothermal well, all open annuli must be cemented solid and a 100-foot cement plug must be placed to straddle the base of ground water aquifers.

Wells used to reinject spent geothermal fluids are jointly regulated by the DWR and the BWPC. While the former is concerned with the engineering and operational aspects of the well, the latter is concerned with prevention of ground water contamination.

Division of Water Resources (DWR)

The Board of Water Resources was established by the Legislature, UCA 73-10-1 et seq., to encourage the use of the State's water resources in a manner that best serves the needs of the people of Utah. The Board's duties include protection of Utah's rights to interstate waters, coordination of Federal water programs, comprehensive planning for water resource usage, and administration and funding of water conservation and development projects. The Board is not granted regulatory authorities to accomplish its goals although it does have recourse to the courts. The Division of Water Resources (DWR) is the administrative arm of the Board and carries out the policies established by the Board.

In its capacity to plan for water use and fund water development projects, the DWR has established a significant involvement in ground water issues. Through cooperative agreements with the U.S. Geological Survey, DWR has participated in many investigations of Utah's ground waters. These studies have built a substantial base of technical knowledge for the development of sound ground water management policies. Where community water systems have a potential health problem, the Board is authorized to assist in funding improvements to municipal water systems. These improvements can include development of ground water resources for public use.

Division of Oil, Gas and Mining (DOGM)

The Division of Oil, Gas and Mining (DOGM) was established by Utah law, UCA 40-6-1 et seq., to administer policy and regulations adopted by the Board of Oil, Gas, and Mining. The Division oversees oil, gas, coal, and mineral exploration and production; mined land reclamation; injection of produced water from oil and gas wells; and abandoned mine reclamation. The Board was established by the same legislation and consists of seven members with various specified backgrounds appointed by the Governor and confirmed by the State Senate.

The Oil and Gas Conservation General Rules and Regulations set standards for exploration, drilling, and production practices. Seismic operators must provide adequate protection to ground water resources by plugging of drill holes with bentonite slurry and setting surface plugs with soil in the upper three feet of the drill hole. In drilling exploration or production wells, operators must install and cement casing designed to protect the ". . . reasonably estimated, utilizable domestic, fresh water levels." The casing must also prevent the migration of oil, gas, or water from one horizon to another. Reserve pits must be constructed so as to prevent the escape of salt water or oil-field wastes. When a well is to be abandoned, plugs must be set to prevent fluid migration in the well bore. This includes a 100-foot plug centered across the base of the fresh water zone and a 50-foot plug at the base of the surface casing string.

DOGM also regulates wells used for disposal of brines and to enhance recovery of oil and gas. These wells, designated as Class II wells, are regulated under the Underground Injection Control program of the Safe Drinking Water Act. Funding for the program is provided by EPA. Regulation is carried out through permitting and includes requirements for plugging nearby wells, monitoring pressure during operation, and periodic reporting of operating data.

Objectives of the Utah Mined Land Reclamation Act, UCA 40-8 et seq., include "To minimize or prevent present and future on-site or off-site environmental degradation caused by mining operations to the ecologic and hydrologic regimes and to meet other pertinent state and federal regulations regarding air and water quality standards and health and safety criteria." DOGM requires plugging of drill holes, a post-mining reclamation plan, and a bond to insure the site is restored to minimum standards set forth in rules adopted by the Board.

The Coal Mining and Reclamation Act, UCA 40-10 et seq., established the basis for the Board of Oil, Gas, and Mining to regulate coal mining and reclamation operations. The performance standards included in the Act require that the operator

"Minimize the disturbances to the prevailing hydrologic balance at the mine site and in associated off-site areas and to the quality and quantity of water in surface and ground water systems both during and after surface coal mining operation. . . ." and to "Insure that all debris, acid-forming materials, toxic materials, or materials constituting a fire hazard are treated or buried and compacted or otherwise disposed of in a manner designed to prevent contamination of ground or surface waters. . . ."

Utah Geological and Mineral Survey (UGMS)

The Utah Geological and Mineral Survey (UGMS) (UCA 53-36-1 et seq.) is a nonregulatory agency within the Department of Natural Resources. Policy for UGMS is set by the Board of the Utah Geological and Mineral Survey. Broadly, UGMS is charged with the responsibilities of investigation and distribution of information about the State's geology and mineral resources. Specifically, their authority includes the study of ". . . all energy resources including geothermal, . . ." and ". . . all mineral bearing waters and other surface and underground water supplies." In addition, the implementation portion of the Utah Ground Water Policy states that UGMS shall identify areas where shallow ground water conditions create a geologic hazard and make recommendations for their mitigation or avoidance.

The Survey, as an agency concerned with the development of knowledge and understanding of the State's geology, is involved with many ground water management issues. A knowledge of the geology of an area is indispensible to the understanding of the ground water hydrology. Geologic and hydrologic data collected by the UGMS, and other State and Federal agencies form the basis for intelligent policy decisions on many ground water issues.

Specific ground water related programs at UGMS are administered within the Applied Geology Program. They include geothermal resource investigations, and review of geologic and hydrologic reports dealing with local and regional ground water problems. Other duties include investigating ground water related geologic hazards, providing assistance to the State and local health departments with siting of waste disposal facilities, and evaluating potential sources of culinary water.

Division of Wildlife Resources

The Division of Wildlife Resources is authorized to protect State waters from pollution by UCA 23-15-6. This authorization forms the basis for the Wildlife Board to establish rules and regulations for protection of lakes and streams and could also be applied to ground water. Ground water is important for wildlife when it emerges as seeps and springs, for maintaining riparian and wetland vegetative communities which provide habitat for wildlife, and by augmenting wetlands and streamflow by recharge during low-water periods. Man-caused activity which degrades the quality of ground water by contamination, or diminishes the quantity through withdrawal, can adversely impact the State's fish and wildlife resources.

Department of Agriculture (DA)

The Utah Department of Agriculture exercises regulatory authority over a number of activities that are potential non-point sources of ground water contamination. Both fertilizers and pesticides must be registered with the Department for use in the State. The Utah Pesticide Control Act, UCA-4-1 et seq., requires registration, proper labeling, certification of applicators, and licensing of dealers. The Utah Fertilizer Act, UCA 4-13-1 et seq., requires registration, labeling, and verification of performance claims. Neither the Utah Pesticide Control Act nor the Utah Fertilizer Act address the problem of potential ground water contamination that may result from poor application practices.

Local Health Departments

Under the Local Health Department Act, UCA 26-24-1 et seq., local health departments are authorized to enforce State and local laws, regulations, and standards relating to public health and sanitation. Under this law, local health departments regulate septic tank installations.

Local Zoning Authority

The Utah Legislature has granted municipal and county governments zoning powers for the purpose of promoting the health, safety, morals, and general welfare (UCA 10-9-1) of the community. Cities with populations over 100,000 have extraterritorial jurisdiction over their entire watershed for purposes of protecting their water supplies from pollution. Cities with populations of 60,000 to 100,000 have jurisdiction over the stream or water source for 15 miles above the point of withdrawal and 300 feet to either side of the stream (UCA 10-8-15). First and second class cities have the right to enact ordinances to prevent pollution or contamination of the streams or water courses from which they derive their water supply. Third class cities have jurisdiction for 10 miles upstream from the point of withdrawal for their public water supply.

Under UCA 10-8-94, enacted by the Legislature in 1985, the powers exercised by cities were extended to towns. The new powers include the right to enact ordinances for public health and operate public water distribution systems.

Other Programs

Federal and State agencies are not the only groups involved in the study of ground water resources and the development of ground water management programs. Local government agencies and State universities have also contributed to the development of our knowledge of the ground water resources and the problems with pollution of these resources.

Soil Conservation Districts, Water Conservancy Districts and local government units have been involved in investigative studies of ground water problems. Through cooperative agreements between Federal, State, and local government agencies, funding under Sections "208" and "205j" of the Clean Water Act and other funding from State and Federal sources, ground water studies have been undertaken. For example, the Division of Flood Control and Water Quality of the Salt Lake County Department of Public Works has worked with the U.S. Geological Survey, Salt Lake County Water Conservancy District, and the Utah Geological and Mineral Survey on a study to characterize the water quality and quantity in the shallow aquifer of the Salt Lake Valley.

Personnel of the Utah Water Research Laboratory at Utah State University have published results of studies of ground water contamination problems in the State. Funding for this work was derived from research funds provided by the Utah State Legislature.

OVERVIEW OF REGULATORY PROGRAMS

In evaluating the effectiveness of the current Federal, State, and local programs for protection of ground water quality, several deficiencies are apparent. The major thrust of current Federal programs is the regulation of the handling and disposal of wastes. Imperatives for ground water protection have largely resulted from initatives by the Congress and Federal Government. State programs suffer from cumbersome institutional means of coordinating ground water management and resolving conflicting policies of different agencies. The State is also heavily dependent on the Federal Government for funding of water resource management programs.

For an effective ground water quality protection program, a strong emphasis is required on prevention of ground water contamination. Contamination often results from handling, storage, and usage or accidental spills of toxic materials. Industrial facilities use large quantities of process chemicals, cleaning agents, and other possible contaminants. Attention needs to be directed to the prevention of contamination from these sources. Pesticides and fertilizers also need to be evaluated for their potential for ground water contamination. Methods need to be found to adequately protect ground water without unduly restricting industry or curtailing the economy.

Some protection is afforded ground water through six Federal laws. These laws were passed with different intents and are administered by several State and Federal agencies. The result is a fragmented and compartmentalized effort to protect ground water quality.

At the State level, seven boards and nine agencies develop and administer policy affecting ground water. Four boards are authorized to regulate activities that may adversely affect ground water. However, a more effective means for coordination of policies between these entities needs to be developed to handle increasingly complex State water management problems.

Many State ground water quality protection programs are dependent on the Federal government for funding. Federal grants fund RCRA, CERCLA, UIC, construction grants for wastewater treatment, water quality planning, the protection of drinking water, studies of ground water resources, and the development of the ground water protection strategy. At present, EPA's ground water strategy does not envision substantial Federal funding for the administration of state ground water quality protection programs. State sources should be developed to carry on this program.

MANAGEMENT ALTERNATIVES TO PREVENT OR CONTROL GROUND WATER POLLUTION

In order to protect Utah's ground water from pollution, an effective program for controlling potential sources of contamination must be developed. The management program should be comprehensive in its coverage and tailored to the sources of pollution. Primary management emphasis should be on the prevention of contamination. A secondary objective is to identify and monitor areas of polluted ground water in order to protect the public health. The final program should combine a number of different management approaches, each selected to address the controls needed for each source of pollution.

Following are a number of management tools that are used or have been considered in other states to prevent or detect ground water pollution:

1. Prohibition

   Certain toxic chemicals present such a direct long-term threat to the health and well-being of human and animal life when they enter the environment that an outright ban on their use may be justified. The ban may be total, such as the Federal ban on the use of DDT or recent state bans on the use of chlordane, or restrictions on usage such as those imposed on pesticides and herbicides.

2. Attenuation

   On-site wastewater treatment systems rely on the physical and chemical properties of the soil to clean contaminants from the effluent. The soil system has a limited capacity to remove pathogenic organisms, organic compounds, and metals. This ability varies with the characteristics of each site. Factors such as the coarseness of the material above bedrock, the type of clay and the organic content of the soil, and the depth to the water table influence the ability of the soil system to remove contaminants. Some constituents in wastewater, such as nitrate and phosphorous, are not removed by the soil and pass into the ground water system where they can pose health problems. Thus, attenuation is a useful management approach for handling wastewater from on-site disposal systems but is dependent on spacing and the site's geologic characteristics for success.

3. Technical Information

   Information on the geology, hydrology, and soils provide the basis for the development of sound ground water protection programs. This information should be readily available, easily understandable, and up-to-date.

4. Land-Use Controls

   Controls on land use envision the limitation or prohibition of certain activities that pose a substantial threat to ground water quality in the recharge area of major aquifers. Examples would include the restriction of landfills, industrial plants and mining operations that handle highly toxic chemicals, and hazardous waste disposal sites from aquifer recharge zones. In practice, local and state planning and zoning agencies should consider ground water quality in making their decisions.

   On a larger scale, land use controls already in effect on public lands protect many of Utah's ground water recharge areas. For example, the watershed management system for the Wasatch National Forest protects the water entering the aquifers and streams along the Wasatch Front. Land use controls of this type clearly benefit the public and have found general acceptance despite their impact on private landowners within public lands.

5. Facility Design Standards

   Design standards for waste disposal facilities minimize the leakage of toxic substances into the environment by preventing their release. For example, new facilities for bulk storage of chemicals and petroleum products, hazardous waste disposal facilities, and mill tailings ponds should be designed to prevent leakage of toxic substances into the soil. Design standards are not generally applicable to existing facilities, and other management methods must be used to control contamination problems associated with them.

6. Quantitative Performance Standards

   Quantitative performance standards establish numerical criteria based on scientifically established standards for maximum acceptable contaminant levels.

   Utah has adopted the Federal Primary Drinking Water Standards of the Safe Drinking Water Act (SDWA) as a basis for monitoring water wells that are used for public water supplies. Some states, such as New Mexico, have established additional standards for chemicals not covered by the SDWA. Wisconsin has established a two-tier standard with a "preventive action limit" as a percent of the "enforcement limit."

The lower preventive action limit forms the basis for design codes and management practices. It is also an alert to the possibility of the need for regulatory action before pollutants reach a dangerous level.

7. Containment

   Long term isolation of hazardous waste is a management alternative for some hazardous waste. However, monitoring of storage or disposal sites for long periods presents problems of funding and managing their continued surveillance.

8. Qualitative Health and Environment Standards

   By establishing broadly defined descriptive goals for prevention of ground water pollution, wide latitude is given to permittees on the methods of compliance.

   Narrative standards essentially establish compliance standards on a case-by-case basis. By doing so, it places a burden on the State to make a determination in each case as to whether the projected discharges meet the narrative standards.

9. Aquifer Protection

   Under provisions of the Safe Drinking Water Act, the EPA can designate an aquifer as the sole or principle source of drinking water for an area. This guarantees protection from contamination by Federally assisted activities. Local, regional, or State agencies can petition EPA for sole or principle source designation. At this time, there are no aquifers in Utah designated as sole or principle sources.

10. Best Management Practices

    Best management practices is a management method that is widely applied to certain agricultural activities, including the application of herbicides, fertilizers, and pesticides. The intent is to minimize surface and ground water contamination by certain types of pollutants so that water quality is not degraded.

    Best management practices are generally a cost-effective and acceptable method of managing many horticultural and agricultural endeavors. However, they depend on voluntary compliance on the part of farmers, ranchers, homeowners, and other land owners to be effective.

11. Ground Water Classification

    A ground water classification system categorizes geographic areas, portions of aquifers, or entire aquifers into different levels of protection based on the quality of the ground water in the aquifer, vulnerability to contamination, yield, or other economic or social considerations.

    Most classification systems rely on the total dissolved solids (TDS) content to distinguish between ground water classes. A TDS of 10,000 mg/l is a common lower cutoff. TDS of 500, 3000 and 6000 mg/l have been used to define intermediate classes. Other states have used narrative classes based on use, depth, or physiography to divide ground water into classes.

    Ground water classification appeals to a wide spectrum of people and organizations, and has been supported as a management approach by EPA. It provides for flexibility in managing ground water quality and allows enforcement manpower to concentrate on areas with high quality water.

12. Hazardous Materials Registration

    Registration of industrial storage and handling facilities provides information to enforcement authorities so that the adequacy of waste and material handling procedures can be determined. It also provides necessary information for response to accidental spills and determines their potential for ground water contamination.

13. Hazardous Materials Certification

    Certification of industrial facilities that are handling hazardous materials or wastes requires the facility to be in compliance with State water protection regulations. Certification is a follow-on program to registration. Certification permits State agencies to develop a more effective prevention program by prior identification of potential contamination problems.

14. Special Protection Areas

    Creation of special protection areas allows the State to protect critical ground water areas from activities that pose a significant threat. Special protection areas provide a method of protecting ground water in areas that are totally dependent on wells for water and have no feasible alternatives. It could also be applied to the protection of water sources for wildlife refuges that are dependent on springs for their existence.

15. Ground Water Monitoring

    Unlike the foregoing management methods, monitoring seeks to detect the presence of ground water contamination so that steps can be taken to prevent further deterioration. There are generally two types of monitoring programs: site-specific and ambient. Site-specific monitoring is used to determine whether a particular facility is polluting the ground water and, if so, the nature, degree, and extent of the pollution. Ambient monitoring is used to determine if pollution is present in ground water.

16. Public Education

An effective education program would include several actions: (1) provide information to the public about the value of the ground water resource, the dangers of contamination and pollution, the difficulty and prohibitive costs of cleanup, and the measures that can and should be taken to protect the ground water resources; (2) provide a vigorous program of education and indoctrination to governmental units and industries regarding their responsibilities and opportunities in ground water protection; (3) provide information to community leaders and legislators so that needed legislation can be passed; (4) provide to the public current and timely information relating to the most urgent ground water protection needs and the progress being made in addressing them.

17. Schedule of the Implementation

Prepare a schedule of implementation for a ground water protection program to maintain momentum and keep the effort on target.

CONCLUSIONS

1. Utah's ground water is one of its most valued resources and deserves protection for present and future beneficial uses.

   The surface and ground water of the State are so intricately interconnected and interrelated that both require a high level of protection. In aquifer recharge areas, such as the Lake Bonneville benches, stream seepage can be a major element of the ground water recharge. In periods of low rainfall, ground water seepage into streams provides the base flow. In a similar fashion, shallow aquifers may recharge deeper aquifers through areas where they are connected. We must diligently protect our underground water if we are to avoid contaminating present and future water supplies that will be needed be industry, wildlife, and the general public in future years.

2. Ground water systems have a limited ability to cleanse themselves by dilution, degradation, or absorption of contaminants.

   Surface water is exposed to the beneficial effects of sunlight, biologic activity, and turbulent water movement. In combination, these factors can cleanse lakes and streams of many contaminants. However, these same processes are not operative in the ground water environment. Once contaminants enter ground water, they tend to persist. Unlike surface water pollution, ground water pollution is extremely difficult and expensive to cleanup in most cases.

3. The Utah Primary Drinking Water Standards do not currently include many contaminants that may be present in drinking water, or address the effects of long-term exposure to these contaminants.

   Many synthetic organic compounds are not considered in the current drinking water standards. Although the health effects of these compounds are not completely known, some are suspected carcinogens. In order to protect the public health, interim standards need to be established, based on currently available scientific information. More or less stringent standards can then be established as new information becomes available.

4. Sources of potential ground water contamination result not only from improper handling or disposal of toxic materials, but also from normal distribution, handling, and use.

   Leakage into the environment and eventual contamination of the ground water system can occur from the application of organic chemicals such as pesticides, herbicides, and improper use of solvents. Application of herbicides or pesticides prior to heavy rain storms can result in contaminants being carried into ground water. Cleaning of industrial equipment without proper precautions and proper disposal can result in solvents seeping into the ground water. Better procedures need to be implemented to prevent escape into the environment from accidental spills or improper use.

5. In designing and implementing a program to protect Utah's ground water quality, certain trade offs must be considered in establishing and enforcing a regulatory program.

   Many of the regulations that may be developed to protect ground water directly impact industries in the State and eventually the State's economy. These economic impacts need to be recognized and their effects considered in the development of ground water regulations.

6. Management of ground water quality and quantity are interrelated. Successful management requires a coordinated program so that one regulatory effort does not contravene the other.

   Over-pumping of aquifers can result in the movement of contaminated ground water into uncontaminated aquifers. Coordination of regulatory efforts is necessary to meet the goals of protecting ground water quality and providing needed water supplies.

7. The protection of ground water quality and the protection of surface water quality are not separable problems and must be addressed with a coordinated protection program.

   Streams and lakes freely interchange water with the ground water system. Along the course of a stream, water may move both into and out of the ground water system. Thus, stream pollution can become ground water pollution and visa versa. To protect one system, both need to be protected.

8. Institutional structures need to be developed

to coordinate State policy on surface and ground water quality and quantity issues.

A forum is needed for consultation, coordination, and cooperation among State agencies in the development of ground water quality protection policies.

9. At the working level, a better means of communication needs to be established through regularly scheduled staff meetings in order to develop more efficient and effective regulatory programs.

   Many regulatory actions require contributions from different groups to establish the basis for an action. Also, some State and Federally mandated regulatory programs are duplicative. Better coordination could eliminate program overlap.

10. Particular attention needs to be paid to the regulation of potential sources of contamination located in aquifer recharge zones.

    In the more populous areas of Utah, ground water recharge usually occurs in coarse alluvial deltas and fans that fringe the valleys. These recharge zones are the source of high quality water tapped by municipal and domestic water wells. These recharge zones need regulatory protection. Contamination entering the ground water in the upland recharge zones can pose a potential health risk.

MANAGEMENT PROPOSALS

The ground water quality protection strategy envisions the development of a prevention-oriented program that incorporates better management of the ground water resources, control over sources of pollution, increased protection of aquifer recharge areas, and better response to incidents of ground water contamination.

To encourage discussion of the elements that should comprise Utah's ground water protection program, the following management proposals are provided. The purpose is to establish both a framework for discussion and provide proposals for consideration in the hope that the end result will be a thoroughly considered, carefully crafted protection program that is both efficient and effective. These recommendations are not intended to preempt alternatives or foreclose changes, additions, or deletions.

MANAGEMENT OF GROUND WATER RESOURCES

Protection of Utah's ground water resources requires an effective management program. Elements of this program should include water quality standards and use classification, inventory of ground water resources, monitoring and development of an information base on ground water quality, and development of an organizational framework to manage a ground water protection program.

Water Quality Standards and Use Classification.

Proposals:

1. Adopt water quality standards or develop other methods that will protect current and probable future beneficial uses. Standards should consist of a classification system based on current beneficial use and criteria to protect these uses. Use classification systems should be based on such factors as existing and future beneficial uses, water quality, and sensitivity to contamination.

Discussion:

Ground water quality standards help to establish clear objective goals. They provide both a basis for evaluating compliance efforts and for design standards for new or renovated facilities. Standards provide industry and other users with a management tool for reaching decisions on facility siting and provide government with guidelines for enforcement actions. By classifying ground water according to beneficial uses, various levels of protection can be established for different uses. Better protection can be provided to areas with high quality ground water and lesser protection given to areas of poorer quality.

Inventory of Ground Water Resources.

Proposals:

1. Continue research programs by the Utah Geological and Mineral Survey, Utah Division of Water Resources, Utah Division of Water Rights, and U.S. Geological Survey to develop and update regional hydrologic maps of the State showing water quality information and major ground water aquifers. These maps should be formated in a manner so that they are compatible and provide information for use by State and local government personnel, industry, and the general public.
2. Expand programs of detailed mapping and mathematical modeling of aquifers that are currently supplying domestic water to the public. These maps should show soil and bedrock types, recharge areas, and ground water flow patterns. This information is needed by local authorities to control pollution sources, and guide land-use and water development decisions.
3. Require geophysical logging and filing of the resultant logs with the State for all public supply, irrigation, and industrial water wells that are designed to yield over 50 gallons per minute and are over 200 ft. deep.

Discussion:

Sound information on ground water resources of the State is indispensable to the intelligent management of the future growth of the State. Moreover, the information must be made available in a form that is both understandable and usable by laymen. At the community level, aquifer maps can provide community leaders information necessary for the protection of the underground drinking water supplies.

Monitoring and Ground Water Quality Data Base.

Proposals:

1. Expand programs for detection and tracking of ground water contamination through ambient and site-specific monitoring of ground water.
2. Develop a ground water quality data and well record management program to coordinate the collection, storage, retrieval, and transfer of ground water quality and well record data between Federal, State, and local agencies and the

private sector.

Discussion:

Periodic monitoring of water wells for dissolved solids, organic compounds, heavy metals, and other potential contaminants is necessary for the protection of the public health. In addition, ambient monitoring can identify potential ground water pollution problems through detection of contaminants in more isolated areas or recognition of contaminant concentration trends. In order to investigate a report of ground water contamination, wells may need to be drilled to obtain water samples for analysis. Tracking a contaminant plume to its source can be an expensive but necessary endeavor if further pollution from that source is to be prevented. Although several State and Federal government agencies routinely collect ground water quality data, better coordination of these activities is needed to identify and control ground water pollution problems in the State.

Management Framework.

Proposals:

1. Establish an interdepartmental coordinating group for water quality protection in the State. Membership should include senior managers of State agencies involved with water management.

Discussion:

To provide better solutions to present and future water-related problems that confront the State requires a forum for interagency coordination and cooperation. Establishing a group with State administrative representation should facilitate the communication necessary to the development of solutions to complex water problems.

Source Control

Federal and state governments regulate wastewater discharges, solid and hazardous waste disposal, handling and storage of hazardous material, and underground storage tanks. The regulations prevent contamination from these sources entering surface and ground waters. These controls are enforced by the EPA and State agencies.

Wastewater Discharges.

Proposal:

1. Continue staff review of construction plans for facilities that discharge directly to ground water.
2. Prohibit wastewater discharge in aquifer recharge areas.
3. Continue current Underground Injection Control (UIC) program to regulate disposal and mineral extraction wells.
4. Encourage, to the maximum extent possible, the reinjection of water produced with oil and gas.

Discussion:

Treated sewage, process water, and cooling tower water occasionally seep into ground water from lagoons. This wastewater should not degrade the aquifer water quality for current and prospective beneficial uses.

Seepage discharge to ground water from lagoons should be controlled in aquifer recharge areas and in the vicinity of wells used for public water supply.

The current UIC program for regulation of disposal and mineral extraction wells should continue. Permit review should be coordinated closely with other State and local agencies regulating public water supplies to determine that there is no threat to public ground water resources.

Water produced with oil and gas is usually highly saline. Even where evaporation rates are high, surface disposal does not answer the problem of disposal of the salt. Reinjecting the water can assist the oil production by maintaining reservoir pressure and also dispose of the water.

Municipal Waste Management.

Proposals:

1. Inventory all operating and abandoned landfills in the State.
2. Ban construction and operation of landfills in aquifer recharge areas.
3. Phase out existing landfills located in aquifer recharge areas and monitor down-gradient area for ground water contamination.
4. Require geologic and hydrologic investigations to be made on existing and proposed landfills to determine their potential for ground water contamination.

Discussion:

Landfills commonly are a source of ground water contamination. Contaminants enter the ground water system as leachate from the landfill. The leachate typically contains variable amounts of heavy metals, organic chemicals, and other undesirable substances that are carried in solution by waters seeping through the landfill. Since landfills are a necessity for small and medium-sized communities, the best way to prevent them from polluting ground water is to locate them in areas where they pose little or no threat to ground water or surface water.

Controls for Industrial Facilities.

Proposals:

1. Maintain existing contamination prevention programs and promote good housekeeping at facilities generating, handling, and storing hazardous chemicals.
2. Continue periodic inspection and operations review of those facilities located in areas particularly sensitive to pollution of ground water.

Discussion:

Improper handling, spillage, and leakage of toxic chemicals can be a major threat to ground water. Disposal of solvents by indiscriminant dumping can negate the beneficial effects of expensive pollution control equipment. Prevention of spills and leaks is largely a matter of awareness and good operating procedures.

Pesticide, Herbicide, and Fertilizer Use.

Proposals:

1. Work jointly with the Utah Department of Agriculture and the U.S. Soil Conservation Service to identify agricultural lands that are particularly susceptible to ground water pollution by pesticides, herbicides, and/or fertilizers.
2. Provide ground water monitoring programs in areas where pesticides, herbicides, and/or fertilizer are in heavy use, and a significant opportunity exists for ground water contamination.

Discussion:

Some croplands, by the nature of the soil type, water table depth, and subsurface geology, are susceptible to contamination by pesticides, herbicides, or fertilizers. If crops require frequent application of highly toxic pesticides to control pests, the ground water is at risk. Monitoring of ground water in these areas allows early recognition and prevention of further contamination.

Recharge Area Protection

The preservation of ground water quality requires increased attention by local governments in planning sites for solid waste disposal and sewage treatment facilities, and siting decisions for residential, commercial, and industrial development.

Local Government Ground Water Quality Protection.

Proposals:

1. Develop local ground water quality protection programs.
2. Encourage local governments to exercise controls over their watersheds and aquifer recharge areas to protect the public health in their jurisdiction and downgradient area.

Discussion:

Cities and towns that draw part or all of their public water supplies from aquifers have a special interest in protecting their ground water from contamination. Local officials need to clearly understand their responsibilities and the means at their disposal to carry out those responsibilities.

State Technical Assistance

Well-informed and concerned citizens and elected officials are crucial to an effective program for protecting the quality of the State's ground water resources.

Technical Assistance.

Proposals:

1. Provide technical assistance to local government units on ground water quality protection.
2. Develop ground water information and education programs for the public and elected officials.

Discussion:

In order for local government leaders to make decisions on siting of public and industrial facilities, they need a basic understanding of ground water and the local hydrologic regime. Officials and the public need to be aware of areas in their community that are susceptible to ground water contamination. Workshops, informal meetings, and training sessions can promote a better understanding of ground water in their local communities.

Contamination Response

When a community is faced with the unexpected loss of their public drinking water because of contamination, they need expert help. The State can assist the community develop alternative sources of supply and discover the source of contamination.

State Program for Contamination Response.

Proposals:

1. Provide funding for development of alternative drinking water supplies where contaminant levels exceed Utah drinking water standards.
2. Provide funds for determining the sources of ground water pollution.
3. Insure that an adequate emergency response capability exists for the cleanup of spilled hazardous chemicals.

Discussion:

When public water supplies are found to be contaminated, alternative supplies for users must be made available quickly. Responsibility can be determined later and liability for replacement accessed.

In order to determine the source and degree of ground water pollution, it may be necessary to drill test wells to determine the source of the contaminant plume. The costs and technical expertise are usually beyond the means and capabilities of small communities. Yet, it is necessary in order to prevent further pollution of the aquifer. The State is in a better position to assume responsibility for remedial programs.

Trucks and railway cars hauling hazardous chemicals are occasionally involved in accidents that result in spillage of their cargo. In order to minimize the contamination of surface and ground water, a fast response is required. Absorbent materials and other cleanup equipment should be stockpiled at Department of Transportation facilities across the state to allow quick response to these episodes.

SUGGESTIONS FOR FURTHER READING

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Fisk, Edward P., Calvin G. Clyde, 1981, *A Survey and Evaluation of Shallow Groundwater Contamination Hazards in the State of Utah,* Utah Water Research Laboratory, Utah State University, Logan, Utah.

Henderson, Timothy R., Jeffery Trauberman, Tara Gallagher, 1984, *Groundwater Strategies for State Action,* Environmental Law Institute, Washington, D.C.

Schlotthauer, William E., Boyd W. Nance and Jerry D. Olds, 1981, *Identification and Characteristics of Aquifers in Utah,* Utah Division of Water Rights, Salt Lake City, Utah.

Seiler, R.L. and K.M. Waddell, 1984, *Reconnaissance of the Shallow-Unconfined Aquifer in Salt Lake Valley, Utah,* U.S. Geological Survey, Water-Resources Investigation Report 85-4272, Salt Lake City, Utah.

Todd, David K., 1983, *Ground-Water Resources of the United States,* Premier Press, Berkeley, California.

U.S. Geological Survey, 1985, *National Water Summary, 1984,* U.S. Geological Survey Water-Supply Paper 2275, Washington, D.C.

APPENDIX I

EXECUTIVE ORDER

STATE OF UTAH

Executive Department.

EXECUTIVE ORDER

UTAH GROUND-WATER POLICY

WHEREAS, allocation, administration, and regulation of ground-water* resources traditionally have been totally within the purview of the State, and institutions and mechanisms for these activities are already in place and functioning well; and

WHEREAS, Utah, one of the most arid states in the nation, recognizes that water is a valuable resource which must be managed in the most efficient, effective, and environmentally responsible manner possible to meet the current uses** and future needs of the State; and

WHEREAS, by managing surface and ground-water resources conjunctively, significant economic efficiencies in storage and distribution systems can be achieved, and water demands can be more adequately met; and

WHEREAS, ground-water quality problems are particularly critical since once an aquifer*** or a portion of it, has been contaminated, cleanup is costly, technically difficult, and time-consuming, because of the (1) difficulty in defining the characteristics of the resource or the contaminated portion thereof, (2) difficulty in early identification of contamination, (3) generally very slow travel time of water through the aquifer, and (4) extremely variable recharge/discharge flow rates; and

*Ground water is defined as the water beneath the surface of the earth that can be collected with wells, tunnels, or drainage galleries, or that flows naturally to the earth's surface via seeps or springs.

**See Sections 73-1-5 & 73-3-8, Utah Code Annotated, as amended.

***Aquifer is defined as a ground-water bearing formation, whether confined or unconfined, sufficiently permeable to transmit and yield water in usable quantities.

WHEREAS, in many areas of the State, ground-water conditions can create and/or aggravate geologic hazards that adversely affect the health, safety, and/or well being of Utah's citizens; and

WHEREAS, in Utah surface and ground-water resources are administered under the same statutes; and

WHEREAS, the State Engineer has been given statutory authority to allocate and administer the water resources of the State; and

WHEREAS, the Division of Water Resources has been given statutory responsibility to conduct studies, investigations, and planning for the full development, utilization, and promotion of the water and power resources of the State and to supervise interstate compact negotiations and administer agreements affecting interstate waters; and

WHEREAS, the Department of Health has been given statutory responsibility through the Water Pollution Control Committee, Solid and Hazardous Waste Committee, and the Utah Safe Drinking Water Committee to develop and administer programs for the prevention, control and abatement of new or existing pollution of the waters of the State;

NOW, THEREFORE, I, Scott M. Matheson, Governor of the State of Utah, by virtue of the authority vested in me by the Constitution and Laws of the State of Utah, do hereby approve this policy which is being followed by State Agencies which have statutory or regulatory authority over water resources of the State:

1. POLICY

(a). The State will continue to assume the leadership role in allocation, administration, and regulation of ground-water resources. Early, constructive, and open debate among state agencies and affected interests will be used in the process to further develop and implement ground-water policy.

(b). Regulatory treatment for both ground water and surface water will be consistent. Ground water, as all other water in the State, has been declared to be the property of the state. Rights to its use can be obtained only by compliance with designated State water laws and procedures. The appropriation system of water rights, with its provisions for change and transfer, subject to administrative approval, will result generally in the most efficient and effective allocation of water.

(c). Approval of new appropriations for ground water will be based upon the long term recharge rate of the basin. This policy will be followed in the future except in certain areas where it can be demonstrated that the mining of ground water is in the best interest of the State.

(d). Resolution of issues concerning allocation, management, and protection of interstate aquifers will be attempted to the extent feasible and practical through interstate agreements as the need occurs.

(e). The quality of ground water will be protected to a degree commensurate with current and probable future uses. Preventive measures will be taken to minimize contamination of the resource so that current and future public and private uses will not be impaired.

(f). Shallow ground-water conditions and geologic hazards associated with ground water shall be identified on a statewide basis and recommendations made for appropriate action.

2. IMPLEMENTATION

(a). The Department of Natural Resources and the Department of Health will organize a standing committee to improve water quantity/water quality coordination. At a minimum, this committee will have representatives from the Division of Water Resources, the Division of Water Rights, Utah Geological and Mineral Survey, the Division of Oil, Gas and Mining, the Division of Wildlife Resources, the Division of Environmental Health, the Department of Community and Economic Development, and the Department of Agriculture.

(b). The State Engineer shall recommend appropriate legislation and/or regulation if deemed necessary to accommodate the State's needs in allocating and managing the ground-water resources.

(c). The Division of Water Resources and the State Engineer shall encourage conjunctive use operations where more efficient use of the water resource can be demonstrated and the natural stream environment will not be unreasonably impaired, and the Board of Water Resources shall promote such operations through technical and financial assistance.

(d). The Department of Health shall develop a ground-water quality strategy for the protection of present and future public and private uses. This strategy shall be developed under existing statutory authority with the coordination of affected agencies and interested parties and with public involvement.

(e). The Utah Geological and Mineral Survey shall identify the areas where ground-water conditions create and/or aggravate a geological hazard, and will provide recommendations for appropriate action to avoid, control, or otherwise prepare for its occurrence.

IN TESTIMONY, WHEREOF, I have hereunto set my hand and caused to be affixed the Great Seal of the State of Utah. Done at the State Capitol Salt Lake City, Utah this 4th day of Oct., 1984.

Lieutenant Governor

GOVERNOR

APPENDIX II

GROUND WATER ASSESSMENT

AGRICULTURE

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INTRODUCTION

Utah's farmers and ranchers derive their income from the production of a wide variety of commodities. Cattle provide the largest portion of farm cash receipts with dairy products a close second. Hay is Utah's largest cash crop with 1984 production of 2.2 million tons. Utah ranks third in the nation in the production of tart cherries, ranch mink, and apricots. The State ranks fifth, nationally, in sweet cherry production and seventh in sheep and onion production. (Gneiting, et al., 1985).

Major recent trends affecting Utah agriculture include declining net income, increasing production costs, and increasing average farm size. Higher costs of interest, energy, machinery, and equipment combined with depressed commodity prices have resulted in declining net income for farmers. While farmland and the total number of farms has been decreasing, average farm size has been increasing (Snyder, 1985). Utah now has 14,000 farms on 11,800,000 acres for an average farm size of 843 acres. While farm productivity is important, emphasis is now being placed on improved profitability.

Agriculture is the largest water consumer in the State and uses about half of the total ground water withdrawn from wells. In 1984 over 329,000 acre feet of water was withdrawn from wells for irrigation purposes. This represents about 10 percent of the State's total agricultural water use (map 1).

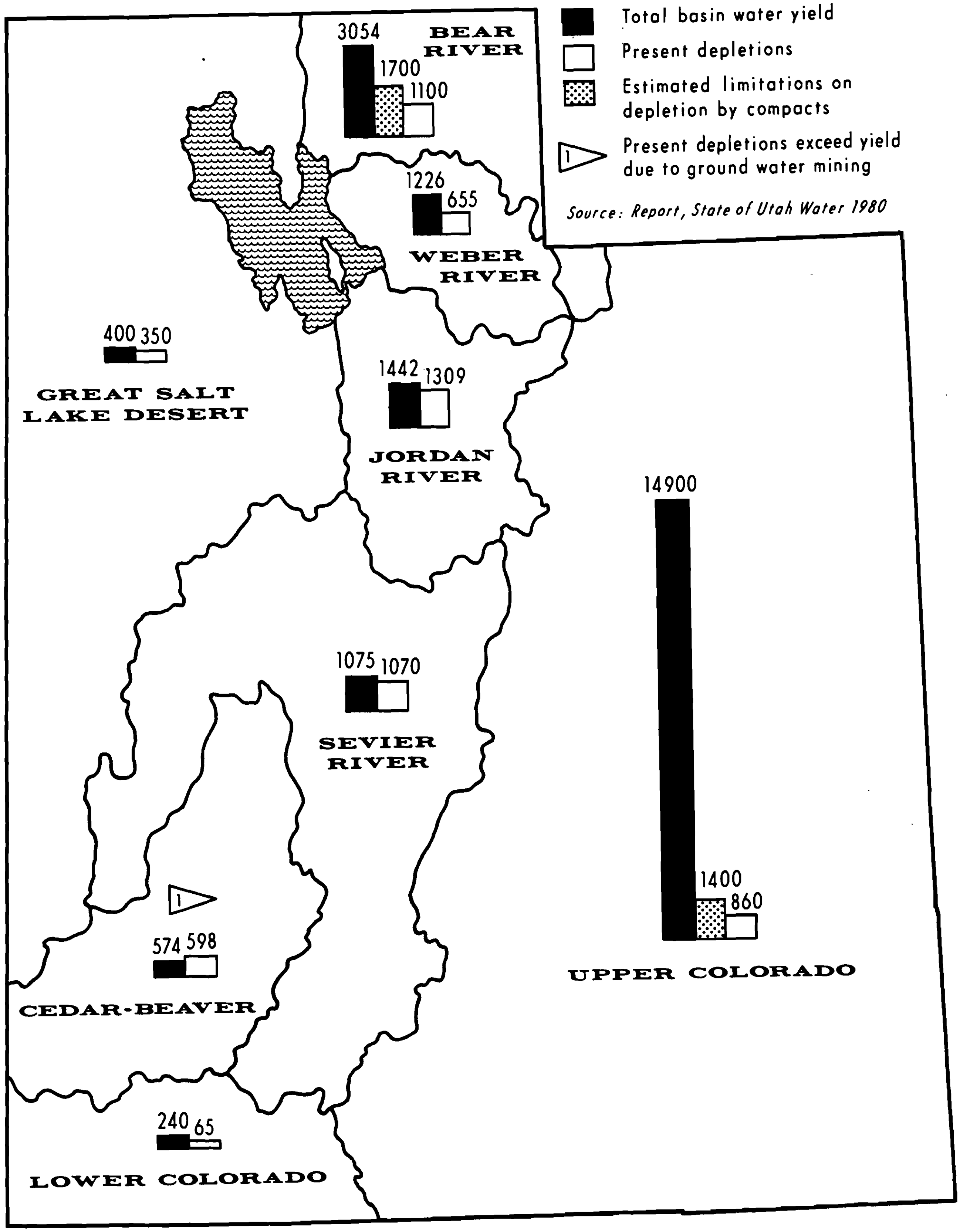
Ground water is generally considered a supply of last resort and is only used when surface sources are not available or have been depleted. Thus, in years of high precipitation, such as 1983 and 1984, use of ground water was reduced. The ten- and fifty-year trend is toward increased agriculture usage of ground water.

GROUND WATER ASSESSMENT

This assessment highlights the ground water issues of major importance to Utah agriculture. Due to the lack of data, detailed analysis is not possible; however, certain issues appear to be of more concern than others due to levels of activity and management practices. This assessment accents important issues and points to areas for further investigation.

AGRICULTURAL CHEMICAL USE

Chemicals used by agriculture in Utah do not appear to pose a major threat to ground water quality. Usage is less intensive than both in California and the mid-western corn-belt states. Only 2 percent of the land area of the State is harvested cropland and, of this, a low proportion is high-value crops



Source: Report, State of Utah Water, 1980

Map 1. *Utah basin water yields by hydrologic area in thousands of acre-feet.*

such as orchard and truck crops that may use heavy applications of agricultural chemicals. The remainder is devoted to hay and other forage crops. In 1982 the *Census of Agriculture* reported 1,118,486 harvested cropland acres in the State. Hay and other forage crops including small grains and silage corn accounted for 95 percent of this total. Expenditures by farmers in 1982 were $9 per acre of harvested cropland for commercial fertilizers and $5 per acre for other chemicals. These figures are relatively small when compared to other states.

The appearance of fertilizer or other agricultural chemicals in ground water depends upon their water solubility, persistence, the amount applied, time elapsed from application until significant rain or irrigation, soil characteristics, and proximity of point of use to ground water recharge areas. While the shallow aquifers may be supplied by agricultural subsurface drainage; the deep aquifers are often recharged at the interface between valley alluvium and the mountains and, thus, are not as likely to receive agriculture drainage water.

Nitrogen fertilizers are more likely to move into ground water than potassium because of their solubility and relatively higher application rates. Phosphate tends to attach to soil particles and thus would not be expected to migrate into an aquifer.

Annually, an estimated 55,000 tons of fertilizer product containing nitrogen in one form or another are applied to Utah agricultural lands. Approximately 20,000 tons of this total are actual nitrates. This is about 79 pounds per acre on the nonhay harvested cropland. Nitrogen application in Cache, Box Elder, and Utah Counties approaches the extent of use experienced in the corn belt states. Typical recommended application rates range from 200 to 300 pounds per acre for corn and high-yielding irrigated wheat down to none on alfalfa hay.

Nationally, nitrates have been found predominately in shallow aquifers. A recent survey of 3,301 wells in Utah by the U.S. Geological Survey indicated that 10 percent of those wells had nitrate concentration above three milligrams per liter (mg/l). A concentration above three mg/l was assumed to indicate the elevated concentrations resulted from human activities. There was no indication which contamination sources might be involved.

Utah has a moderate to low level use of agricultural pesticides relative to other states. Significant ground water contamination from this source does not presently appear to be a major problem. In a recent study of large fields in the Imperial Valley of California, the seasonal losses of insecticides were below one percent of the amounts applied. Seasonal losses of soil-applied herbicides were usually one or two percent of the amounts applied. With respect to possible ground water contamination, the study reported:

> *"Except for the pyrethroids, most of the pesticides were transported in the water phase. None of the pesticides were identified in tile drain effluents at concentrations above minimum detectable levels of one to two parts per trillion, indicating that most of the presently used pesticides are not sufficiently persistent, or they are not sufficiently mobile to reach ground water in the relatively heavy soils in the Imperial Valley." (Spencer, et al., 1985.)*

The use of pesticides on watersheds can be a possible source of ground water contamination. Of particular concern is the use of the nonselective herbicide picloram on forest and range. Picloram (Tordon) is persistent, water soluable, and highly mobile. An estimated 25,000 pounds of active ingredients were used in 1980 within the State.

The four most commonly used chemicals in Utah in 1980 were parathion (100,000 lbs.), atrazine (300,000 lbs.), 2,4-D (2,000,000 lbs.), and DCPA (200,000 lbs.). These chemicals would generally not be expected to adversely impact ground water under normal conditions. Parathion is a highly toxic insecticide which is usually applied as a fog or mist. This chemical has an extremely short life span and degrades quickly; it is used primarily in orchards. Atrazine is a herbicide used on broadleaf weeds in crops and in some rangeland application for control of thistles and cheatgrass. This chemical is toxic and is relatively persistent. 2,4-D is a commonly used herbicide for broadleaf weed control in a variety of situations. It is persistent; however, its toxicity level is low. DCPA is a herbicide for grass control and is labeled for home and garden use. It is very safe and has an extremely low toxicity.

SALINITY

Salt loading into ground water due to agricultural practices is a serious problem in the Upper and Lower Colorado and Great Basin Regions of Utah. Problems arise when salt is dissolved by irrigation water that is applied to fields and is carried into the ground water. There are both natural and man-induced salt problems that occur in Utah. The natural salt yield, due to precipitation-infiltration, i.e. ground water recharge, and ground water movement, may not be controllable. The man-induced salt problems relate to agriculture, industry, and other sources can be mitigated.

Certain types of bedrock and soils are sources of salinity that affect ground water quality in Utah. Late Cretaceous Mancos Shale outcrops are significant sources of salt contamination in the Colorado River Basin. Outcrops of Mancos Shale occur in the badlands along the Paria River, Fremont River, Kaiparowits Plateau, Price River, San Rafael River, and Dirty Devil River; the Mancos Shale underlies the Ashley Valley and the Price area. Outcrops of the gypsiferous Carmel and Summerville Formations also affect the water quality of runoff from the San Rafael and Dirty Devil Rivers. In the Great Basin the channel, gully and sheet erosion of numerous gypsiferous sediments, marine shales and salt bearing outcrops have a major effect on water quality. Critical salt contributing areas include outcrops of the Arapien Shale, Tropic Shale, Moenkopi, Chinle, Kayenta, Carmel, Curtis, and Sommerville Formations. Lake Bonneville sediments contain the greatest amounts of salt; however, most of this salt is located in the Great Salt Lake and the various playa lakes. These areas are not involved in agriculture or major ground water use.

The agriculturally derived salinity problems, directly relate to the use of ground water and surface water for irrigation purposes. Inefficiencies in the delivery and application methods during irrigation seasons contribute to an increase in deep percolation through salt-laden soils and rock. Irrigation water picks up salt as it passes across fields and carries it into streams and shallow ground water systems. Percolation of irrigation water may also result in the deposition of salts in the soil profile. Salinity may eventually become a barrier to economic production of any crop and can lead to the abandonment of irrigated land and the loss of food and fiber production.

The major ground water problems in Utah related to agriculture involve on-site, off-site, and regional impacts from increased salinity. The on-site problems involve salt migration into soil profiles and percolation of salt-laden water in the shallow aquifer systems. Off-site problems involve the increase in salinity in the deep ground water systems. Contamination of the deep aquifers with saline water derived from inefficient irrigation water management (excessive deep percolation) is a regional problem, especially in the Colorado River Basin.

In parts of the Great Basin and Lower Colorado River Basin of southwestern Utah the ground water regime has been altered and salinity within confined basins is increasing. Prior to ground water withdrawals, these basins were open and water flowed into and out of the basin. As ground water withdrawals increased, discharges from the basin have declined. The ground water is recharged from precipitation and from percolation of irrigation water. The irrigation water is higher in salt content and the recycling of this water is resulting in increased levels of total dissolved solids. This increasing salinity will become a problem for irrigators in the future.

Approximately 40 percent of the irrigated acreage (0.5 million acres) in Utah contributes to the salinity problem. Irrigation efficiencies within the State average between 21 percent and 35 percent. These efficiency figures indicate that there is a statewide need for irrigation water management improvement. (map 2, Irrigation Statistics.)

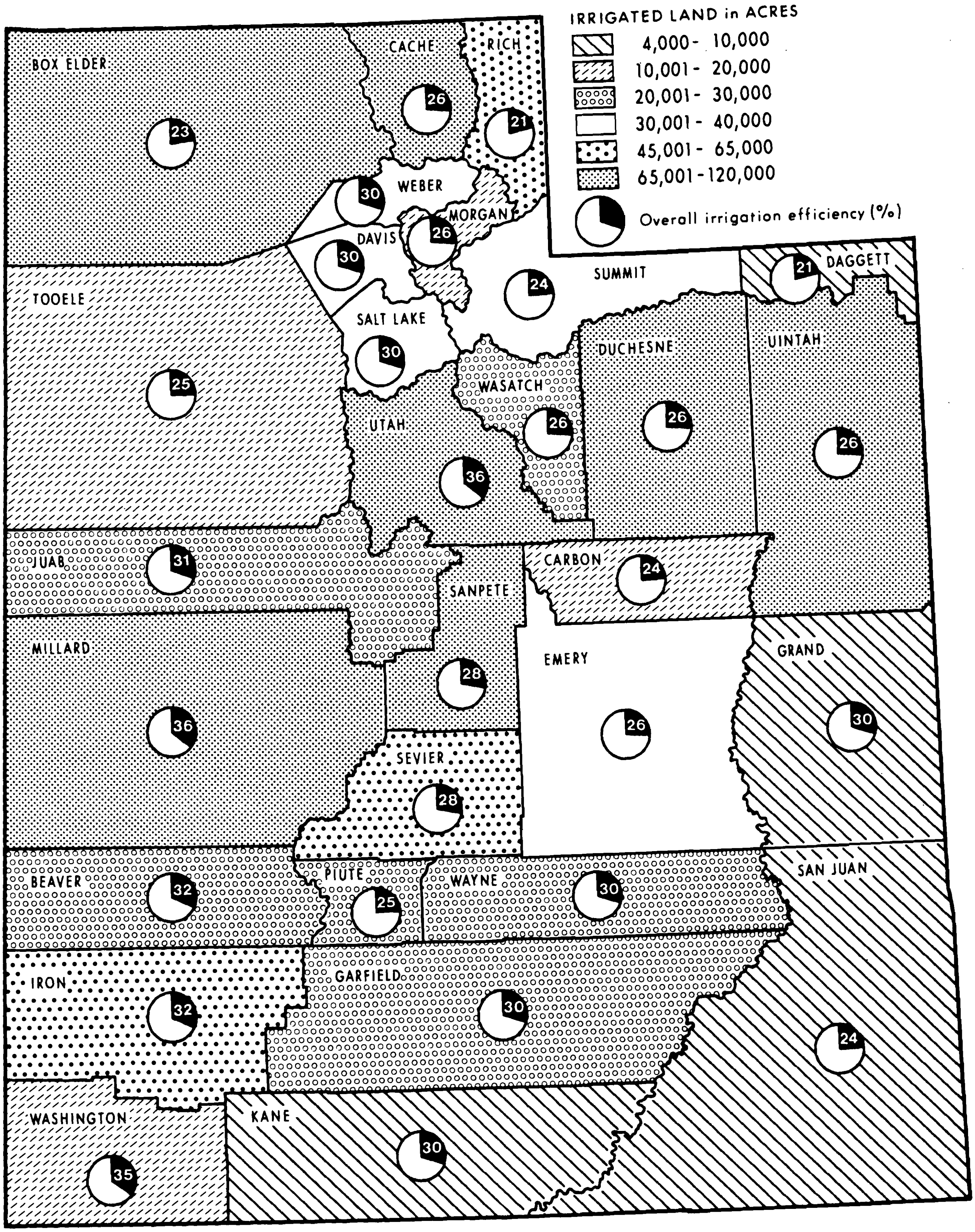
Realistic short-term goals for irrigation efficiency improvement are in the range of 35 percent for on-farm practices and 45 percent for targeted areas. A long-term goal of 45 percent for a Statewide average is attainable according to the U.S. Soil Conservation Service (SCS). The improvement of irrigation efficiencies will have a direct effect on the deep and shallow aquifers impacted by salt loading. This goal may be accomplished through education, information dissemination, and direct government agency support involving financial as well as technical support in the form of farm planning and engineering.

The SCS, working with State, local, and other Federal agencies, is currently involved in the fifth year of a 10-year Uinta Basin Salinity Program to lower salt yields to the Colorado River Basin. The Price-San Rafael Salinity Basin Program is in the initial stages of planning by the SCS.

CONCENTRATED ANIMAL FEEDING OPERATIONS

There are several geographic areas in the State where shallow ground water may be contaminated because of a combination of geology, high ground water conditions, and animal confinements and pasturing. These areas include Cache Valley, Heber Valley, the bench lands along the south slope of the Uinta Mountains in the Uinta Basin, parts of Beaver County, portions of Utah County and Salt Lake County, and perhaps some other small isolated areas. Septic tanks are also common in many of these same areas making it difficult or sometimes impossible to differentiate the source of pollution. More intensive site specific ground water monitoring would be necessary to confirm suspected contamination and identify pollutant sources.

A study in 1982-1983 by the U.S. Geological Survey (Seiler and Waddel, 1984) of the unconfined shallow ground water aquifer in Salt Lake Valley revealed nitrate-nitrogen concentrations ranging from 0.1 to 86 milligrams per liter with some of the highest concentrations occurring in wells near animal confinement areas. To date, culinary wells in the



Source: Utah Department of Agriculture Irrigation Statistics

Map 2. *Utah irrigation statistics*

COUNTY	Overall Irrigation Efficiency (Percent)	Onfarm Irrigation Efficiency (Percent)	Delivery System Efficiency (Percent)	Acres Irrigated Wells (1000's)	Acres in Group Systems (1000's)	Acres Irrigated Total (1000's)
BEAVER	32	42	76	8	20	28
BOX ELDER	23	28	82	30	87	117
CACHE	26	30	87	0	101	101
CARBON	24	29	82	0	14	14
DAGGETT	21	28	75	0	10	10
DAVIS	30	35	85	0	32	32
DUCHESNE	26	33	80	0	72	72
EMERY	26	30	85	0	37	37
GARFIELD	20	38	80	0	25	25
GRAND	30	35	85	1	3	4
IRON	32	38	84	31	17	48
JUAB	31	40	78	4	24	28
KANE	30	46	65	4	4	8
MILLARD	36	40	89	8	92	100
MORGAN	26	33	79	2	9	11
PIUTE	25	32	77	8	16	24
RICH	21	28	75	0	48	48
SALT LAKE	30	35	85	0	43	43
SAN JUAN	24	30	80	1	7	8
SANPETE	28	33	85	0	82	82
SEVIER	28	33	85	7	52	59
SUMMIT	24	30	80	17	23	40
TOOELE	25	32	78	7	11	18
UINTAH	26	33	80	6	73	79
UTAH	36	42	85	10	90	100
WASATCH	26	34	76	6	21	27
WASHINGTON	35	44	80	0	18	18
WAYNE	30	36	83	8	13	21
WEBER	30	38	8	0	44	44
STATE	28	37	80	158	1088	1246
	Weighted Average	Weighted Average	Straight Average			

Source: Utah Department of Agriculture Irrigation Statistics

Table 1. *Utah irrigation statistics*

Salt Lake Valley have not been impacted because they are drilled in the deep aquifer (100 feet or greater) and in accordance with Health Department regulations.

A study of the shallow ground water aquifer in the Benjamin Drainage District of Utah County by the Mountainland Association of Governments (MAG TWP #62) documented poor water quality with suspected sources being septic tanks and agricultural practices but was not able to differentiate the sources. The deep water was of excellent quality (MAG TWP #49).

In the Heber Valley, Fisk and Clyde (1981) stated that it is likely that nitrates, phosphorus, and other pollutants from animal wastes and irrigation return flow are reaching the shallow, unconfined ground water. This same situation probably could occur in other inhabited valleys of the State. In Cache Valley, for example, a number of communities and industries related to agriculture could be significant sources of shallow ground water contamination. According to the Bear River District Health Department, many of the small community culinary water systems as well as the many private wells in the Cache Valley area withdraw water from the shallow aquifer (less than 100 feet deep).

Water Rights

Utah law treats ground water essentially the same as surface water; i.e., water is the property of the State but can be appropriated for beneficial use by following specified procedures. In time of shortage, the earliest appropriator has priority of use.

Conspicuous by its absence is any reference to artificial recharge or conjunctive use. This is largely due to the fact that the most extensive ground water development has taken place in areas where there is no dependable surface supply that would lend itself to coordinated management. With increasing water use along the Wasatch Front, however, the time is rapidly approaching when additional legislation or administrative procedures will be needed to address artificial recharge and conjunctive use.

Rights of appropriators to artesian pressure, in addition to flow, were determined by a 1969 Utah Supreme Court decision. Dewsnup and Jensen (1973) summarized this as follows:

"Historically, under Utah law an appropriator who received water by artesian flow has been entitled to have this hydrostatic pressure maintained as part of the water right. . . . the court concluded that a user from a ground water basin does not have an absolute guarantee to hydrostatic pressure but must suffer some reasonable reduction in that pressure in order to assure maximum beneficial development . . . "

Ground water development in Utah has traditionally taken place only after all available surface water has been developed. Well drilling is fairly expensive and is not guaranteed to produce a usable supply. Unless there is artesian pressure, operational costs of pumping are high as compared to a surface supply. There has also been an innate distrust of a water supply which is not totally visible and which is subject to physical processes not fully understood by the layman.

Several factors will tend to increase the use of Utah's ground water supplies. First, improved location and drilling techniques have reduced the development costs and reduced the uncertainty in the eyes of many prospective users. Second, and perhaps more important, in many areas the surface water supply is essentially totally appropriated. Additional development would invariably require construction of costly facilities.

Other Issues

Several other issues related to ground water bear further note and consideration. Utah is a rapidly growing State and will depend heavily on its ground water resources in the future. As ground water is developed more care will be required to protect the quality and enhance the utilization of the resource. Urban development will conflict with agricultural land use and the same will be true for water use.

Water table levels are a constant public issue. During the past three years, high precipitation levels have recharged ground water systems. High water tables can flood agricultural fields, retard crop plantings, and kill some crops. However, high water tables can reduce the need for surface application of irrigation water during normal dry seasons by providing sub-irrigation to crops. Marshlands and other wetlands are maintined by high water tables. During years of low precipitation water tables decline and pumping costs increase. Many ground water systems are recharged from irrigation canals. As management of water improves, wetlands and other near surface ground water areas may dry up. Seepage from canal systems is also causing problems in areas where urban development is moving into traditional agricultural areas. Cases of basement floodings related to irrigation practices are isolated but numerous. Urban developments or farm field alterations may also block historic drainage channels and force surface supplies underground.

Current farm management practices for the control of soil erosion and water pollution may adversely as well as positively impact ground water. These practices, including terraces, conservation tillage, sediment basins, grass plantings, and berming encourage water to infiltrate into the soil and subsequently into the ground water. The magnitude and character of the impact to ground water from these practices directly relates to the infiltration rate of the soil. The lower the infiltration rate, the less chance for agricultural chemicals to reach the ground water and the greater the chance the chemicals will naturally degrade through exposure to the sun. The higher the infiltration rate of the soil, the greater the potential impact on ground water due to the lack of time to degrade. Surface runoff across fields and through manure piles is discouraged in favor of infiltration. The water carries into the ground some of the pollutants it contacted on the surface. The full impacts, both positive and negative, of these practices on ground water are unknown and have been given little attention to date. The main emphasis has been on reducing overland flow and contamination of surface water.

CONCLUSIONS AND RECOMMENDATIONS

Ground water investigation and protection is a relatively new area of concern. Some data has been collected to form the basis for policymaking, but it is difficult to determine the interrelationship between surface and ground water contamination. In many cases, surface water infiltrates into shallow aquifers, migrates a short distance, and resurfaces down gradient. In these cases the same controls to protect surface water would be adequate to protect ground water. In other areas ground water is confined in deep aquifers and requires special care and protection as recharge of these aquifers is slow and pollutants may be present for many years.

Agriculture has several concerns which relate to ground water. Agricultural chemicals have been shown to adversely impact ground water supplies in other states. These chemicals are not widely used in Utah, probably due to the limited amount of irrigated land, cropping patterns, and chemical costs. New farming practices may increase the use of chemicals in the future and there is a need to ensure that the timing, amount, and method of application of these chemicals is conducted in an environmentally safe manner. Certain chemicals used to treat the vast rangelands of the State may be of particular concern. There is a need to work with Federal, State, and private land managers to ensure that these range treatments do not adversely impact ground water supplies.

Salinity control efforts are ongoing in several areas of the State. Utah is a member of the Colorado River Basin Salinity Control Forum and is working to control salt loading of the River. The prime method for salinity control from agricultural lands is through increased delivery efficiency and irrigation water management. This is particularly true for the southwestern part of the State where ground water supplies are showing increased salinity levels due to recycling of water.

Confined animal feeding operations are faced with the difficult task of handling animal wastes. Surface streams are protected by the use of manure bunkers, lagoons, or berms. These structures result in the percolation of pollutants, particularly nitrates into ground water. Although there are few clearly documented cases of contamination from feedlots, inadequate monitoring programs may mask the severity of this problem.

Farmers and ranchers are concerned not only with maintaining water quality, but also with ensuring adequate quantities. Ground water is currently used only when surface supplies have been depleted. This is due primarily to the costs associated with well development and pumping. Continued growth in the State will undoubtedly lead to further development of ground water resources. The courts will be asked to define the rights of users as conflicts develop and guarantees of quantity, pressure, and quality will be at issue. Other conflicts arise when urban development moves into agricultural areas.

Many of the recommended solutions for the control of surface water contamination have adverse impacts on ground water supplies. To control surface runoff, water is forced to infiltrate through the soil profile. Surface pollutants that are contacted may then be carried into the ground water. In these cases, trade-offs must be made between surface and ground water contamination.

There is a clear need to document quality and uses in areas of major ground water development. This information would provide a basis for determining which ground water supplies require protection and how much protection should be provided. Sensitive areas may be identified and appropriate balances made for protection.

Utah has a system of 39 Soil Conservation Districts across the State that are responsible for managing and improving the natural resources within their respective jurisdictions. These districts are supervised by five locally elected representatives and are legal subdivisions of the State. The districts are currently used in programs to control water pollution from agriculture and to identify natural resource problem areas and implement solutions. The districts may also be a valuable resource in identifying sensitive ground water aquifers and implementing control measures. Many of the control measures required for agricultural problems are management-oriented and few structural measures are required. The districts are valuable in educating local citizens on problems and appropriate management techniques.

Ground water protection poses important problems for those involved in natural resource conservation and development. Farmers and ranchers across the State are front-line land managers and have a deep concern for the resources under their stewardship. The most important step in this effort will be identifying the site-specific concerns and educating those who have responsibility for implementing protection strategies. This may be accomplished through a joint cooperative effort of all concerned.

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HAZARDOUS WASTE

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INTRODUCTION

Recent public awareness of the adverse effects of hazardous waste disposal practices on human health and the environment has prompted a great deal of interest and concern regarding the past, current, and future handling of hazardous waste. This awareness has resulted in the development of protective measures to regulate current hazardous waste handling practices, the prevention of future discharges of hazardous waste, and the investigation and cleanup of uncontrolled and abandoned hazardous waste sites.

Hazardous waste handling and disposal practices in the State of Utah are regulated by the Utah Hazardous Waste Management Regulations (UHWMR), which are essentially equivalent to the Federal regulations governing hazardous waste under the Resource Conservation and Recovery Act (RCRA). In addition, the State of Utah investigates uncontrolled and abandoned hazardous waste sites in cooperation with the U.S. Environmental Protection Agency (EPA), under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Industrial growth in Utah results in a constant increase in the amount of hazardous waste generated in the State. In addition, past industrial activity has resulted in many abandoned disposal sites which are potentially hazardous. The proper handling of hazardous waste, and the investigation of past sites is essential to ensuring the protection of the citizens, environment, and ground water of Utah.

UTAH HAZARDOUS WASTE PROGRAM

Program Administration

The Utah Solid and Hazardous Waste Committee (the Committee) was organized under authority of the Utah Solid and Hazardous Waste Act (the Act), and was given the responsibility of creating and administrating the hazardous waste program in Utah. The Committee consists of nine representatives from the regulated community, and the public and private sectors, all of whom are appointed by the Governor with the consent of the State Senate. The Act provides the Committee with the authority to conduct the activities which are necessary to effectively direct the program. Some of these activities include authority to issue orders, to conduct inspections, and to promulgate and adopt rules.

The Committee's Executive Secretary is also the Director of the Utah Bureau of Solid and Hazardous Waste (the Bureau), which is a bureau of the Division of Environmental Health, Department of Health. The Bureau, through authority delegated to the Executive Secretary by the Committee, performs many of the Committee's routine duties, such as reviewing plans and permits, making inspections, and conducting compliance and enforcement activities.

Although the Executive Secretary has been delegated the responsibility for directing the program, the Committee retains authority over issues involving enforcement, permitting, and program modifications. Each month, the Committee holds a meeting during which time the Bureau makes recommendations regarding enforcement actions, plan approvals, program modifications, and such other business requiring Committee action. The Committee discusses the recommendation, providing time for a response by companies or individuals when appropriate. Decisions are made by the Committee, based on the discussion and presentations, which are in the best interest of the State.

Hazardous Waste Management Regulations

Utah received final authorization from EPA to administrate the State hazardous waste management program on October 24, 1984. In order to receive authorization, the State was required to develop a program that is essentially equivalent to the Federal program regulating hazardous waste under RCRA. The Utah Hazardous Waste Management Regulations (UHWMR) constitute the focal point of the Utah hazardous waste management program. They were developed as the equivalent to the Code of Federal Regulations Volume 40, Parts 260-267 and 270. These regulations are designed to ensure proper handling of hazardous waste, and protection of human health and the environment. The UHWMR identifies the types of wastes that are regulated, and the standards applicable to disposal, storage, treatment, and transport of hazardous waste in the State.

Wastes regulated under UHWMR fall into four basic categories; these include wastes from non-specific sources, wastes from specific sources, commercial chemical products, and characteristic wastes. The following list briefly describes each of these categories:

1. *Wastes from non-specific sources:* These wastes are a result of generic processes which could be employed in many different industries. For example; degreasing is a common process used by many industries, and results in the generation

of spent solvents. These spent solvents are listed as hazardous wastes from non-specific sources.

2. *Wastes from specific sources:* These wastes are a result of standard processes used in specific industries. For example, the separation of oil, water, and solids in the petroleum refining industry results in the generation of waste sludge that is contaminated with heavy metals and organics. This sludge is listed in the UHWMR as a hazardous waste from a specific source.
3. *Commercial chemical products:* Virgin chemicals which must be discarded fall in this category. An off-specification material which cannot be used for any other purpose and must be discarded is an example of a commercial chemical product that is considered a hazardous waste.
4. *Characteristic wastes:* Part II of the UHWMR specifies four tests which define a hazardous waste. These tests include ignitability, corrosivity, reactivity, and extraction procedure (EP) toxicity. If a waste fails one of these tests, it is considered a characteristic hazardous waste.

The combined categories of wastes from non-specific sources, wastes from specific sources, and commercial chemical products include a total of approximately 750 substances which are currently regulated by the UHWMR. In addition, many other wastes fail one or more of the characteristic tests, and must be handled according to the provisions of the regulations.

The regulated community includes generators, small quantity generators, transporters, and treatment, storage, and disposal facilities. Generators include any facility which produces more than 1000 kilograms of hazardous waste in a calendar month, or accumulates more than 1000 kilograms on site. These facilities are subject to full regulation under Part V of the UHWMR. Small quantity generators include facilities which generate less than 1000 kilograms of hazardous waste in a calendar month, and are subject to a reduced set of regulations. Facilities which transport hazardous waste are subject to the manifesting and transportation requirements of Parts IV and VI of the UHWMR. Treatment, storage, and disposal facilities are engaged in the business of handling and disposing hazardous waste. These facilities are subject to the most stringent requirements under the UHWMR.

The UHWMR defines the regulatory requirements for Treatment, Storage, and Disposal (TSD) facilities. These requirements are divided into two sections, interim status standards and permitting standards. When the RCRA hazardous waste regulations became effective, existing TSD facilities applied for interim status and were required to immediately comply with interim status standards (Part VII, UHWMR). Any TSD facility which begins operation after the effective date of the regulations must comply with permitting standards (Part VIII, UHWMR). The purpose of the interim status regulations is to provide a transitional period for existing facilities during which time hazardous waste disposal units can be upgraded or closed. Although permitting and interim status standards are very similar in many respects, some aspects of the interim standards are less stringent. Eventually, all TSD facilities will be required to comply with permitting standards, or close their hazardous waste disposal units.

Operational requirements for TSD facilities include design specifications, safety measures, inspection standards, contingency plans, personnel training plans, and ground water monitoring. Ground water monitoring is required at all facilities that engage in the land disposal of waste. These standards include the installation of monitoring wells up-gradient and down-gradient of the disposal unit in the uppermost aquifer, and the collection and analysis of ground water samples to determine the impact of a land disposal operation on the ground water. Facilities which detect contamination of the ground water must submit a plan to investigate the extent of contamination, and a proposal for remedial action at the site, that will prevent further release of contaminants and provide for clean-up of contaminated ground water and soil.

When the decision is made to close a hazardous waste disposal unit, there are basically two options available. All waste can be collected and transported to an approved disposal site, or the waste can be stabilized in place. The selection of a closure option is contingent on many factors including regulatory requirements, health and environmental impact at the site, and cost effectiveness of the various closure alternatives. Closure at land disposal facilities must include the sampling of ground water monitoring wells and evaluation of the impact of the disposal unit on ground water.

Closure of a hazardous waste management facility is typically very costly, regardless of the method of closure selected. Therefore, the regulations require the company to provide assurance that the necessary monetary resources will be available when closure is initiated. There are a number of possible financial assurance mechanisms outlined in the regulations, each of which is intended to insure adequate funds for proper closure of hazardous waste management facilities and protection of human health and the environment.

The manifest system under the hazardous waste management program provides a certified "paper trail" designed to insure proper handling of hazardous waste from generation to final disposal. The manifest regulations require generators, transporters, and treatment, storage, and disposal facilities to identify amounts and types of waste generated and certify that the waste arrived at the facility designated on the manifest. Proper use and monitoring of the manifest system assists in the prevention of illegal and irresponsible dumping of hazardous waste.

Hazardous and Solid Waste Amendments of 1984

On November 8, 1984, the U.S. Congress enacted amendments strengthening the Resource Conservation and Recovery Act. Many of these amendments were designed to address problems that have developed in the RCRA program. Some of the more significant changes are outlined below:

1. One of the new RCRA provisions directs EPA to promulgate regulations for generators of small quantities of hazardous waste. Previously, EPA regulated only those facilities generating more than 1000 kilograms of hazardous waste per month. Under the new law, facilities that generate at least 100 kilograms but less than 1000 kilograms per calendar month must comply with the regulations covering transportation and disposal of hazardous waste.
2. The reauthorization of RCRA also includes regulation of Underground Storage Tanks (UST). The UST program expands beyond the previous purview of RCRA because it applies to the storage of products as well as wastes. The UST program bans the installation of unprotected tanks, initiates a tank notification program, sets Federal technical standards for all tanks, coordinates Federal and State efforts, and provides for Federal or State inspection and enforcement.
3. The land disposal of hazardous waste will be banned unless EPA determines that the prohibition of one or more methods of land disposal is not required to protect human health and the environment. EPA was granted 24 months to make a determination regarding the land disposal of hazardous waste.
4. Hazardous waste landfills and surface impoundments must meet new minimum technology requirements which are designed to prevent ground water contamination.
5. Within 12 months EPA must make a determination regarding the need to regulate used oil.
6. Expands requirements for monitoring and cleanup of ground water at facilities holding RCRA permits.

The State of Utah currently does not have authority to administrate the reauthorization requirements. However, the State does intend to secure this authority as expeditiously as possible. During the interim period, EPA Region VIII will enforce these requirements.

The Utah Hazardous Waste Management program is in a constant state of review and revision. As more information is gathered and new problems identified, the regulations are amended and the program revised in an attempt to ensure proper handling and disposal of hazardous waste, and the prevention of ground water contamination.

Comprehensive Environmental Response, Compensation, and Liability Act

In 1985, Utah entered a cooperative agreement with EPA to investigate inactive and abandoned hazardous waste sites in the State under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Through this agreement, Utah was granted Federal funds to locate and evaluate sites which pose a potential threat to human health or the environment.

Once located, these sites undergo a Preliminary Assessment (PA). The purpose of the PA is to locate and consolidate any existing data or records on the site. If adequate information is collected through the PA to ensure the site is safe, it can be declared nonhazardous and dropped from consideration. However, if the site warrants further investigation, a Site Investigation (SI) or Remedial Investigation and Feasibility Study (RIFS) is conducted. An SI is generally conducted if existing information is incomplete or unreliable. The SI involves a more thorough record review than the PA, and usually includes the collection and analysis of samples from the site. A RIFS is conducted if the PA or SI reveals the potential for adverse impacts to human health or the environment. The RIFS is a detailed investigation of the site which includes analysis of all potential exposure pathways (including ground water) as well as analysis of feasible remedial actions. Based on the recommendations of the RIFS, a decision is made regarding which remedial design is most appropriate for the site. After the decisions are made, remedial activities are initiated.

The Hazard Ranking System (HRS) is a standardized scoring procedure designed to evaluate the relative impact of CERCLA sites on a national basis. This scoring method provides for an evaluation of the effect of hazardous sites on the population and the environment. Investigations include study of the ground water, surface water, and the air as potential exposure pathways. Also included is an evaluation of the fire or explosion hazard and documented cases of injury, illness, or death due to the hazardous site. After scoring, the site can be nominated for the National Priority List (NPL), which is used by the Federal government to allocate funds to the various sites for remedial cleanup activities.

All sites must be thoroughly investigated, and all hazards completely evaluated to determine the proper remedial activities at these sites. Remedial action at inactive and abandoned hazardous waste sites is essential to ensuring proper protection of the citizens and environment of Utah.

HAZARDOUS WASTE GENERATION IN UTAH

General Information

Industrial and commercial activity in the State of Utah results in the generation of large quantities and numerous types of hazardous waste. There are currently over 300 hazardous waste generators, more than 70 hazardous waste transporters, and approximately 40 treatment, storage, and disposal facilities in the State. In addition, there are an unknown number of small quantity generators which were virtually unregulated prior to the congressional reauthorization of RCRA. During the 1983 reporting year the generators and TSD's alone generated nearly 1,000,000 tons of hazardous waste in Utah. The vast majority of this waste was disposed or recycled within the State. It is apparent that improper handling of hazardous waste of this magnitude could quickly become a serious health and environmental problem.

According to the most recent (1983) report on hazardous waste generation in Utah, the majority is classified as characteristic ignitable waste, or corrosive waste. There are also a variety of wastes generated by petroleum refining and by the steel and iron industry. In addition, there are a number of spent solvents from non-specific sources generated by various industries in Utah.

Virtually all of these wastes contain metal or organic contaminants which are potentially hazardous to human health and the environment if handled improperly. These wastes have the potential to migrate, and contaminate ground water when spilled or improperly disposed.

The vast majority of hazardous waste generated in Utah originates at facilities located in the Wasatch Front region between Brigham City and Provo. However, other industrialized areas of the State, also have hazardous waste generators and disposal units. These include Cache Valley, the Uinta Basin, the Price area, and Cedar City. There are also a few generators located at various other sites throughout the State.

U.S. Pollution Control Incorporated (USPCI) is a large commercial hazardous waste disposal facility located approximately 80 miles west of Salt Lake City. USPCI is one of the few commercial disposal facilities in the western United States, and is therefore used by many hazardous waste generators throughout the region. In late 1984 through 1985 business at USPCI increased substantially as a result of large quantities of hazardous waste being transported into Utah. Virtually all of this waste is transported by truck or railroad, and is deposited in land disposal units at USPCI. Proper control and monitoring of the transport and disposal of hazardous waste at commercial facilities is essential to the protection of human health and the environment.

Remedial Investigations and Feasibility Studies are currently being conducted at three CERCLA sites in Utah. These sites include the Midvale Tailings, Olsen/Neihart Reservoir, and Portland Cement Co./Sites #2 and #3. Completion of the RIFS investigations at these sites is scheduled for early 1987. At that time an appropriate remedial activity will be selected and cleanup will begin as funds become available. In addition, a number of military installations in Utah are conducting investigations of abandoned disposal sites.

Also, there are approximately 150 sites in the Preliminary Assessment/Site Investigation of a current CERCLA study. These sites include a variety of disposal activities, many of which are a result of mining activities and the processing of ores in smelters and leaching operations. If the PA/SI at any of these sites reveals a need for further investigation, the sites will be proposed for future RIFS investigations.

Disposal Practices

Land disposal is currently the most common method of hazardous waste disposal in Utah. The most common types of land disposal include surface impoundments, landfills, and land treatment facilities. Alternative methods of disposal include incineration, or treatment to render the waste non-hazardous.

Surface impoundments are defined as topographic depressions, excavations, or diked areas designed to hold an accumulation of liquid wastes. Surface impoundments are frequently used in Utah for the storage of waste sludges from the petroleum refining industry, and the disposal of pickle liquor and other corrosive wastes in the steel and metal processing industries. Surface impoundments are also occasionally used for the disposal of organic solvent wastes from degreasing processes. All of these wastes are typically contaminated with heavy metals or hazardous organics that may contaminate ground water.

The ability of an impoundment to prevent the migration of contaminants is strongly dependant on the location and design of the unit. Many impoundments constructed in the past were merely excavations built without synthetic or natural liners. Modern impoundments are usually designed to include liners which inhibit the migration of liquids into the subsurface. However, extreme care must be exercised during construction to ensure the proper function of the liner. In addition, the problem of leaking surface impoundments can be drastically reduced by locating the unit in areas that have favorable environmental and hydrogeologic conditions.

There are currently 18 RCRA facilities in Utah which use surface impoundments for disposal or storage of hazardous waste. There are also a number of CERCLA studies which include the investigation of abandoned surface impoundments. Monitoring data has demonstrated ground water contamination resulting from the migration of contaminants from several impoundments. In addition, there are many more impoundments which are suspect, and which are currently under investigation to determine the integrity of their containment systems.

Land treatment is a method of land disposal commonly used in the oil refining industry. The purpose of land treatment of hazardous waste is to render the waste non-hazardous through chemical or biological degradation processes in the soil. The procedure involves the application of oily waste to the land surface, and the enhancement of the chemical and microbial activity. The microbial activity breaks down organic compounds and leaves the inorganic compounds as a stable component of the soil. When properly designed, constructed, and managed, land treatment facilities may be an effective method of hazardous waste disposal. However, improper management can result in the migration of organic contaminants and heavy metals to the ground water. In addition, heavy metals will always remain after closure of the unit in greater concentrations than in the natural soils. There are currently three land treatment facilities in Utah, and ground water monitoring at one of these units indicates contamination of ground water due to the treatment process.

Landfills are also commonly used for the disposal of hazardous waste. The Utah Hazardous Waste Management Regulations define a landfill as a means of land disposal, a surface impoundment, or an injection well. Most landfills are earthen structures, similar to surface impoundments, in which drummed or solidified waste is placed in the structure and covered with soil. Landfills are not a common method of hazardous waste disposal in Utah, however, USPCI operates three large landfills at their Grassy Mountain Facility and plan to open nine more. The primary purpose of a landfill is to isolate the waste in a stable, encapsulated unit. Improper landfilling and the natural deterioration of containers can result in leaking of hazardous waste into the landfill matrix, and eventual migration to the ground water. Recent studies indicate that even properly designed landfills will eventually fail, resulting in contaminant migration and ground water contamination.

The UHWMR requires ground water monitoring capable of immediately detecting the release of hazardous constituents to the environment from land disposal facilities. These systems usually consist of a single monitoring well up-gradient of the disposal unit and three monitoring wells down-gradient. Samples are collected from all wells and analyzed for specific parameters, and laboratory results are statistically compared to determine the impact of the disposal unit on ground water.

Ground water monitoring at many land disposal facilities in Utah has demonstrated contamination due to the disposal unit. It is perhaps unreasonable to assume that all land disposal can be totally eliminated, however measures to reduce the amount of waste generated will significantly assist in solving the problem of ground water contamination at land disposal sites. In addition, proper design, construction, siting, and monitoring of these facilities will help ensure protection of Utah's ground water resources.

EVALUATION OF UTAH HAZARDOUS WASTE PROGRAM

PROBLEMS

Implementation of the UHWMR has revealed a number of problems which impair the ability of the program to effectively protect Utah's citizens, the environment, and the ground water. A detailed explanation of these deficiencies requires technical and legal explanations which are beyond the scope of this report, however the major problems are briefly summarized in the following paragraphs.

Utah has a unique problem in that large volumes of ground water are very saline and therefore not currently useful as a potable water supply. Industry will thereby justify further degradation of the saline ground water through the addition of contaminants. This results in controversy between the State and the regulated community with regard to the need to protect these resources.

Closure of a hazardous waste disposal facility typically will include establishing standards or monitoring criteria which will trigger corrective action or clean up of contaminated ground water and soil. The absence of guidance regarding the potential health effects of many contaminants due to chronic exposure renders the task of establishing standards very difficult. In the absence of guidance, the standard is usually set at the background level. In the case of organic contaminants, it is typically zero. This situation results in a great deal of controversy regarding the appropriate clean-up standards for contaminated ground water and soil.

The Bureau has encountered situations where contaminated ground water discharges to a surface water body. The emergence of contaminated ground water results in an increase in human and environmental exposure to hazardous contaminants. However, the Bureau does not have authority to regulate contaminated surface water.

Siting criteria in the UHWMR for a permitted hazardous waste disposal facility only includes seismic and floodplain considerations. The regulations do not include siting provisions to protect ground water in environmentally sensitive areas.

While emphasis is placed on hazardous waste land disposal in the UHWMR, it is perhaps the least desirable management option. Ground water monitoring has demonstrated contamination at many land disposal facilities in Utah and throughout the nation. Congress recognized problems inherent with land disposal and included a mandate in the RCRA reauthorization which requires EPA to investigate the banning of land disposal of hazardous waste to ensure protection of human health and the environment. Total elimination of land disposal is probably unrealistic with current technology, however the investigation of alternatives such as volume reduction and recycling should be encouraged.

Hazardous wastes identified in the regulations are subject to the requirements of UHWMR. Although hazardous wastes commonly produced by industry are included, there is a myriad of hazardous substances which are not currently subject to control when discarded. Improper handling of hazardous wastes not subject to regulation, may lead to environmental damage and ground water contamination. The EPA has authority to evaluate potentially hazardous wastes and add these wastes to the listing, but this process is slow and cumbersome.

The UHWMR excludes those wastes derived from the extraction, beneficiation, and processing of ores and minerals. This exclusion includes many mining wastes which are known to be hazardous. CERCLA investigations include mining-related activities, and hazards created by improper waste handling. There are also other exclusions which limit the ability of the program to effectively monitor all hazardous waste.

Monitoring, investigating, and closure of hazardous waste disposal facilities is usually resource intensive in terms of both personnel and funding. At many sites cost is the primary factor prohibiting the thorough cleanup of a hazardous situations.

RECOMMENDATIONS

The hazardous waste program in Utah has encountered many problems as it has evolved and progressed. The following measures are proposed to address these problems, and assist the Bureau in protecting Utah's ground water resources from contamination by hazardous waste:

1. Develop a statewide policy which establishes protection standards for Utah's ground water resources. These standards should be based on the naturally existing chemical quality of the ground water and should consider future uses. Establishment of this policy provides the State with a basis for discussion of ground water clean up and corrective action at facilities where ground water contamination has occurred. In addition, the policy would provide the State with the ability to prevent improper siting of facilities in areas where potable ground water supplies could be impacted.

2. Establish ongoing communication between agencies that have authority to protect both ground water and surface water. The primary goal of the State's environmental protection program is to ensure the protection of Utah's resources. The complex interconnection between ground water and surface water mandates communication between agencies in order to ensure proper protection of all of Utah's water resources.
3. Establish a program to educate and inform communities, government agencies, and the private sector regarding their responsibilities for hazardous waste management and the protection of the water resources.
4. Activities such as waste minimization, recycling, neutralization, treatment, incineration, and energy recovery should be encouraged. This will result in a reduction of the amount of hazardous waste which must be discarded, and a consequent reduction in the risk of ground water contamination.
5. Continually evaluate and update the hazardous waste program to incorporate innovative modifications and adopt regulations that will assist in the protection of Utah's ground water.

REFERENCES

Report on Hazardous Waste Generation and Disposal in Utah; 1983; Utah Bureau of Solid and Hazardous Waste.

Utah Hazardous Waste Management Regulations; Utah Department of Health, Division of Environment Health.

Utah Solid and Hazardous Waste Act; Title 26, Chapter 14, Utah Code Annotated 1953, as amended, 1981.

Mining and Mine Facilities

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INTRODUCTION

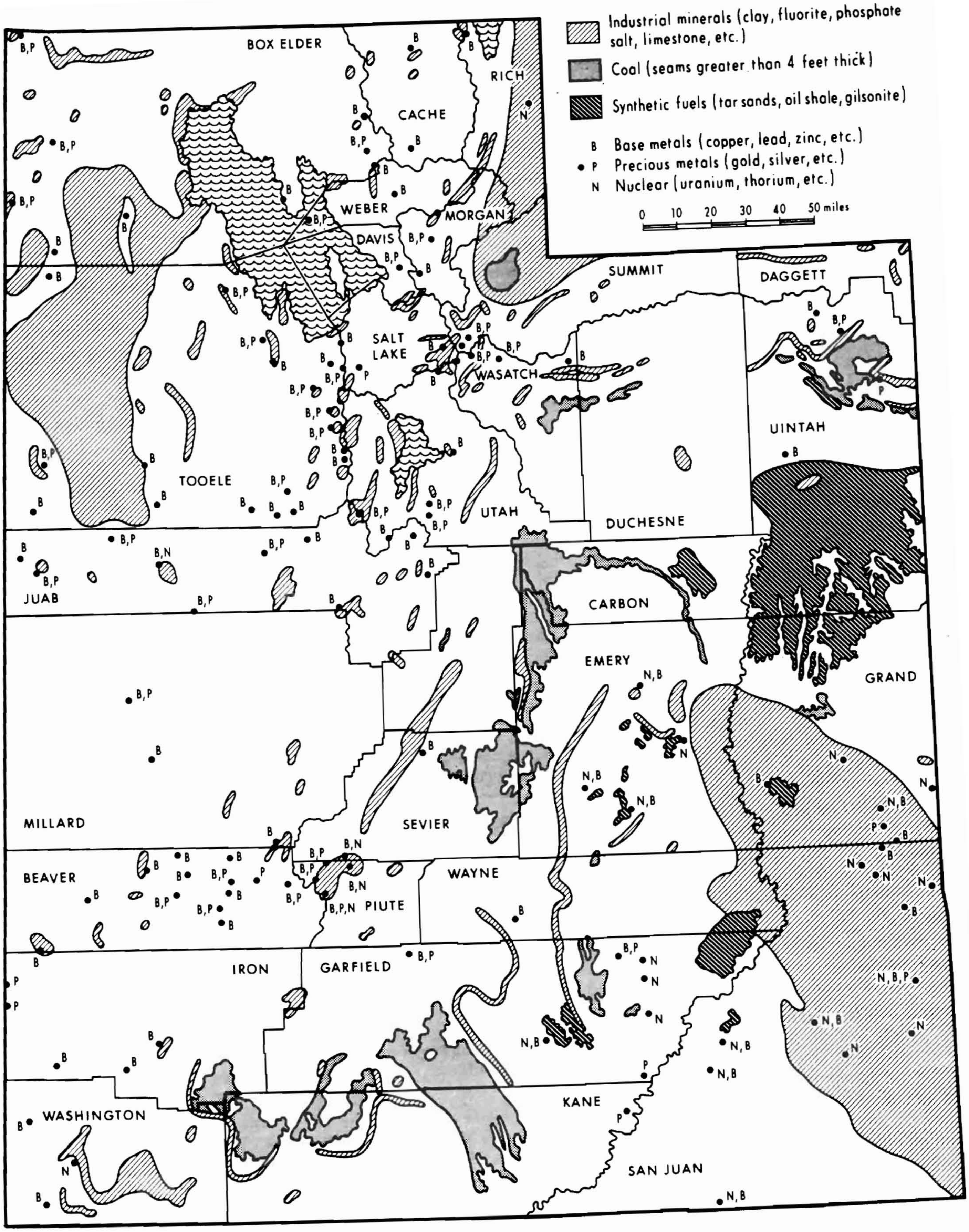
IMPORTANCE OF MINING TO UTAH'S ECONOMY

Utah's rich endowment of mineral deposits is inextricably entwined with the State's economy. Mining in Utah began in 1849 with the discovery of iron ore near Cedar City, Utah. Coal was found near Coalville in 1850, and gold and silver were discovered near Bingham in 1863. The coming of the railroad in 1869 secured Utah's position as one of the nation's principal metal producing states.

Utah's base and precious metal deposits include iron, copper, lead, zinc, gold and silver. Major ore deposits are located in the Oquirrh Mountains, Tintic Mountains, San Francisco Mountains, central Wasatch Mountains, and Cedar Valley. Metals such as antimony, beryllium, mercury and vanadium are mined primarily in west-central and central Utah. Uranium has been mined in southeastern and southern Utah. Coal is mined in central, east-central, and southern Utah. Oil shale and tar sands are found in the Uinta Basin and eastern Utah. Nonmetals including phosphate, potash and fluorspar are found primarily in the southern Uinta Mountains and east-central Utah. Abundant deposits of sand and gravel are present along the shore edge of ancient Lake Bonneville. Dimension stone and limestone are available in most parts of the State.

Figure 1 locates past, present, and potential future mining areas in the State of Utah. There have been approximately 2,000 significant-sized mines in the State over the past 130 years. The total estimated value of mineral commodity production in Utah for 1983 is almost one billion dollars (table 1). The leading commodities are copper, coal, gold and silver. Most of the copper, and significant amounts of gold and silver were produced by Kennecott Corporation from the Bingham Mine, which closed temporarily in 1985.

As an important part of Utah's economy, mining provides jobs, raw materials for manufacturing, and coal and uranium for power generation. Of the 91 minerals and materials used in our everyday lives, 65 are mined in the State. In 1980, Utah was ranked ninth in the nation by the Bureau of Mines in overall production of minerals, placing it above its neighboring states of Idaho, Wyoming and Nevada.



Compiled from: Doelling, 1983; Bullock, 1980; Ritzma, 1979 and Doelling, 1982

Figure 1. *Past, Present and Potential Mining Areas of Utah.*

Table 1. *Utah Mineral Production and Ground Water Problems*

Mineral	*1983 Market Value[1] or Quantity*	*Ground Water Problems[3] or Comments*
Copper	$309.8 million	Process water and leachate have a low pH creating disposal problems. Sulfate plume at Kennecott Mine.
Coal	$287.6 million	Mine water commonly has a low pH and high dissolved solid content creating disposal problems.
Potash — Salt	$23.2 million	Possible injection and extraction well failure, may cause leakage into other aquifers.
Beryllium	NA[2]	Mines commonly have water and tailings with a high dissolved solids and uranium content.
Uranium & Vanadium	NA	Mines commonly have water and tailings with a high radioactivity level.
Gold & Silver	$100.2 million	Many mines commonly have water and tailings with a low pH, and a high mercury or cyanide content.
Gilsonite	NA	Mine water has a high pH, creating disposal problems.
Lead & Zinc	NA	Mines commonly have water and tailings with a high dissolved solids content and a low pH.
Molybdenum	NA	Present production is mainly a by-product of other operations. Future mines may produce water with a low pH and a high dissolved solids content.
Limestone & Dolomite	$15.1 million	No known problems.
Phosphate	NA	Large deposits available for mining. High sulfate and dissolved solids level in ground water probably naturally occurring.
Stone	$10.0 million	Open quarries invite dumping of refuse by local residents.
Clay (Fullers earth)	$0.99 million	No known problem.
Oil Shale & Tar Sands	NA	Production is in pilot stages. Problems expected with disposal of water and tailings that may have a high metal or dissolved solids content.
Gypsum & Anhydrite	$2.4 million	Gypsum residue at processing plants and mines is sufficiently soluble to be leached and carried to the water table.
Alunite		No known problems associated with abandoned mines.
Iron		No known problems associated with abandoned mines.
Sand & Gravel	$14.9 million	Open quarries invite dumping of refuse by local residents.

Table 1. *Utah Mineral Production and Ground Water Problems* (continued)

Mineral	*1983 Market Value[1] or Quantity*	*Ground Water Problems[3] or Comments*
Mercury	NA	Production small. Tailings and waste water commonly have a high dissolved solids content.
Magnesium & Lithium	NA	No known problems associated with production at Great Salt Lake.
Manganese, Fluorspar		Very limited production in past.
Barite, Antimony and Sulfur		Problems not known.

[1]Utah Geological and Mineral Survey Notes, Utah Mineral Production Summary, 1983.
[2]Not available
[3]From unpublished data

Overview of Mining and Mineral Processing Methods

Utah's diverse landscape encompasses and accommodates a variety of mineral resources and mining methods, all of which interact to determine the degree of potential impacts on the environment. Mining activities involve surface and subsurface disturbances and thus, impacts to ground water quality and quanity are unavoidable. Mining and mineral processing disturbs the soil and produces large volumes of wastes. The nature of wastes and the potential contaminants are diverse and highly dependent upon the composition of the mineral deposit and the mineral extraction process. Because mine spoils are generally of large volume and low hazard, Congress exempted mining and processing of ores and minerals from provisions of the Resource Conservation and Recovery Act (RCRA). These provisions are being reviewed and will likely be narrowed.

Mines in Utah are often located in relatively remote locations. Major waste disposal and primary mineral processing activities generally must be located in close proximity to the mine, due to the cost of moving materials. Thus, siting options for facilities are limited.

Conventional underground mining includes:

Self-supporting openings: open-stopes, room-and-pillar, sublevel stoping, shrinkage stoping, stull stoping. These are usually completed in strong, competent rock and leave permanent openings.

- *Supported openings:* cut-and-fill stoping, long-wall mining, short-wall mining, top slicing, square-set and fill stoping. These methods use backfill (broken rock, tailings), broken and caved roof materials, or artificial supports (timbers, etc.).
- *Caving methods:* sublevel caving, block and panel caving. These methods are adapted to weak, massive ore bodies and require that large volumes of rock slowly cave when ore is withdrawn from below.

Surface mining methods include:

- *Open pit:* single and multiple bench pits, strip mining, and glory-hole mining. Surface mines are not extremely deep and often do not intercept ground water in Utah.
- *Placer mining:* these are usually located in unconsolidated or semiconsolidated sands and gravels in active or ancient stream beds.
- *Brine recovery:* uses evaporation ponds in and near the Great Salt Lake. The evaporites are then mined out of the ponds.

Solution mining includes:

- *Hot-water solutioning:* dissolves bedded salt and potash.
- *In situ leaching:* uses acid or other leaching solutions such as ammonium or sodium carbonate to mine uranium and copper.
- *High velocity jetting:* utilizes high pressure water jets to mine uranium.
- *Dump and heap leaching:* uses chemicals to

mine copper, uranium, precious metals from low-grade ore.

Processing of mined materials includes:

- *Concentrating, smelting and refining:* wastes from processing may be slag or simply a ground-rock slurry fed into tailings ponds or refuse piles. In addition to the constituents originally in the mined material, wastes may contain sulfuric acid, alkaline solutions (e.g., lime or sodium carbonate), cyanide (e.g., gold and silver operations), organics (e.g.,from retorting wastes), oil and grease, trace metals, pyrites, and salts (e.g., coal cleaning). The type of wastes from mineral processing is highly dependent upon the minerals and the extraction process.
- *Physical treatments:* crushing, grinding, washing, sizing, cleaning, magnetic separation, etc.
- *Other processes:* flotation, hydrometallurgy, pyrometallurgy, solar concentration of brines, retorting, and in situ retorting.

POTENTIAL IMPACTS ON GROUND WATER RESOURCES

CONTAMINATION OF GROUND WATER RESULTING FROM MINING ACTIVITIES

Contamination of Ground Water Resulting from Weathering of Certain Minerals

The mining of commodities associated with sulfide, radioactive, or toxic minerals, or of minerals which require leaching, pose a threat to ground water (table 1). Ground water contamination has not been a problem with the production of sand and gravel, clay, stone, limestone and dolomite.

Sulfide minerals are commonly associated with deposits of copper, silver, gold, lead, zinc, mercury and coal. Sulfide minerals may oxidize and form sulfuric acid when exposed to air and moisture. Many metal compounds are soluble in the resulting acid solutions. Sulfuric acid is rapidly neutralized by reaction with limestone or other carbonates present in the soil, tailings, or mine walls. The result is generally a highly soluble sodium sulfate solution and an increase in dissolved solids in the surface and ground water.

Sulfate minerals entering the ground water system in large quantities down gradient from large mining and leaching operations can create a major problem. Plumes with high concentrations of sulfate are present in the ground water beneath a wide area in the Jordan Valley, down gradient from the Bingham Copper Mine (Hely, et al, 1971). Much of this water exceeds the maximum allowable sulfate concentration and is unsuitable for drinking purposes.

Contamination of Ground Water Resulting from Coal Preparation

Water is used in coal preparation plants for washing, sizing, and cleaning the coal. New technology allows the recovery of very fine coal particles which previously were discarded as waste into streams or other disposal areas. Recent mining and reclamation water quality protection laws require that sedimentation ponds be constructed to treat water from preparation plants prior to discharge into receiving waters.

Pyrite and other sulfide and sulfate compounds, although typically present in low concentrations in Utah coal, are exposed to air and water by crushing, grinding and washing. Sludges containing pyrite, shale and other material from the washing and cleaning operations are slurried into ponds for dewatering with the supernatant water recycled back to the plant. Coarser debris and refuse is disposed of in refuse disposal piles. These discarded wastes contain sulfide compounds that, when exposed to weathering processes, may contribute to acidification of the ground water resource. In Utah, data from coal mining operations do not indicate that this phenomenon is widespread. Instead, pH levels in monitoring wells are typically greater than neutral or slightly alkaline, ranging between 7.5 and 8.5.

Limited monitoring of ground water does not indicate the presence of acidification or contaminants down gradient from preparation plants, even though at older plants the ponds and refuse piles were not located with a consideration of the ground water regime. This is not to say that a problem does not exist but that data collected to date do not indicate contamination above naturally occurring levels for major constituents. It is likely that acids formed by weathering of pyritic material are neutralized by carbonates or buffered by bentonitic clays in the bedrock.

Contamination of Ground Water Due to Certain Types of Mining Activities

The mining method by which deposits are recovered has a direct bearing on the potential for ground water impacts:

Underground workings: Ground water problems caused by underground workings include acid mine drainage (AMD), and increased content of heavy metals, total dissolved solids, and sulfate. Also in underground workings, nitrate levels may increase in mine water because explosives contain nitrates. Radium is often precipitated in uranium mines by dewatering operations. The amount and rate of sulfuric acid formation, and the quality of water discharged, are a function of the amount and type of pyrite in the overburden rock and ore, time of exposure, characteristics of the overburden, and amount of available water (Moth et al. 1972).

The transformation of pyrite to soluble iron and sulfuric acid is characterized by the following reactions. Equation 1 shows the oxidation of pyrites, such as ferrous sulfide. The primary products of the reaction are ferrous sulfate and sulfuric acid, which react to generate ferric sulfate (equation 2). The ferric sulfate reacts with water to form ferric hydroxide (yellowboy) and sulfuric acid which feeds the reaction (equation 3).

(1) $2FeS_2 + 2H_2O + 7O_2 \longrightarrow 2FeSO_4 + 2H_2SO_4$

(2) $4FeSO_4 + 2H_2SO_4 + O_2 \longrightarrow 2Fe_2(SO_4)3 + 2H_2O$

(3) $Fe_2(SO_4)_3 + 6H_2O \longrightarrow 2Fe(OH)_3 + 3H_2SO_4$

The predominate metals that occur as sulfides and sulfates are: antimony, arsenic, cobalt, copper, iron, lead, mercury, molybdenum, nickel, silver, and zinc. During the actual mining process, AMD is usually not significant and water from mine dewatering activities is usually discharged to holding, settling, or treatment ponds. The water is subsequently discharged in accordance with applicable point discharge regulations, i.e., NPDES permits. AMD may become significant after workings are closed.

The formation of sulfuric acid, causes the solubility of other metals and compounds to increase. Thus, AMD may contain a variety of ions, including aluminum, manganese, zinc, cadmium, and lead. The primary problem associated with AMD is the contamination of water otherwise suitable for recreation, public consumption, agriculture, and industry. In Utah, AMD is not a major surface water problem, although it is associated with some abandoned metal mines. Alkali soils, bentonite, water, overburden, and carbonate rocks prevalent in Utah rapidly neutralize or buffer most acid as it is formed. Metal compounds dissolved by the acid water are insoluable in neutral solutions and rapidly precipitate. However, the neutralization of the acid produces soluble salts and results in an increase in dissolved solids, primarily sulfate, which is undesirable. Most water pumped from mines contain suspended solids that are removed by settling before discharge.

Surface mine excavations: Ground water in disturbed materials can be subject to quality changes due to oxidation of sulfides and formation of sulfuric acid.

Solution mines: Potash, sulfur and salt mines are usually overlain by impermeable and relatively competent cap rocks. Evaporite minerals do not form aquifers due to their low permeability. Leaching of uranium has not been widely practiced in Utah, but programs usually involve aquifer restoration activities. In situ leaching for metallics has also not been widely practiced, usually because the host rock has low permeability and porosity.

Brine recovery: These operations involve solar concentration of salt water in surface ponds. The ponds are usually constructed with material of a low permeability over areas where the natural ground water is saline.

Waste rock dumps: Overburden and waste rock removed during mining are generally left near the mine. Waste rock contains minerals that are at concentrations below the economic level for processing. This rock may contain sulfides which will oxidize if sufficient percolating water is available. Acid forms in waste rock dumps in the same manner as in mine workings. Usually, acid formation from waste dumps is not a significant problem in Utah because the climate is arid, and the acid is rapidly neutralized by carbonate rocks. However, percolating water may acquire dissolved solids which may subsequently leak into streams and underlying aquifers.

Dump leaching: Secondary recovery of metals from waste rock containing low levels of mineralization is practiced by percolating acidic waters through mine dumps. Leaching has historically been practiced on dumps which have not been specifically prepared to minimize seepage losses, and the process relies on low permeable soils or liners to collect leach waters. Ditches and ponds used for collecting and holding acidic water may allow significant seepage, and thus contaminate the ground water. Acid formation may continue to occur as long as water is added. Neutralizing a large dump is extremely difficult. Generation of acid may be stopped by withholding water or by the addition of basic materials. The latter technique is difficult and has not been proven on a large scale.

Heap leaching: Heap leaching is practiced in gold and uranium recovery operations because leaching of low grade ore is very economical. In this process, sulfuric acid or cyanide solutions are applied to low grade ore or to mine waste dumps and allowed to percolate through the material. The pregnant solution is then captured and processed to extract the metals. Since it is to the mining company's economic advantage to collect as much of the pregnant solution as possible, collection structures are carefully designed. Therefore the potential for ground water contamination from heap leaching is low. However one problem associated with heap leaching is the leaching process itself, which can be difficult to stop. Mitigating measures, if the dumps occupy a fairly small area, are to cover the dump with impermeable materials, plant vegetation, and construct seepage collection structures.

Low grade silver and gold ores are leached by percolating a basic sodium cyanide solution through the broken ore. The pregnant solution is then collected and processed to recover the metals. Because cyanide is highly poisonous, synthetic liners are required to be placed under the leach pads and collection ponds. New facilities are to have double liners and leak detection systems. Following the conclusion of operations, the cyanide should be neutralized.

Tailings disposal areas: Tailings are the wastes and waste rock remaining after concentrating the primary minerals. Tailings are usually transported and deposited in a water slurry. Since tailing deposits typically are very large, contain large volumes of water, and in the past have not been constructed with impermeable liners, seepage of water high in metals, total dissolved solids, and sulfate is likely. The composition of the waste is dependent upon the mineral processing. For example, some iron concentrators use strictly physical separation, that is, crushing, grinding, and magnetic separation. The resultant tailings are innocuous. In other cases, acid or cyanide is used in the slurry process and these products can seep from unlined ponds.

Holding ponds: Mining operations often use ponds for holding the water from processing plants, mine dewatering, and leaching operations. Most of the ponds constructed prior to the 1970's or early 1980's do not have clay or synthetic liners. However, some ponds that were constructed to receive pregnant leach solution, to recycle water, or to collect water of exceptionally poor quality, were lined.

Holding ponds at abandoned mining operations may be contributing to ground water contamination (table 2). Surface runoff entering an abandoned pond may leach sulfide wastes and carry dissolved metals and sulfate to the ground water.

Retorting wastes: These wastes may contain residual organic materials and sulfides. Spent shale is usually low in permeability, and, if kept reasonably dry, should not generate harmful contaminants. In situ retorting may produce contaminants in saturated earth materials. The potential for ground water contamination is also dependent upon subsurface geologic conditions at the site.

Smelter wastes: Although smelters are associated with mining, they are not regulated in Utah as mining operations. Wastes include slag, emission dusts, sludges, acid plant blowdown, and waste water. Dry slags and dusts may contaminate ground water when exposed to moisture from precipitation or run off. Acid ponds and sludges have a greater potential for contamination. Ground water contamination from waste at smelter sites is treated in this ground water report under the hazardous waste section.

Table 2. ***Inactive and abandoned Mine and Mill Tailings and Holding Ponds***

Site	*Location*	*Ground Water Problem or Threat*
AEC Mill Site	Monticello San Juan County	· Carbonate tailings pile. · Vanadium tailings. · Acid tailings from leach process. Contamination of Dakota Sandstone with vanadium, uranium, radium 226, arsenic, nickel, zinc, molybdenum, sodium, sulfate, chloride and nitrates. · Residential water sources threatened within 1000 feet of dumps. · Contamination of Montezuma Creek 2 km downstream from site. · Study and draft proposal available.
Blanding Uranium Mill	Blanding, San Juan County	· Dumps reported but have not been investigated.

Table 2. ***Inactive and abandoned Mine and Mill Tailings and Holding Ponds*** **(continued)**

Site	*Location*	*Ground Water Problem or Threat*
Canyonlands 21st Century Corp.	Blanding, San Juan County	· Leach piles of silver ore.
Dry Valley Mill	San Juan, San Juan County	· No contaminants detected, but radium waste present in tailings with volume of 5500 yds^3. · Less than 1 mile from three wells; 15 persons threatened.
Green River Uranium Mill	Green River, Grand County	· Partially covered tailings in wash in close proximity to the Green River — potential for surface water contamination. · Has not been investigated by Environmental Health. · Being investigated under UMTRAP by Sandia Laboratories for contamination of the ground water and the Green River.
Atlas Minerals Uranium Mill	Moab, Grand County	· Uranium tailing adjacent to Colorado River. Potential for surface and ground water contamination.
Mayflower Mountain Tailings	Mayflower Mtn., Wasatch County	· 400,000 tons of tailings in 3 ponds from the flotation treatment of copper, lead, zinc, silver, and gold ore. · Ground water samples indicate excessive cadmium, lead, and arsenic.
Old Cobalt Tailings Pond	Lake Point, Tooele County	· Dumps reported but have not been investigated.
Richardson's Flat	Park City, Summit County	· Seven million tons of tailings, containing lead, arsenic, and cadmium leaching into the surface and ground water. · Study available.
Silver Creek Tailings	Park City, Summit County	· Solvents and acids used to leach silver from tailings piles; tailings are porous and leachable. · Threat to a shallow aquifer, 0-10 feet beneath housing development.
Vitro Uranium Tailings	Salt Lake City, Salt Lake County	· Site being investigated by UMTRAP; cleanup underway. · About 128 acres of uranium mill tailings containing radium 226, arsenic, cadmium, chromium, and lead. · Organic sludges of unknown origin found during cleanup.

Source — Utah Division of Environmental Health, Potential Hazardous Waste Site Preliminary Assessment Files, 1985.

DEGRADATION OF GROUND WATER BY MINE DEWATERING

Mine development impacts ground water resources by dewatering operations and the diversion of subsurface flow. Mineral production often requires lowering of the water table in order to obtain entrance to surface or underground workings. The amount of ground water that enters and is removed from workings varies and is a function of climate, geology, and operation size. Mines located in areas of high precipitation and permeable rocks are more likely to require dewatering than those located in areas of low precipitation and impermeable rocks. At present, dewatering in Utah mines ranges from less than 10 gallons per minute to approximately 1,500 gallons per minute. Pumping rates up to 10,000 gallons per minute were required in the past to dewater the Burgin Mine near Eureka. Discharge water from the Burgin Mine contained an undesirable concentration of 6000 milligrams per liter of sodium chloride. Saline or toxic mine discharge requires an environmentally safe disposal site or method of treatment.

Subsidence, associated with underground development, may cause extension and expansion of existing fracture systems and an upward propagation of new fractures. Readjustment or realignment in fracture systems may produce an increase in ground water flow. Consequently, ground water is diverted into underground workings and dewatering operations are necessarily enlarged. Diversion and dewatering of the aquifer system may enhance oxidation processes in rocks overlying the mine workings and increase the total dissolved solid content of mine water. Moreover, dewatering may also deplete aquifer storage and thereby, decrease flow to springs, seeps, and perennial streams (figure 2).

The size of mining operations is generally expanding in order to develop lower grade mineral resources. Accordingly, the potential for enhancing oxidation processes and the contamination of water is expected to increase. Informed planning will require an adequate ground water data base to assess potential environmental impacts from mine dewatering and to prevent degradation of water supplies utilized by private individuals, municipalities, agriculture, and wildlife.

ISSUES

REVIEW OF FACILITY DESIGN CRITERIA

The key regulatory powers over mine facility design include: Federal Mine Safety and Health Administration (dam design), the Utah State Engineer (dam design, construction), the Utah Division of Environmental Health (construction), the Utah Division of Oil, Gas, and Mining (safety, effect on the water regime, reclamation, bonding, subsequent and concurrent land use), and the City/County Water Quality & Flood Control Districts (construction).

Pond facilities containing large volumes of contaminated water have great potential for contaminating ground water. The design and construction of ponds that contain greater than 20 acre feet of water, or, are located in critical areas as determined by the Utah State Engineer's Office, must be constructed in accordance with the State Engineer's specifications. Depending on the location and the quality of water in the pond, the plans are generally reviewed by the Division of Environmental Health, the City and the County Engineer, and the Division of Oil, Gas and Mining.

Since the early 1980's, the Division of Environmental Health has required that most holding ponds associated with mining operations be lined with a low permeability material such as clay, or a synthetic liner. In addition, the installation of adjacent monitor wells or lysimeters were required to detect any ground water contamination. The implementation of the State mine reclamation regulations in 1975 by the Utah Division of Oil, Gas and Mining, required the appropriate closure of mine facilities in order to minimize long-term environmental impacts.

POSTOPERATION MINE CLOSURE

Mine closure requires adequate planning to protect the ground water resources. Permanent portal closure requires proper design to address postoperational mine flooding and the build-up of hydraulic head. State regulatory authorities currently recommend that operators install solid concrete block seals 25 feet in from the portal, and backfill the remaining space with nontoxic, noncombustible material. If the mine has ground water inflow, the lowest permanent portal seal should incorporate a two inch diameter drain pipe to prevent portal seal "blow outs."

Shafts are permanently sealed by backfilling with nontoxic, noncombustible material to within several feet of the shaft collar. A concrete cap with an inspection port is installed above the backfill. Permanent shaft seals prevent surface water from entering the abandoned workings and the ground water system.

ABANDONED MINING OPERATIONS

Under Utah statutes, abandoned mines are those

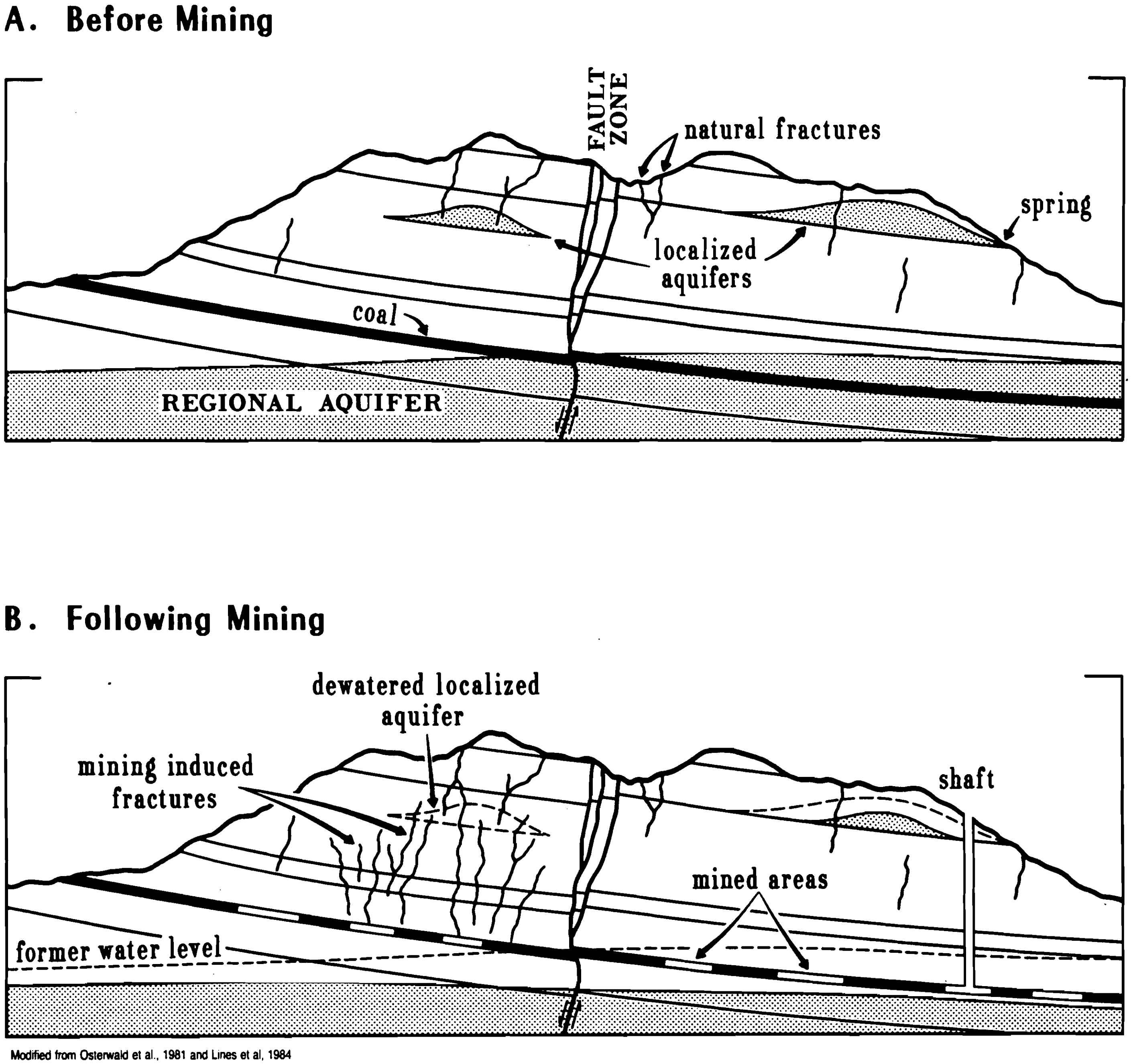


Figure 2. *Effects of Mining on Ground Water.*

that did not produce minerals after August 3, 1977. In order to be eligible for reclamation under the Abandoned Mine Reclamation (AMR) Program there must also be no reclamation responsibility held by any party. The Superfund Program does not have a cutoff date but does tend to focus on the pre-RCRA (1979) sites. Some hard rock mine and mill sites fall into a nebulous category of inactivity but most are clearly left without further plans for use. According to the EPA (1975), during the period from 1930 through 1971, approximately 50,000 to 150,000 acres were utilized for mining in Utah, and less than 20% of these lands have been reclaimed.

The AMR Program, administered by the Division of Oil, Gas, and Mining, has inventoried abandoned tailings, holding ponds, ground water contamination, acid mine drainage from abandoned hard rock sites, and high boron content drainage from coal mines. The AMR Program is currently conducting a study in conjunction with Salt Lake County to assess the quality of mine water discharged by abandoned mines in the Big Cottonwood Mining District.

The Division of Environmental Health investigates active or abandoned tailings and holding ponds which may impact underlying aquifer(s) (table 2). One site, the Vitro tailings, is undergoing cleanup at this time, and sites at Park City are currently the subject of detailed ground water studies. Kennecott Corporation is conducting a 5-year study of contamination down gradient from their mine at Copperton. Detailed studies have also been made at the Rio Algom and Atlas Minerals mills in southeastern Utah.

Both the AMR and the Superfund Programs are assessing the total impact of past mining practices in the State, prioritizing these sites within the constraints of the law, and embarking upon cleanup. It is clear, though, from preliminary information that some aquifers, river systems, and communities are being impacted by degradation of ground water from mining activities. Clean up of these sites to minimize further impact on ground water may involve land reclamation, mine sealing, water quality control, and water quality treatment. Primary land reclamation techniques include regrading and revegetating waste dumps, spoil neutralization, sludge applications, and microorganism control. Percolation through dumps can be decreased by sealing with clay seals. Neutralization of toxic chemicals can be accomplished by oxidation, activated carbon systems and evaporation ponds. Funding of both programs is critical to the extensive environmental work which will be necessary to minimize the detrimental effects on ground water.

REGULATIONS

CURRENT ENVIRONMENTAL REGULATIONS FOR MINING OPERATIONS

Current laws and regulations controlling ground water contamination at active mines include:

- ☆ *Utah Mined Land Reclamation Act, Title 40-8, 1975.* These regulations apply to all mines larger than two surface acres and provide for the control of mine operations, termination of operations, and reclamation.
- ☆ *Surface Mining Control and Reclamation Act (SMCRA) of 1977, P.L.95-87, and equivalent Utah Coal Mining Reclamation Act, Title 40-10, 1978.* These acts regulate surface and underground coal mining activities and provide comprehensive regulatory authority to protect the public health, safety, and the environment.
- ☆ *Nuclear Regulatory Commission Regulations.* These regulations control uranium milling, and seepage from tailings impoundments. EPA currently sets certain radiologic standards that NRC must enforce.
- ☆ *National Environmental Policy Act (NEPA).* This act requires environmental impact evaluations of all major Federal actions. The costs and benefits of alternatives, including those for control of ground water impacts must be examined. Evaluations are required for all new mines located on public lands and all abandoned mine reclamation projects.
- ☆ *Safe Drinking Water Act (SDWA).* This act provides for the protection of underground sources of drinking water by controlling underground injection of substances.
- ☆ *Clean Water Act (CWA).*
- ☆ *Toxic Substances Control Act (TSCA).*

Current laws and regulations regulating abandoned mines include:

- ☆ *Public Law 95-87, SMCRA, and the Utah State counterpart.* These regulations provide a program for funding reclamation work at abandoned mines that pose a threat to the public safety or the environment.
- ☆ *Uranium Mill Tailings Remedial Actions Program (UMTRAP).*
- ☆ *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Utah State counterpart.* These regulations provide a program for responding to toxic substances at abandoned industrial and mining

sites.

Developing Ground Water Regulations for Mining Operations

Several environmental regulations are being developed for mining operations. The EPA is considering a reinterpretation of the mining waste exclusion in RCRA and is considering the listing of smelter waste for regulation.

SUMMARY AND RECOMMENDATIONS

SUMMARY

Mining is important to Utah's economy, providing jobs, raw materials for manufacture, and power generation. The 1983 market value of mining products in Utah approached one billion dollars (table 1).

Mining and mineral processing involve disturbing earth materials and produces large volumes of waste. Thus, impacts on the ground water are unavoidable. However with proper design, operation, and closure these impacts can be minimized.

Ground water is threatened by mining of sulfide minerals, associated with copper, gold, silver, lead, zinc, mercury, uranium and coal. Acid mine drainage (AMD) may form from oxidation of sulfide minerals and has been identified at some abandoned hard rock mine sites. In addition, radioactive elements may leach from uranium dumps. Surface operations involving the storage of waste rock and tailings can result in downward seepage of contaminated water if the storage facility is not lined. Heap and dump leaching operations, are designed to recover pregnant leach solutions. When improperly designed, these systems will leak acid leachate or cyanide solution to the ground water system.

Mining also impacts ground water by disrupting aquifers, springs, seeps, and perennial stream flow. Adequate planning and collection of pre-mining data will lessen impacts to water that is used for domestic, agriculture and wildlife supplies.

Since the late 1970's and early 1980's, the State Engineer has regulated the construction of holding ponds and dams which are in excess of 20 acre feet. Ground water monitoring is required where there is concern for contamination. Closure of some mines has been required under Utah statute since 1975 in order to reduce the long term impacts of pollution.

Numerous abandoned mine and mill operations exist in Utah. Those threatening ground water by producing AMD, or having unlined ponds or storage areas are being evaluated. Two programs are available in Utah to clean up these sites, the Abandoned Mine Reclamation Program and the Superfund Program. Work has begun on some sites and ground water monitoring is underway on other sites. Adequate Federal funding is needed to complete this work.

RECOMMENDATIONS FOR MINIMIZING GROUND WATER IMPACTS BY FUTURE AND EXISTING MINING OPERATIONS

Ground water is an important natural resource in Utah. However, not all ground water is useable, due to such factors as poor water quality, low well yields, great pumping depths, and better availability of alternate supplies. A strict non-degradation ground water policy is untenable for the mining industry. Ground water policy should be directed toward protecting ground water at places of current and foreseeable future use. Impacts in mining areas should be kept to a minimum. This strategy requires the recognition and the protection of useable aquifers and an assessment of the potential for a given activity to affect a ground water resource. These goals can be attained by requiring detailed ground water studies in areas targeted for mining, and the construction and design of facilities to safeguard the resource.

In order to avoid duplication and inefficiency, regulatory policy should, as much as possible, work within the framework of existing laws and regulations rather than develop another set. Minimizing ground water contamination and depletion as a result of current and future mining operations is a realistic goal and may be achieved through:

1. Lining solid and liquid waste disposal facilities using natural or synthetic liners;
2. Installing leach detection and collection systems;
3. Locating new facilities deemed potentially detrimental to ground water resources in ground water discharge zones, or over non-critical ground water recharge areas, in order to minimize contamination;
4. Constructing storm water and surface water diversion systems to divert surface waters away from disturbed mine areas;
5. Locating ground water monitor wells, upgradient and downgradient from contaminant sources to monitor the lateral and vertical ground water impacts adjacent to a site. Monitoring will not prevent contamination but will allow for proper remedial action to be im-

plemented before extensive problems occur;

6. Planting vegetation and implementing spoils reclamation to minimize long-term leaching of disturbed areas;
7. Minimizing excessive pumping of good quality waters during mine dewatering; and
8. Treating wastes and waste water prior to release or discharge to holding ponds.

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OIL AND GAS EXPLORATION AND PRODUCTION

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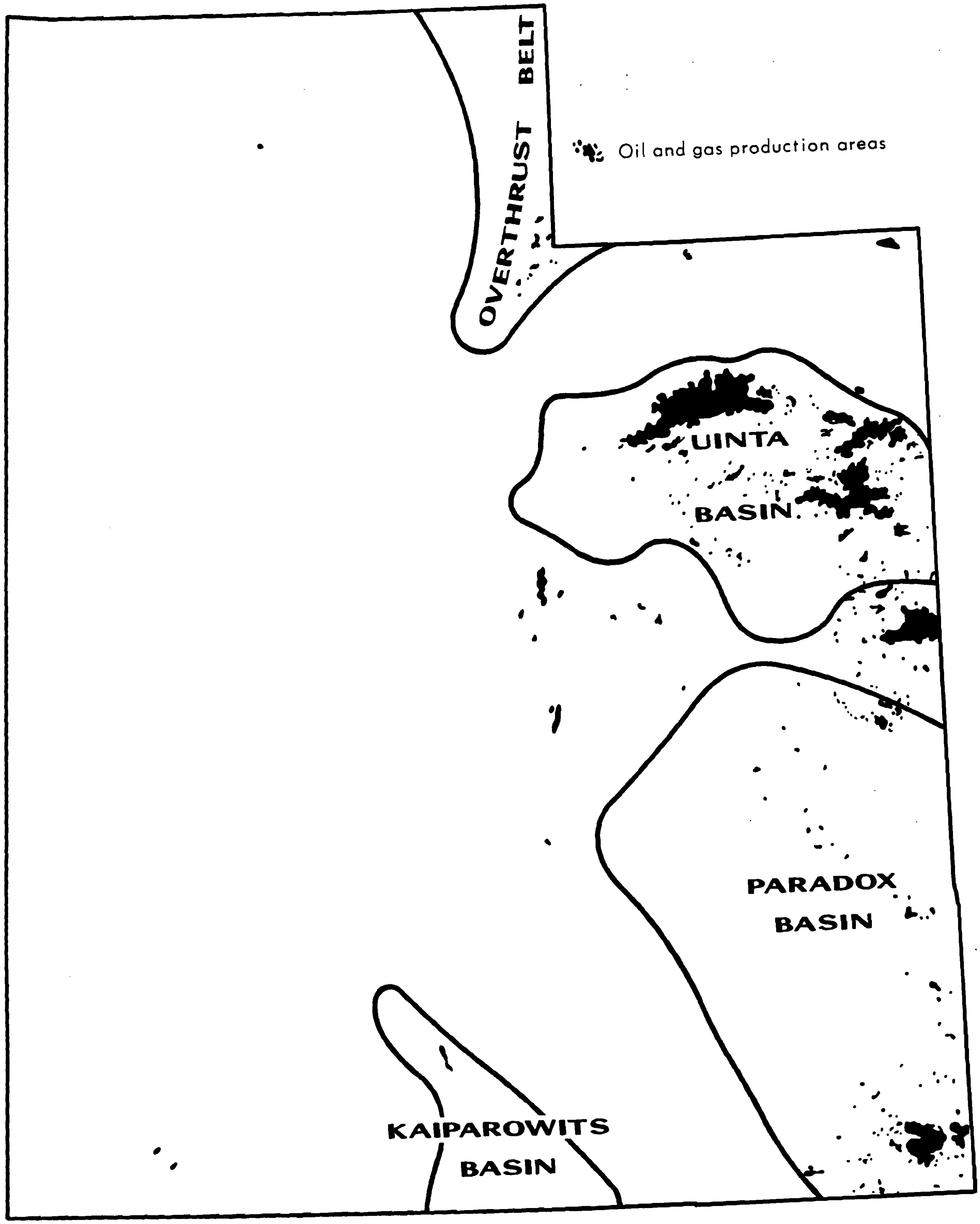

Source Map: Oil and Gas Production of Utah

Figure 1. *Oil and Gas Production Areas of Utah.*

INTRODUCTION

Oil and Gas exploration and production are major industrial activities in Utah and contribute substantially to the State's economy (figure 1). In 1984, 537 new exploration and production wells were drilled. Drilling activity was concentrated in Utah's portion of the Overthrust Belt and in the Uinta Basin. Production of oil was the second best year on record with the 38 million barrels produced in 1984 only exceeded by the 40.1 million barrels produced in 1975. Based on an average value of $27.00 per barrel the gross value for oil produced in 1984 exceeded one billion dollars. Inclusion of the value of natural gas and natural gas liquids adds an additional 300 million dollars to the total value of oil and gas production. Approximately 85% of the revenue from State owned lands and State school trust lands come from oil and gas royalties and production.

The steep decline in world crude oil prices in the early months of 1986 has had a strongly adverse effect on the Utah petroleum industry. Drilling of new exploration and production wells has dropped sharply. Revenues and taxes from oil and gas production have also suffered declines. Improvements in the economic health of the industry will depend on higher crude oil prices.

Oil and gas exploration and production expanded in the 1970's and early 1980's in the wake of the OPEC price escalation to cover the length and breadth of the State. Exploration extended into the Great Basin west of the Wasatch Front as companies searched for fields similar to recent discoveries in Nevada. The new fields in the Utah/Wyoming Overthrust Belt spawned exploration southward into central Utah and westward to Bear Lake. The Uinta Basin, site of the giant Altamont-Bluebell field, continues to receive some new exploration and production drilling. Other areas that received attention include the Paradox Basin in southeastern Utah, the flanks of the San Rafael Swell, and the north flank of the Uinta Mountains. Oil and gas exploration and production has had by far the most widespread economic impact of any industrial activity within the State.

POTENTIAL GROUND WATER CONTAMINATION PROBLEMS

In the exploration for, and production of oil and gas, ground water contamination can develop from improper or inadequate protection of the near-surface fresh water zones, improper disposal of saline produced waters and drilling muds, and defective plugging and abandonment of oil wells.

Near-surface fresh water aquifers can become contaminated if insufficient surface casing is used or inadequately cemented in the well bore. The Board of Oil, Gas & Mining (the Board) requires casing to be run to a depth below "all known or reasonable estimated, utilizable, domestic fresh water levels". However the Board has not defined these terms. The Division of Oil, Gas & Mining (DOGM) which serves as the Board's staff, is conducting a cooperative study with the U.S. Geological Survey Water Resources Division to map the base of moderately saline water throughout the Uinta Basin and in San Juan County. Information from this study will be used to consider changes in installation of surface casing, selection of injection intervals and plugging requirements. These studies may also determine if past oil and gas activities have contributed to ground water pollution.

The disposal of saline produced water and drilling fluids can produce ground water contamination problems if done improperly. Most water produced with oil and gas is reinjected into the productive formation. However, some produced water is trucked to commercial disposal pits. Problems arise when these pits leak and permit saline water to contaminate the underlying aquifer.

The Board regulates wells used to reinject produced water (Class II wells); on-site disposal of produced waters; and disposal of other oilfield wastes. To avoid overlapping regulation of off-site disposal of produced water, the Bureau of Water Pollution Control (BWPC) in the Department of Health, and the DOGM have agreed that DOGM and the Board, rather than the BWPC, should have primary regulatory jurisdiction over this disposal activity.

The Board has recently adopted substantial revisions, effective December 2, 1985, to the *Oil and Gas Regulations,* including revisions affecting Class II injection wells and on-site disposal of formation water. The DOGM is preparing additional changes regarding off-site disposal of produced formation water and upgrading of existing regulation to meet concerns of the BWPC.

Following the completion of the drilling of an oil exploration or development well, drilling fluids remaining in pits at the drill site are discarded. Drilling fluids in use today typically do not contain toxic materials, although those previously used in the industry frequently did. Today's drilling fluids are also designed to be self-sealing, which discourages leaching from disposal pits. Occasionally, however, these drilling fluids may contain metals, organic compounds, and other substances. If the well penetrated the Paradox Salt or other salt bearing formations, salt may be present in the cuttings. The metals, organic compounds, and salt can pose a threat to ground water if they are leached from the pit.

The Board's regulations concerning disposal pits combine siting and design criteria. If the area is underlain by tight soils such as heavy clays, liners are not required. If underlying soils are porous, pits must be lined as required by the DOGM. Generally, sites over alluvial aquifers should be avoided.

A companion problem related to the regulation of oil and gas exploration and production is the dispersed regulatory efforts regarding similar activities. Despite the use of the same kind of drilling equipment, drilling techniques, engineering, design and safety procedures, the purpose for which the well is intended determines the state agency that regulates the process.

The Board regulates oil and gas drilling. If the well is a geothermal exploration or production well, it falls under the regulations of the Division of Water Rights. However if the well is for reinjection of spent waters in a producing geothermal field, the Division of Water Rights and the Division of Environmental Health both have jurisdiction. Finally, if the well is drilled for solution mining of potash or other minerals i.e., a Class III well, it falls wholly under the Division of Environmental Health's jurisdiction. Consolidation of the regulation under one agency would yield dividends in both efficiency and effectiveness by eliminating present duplication and overlap.

ISSUES

1. Should additional changes be made to the Board's regulations to clarify certain definitions and disposal practices?
2. Are enforcement efforts adequate with respect to commercial water hauling contractors and their compliance with applicable disposal regulations?
3. Is consolidation of regulatory jurisdiction over drilling operations required to avoid overlapping and inefficient regulation?

RECOMMENDATIONS

1. The Board of Oil, Gas and Mining should consider further revision of rules in order to provide additional protection to the ground water resource:
   a. Revise standards for location, design, and closure of drill mud pits in order to control leaching of toxic materials to ground water.
   b. A definition for "utilizable, domestic fresh water" should be added to the oil and gas rules to reflect the quality and economic availability of ground water.
2. The Bureau of Water Pollution Control and/or the Board of Oil, Gas and Mining should consider revising regulations pertaining to siting and operation of commercially operated produced water disposal ponds. Design requirements should be tailored to the proposed site. A program of increased inspection of existing facilities and enforcement of siting and design requirements for new facilities, should be considered.
3. The regulation of petroleum, geothermal energy, mineral production and reinjection wells should be consolidated, to the extent practical into regulations overseen by the Board of Oil Gas and Mining. Most other mineral and petroleum production activities are presently regulated by DOGM. This change would require action by the Legislature.

On-Site Wastewater Treatment Systems

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SECTION ONE

INTRODUCTION

Approximately 18 million housing units, or 25 percent of all year-round dwellings in the United States are served by on-site wastewater treatment and disposal systems (U.S. Environmental Protection Agency, 1980a). With most of Utah's population concentrated along the Wasatch Front and served by municipal sewer systems, only about 16 percent of the State's year-round housing units are served by on-site wastewater treatment and disposal systems (Winneberger, 1973). In addition, there are thousands of seasonal recreational dwellings, located primarily in the mountainous areas of the State, that are served by on-site wastewater treatment and disposal systems. The great majority of the State's on-site wastewater treatment and disposal systems are septic tank and soil absorption systems (STSASs), but a small percentage are cesspools which have been in existence since the 1940's and 1950's. Other means of waste disposal such as earthen pit privies, vault privies, and sewage holding tanks are also utilized to a limited degree for recreational dwellings and other similar facilities. However, the latter two disposal devices cannot be regarded as on-site disposal systems since the contained wastes are required to be collected and disposed of at approved sites.

Nationwide, it is estimated that only 32 percent of the total land area in the United States has soils suitable for STSASs (U.S. Environmental Protection Agency, 1980a). Mountainous terrain, high water table conditions, and extensive areas underlain by shallow bedrock combine to reduce even further the total land area in Utah suitable for STSASs.

Rural areas, in particular, rely on STSASs for single-family residences, but these disposal systems also serve stores, offices, factories, and other establishments. Suburban areas of the State's major cities also utilize many STSASs.

Where soil, ground water, and other site conditions are suitable for their use, STSASs can provide excellent, reliable sewage disposal at a reasonable cost, while still preserving environmental quality. These systems are usually the most cost effective sewage disposal system available.

SECTION TWO

DESCRIPTION AND MAINTENANCE OF SEPTIC TANK AND SOIL ABSORPTION SYSTEMS

All STSASs are composed of the following three components: (1) a building sewer, (2) a septic tank, and (3) a soil absorption system. Sewage flows through the building sewer into the septic tank where its velocity is reduced and many of the suspended solids settle to the tank bottom or float to the wastewater surface. Although some biological decomposition occurs in the tank due to the action of anaerobic bacteria, septic tanks are not particularly effective in bacteria removal. The most important function of the septic tank is to protect the absorption capability of the soil absorption system by removing solids. The principal sewage treatment opportunity occurs when aerobic bacteria in the soil act on the sewage. For this reason, soil absorption systems should be used only in well-drained soils of suitable texture, where an appropriate separation between the bottom of the soil absorption system excavation and the maximum seasonal ground water elevation can be maintained.

A good soil system for receiving septic tank effluent should absorb all effluent generated, provide a high level of treatment before the effluent reaches ground water, and have a long useful life. Ideally, a soil should be able to convert a pollutant into an unpolluted state at a rate equal to or greater than the rate at which it is added to the soil.

In considering ground water contamination from STSASs, attention must be directed to the transport and fate of pollutants from the soil absorption system through underlying soils and into the ground water. Physical, chemical, and biological removal mechanisms may occur in both the soil and ground water systems. As septic tank effluent moves through the soil pores, remaining suspended solids are removed by filtration. The point at which removal occurs varies with the size of particles, soil texture, and rate of water movement. Absorption, ion exchange, and chemical precipitation are the most important chemical processes governing effluent renovation. The biological transformations that occur in the soil are organic matter decomposition and nutrient assimilation by plants.

All STSASs require periodic maintenance involving removal of settled solids (sludge) and floating scum. This maintenance should be performed every three to five years, depending on the rate that sludge and scum accumulates. Septic tank wastes (septage) are required to be disposed of only at sites designated and approved by health authorities. Improper disposal of septage wastes causes potential and actual ground and surface water pollution.

SECTION THREE

HISTORICAL USE AND CURRENT REGULATION OF ON-SITE WASTEWATER TREATMENT SYSTEMS IN UTAH

A. Historical Use of On-Site Wastewater Treatment Systems

Earthen pit privies and direct discharge to streams or rivers were the primary means of wastewater disposal during the early pioneer history of the State. In 1935, the Utah Department of Health (UDH), in cooperation with the U.S. Public Health Service, developed recommended plans and specifications for crib-lined earthen pit privies. These units served as a principal means of wastewater disposal during the 1930's and early 1940's for all kinds of facilities including single-family dwellings, schools, churches, and other public establishments. The 1935 specifications for earthen pit privies (Utah State Board of Health, 1935) stated that the pit "should not be dug to existing ground water levels;" the 1941 version of the same specifications (Utah State Department of Health, 1941) stated that in high ground water areas, pits "should extend to within one foot of the ground water surface."

With the advent of indoor plumbing fixtures, cesspools served as the primary means of subsurface disposal until the 1950's. Cesspools were simply large, deep excavations in the ground, cribbed with wood or coarse stone, which frequently extended below the ground water surface.

The UDH's first bulletin recommending and describing the construction of STSASs was published in 1943 (Utah State Department of Health, 1943). In 1955, the UDH adopted its first regulation governing STSASs titled *Individual Sewage Disposal System Regulations*. The regulation contained no minimum separation between the bottom of the absorption system excavation and the maximum ground water table, but did have a general statement that "Installations in low swampy areas, areas with a high water table . . . are not acceptable." (Utah State Department of Health, 1955).

B. Recent Regulation and Current Use of On-Site Wastewater Treatment Systems

With the formation of the Utah Water Pollution Control Board in 1964, a five-part *Code of Waste Disposal Regulations* was adopted in 1965. Parts IV and V of the regulation, respectively titled "Individual Wastewater Disposal Systems" (IWWDS) and "Small Underground Wastewater Disposal Systems", addressed on-site wastewater disposal systems. Both regulations set minimum State standards, allowing Local Health Departments (LHDs) to adopt more stringent requirements when deemed necessary.

Part IV applied to wastewater discharges from single homes (up to four individual dwelling units), and to commercial installations serving not more than four individual family units. It was administered and enforced primarily by LHDs. Part V applied to domestic wastewater discharges from multiple dwellings containing more than four individual family units and to public and commercial installations serving more than 50 persons. Plan review and enforcement actions for these larger disposal systems were provided by the UDH's Bureau of Water Pollution Control, but LHDs shared some responsibility in identifying and verifying suitable absorption system sites and inspecting completed systems. Both regulations required only a one-foot separation between the bottom of absorption system excavations and the maximum seasonal ground water elevation.

With recodification of all State health laws in 1982, statutory authority for IWWDSs was given to the UDH. In 1984, the *Regulations For Individual Wastewater Disposal Systems* (RFIWWDS) were adopted by the UDH following a series of public hearings and subsequent meetings with representatives of two real estate associations and individuals opposed to certain provisions of the proposed regulation. Those discussions and subsequent compromises to the regulations centered primarily on two proposed requirements — (1) a four-foot minimum separation between the bottom of absorption system excavations and the maximum ground water elevation, and (2) the establishment of minimum area for lots with single-family residences that would be served by STSASs.

As adopted, the RFIWWDS contains a two-foot separation requirement between the bottom of absorption system excavations and the maximum ground water elevation, and minimum lot size requirements for lots with single-family residences served by IWWDSs. Because of changes in the statute, these regulations now apply to all systems for underground disposal of domestic wastewater which are designed for a capacity of 5,000 gallons per day or less, but does not apply to multiple dwelling units owned by separate owners except condominiums and twin homes. Nearly all (98 percent or more) of the STSASs installed in Utah are IWWDSs governed by these regulations. Although promulgated by the UDH, LHDs provide primary administration and enforcement of these regulations.

Underground disposal systems designed for more than 5,000 gallons per day are governed by the Utah Water Pollution Control Committee, and must be designed in accordance with the recently revised Part

V of the *Wastewater Disposal Regulations* entitled "Large Underground Wastewater Disposal Systems". The UDH's Bureau of Water Pollution Control administers and enforces this regulation. It mandates the design of large common STSASs serving multiple units under separate ownership, and requires such systems to be under sponsorship of a body politic.

The number of STSASs installed in the State varies from one LHD to another, with most STSASs being installed in the large multicounty health districts such as the Southwest District, the Bear River District, and the Central District Health Departments. Most highly urbanized LHDs such as those serving Weber, Salt Lake, and Utah Counties also install large numbers of STSASs. Because of its size and boundaries, Davis County is an exception since most of its residents are served by municipal sewer systems, with only relatively few STSASs being installed each year.

A UDH survey conducted in 1980/1981 showed approximately 3450 STSASs being installed annually in Utah (Utah Department of Health, 1981a). If the estimated 400 gallons of wastewater per day per single-family residence is discharged through that number of new STSASs, the total wastewater entering the soil through these systems each year is over 1.3 million gallons per day and over 503 million gallons per year. The general economic recession and reduction in building activity that occurred in the early 1980's reduced STSAS installations to a lower level. Since 1984, the number of installations is increasing.

The 1980/1981 survey indicated that on the average, 33 percent of annual environmental health man-hours at the LHD level was devoted to STSAS programs. However, the range of annual man-hours devoted to that program by all LHDs ranged from only 2 (Davis County Health Department) to as high as 75 percent (Uintah Basin District Health Department).

It is estimated that thousands of unapproved privy toilets exist throughout Utah. In 1984, the UDH adopted the "Regulations For the Design, Construction, and Maintenance of Vault Privies and Earthen Pit Privies." These disposal units are allowed for labor camps, some recreational camps, and for a limited number of other approved uses. Requests for the use of vault privies and earthen pit privies are evaluated on a case-by-case basis by LHDs.

C. Formation of Wastewater Disposal Technical Review Committee

In 1983, an advisory Wastewater Disposal Technical Review Committee was established by the UDH to identify and evaluate experimental IWWDSs for use where soil, ground water, and other site limitations prohibit the use of conventional STSASs. Since its formation, the committee has evaluated and recommended two experimental systems for subsurface disposal — the Wisconsin Mound System and the Low-Pressure Pipe Waste Treatment System. Experimental installation criteria were also developed for installation of those two experimental systems in (1) existing earth fill and (2) engineered earth fill. An official interpretation was developed in 1985 to permit installation of shallow conventional IWWDSs with "capping fill" on sites where the maximum ground water elevation precludes the use of conventional STSASs. Two compost toilets were also recommended as experimental waste disposal systems by the committee. Compost toilets are waterless toilets similar to vault toilets that appear to have some application for recreational camps, labor and construction sites, and other related facilities. Prior to installation, experimental disposal systems must be jointly approved by the UDH and LHD having jurisdiction.

Since the formation of the Wastewater Disposal Technical Review Committee, plans for over 20 experimental IWWDS have been approved. To date, 6 Wisconsin Mound Systems and 3 Low-Pressure Pipe Systems have actually been installed. Although most approved experimental disposal systems are proposed for single-family dwellings, some have been designed for other facilities including a mining operation, a dam construction site, a convenience store, and a small office building. The UDH believes that the experimental IWWDS presently being tested will overcome some of the soil and site limitations which presently prohibit installation of conventional STSASs. The design features in the systems, including periodic dosing of absorption systems under low pressure, are expected to provide adequate protection of ground water from sewage contamination.

When the UDH and the Wastewater Disposal Technical Review Committee feel that sufficient successful experience has been obtained with experimental IWWDS, it may designate them as approved alternate IWWDSs. The UDH would then adopt construction standards and regulations governing their use. Alternate IWWDSs could then be regulated and approved solely by LHDs.

SECTION FOUR

Potential Sources of Ground Water Contamination from On-Site Wastewater Treatment Systems

A. Potential Contaminants

When considering potential ground water pollution sources, STSASs rank highest in total volume of wastewater discharged directly to soils overlying ground water, and are a frequently reported source of contamination (Miller, 1980). Nationwide, it is estimated that as many as one-half of existing STSASs are not operating satisfactorily, resulting in both surface and ground water contamination. Ground water degradation usually occurs in areas having high densities of STSASs and results in high concentrations of nitrates, bacteria and other pollutants associated primarily with domestic wastewater. Recent studies indicate significant amounts of organic contaminants are also being introduced to ground water by STSASs.

B. Pathogenic Organisms (Bacteria and Viruses)

The quality of effluent from the septic tank portion of the system is of greatest concern in terms of ground water pollution from biological contaminants. The following table is a general biological characterization of that effluent (Canter and Knox, 1985):

Organism	*Number/100 ml*
Total Bacteria	3.4×10^8
Total Coliform	3.4×10^6
Fecal Coliform	4.2×10^5
Fecal Streptocci	3.8×10^3
Pseudomonas Aeruginosa	8.6×10^3

In addition, results of analyses for Staphylococcus and Salmonella have indicated their presence in septic tank effluents, but in lower concentrations. Little qualitative work has been done with regard to virological contaminants. However, viruses not normally present in healthy individuals can occur in significant concentrations from an infection and, as a result, the potential for spreading the viruses increases. The same study has found levels in septic tank effluent ranging from 32-7000 pfu/liter.

Biological contamination of ground water from pathogenic organisms is dependent on several environmental factors such as rainfall, soil moisture, pH, soil texture, and hydraulic loading. Under optimum design conditions, most pathogenic organisms are inactivated in the upper reaches of the soil. However, under less favorable conditions, survival rates have been reported in excess of 170 days and travel distances over 600 feet.

C. Inorganic Contaminants

The most serious potential inorganic contaminants include phosphorus, nitrogen, chloride, and metals. As with biological contaminants, their pollution of ground water also depends on the same environmental considerations, with localized cases of degradation being reported.

Phosphorus has not been a major problem because it is easily retained through chemical changes and absorption. However, nitrogen, in some forms, is very mobile and may easily reach ground water. This can cause both a health hazard and environmental degradation.

Metals, particularly lead, are also a potential ground water contaminant in septic tank effluent associated with antiquated plumbing systems (U.S. Environmental Protection Agency, 1977).

D. Organic Contaminants

Recent evidence indicates many aquifers have been contaminated by organic chemicals. Some of these chemicals are carcinogenic, and pose a health threat. Studies have shown that some of these chemicals have entered ground water through STSASs. The transport of these contaminants is a relatively new topic of concern and is receiving increased interest due to the persistent nature of the chemicals. A large number of organic chemicals are in existence, and their number is steadily increasing. One chemical identified by the U.S. EPA as a major source of contamination is trichloroethylene which is a component of some septic tank cleaning solvents.

SECTION FIVE

Issues Affecting Ground Water Contamination by On-Site Wastewater Treatment Systems

The following are issues relating to the contamination of ground water by septic tank effluent:

A. Ground Water Separation and Monitoring

The quality of the septic tank effluent and the efficiency of the soil underlying the soil absorption system in renovating the effluent is of primary concern. It is the constituents that pass through the unsaturated soil beneath the absorption system that contaminates ground water. The effectiveness of soil absorption systems depends on several factors, the most important of which are the type of soil and degree of saturation (Peavy and Groves, 1977). Fine-grained soils are effective in removing contaminants such as bacteria, but are easily saturated and thus may lose some of their effectiveness. A water-logged soil destroys the aerobic organisms in the soil, producing anaerobic conditions. Such conditions tend to preserve the organic matter in septic tank effluent, thus delaying decomposition and increasing mechanical clogging of the liquid-soil interface with organic matter, slimes, and sulfides (Salvato, 1972). Romero (1970) reported that pollutants were found to move from five to ten times further in saturated soil than in unsaturated soil. Coarse-grained soil promotes aerobic conditions which are generally more favorable for conversion or removal of contaminants from septic tank effluent (McGauhey and Krone, 1967). However, where ground water levels are near the surface, rapid percolation through coarse-grained soil can result in short retention times in the aerated portion of the soil profile and rapid transfer of contaminants to ground water.

Health departments regulating installation of STSASs commonly have several criteria that must be met before a site is considered suitable for wastewater disposal. These criteria usually include a specified soil percolation rate, a minimum separation between the bottom of the absorption system and the maximum seasonal ground water elevation, and a minimum thickness of permeable soil between the bottom of the soil absorption system and bedrock or impermeable layers. Such regulations are intended to assure that septic tank effluent remains below ground and that health problems associated with surfacing sewage are avoided. However, when those criteria are applied to areas with permeable soils and high ground water, or where high STSAS densities are permitted, ground water contamination may occur. The RFIWWDS presently permit installation of STSASs in soils that percolate as fast as one minute per inch and where depth to ground water is two feet below the bottom of the soil absorption system. Under those conditions, the retention time of the effluent in the unsaturated portion of the soil above ground water would be about 24 minutes, which may be an inadequate period for renovation to occur. Ground water contamination may occur from septic tank effluent that has been inadequately renovated by the soil.

In 1963, two years prior to development of Parts IV and V of the *Utah Code of Waste Disposal Regulations,* the U.S. Public Health Service recommended a four-foot separation between the bottom of absorption system excavations and the maximum seasonal ground water elevation in its "Manual of Septic Tank Practice". By about 1980, at least two LHDs had adopted requirements for a four-foot separation from the maximum seasonal ground water elevation, which exceeded the one-foot separation required by the UDH regulations. A recent survey (Bartsch, 1982) of all state STSAS requirements showed that 24 states (47 percent) required at least a four-foot separation from the maximum seasonal ground water elevation, and 10 states (19 percent) required a separation of either two or three feet. Only five states (10 percent), including Utah, required a separation of one foot or less between the bottom of absorption system excavations and the maximum seasonal ground water elevation.

Irrigation practices, particularly those involving flood irrigation, frequently have an adverse effect on STSASs. Fluctuating ground water which rises above the elevation of soil absorption systems can flow into septic tanks and enter basements through building sewers. The end result is the destruction of property by sewage-contaminated ground water, and an increase in the potential for disease transmission.

Proposed deep STSASs must be evaluated very closely since they are more susceptible to inundation by fluctuating ground water levels. Increased emphasis should be placed on identifying maximum seasonal ground water elevations and using that information to determine the maximum allowable depth for a soil absorption system and the required elevation of the bottom floor of the dwelling. Increased use should be made of sewage pump wells and ejector pumps in those installations where wastewater must be raised to a higher elevation to permit adequate separation between the maximum ground water elevation and absorption systems.

On selected sites where high ground water precludes the use of conventional IWWDSs, experimental IWWDSs may be considered. Experimental IWWDSs are being used successfully in Utah where the maximum seasonal ground water elevation is 24 inches below ground surface. A "capping fill" over conventional IWWDSs can also be used on sites where the maximum seasonal ground water elevation is at least 34 inches below ground surface.

Evaluating the potential of STSASs for contaminating ground water requires an understanding of both site and regional ground water conditions. Recharge areas and flow patterns must be delineated, and the amount of recharge established to determine the effect of natural dilution on the effluent. Acquiring such data goes beyond widely established STSAS siting criteria, but is information that must be obtained, or closely estimated, if ground water quality in critical aquifers is to be protected. Parameters selected for monitoring should include those which are considered health hazards or are indicators of contamination. Parameters of importance should include bacteriological testing because it is easier and less expensive than virological. Fecal coliform and fecal streptococci can serve as suitable indicators of biological contamination. Nitrate monitoring is important since the unsaturated zone is not effective in nitrogen removal. This is also a good warning indicator of other possible contaminants. Due to the increasing rise of metals and organic constituents in septic tank effluents, it is becoming important to monitor for these pollutants, particularly in high density areas or sensitive aquifer recharge situations. However, this type of monitoring is expensive and extremely sensitive to environmental variables. Some consideration has been given to the use of total organic carbon and total halogenated organic chemical parameters as possible indicator tests.

B. Septic Tank Densities/Lot Size

A major concern in utilizing STSASs for wastewater disposal is that the density of systems may become greater than the ability of the subsurface environment to receive and purify effluent, prior to its movement into ground water (Canter and Knox, 1985). Most biological contaminants associated with sewage effluent are attenuated to acceptable levels by movement through three to five feet of soil (Seabloom, 1976; Parker and others, 1978; U.S. Environmental Protection Agency, 1980b). However, nitrogen, viruses, and certain chemicals are not readily affected by movement through soil, and may reach ground water. Once in the ground water, contaminant levels can become quite high, and pollution can migrate considerable distances with minimal attenuation.

Regional ground water contamination has occurred in heavily populated urban areas that rely on STSASs (Morrill and Toler, 1973; DeWalle, Schaff, and Hatlen, 1980; Brookhaven National Laboratory, 1982). The density of STSASs in those areas is high, ranging up to 900 systems per square mile. Generally, the density range of STSASs are considered low (if less than 10 per square mile), intermediate (if between 10 and 40 per square mile), and high (if greater than 40 per square mile) (U.S. Environmental Protection Agency, 1977; Miller, 1980). More than 40 systems per square mile have a potential for ground water contamination (Miller, 1980). Unless large numbers of STSASs are allowed in sensitive aquifer recharge areas, regional ground water contamination resulting from such systems is unlikely, because most metropolitan areas are sewered. However, STSASs are often concentrated in out lying subdivisions, and nonuniform distribution can lead to densities greater than 640 per square mile (one system per acre) on a local basis. The potential for ground water contamination in these areas is high.

In general, the greater the STSAS density, the greater the potential for ground water contamination. However, the volume of wastewater discharged into the ground at any particular location cannot be used to determine the existence or magnitude of a ground water contamination problem (Miller, 1980). The hydrology, geology, topography, soils, and climate of a site, as well as system construction and maintenance, all affect the manner in which a STSAS functions. However, STSAS density is recognized as a major contributor to ground water contamination (Miller, 1980; Comprehensive Water Resource Management Committee, 1983). It follows, that the potential for ground water contamination can be reduced by limiting STSAS density to levels commensurate with the ability of site conditions to attenuate or dilute contaminants.

A simple technology is not yet available for making quick and accurate determinations of appropriate septic tank system densities. Necessary data on ground water characteristics (recharge areas, flow direction, quality, depth, and seasonal fluctuations), soil chemistry, geology, and climatic conditions are time consuming and costly to acquire. For these reasons, many health departments and environmental organizations have adopted lot-size requirements based on easily available site information. The criteria most often used are depth to ground water, soil permeability or type, and source of culinary water. Determining lot size based on incomplete data necessitates a conservative approach to insure that STSAS densities are sufficiently low to prevent ground water contamination. Conversely, a determination made with more complete information could result in smaller lot sizes and higher system densities.

The RFIWWDS do not directly address STSAS density, but do require minimum lot size for single-family dwellings. Once lot size is established, STSAS density is also fixed. A review of these requirements shows that under some circumstances application of the regulations regarding lot size can result in STSAS densities far greater than those known to have caused ground water contamination in other parts of the country.

The RFIWWDSs provide two methods for determining lot-size for single-family residences served by STSASs. Methods for establishing lot sizes with densities greater than 40 per square mile should require a comprehensive evaluation of site conditions to justify the higher densities. It was on that basis that the following two methodologies were evaluated.

Method 1 leaves lot-size determination to the

LHD. Individuals or developers requesting a lot-size determination under this method must submit a report which considers among other things soil type and depth, site drainage, protection of surface and ground water, topography, geology, hydrology, sewage volume, and climatic conditions. The LHD uses that information to make the lot-size determination, and may, if it chooses, involve other affected governmental agencies and the UDH in the decision. The lot-size determination and the resulting STSAS density made on the basis of method 1 should prove acceptable, if the reports submitted by applicants are accurate and complete, and the SHD personnel are trained to correctly interpret the data.

Method 2 is only used when LHDs have not already established minimum lot sizes. It relies on a table that establishes a matrix between the source of culinary water available to the lot and soil suitability. Soils classified under the Unified Soil Classification System are grouped into five categories ranging from good to unacceptable. Water supply to each lot is either public or private. Where a public water supply is available, lot size can vary from 12,000 to 20,000 square feet depending on soil type present. Assuming that approximately 25 percent of a subdivision development is comprised of roads or common areas, lots in that size range would result in STSAS densities of between 1066 and 1777 systems per square mile. This density is far higher than the densities reported in areas experiencing serious regional ground water contamination problems. Likewise, where individual water-supply wells are used, lot size would range from 1.0 to 1.75 acres depending on soil type. The density would range from 274 to 480 systems per square mile, resulting in a density that is more than half as high as some areas experiencing ground water contamination. Method 2 does not take ground water conditions into consideration in determining minimum lot size, nor does it consider existing or potential uses of the ground water, other than for culinary purposes. For those reasons, and because of the extremely high densities allowed, method 2 does not appear to be adequate, and may in some areas contribute to ground water contamination.

C. Site Evaluation

Shallow ground water, impermeable or excessively permeable soil, shallow bedrock, caliche, steep or unstable slopes, and flood hazard are all factors that can result in system malfunction and ground water pollution. Several additional important siting factors are discussed in this section.

Information on geology, hydrology, soils, and topography is available for most areas of Utah; however, scales are variable and detailed information on a site-specific basis is limited. Most geologic and hydrologic data are generic and require interpretation by trained individuals to be useful for siting STSASs. U.S. Soil Conservation Service soil reports are available for many areas. The more recent reports rank the soil according to suitability for STSASs. However, the Soil Conservation Service system rates the soils for hydraulic malfunction (allowing sewage to surface) and only marginally considers the likelihood of ground water pollution. In addition, information is usually only provided to a depth of five feet which is too shallow for most STSAS applications. Geologists from the Utah Geological and Mineral Survey and Soil Scientists from the U.S. Soil Conservation Service have provided invaluable assistance to the UDH and LHDs on numerous issues regarding STSASs. An additional resource are the geologists recently hired by some counties.

Some counties have developed overlays for geologic maps which identify soil and ground water conditions for entire counties or for specific areas. This information is valuable in the planning and zoning process in identifying areas where ground water may be contaminated by effluent from STSASs. In a few instances, comprehensive reports and maps have been published by the Utah Geological and Mineral Survey which evaluate STSAS suitability for communities, and environmentally sensitive areas. These have proven to be extremely valuable to planners and health authorities.

A major problem in siting STSASs are geologic formations composed of shale and mudstone that crop out over large areas of Utah. The rocks and the soils derived from them have a low permeability. Geologic and soil conditions in these areas are generally unsuitable for most methods of on-site wastewater disposal. These formations crop out primarily in the eastern and southern parts of the State (Carbon, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Uintah and Washington Counties) and include the Mancos, Chinle, and Ankareh Shales, and the Duchesne River, Wasatch, and Moenkopi Formations. A number of other rock units throughout the State are composed of shale or mudstone beds that adversely affect STSASs on a local basis. Clay-rich rock formations weather in place and develop residual soils of variable thickness. It is often difficult to identify the transition point where residual soil changes to weathered bedrock. Mesozoic and Cenozoic shale and mudstone are not well indurated, even when unweathered, and are easily excavated with a backhoe. That characteristic, combined with the difficulty of distinguishing residual soil from weathered rock, can result in installation of STSASs directly in the bedrock. When installed in shale or mudstone, the systems may work well initially, but clay in the rock will eventually swell and close the cracks and joints through which the effluent was moving. The result is system failure.

A second problem related to geologic conditions in Utah is the shallow (less than four feet) soil cover over the rock. This is particularly true in the Uinta Basin and portions of southeastern Utah. Lack of minimum required depth of suitable soil frequently prevents installation of STSASs. Alternative methods of wastewater disposal may be acceptable in some areas, but often conditions are such that even they are not feasible.

In past years, percolation test have often served as the single most important evaluation criteria for determining suitability of absorption system sites. Percolation test results should only be considered useful and reliable when used with soil logs from soil exploration pits and other site data. Several states no longer require percolation tests for every absorption system site, but instead use soil classification data, either solely or in combination with percolation test data.

Percolation tests made in certain soils, such as clay, may give anomalously fast results due to the interconnecting system of cracks associated with columnar and blocky secondary soil structure. With continuous wetting, the clay swells and closes the cracks. Several sources of testing error can also affect the results of percolation tests, resulting in under-designing or over-designing of absorption systems.

Present UDH regulations use both percolation test results and soil exploration pit data for designing absorption systems. Absorption fields must be designed according to percolation test results, but seepage trenches and seepage pits may be designed according to either percolation test results or soil description data. UDH regulations governing STSASs now incorporate the Unified Soil Classification System, and this has resulted in greatly improved soil classifications for STSASs.

Installation of STSAS, particularly common systems or groups of systems in housing subdivisions, should be preceded by a careful site evaluation. Although the UDH has no statutory authority for the siting of housing subdivisions, criteria for determining the feasibility of STSASs in such developments was included in the RFIWWDS, and are used to conduct reviews at the request of LHDs.

In summary, few if any sites in Utah can be completely characterized on the basis of existing geologic or hydrologic data. Although some published information is available for most sites, detailed field investigations are necessary to provide the kind of site-specific information needed to properly install STSASs. Considering the importance of site conditions to the successful functioning of STSASs, site evaluations should only be made by qualified personnel.

D. Disposal of Sanitary Wastes at Well Drilling Sites

With the recent increase in oil exploration in Utah, related to the Overthrust Belt, numerous complaints have been received by health authorities regarding improper disposal of sanitary wastes at oil and gas well drilling sites. Most of the complaints have concerned the discharge of sewage onto the ground surface or into so-called "rat holes", which are 20- to 50-foot holes, bored with a large drill rig. Many, if not all, of these "rat holes" extend either directly to ground water or into creviced bedrock formations. Disposal practices of this kind represent a serious threat to ground water. Such disposal practices are clearly prohibited by the RFIWWDS.

As a result of the complaints and subsequent meetings on the issue with the UDH, the Utah Division of Oil, Gas and Mining has agreed to modify their permitting, inspection, and notification procedures for drilling sites. The new procedures will require that all well drilling and well servicing firms submit plans for sanitary waste disposal to the LHD having jurisdiction prior to commencement of drilling operations. LHDs will also receive weekly notifications of "Applications for Permit to Drill" that have been approved in the State, and oil and gas well inspectors will monitor well drilling sites for sanitary waste disposal problems and notify LHDs if such problems are observed.

Geothermal wells and production sites are regulated by the Utah Division of Water Rights. Regulations governing those wells are presently in the process of being revised. Recommendations to help insure the proper disposal of sanitary wastes at those sites were submitted by the Department for inclusion in the revised geothermal well regulations, and again involve LHD approval of plans for such disposal.

E. "Dry" Subdivisions

Numerous housing subdivisions have been approved in the State in past years that have ". . . no individual or central piped public water systems . . .," or no legal or demonstrated means of developing such water systems. Most of these subdivisions are in mountainous areas and many are in sensitive watersheds. Because these "dry" subdivisions are approved and marketed on the basis that no water supply will be provided to the lots, they have been allowed in areas with extensive shallow ground water conditions. Under these circumstances, toilet wastes are frequently disposed of by means of earthen or vault pit privies, or by other unknown or unapproved means of waste disposal. One of the primary reasons that vault and earthen pit privies are unacceptable for single-family dwellings, whether for seasonal or year-round living, is that they are designed for disposing of *only* toilet wastes and not the "gray water" wastes coming from the sink, bathing and laundry facilities. Since "dry" subdivisions have no appropriate method for disposing of "gray water", it is frequently discharged to the ground surface. Numerous studies have shown that "gray water" wastes also contain contaminants that can pollute ground water (Laak, 1980).

A recent survey of "dry" subdivisions (Utah Department of Health, 1985c) identified a number of environmental health and associated problems related to these developments. In all, the survey identified over 45,600 "dry" subdivision lots in the State. Based on that information, a position statement was developed by the Division of Environmental Health and sent to all LHDs and county commissions in September 1985, recommending that city and county subdivision ordinances be reviewed for adequacy and, where necessary, modified to clearly prohibit "dry" subdivisions. Local health departments were also encouraged to adopt their own regulations to prohibit "dry" subdivisions.

F. Issuance of Local Building and Septic Tank Permits

A 1980-1981 survey of LHDs (Utah Department of Health, 1981b) showed that all but 2 of Utah's 29 counties have a building permit program which requires "sign-off" by LHDs prior to issuance of building permits. In spite of this, only 69 percent of LHDs regard county building permit requirements as being uniformly enforced and effective.

A significant percentage of LHDs (47 percent) reported there are cities or towns within their jurisdictions without building permit requirements. Those cities or towns without building permit requirements typically had relatively small populations, were located in the more rural areas of the State, and relied heavily on STSASs. Building permit requirements administered by cities and towns were regarded by LHDs as being less uniform and consistent than county programs.

The survey showed that about 75 percent of the LHDs that have their own STSAS permit requirement, operate separately from the city or county. LHDs usually charge a septic tank permit fee, which averaged $12.60 and ranged between $5 and $45. A recent survey (Hoyt, 1985) by the Bear River District Health Department of its septic tank permit fee resulted in a substantial increase in the fee to $60 for every STSAS. The study justified an even higher fee in the more outlying rural areas of the health district. Charging the present fee represents an "average" based on the study results. Similar studies in other LHDs would likely justify similar increased septic tank permit fees which could in turn help fund and staff STSAS programs.

Penalties for permit violations appear to be inadequate in some local jurisdictions, and nonexistent in others. Strict building permit requirements at the county and municipal level that are properly coordinated with STSAS permitting administered by LHDs could substantially reduce the potential for ground water pollution by curbing or preventing the use of unapproved STSASs in unsuitable sites.

Serious problems identified by the survey with building permit requirements throughout the State as related to STSASs included (1) lack of uniform applicability, (2) lack of enforcement, (3) need for improved coordination between city and county building officials, (4) issuing of building permits without health department "sign-off", (5) building occupation and use of STSASs prior to final inspection by health authority, and (6) the "bootleg" installation of STSASs without the knowledge and approval of LHDs.

G. Installation, Inspection and Maintenance

Generally speaking, three major shortfalls have been identified which compromise the effectiveness of installation requirements in existing regulations: (1) inexperienced contractors, (2) inability of contractor or installer to understand and follow plans, and (3) adverse weather conditions. In addition, a lack of regulations requiring the periodic inspection and maintenance of STSASs after they are installed contributes to system failure.

One of the most important issues in the proper administration of STSAS requirement is the submission of plans to the health authority for review. Although not always complied with, this plan review is in both UDH regulations governing STSASs. This procedure allows the UDH and LHDs the opportunity to identify problems in the initial design and siting of STSASs, and obligates the owner to install the system in accordance with the approved plans. A provision in the RFIWWDS states that "Construction of STSASs shall not commence until plans have been approved by the health authority, and the installer shall not deviate from the approved design without the approval of the reviewing health authority." In addition, some LHDs conduct on-site evaluations of all proposed STSAS sites prior to approving the plans. Because of limited resources, other LHDs rely principally on the submitted soil and plan data, and conduct site inspections only in areas believed to have adverse conditions.

If STSAS requirements are to effectively prevent public health hazards, environmental degradation, and nuisances, the identification and correction of construction deficiencies is necessary. A provision in the RFIWWDS states that whenever an IWWDS is found to be creating or contributing to an insanitary condition, or is discharging wastewater into the waters of the State (which includes ground water), the health authority may order the owner to cause the condition to be corrected or eliminated.

The great majority of STSASs inspections are performed by LHD Registered Sanitarians. Systems receiving more than 5,000 gpd of wastewater are inspected by UDH Public Health Engineers. State regulations governing on-site wastewater treatment systems require inspection of systems by a health authority following construction, many systems are installed and used without being inspected. Where LHD resources permit, a program to inspect STSASs at each critical stage during construction is desirable to detect construction errors.

Proper maintenance of STSASs is a prerequisite to their successful operation. Historically, on-site wastewater treatment technology has not received high priority for management resources because of its use in rural or semirural areas, and its often perceived minor impact on health and the environment. In spite of their functional simplicity and low maintenance requirements, most septic tanks receive no maintenance at all until the disposal system ceases to function. The 1980/1981 survey of STSAS programs (Utah Department of Health, 1981a) showed that the average estimated frequency for cleaning septic tanks in all LHDs was 8.4 years, which falls far short of the recommended cleaning frequency. Only 46 percent of LHDs had a program for encouraging septic tank owners to clean and maintain their septic systems.

The RFIWWDS requires maintenance of STSAS with the statement that ". . . Adequate maintenance shall be provided for septic tanks to insure their proper function. . . ." Septic tanks are also required to be located so as to be accessible for servicing and cleaning, with no structures or other obstructions placed over them to interfere with maintenance operations. Detailed recommendations for the inspection and cleaning of septic tanks are also included in the regulation. Part V of the *Wastewater Disposal Regulations* requires maintenance be provided by the owner, and also requires preparation of a document outlining necessary maintenance procedures for STSASs. No recommendations or guidelines for septic tank maintenance are provided in the regulation. A pamphlet for public use was developed by the UDH in 1982 which provides recommendations and illustrations for cleaning and maintaining STSASs.

In 1984, the Utah Department of Health (UDH) adopted a regulation governing the collection, transportation, and disposal of septic tank wastes (septage) entitled "Regulations For Waste Disposal By Liquid Scavenger Operations". Prior to the adoption of this regulation, less than half of the local health departments had ordinances addressing the collection, transportation, and disposal of septage.

Traditionally, the responsibility for operation and maintenance of STSASs has been left to the owner. The results of that policy have been less than satisfactory. When STSAS tank densities are high, inadequate homeowner maintenance and resulting disposal problems often provide impetus for change from private to public responsibility for wastewater management. As an alternative, on-site wastewater management entities have been established in some areas to assume maintenance responsibility. These entities need the authority to issue orders requiring the repair, replacement, or abandonment of improperly functioning systems. If the owner does not comply with the order to repair or rehabilitate the system, the management entity could require that copies of all violations be filed with the County Recorder. The effect of such a filing requirement would be to give notice of the violation in the chain of title whenever an abstract or title insurance policy is prepared. Any potential mortgagee or buyer would thereby be alerted to the violation.

As the technology for handling on-site systems has evolved and the services rendered by industry have increased, local governments have attempted to keep pace. However, the limited budgets of LHDs generally have not permitted the acquisition or training of staff necessary to keep pace with all aspects of on-site wastewater management. The limited staff of most LHDs must deal with an increasingly complex technology and, as a result, inefficiencies develop. Without support, either from communities through self-management or from a higher level of government, it will be difficult to achieve the efficiency desired in maintaining STSASs.

H. Management and Impact of STSASs on Culinary Water Supply Systems

Although Utah statutes grant authority to the Utah Public Drinking Water Committee over public water supply systems, authority over the environmental health aspects of individual or nonpublic culinary water supply systems has not been specifically granted to either the Department or the LHDs. LHDs have generally assumed some responsibility over individual or nonpublic culinary water systems. However, few LHDs have developed an adequate solution. Most LHDs do not have regulations which govern the sanitary aspects of constructing, storage and distribution facilities for individual or nonpublic water systems. State health regulations require that STSASs be isolated from nonpublic or individual water systems, but compliance with minimum isolation requirements does not guarantee acceptable water quality in every instance. Improperly constructed water systems, or wells not completed in confined aquifers, may be especially susceptible to contamination from STSASs. The "Regulation For Water Well Drillers" promulgated by the Utah Division of Water Rights provides general requirements for the drilling of all water wells. It requires a minimum grouting depth of only 18 feet in wells drilled in all formations (including unconsolidated gravel), which is inadequate to provide assurance that contamination from STSASs will not enter the wells.

The exact magnitude of the impact of STSASs on public and nonpublic water supply sources cannot at this time be accurately determined. Although individual culinary water wells and abandoned hand-dug wells are believed to have been contaminated by septic tank effluent in several areas of the State (Mountainland Association of Governments, 1980), most of these cases are not well documented. Further, there have not been any major waterborne disease outbreaks as a result of this type of contamination. Although uncertainties exist in this area because of a lack of data, public water supplies are required to monitor their water quality and, as a result, generally reliable information is available. Nonpublic culinary ground water sources which are regulated by LHDs are usually not monitored other than when first constructed. Therefore, ongoing water quality data which would indicate problems with these systems is not available.

The general lack of stringent construction standards for individual or nonpublic water systems suggests a greater potential for contamination of these systems by septic tank effluent than for public water supply sources. Many individual or nonpublic wells are drilled into shallow ground water aquifers which are more susceptible to contamination. It is only reasonable to assume that some of these shallow wells have been drilled into aquifers already contaminated by septic tank effluent.

I. Local Environmental Health Manpower Needs

Local health departments have traditionally been understaffed with sanitarians. For many years following the creation of the UDH, environmental health services provided by sanitarians were practically unavailable in outlying areas of the State. As late as the 1970's, several multicounty health departments, including one department with 6 counties, were being served by only 1 LHD sanitarian.

Even with the increased emphasis given to the hiring of LHD sanitarians in the late 1970's, staffing at the local level has not kept pace with increasing workloads, and most LHDs are about one-third understaffed as indicated by the following table:

Year	*Full-time field sanitarians employed in LHD*	*Full-time field sanitarians needed (1/15,000 pop.)*	*Approximate additional sanitarians needed*	*Approximate percent of understaffing by sanitarians*
1976	55.5	89	33	37
1978	65.5	97	31.5	32
1980	64	107	41	38
1985	74	111	37	33

In addition to the chronic understaffing of LHDs a number of other factors can affect environmental health staffing needs. These factors include the size of the geographical area served by each health department, a large per capita number of food establishments, labor and migrant camps, numerous recreational developments and subdivisions, and a higher than average number of visitors and tourists resulting in increased numbers of campgrounds, hotels, motels, and public swimming pools. All of these factors serve to modify environmental health program priorities and dilute available manpower that might otherwise be utilized in STSAS programs.

J. Training of Health Department Personnel and Contractors

Inadequate training of UDH and LHD personnel in all aspects of on-site wastewater treatment systems is a continuing problem. We cannot expect ground water to be protected from contamination by STSASs if those systems are sited, designed, installed, and inspected by inadequately trained personnel. Past training concerning STSASs has consisted primarily of infrequent seminars sponsored by the Utah Environmental Health Association. In recent years, the UDH has sponsored only two seminars on experimental and alternate on-site wastewater treatment technology.

Formal training for licensed contractors who install STSASs exists only in one LHD where a Certified Soil Tester Program has been instituted by regulation. This program consists of a three-day training course in critical aspects of STSAS installation, including soil and ground water evaluation and requirements of system design. Only engineering firms and those individuals and contractors receiving the designation of Certified Soil Tester are permitted to conduct required site evaluations and soil tests for STSASs in the jurisdiction of that LHD. The advantages to this program include (1) improved reliability of soils information, (2) better enforcement, (3) more efficient use of LHD sanitarians, (4) development of more responsible and conscientious contractors, and (5) the generation of revenues for the LHD from those who become certified (Hall, 1985).

K. Lack of Enforcement

One of the most serious problems affecting proper installation of STSASs is lack of enforcement by both the UDH and LHDs. Enforcement is most acute in rural LHDs. Although adequate enforcement options exist for health authorities to implement action in situations where ground water contamination is or may be occurring, such enforcement actions are frequently not undertaken for several reasons. Some LHDs, particularly those in the rural areas of the State, appear to make inadequate use of administrative remedies such as issuing of notices or orders, and the requesting of hearings for violators. Further, even though Section 26-24-19 of the Utah Code Annotated, 1953, as amended, states that county attorneys shall act as legal advisor to LHDs, a number of LHDs do not receive adequate support and assistance from their county attorneys to undertake legal actions against those violating the STSAS regulations. There have been instances when violations have occurred involving installation of "bootleg" STSASs or failure to obtain septic tank permits. Available administrative remedies were used to enforce the regulations without success, and subsequent requests for assistance from the county attorneys were not met.

Section 26-23-1 of the Utah Code Annotated, 1953, as amended, states that whenever a county attorney fails to undertake appropriate legal action requested by the Executive Director of the UDH, the Office of the Attorney General shall undertake such legal action. In a recent enforcement action involving STSASs in a LHD, the Office of the Attorney General has declined to become involved because of its inadequate resources and other pressing priorities.

On numerous occasions, local politicians, usually county commissioners, have instructed LHDs to approve STSASs in areas with unsuitable soil or ground water conditions. In a few instances, the UDH has also been pressured by either local politicians or State legislators to approve STSASs on sites with unacceptable soil and ground water conditions.

Unenforced violations of STSASs appear to multiply as information regarding such incidents is passed from contractor to contractor. Without a uniform, strictly enforced STSAS program, a properly installed and approved STSAS may soon become the exception, rather than the rule.

L. Funding of Environmental Health Programs in LHDs

In 1984, a task force was organized to study and make recommendations for funding of LHDs. The task force was comprised of representatives from the UDH and the Utah Association of Counties. The task force endorsed the Basic Public Health Minimum Performance Standards which mandate LHD programs for STSASs, but concluded that LHDs were generally underfunded to provide all of the services that were expected.

M. Research on On-Site Wastewater Disposal Systems in Utah

While some states, such as Wisconsin and Oregon, have developed relatively extensive research programs for on-site wastewater disposal systems, Utah has never funded such research. In fact, very little research into on-site wastewater disposal systems has been performed in the State by any level of government. A properly funded research program, preferably conducted by one of the State's universities, could contribute substantially to the on-site wastewater disposal system programs throughout the State. Research topics could be evaluated and recommended by entities such as the Wastewater Disposal Technical Review Committee, the Utah Water Pollution Control Committee, and the Utah State University Waste Research Laboratory. Considerable research into on-site wastewater disposal systems could be accomplished by university graduate students with only limited expenditure of funds.

SECTION SIX

CONCLUSIONS

A. In spite of the ground water pollution potential that exists with STSASs, they will remain the principal means of wastewater treatment and disposal in Utah where housing density cannot economically justify municipal sewage treatment systems.

B. The State's previous one-foot minimum separation requirement between maximum seasonal ground water elevation and absorption system excavations was inadequate to protect ground water from sewage contamination. The past inadequate separation distance has contributed to ground water contamination by allowing STSASs to be installed in areas with high ground water tables. The recent increase in the separation distance to two feet is a positive sign, but substantial evidence exists that the two-foot separation distance from the maximum seasonal water table is inadequate in many situations.

C. Accurate site evaluations are critical to the proper design of on-site wastewater disposal systems.

D. Building permit and septic tank permit programs throughout the State reflect a lack of uniformity and adequate enforcement.

E. The majority of on-site wastewater disposal systems in Utah are not properly maintained.

F. Local health departments are understaffed.

G. There is a need for training of both health department personnel and contractors.

H. Guidelines for nonpublic water supply systems need to be developed.

I. There is a severe shortfall in regulation enforcement, particularly in the failure to fully utilize administrative enforcement remedies. Also, in many instances, county attorneys are not providing the necessary assistance in enforcement actions.

J. Local health departments are underfunded for STSAS programs.

K. On-site wastewater disposal system research is needed.

SECTION SEVEN

RECOMMENDATIONS

The following recommendations for implementation by either the UDH or LHDs have the potential to significantly decrease contamination of ground water by STSASs in Utah:

A. **Ground Water Separation and Monitoring**

1. Increase the required separation between the maximum seasonal ground water elevation and the bottom of absorption system excavations to a minimum of four feet. A differential protection matrix based on soil texture and maximum seasonal ground water information could be considered for the regulations, but its use would require more accurate and, consequently, more expensive site evaluations.
2. Proposed deep STSASs should be carefully evaluated to insure they will not contaminate, or be adversely affected by ground water.
3. Increased use should be made of sewage pump wells and ejector pumps in those installations where wastewater must be raised to a higher elevation to permit adequate separation between the maximum ground water elevation and absorption systems.
4. Consider the installation of experimental IWWDSs on selected sites not meeting minimum requirements for conventional IWWDSs. "Capping fill" conventional IWWDSs will also provide increased protection of ground water from sewage contamination on some sites.
5. Ground water monitoring wells should be installed in selected STSASs, particularly in environmentally sensitive areas, to permit monitoring of the ground water elevation and sampling of the upper portion of the saturated zone just below the soil absorption system for evidence of pollution.
6. At those sites where the maximum seasonal ground water elevation fluctuates widely and is difficult to determine, ground water monitoring wells should be installed for a suitable period prior to approval of STSASs to insure accurate ground water elevation determinations.

B. **Septic Tank Densities/Lot Size**

1. Conduct further study into the issue of STSAS density in Utah and make appropriate recommendations for modification of existing UDH regulations.

C. **Site Evaluation**

1. Allow the installation of experimental IWWDSs in certain types of bedrock, such as shale, where it can be demonstrated that these formations can adequately disperse the proposed volume of sewage over the intended life of the system, and that culinary quality ground water would not be contaminated.
2. Develop a separate document or section in the STSAS regulations on the siting of such systems to bring together all pertinent requirements concerning site evaluation. Define bedrock and include a discussion of weathered bedrock and its effect on septic tank system siting.
3. A better definition of bedrock is necessary. It should include a discussion of weathered bedrock and its effect on septic tank system siting.
4. Require additional ground water information to insure the siting data for multiple STSASs in subdivision developments and common STSASs is adequate. Characteristics of aquifers in the site vicinity, location of recharge and discharge zones, direction of ground water flow, and existing patterns of ground water use should be determined and considered when installing STSASs.
5. Health authorities should utilize the numerous geological resources to the fullest extent possible in identifying sensitive ground water areas that may be contaminated by STSASs, and in determining whether those systems or dwellings may be adversely affected by high ground water or unsuitable soil conditions.
6. Each LHD should obtain its own library of geologic, hydrologic, and soil studies that pertain to its jurisdiction.
7. Each LHD should identify and keep records on those areas within their jurisdiction with high or widely fluctuating ground water tables or unsuitable soil formations.
8. The overly large percolation test hole diameter of 4 to 18 inches specified in the UDH regulations is a source of testing error that should be changed to a diameter of 8 to 12 inches.
9. Less reliance should be placed by health authorities on percolation test results per se. Soil profile data from soil exploration pits should be used in evaluating and interpreting percolation test results.
10. All STSASs should be designed using a combination of percolation test results and soil description data.
11. Training in use of the Unified Soil Classification System, rock classification, and geologic and hydrologic maps needs to be provided to both UDH and LHD personnel.
12. Where resources permit, LHDs should conduct an on-site inspection of every proposal for an STSAS, prior to approving plans for those systems.

D. **Disposal of Sanitary Wastes at Well Drilling Sites**

1. Local health departments should closely monitor oil, gas, and geothermal sites to insure that sanitary wastes generated on the sites are disposed of in accordance with applicable regulations.

E. **"Dry" Subdivisions**

1. Local health departments and county commissions should adopt ordinances that prohibit development of "dry" subdivisions.

F. **Issuance of Local Building and Septic Tank Permits**

1. Septic tank permit fees should be reevaluated by LHDs, and where justified, increased to help fund and staff STSAS programs.
2. Counties and municipalities should have bona fide building permit programs that require "sign-off" by LHDs prior to issuance of building permits.
3. Penalties for building permit and septic tank permit violations should be increased significantly to serve as a deterrent to future violations.

G. **Installation, Inspection and Maintenance**

1. The UDH and LHDs should strictly enforce the requirements for plan submission and review for all STSASs.
2. LHDs should periodically conduct a sample survey of approved and installed STSASs to determine the number of failing systems

and identify program weaknesses.

3. Known malfunctioning STSASs should be corrected or eliminated with appropriate enforcement action by health authorities.
4. A checklist of specific aspects of STSASs that require inspection should be developed and utilized by UDH and LHD personnel to help insure that no pertinent design requirements are overlooked.
5. If STSASs are installed differently than shown by the approved plans, "as-built" plans should be required to identify system location and document compliance with minimum regulations.
6. Distribute maintenance instructions on every approved STSAS.
7. Routine, preventative cleaning every three to five years of all septic tanks (depending on usage and capacity), combined with appropriate record keeping, should be encouraged and promoted by the UDH and LHD. Septage wastes must be disposed of in accordance with applicable regulations.
8. The UDH and LHDs should undertake public awareness campaigns with radio or newspaper announcements encouraging periodic cleaning of septic tanks.
9. The use of on-site wastewater management entities should be investigated to provide operation and maintenance services, particularly where STSAS density is high.

H. Management and Impact of STSASs on Culinary Water Supply Systems

1. A guideline or recommended regulation for the design and construction of nonpublic water supply systems needs to be developed by the UDH and made available for use by LHDs.
2. Study and document culinary water sources suspected of being contaminated by septic tank effluent.

I. Local Environmental Health Manpower Needs

1. Increase environmental health staffing of LHDs to at least minimum recommended levels.

J. Training of Health Department Personnel and Contractors

1. Certified Soil Tester Programs should be adopted by all LHDs.
2. All contractors installing STSASs should be properly licensed, with license checks made periodically by LHDs.
3. Frequent training seminars on STSASs and experimental IWWDSs should be provided for both UDH and LHD personnel.

K. Lack of Enforcement

1. Greater emphasis by both the UDH and LHDs should be given to the use of administrative remedies for STSASs enforcement issues, prior to requesting legal assistance. Rural LHDs in particular need to establish clear administrative enforcement procedures involving issuing of notices, orders, and the conducting of hearings for violators.
2. Educate State and county attorneys concerning pertinent regulations and the environmental consequences of violations by establishing an improved, ongoing dialogue between county attorneys, local boards of health, directors of LHDs, and directors of environmental health.

L. Funding of Environmental Health Programs in LHDs

1. Adequately fund LHD STSAS programs.
2. Include UDH and LHD directors of environmental health programs on committees organized to study STSAS funding.

M. Research on On-Site Wastewater Disposal Systems in Utah

1. Develop research funding for on-site wastewater disposal systems by one or more of the State's universities.

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Glossary of Acronyms Used

IWWDS — Individual Wastewater Disposal System

LHD — Local Health Department

RFIWWDS — Regulations For Individual Wastewater Disposal Systems

STSAS — Septic Tank and Soil Absorption System

USEPA — U.S. Environmental Protection Agency

UDH — Utah Department of Health

SOLID WASTE

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INTRODUCTION

Ground water problems resulting from the disposal of solid waste are usually overshadowed by problems and publicity surrounding the disposal of hazardous material; yet solid waste disposal facilities pose a serious ground water contamination threat which must be considered prior to the construction of facilities. Many wastes which contain hazardous constituents are not included in the purview of Utah's hazardous waste management program due to regulatory exemptions, and can be disposed of in solid waste landfills. In addition, many industrial wastes which are now regulated by the hazardous waste program were disposed of in solid waste landfills, prior to the implementation of hazardous waste regulations.

The lack of adequate regulatory control of solid waste disposal facilities allows the disposal of many wastes in a manner that could readily result in the generation of contaminated leachate, which may eventually contaminate the ground water resources. Existing regulations should be significantly revised to effect changes that will ensure the proper protection of Utah's ground water resources. All solid waste landfills must be inventoried and investigated to determine the extent of existing problems. Regulations governing solid waste disposal must be revised to include specific construction and operational performance criteria. An enforcement program which routinely monitors operating landfills must be developed to ensure compliance with State policies and regulations.

PROGRAM ADMINISTRATION

Prior to June 20, 1981, the solid waste disposal program was administered and enforced by the Utah Department of Health, Bureau of Solid Waste Management. In June 1981, authority to administrate the program was transferred to the Utah Solid and Hazardous Waste Committee (the Committee). The Committee subsequently delegated authority to approve permits to the Committee's Executive Secretary who also acts as the Director of the Bureau of Solid and Hazardous Waste, Division of Environmental Health, Department of Health. The Bureau staff reviews all solid waste disposal permit applications to determine compliance with the Code of Solid Waste Disposal Regulations. Operating permits are issued by the Bureau Director under authority granted by the Committee. However, disputed Bureau decisions regarding permit applications can be appealed to the Committee for final resolution.

The Bureau has delegated responsibility for routine inspection of solid waste landfills to the local health departments. Enforcement actions against landfills in violation of the regulations are therefore usually initiated by the local health department. However, authority to enforce the regulations rests with the Bureau and the Solid and Hazardous Waste Committee; therefore, enforcement is ultimately the responsibility of the Bureau and Committee.

REGULATIONS

The Utah Solid and Hazardous Waste Act (Chapter 14, Title 26, Utah Code Annotated 1953, as amended June 20, 1981) constitutes the authority delegated to the Utah Department of Health for the purpose of establishing minimum requirements for the disposal of solid waste in the State. Prior to 1974, the only regulation governing solid waste disposal was the prohibition of open burning. Requirements for solid waste disposal were established in 1974 by the *Utah Code of Solid Waste Disposal Regulations;* with which all owners and operators of solid waste management facilities must comply. In 1981, the regulations were amended to exclude hazardous waste, which is now regulated by the Utah Hazardous Waste Management Regulations (UHWMR).

The *Code of Solid Waste Disposal Regulations* was developed to correct problems such as air and water pollution, health threats, wind dispersal of trash, open burning, noxious odors, and rodent infestation at open dumps. Upon promulgation of the regulations, all existing facilities were to comply with the regulatory requirements. The regulations include procedures for submittal of permit applications, permit approval criteria, site operation requirements, handling procedures for special wastes, and closure criteria for open dumps. The emphasis of the initial solid waste regulations was to address the more obvious problems of air and water pollution, and adverse health effects due to existing disposal practices. Less emphasis was placed on the more obscure problem of ground water contamination.

Permit application requirements pertinent to ground water include the following:

1. A map illustrating wells, watercourses, surface drainage channels, rock outcroppings and topography of the landfill area.
2. Description of soils to a depth of five feet below the proposed excavations.

3. The maximum ground water elevations throughout the site.
4. A general description of the geology of the area.

This information is used by the Bureau to evaluate the proposed site according to the plan approval criteria outlined in the regulations. Unfortunately, minimum standards for the submittal are not well defined. Current Bureau policy dictates only that the application include the required information.

The regulations which address permit approval criteria include only cursory consideration of the relationship between ground water and the landfill cells. The regulations suggest a minimum of five feet of separation between ground water and the bottom of the landfill cells. However, exceptions to this rule are permitted if the site can be modified to preclude wetting by ground water of the waste.

The primary operating requirements for landfills include placing six inches of soil cover over the landfill after each operating day, and the elimination of open burning. Additional operating provisions include litter control, dust control, supervision of the site, and maintaining records of the amounts of solid waste disposed. Currently, there are no policies or regulations outlining performance standards for the soil-cover material. Development of these standards should require operators of landfills to install a cap that would significantly reduce infiltration and provide an effective means of reducing the potential for ground water contamination.

Hazardous and special wastes are also addressed by the *Solid Waste Disposal Regulations*. Those hazardous wastes which are not regulated by the UHWMR can be disposed of in a separate area of the disposal facility, but must be immediately covered. Special wastes include: automobile bodies, construction debris, large appliances, animal carcasses, wastewater treatment plant sludges, etc. The regulations also define minimal handling requirements for these special wastes.

Closure requirements for existing open dumps include the eradication of rodents, extinguishing of all fires, revegetation, if feasible; and the covering of waste with two feet of suitable material. The cover must be graded to provide proper drainage and prevent ponding. Technical performance standards for the closure of open dumps are not codified, and have not been established as policy in the Bureau.

Conceptually, many of these regulations assist in protecting ground water. However, technical criteria governing installation and operation of a landfill is practically non-existent, and permit applications typically address only the minimum requirements of the regulations. This may result in inadequate management and construction of disposal facilities, and the generation of leachate that would contaminate adjacent ground water. Greater use of current technology and compliance with minimum technical performance standards for the design and closure of cells would significantly reduce the potential for ground water contamination.

SOLID WASTE IN UTAH

Solid waste disposal facilities in Utah receive a variety of wastes, many of which may contain hazardous constituents, capable of migrating and contaminating ground water. Many landfills contain large amounts of residential waste containing hazardous materials such as chlorinated hydrocarbons in the form of cleaning solvents and pesticides. Paint and paint sludges are also common residential wastes and may contain hazardous lead compounds. Also, many other residential wastes such as oils, cleaning solutions, and aerosols contain hazardous constituents.

In the past, industrial waste was commonly disposed of in solid waste disposal facilities. Many of these industrial wastes contain organic and heavy metal constituents, which are capable of contaminating ground water. Their disposal in solid waste landfills could create ground water problems for the future. Currently, the hazardous waste program requires disposal of many industrial wastes in hazardous waste disposal facilities.

Permit applications for Solid Waste Disposal Facilities are typically submitted by city or county governments, private industries, and occasionally by private citizens. The widely dispersed population in Utah has resulted in the construction of a large number of facilities throughout the State to serve each individual community or industry. Currently, there are approximately 250 operating landfills in the State. Many of these landfills were constructed by very small communities, private industries, the Forest Service, and the Bureau of Land Management (BLM). In addition, there are an unknown number of solid waste disposal facilities which have been closed. Due to the lack of a centralized recordkeeping system, the exact number of operating and closed facilities in the State is unknown.

At present there are only three known facilities in Utah which have implemented ground water monitoring programs in an effort to assess potential impacts on the ground water due to waste disposal. These facilities include the Salt Lake County landfill, the Bay Area Refuse Disposal (BARD) facility and the North Area Refuse Disposal (NARD) facility. The latter two facilities are in Davis County and are under the jurisdiction of the Davis County Health Department. Monitoring at the BARD and Salt Lake County sites has identified contaminants in the ground water. The NARD site is still under investigation, and further study is necessary before the site can be completely evaluated.

The U.S. Environmental Protection Agency has recently initiated a program to evaluate solid waste disposal units (SMU's) at industrial facilities throughout the country. All treatment, storage, and disposal facilities, which are regulated, are required to submit a report on all SMU's at the facility . SMU's consist of any unit operated currently or historically for the disposal of any waste generated by the facility. Many industries in Utah are in the process of evaluating SMU's, and the information generated by this study should significantly assist the Bureau in evaluating potential problems due to industrial waste disposal.

Due to a lack of resources, the majority of the Bureau's effort is concentrated on the hazardous waste program, with minimal effort concentrated on the solid waste program. Enforcement of the solid waste disposal regulations has been delegated to the local health departments. However, resources for enforcement of the regulations are limited in these organizations, and enforcement is not generally a high priority.

RECOMMENDATIONS

There are a number of problems with enforcement and administration of the solid waste disposal program in Utah. These problems are explained in the following text, and possible solutions are presented.

1. Currently, there are, approximately 250 known solid waste disposal facilities in Utah and an undetermined number of closed sites. Only three sites have initiated investigations to evaluate potential impacts on ground water. A thorough inventory of all disposal facilities (including closed sites) in the State, and an investigation of each site is necessary to define the extent of ground water problems associated with solid waste disposal.
2. Solid waste disposal regulations in Utah are outmoded and must be revised to provide proper protection for ground water. Existing regulations provide only a cursory evaluation of ground water during the permit application review process. Revision of the regulations should provide the Bureau with authority to require: siting criteria which would consider ground water, comprehensive investigations of potential ground water impacts including installation of ground water monitoring systems, control of run-on and run-off, and engineering technology which would minimize leachate generation and migration.
3. The majority of the investigative and enforcement resources within the Bureau of Solid and Hazardous Waste is directed to the hazardous waste program. The Bureau needs additional manpower to develop an enforcement program and tracking system that will ensure compliance with the regulations, and provide proper protection of Utah's ground water.

SURFACE IMPOUNDMENTS AND URBAN RUNOFF

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INTRODUCTION

Surface impoundments are used for storage and disposal of waste water. The waste water may be derived from community sewage collection or treatment facilities, industrial process or waste water, agricultural facilities such as feed lots, and storm runoff.

Small communities favor the use of surface impoundments, or lagoons, for treatment of raw waste water or effluent from sewage treatment processes. They offer an effective, low cost, low technology method of waste treatment. Industry uses surface impoundments to store or dispose of industrial waste, process, or cooling water. Farmers use surface impoundments to retain water from the cleaning of dairy barns and runoff from animal feed lots. In urban areas, surface impoundments or detention basins are used to hold excess storm water runoff. When the impounded water is contaminated, the ground water can be polluted by seepage.

Surface impoundments are common throughout the State's populated areas. In a survey of Utah made in the late 70's, Cleave et al (1980) reported locating 55 municipal sites, 38 industrial sites, and 6 agricultural sites. Each site had one or more impoundments ranging in size from less than one acre to hundreds of acres. The survey also counted 3 mining sites and 37 oil and gas sites. Impoundments at mining, and oil and gas exploration or production facilities are discussed in the ground water assessments of these activities.

Urban runoff is a catchall term for the runoff resulting from precipitation in an urbanized area. Typically it will contain varying amounts of salt, oils, grease, and other organic and inorganic chemicals that result from road deicing or small spills. Urban runoff can carry contaminants into the ground water through infiltration along creeks, drainage channels, canals, lakes, reservoirs, or other impoundments; absorption and infiltration in soil-covered areas; and by disposal in dry wells. Urban runoff is generally considered to be a major contributor to the degradation of the ground water in the shallow aquifer along the Wasatch Front.

REGULATION OF SURFACE IMPOUNDMENTS

Surface impoundments are regulated according to their intended use. The Bureau of Water Pollution Control (BWPC) of the Utah's Department of Health (UDH) Division of Environmental Health (DEH) regulates surface impoundments (lagoons) used for sewage treatment. Industrial impoundments and storm-water detention basins are regulated under the Environmental Protection Agency's (EPA) National Pollution Discharge Elimination System (NPDES). The State Engineer, Division of Water Rights, regulates construction, modification, and operation of large impoundments used for water storage.

WASTE STABILIZATION (SEWAGE) LAGOONS

Sewage lagoons utilize aerobic and anaerobic processes to treat waste water. In the near surface part of the lagoon, algae and aerobic bacteria decompose the waste material. In the sludge layer on the bottom of the lagoon, waste is decomposed into methane and carbon dioxide by anaerobic bacteria. The sludge layer also acts as a filter to slow seepage through the bottom of the lagoon.

Sewage waste water commonly contains two potentially serious ground water contaminants: nitrogen as ammonium (NH_4+) or nitrate (NO_3-), and bacteria. In addition, increased levels of potassium, phosphorus, chloride, sulfate, and dissolved solids are present. Although nitrogen is a major component of the air and an important plant nutrient, it can be harmful to humans and livestock when high concentrations of the nitrate form are present in drinking water. However, waterborne disease from bacteria or viruses is a more serious and more common ground water contamination problem near sewage lagoons.

To minimize adverse ground water and health impacts, sewage lagoons must be located distant from wells used as a source of drinking water. Lagoons should be located in areas with a substantial depth to ground water; have a thick soil underlayer and a well-compacted clay liner; and have sufficient capacity for a long retention time. Long retention time is critical for the complete biochemical treatment of the wastes and the reduction of bacteria and nutrients in the water. A well-compacted, unsaturated, underlying soil layer encourages the build-up of a sludge layer in the bottom of the lagoon and the removal of bacteria by filtration and ammonium by attachment to soil particles.

The Bureau of Water Pollution Control in Part III of the *Code of Waste Disposal Regulations* provides criteria for the location, construction, and operation of waste stabilization ponds (lagoons). The regulations require lagoons to be distant from areas of human habitation and water supply facilities (Reg. III-84). They are to be sized to meet the prescribed retention times and the embankments constructed to prevent seepage (Reg. III-85-87).

Regulation III-88 establishes requirements for the design of the lagoon bottom. Vegetation and porous topsoils must be removed and gravel or limestone areas are to be avoided. If anticipated seepage exceeds 1/4 inch per day, the bottom should be sealed with clay, bentonite, asphaltic coating, or other sealants. In areas where ground water is a source of water supply, lagoon sealing is required.

INDUSTRIAL IMPOUNDMENTS

Surface impoundments used by industry are regulated by the Bureau of Solid and Hazardous Waste Management (BSHWM) under the Utah Hazardous Waste Management Regulations. Section 7.8, "Surface Impoundments," sets requirements for operation, inspection, and closure for owners and operators of facilities that use surface impoundments for the treatment, storage, or disposal of hazardous waste. Section 8.6, "Ground Water Protection," provides more extensive regulations for ground water protection by the owners or operators of hazardous waste facilities. Included in the latter regulations are applicability qualifications, protection standards, ground water monitoring requirements, and standards for closure and post-closure maintenance of the facility. Section 8.2, "General Facility Standards," sets standards for security, personnel training, inspection, and location of hazardous waste impoundments.

AGRICULTURAL IMPOUNDMENTS

Agricultural impoundments that contain runoff or wash water from dairy facilities or animal feeding operations are currently regulated by EPA under the NPDES regulations. However, Utah is currently assuming responsibility for this regulatory program and has provided for regulation of large animal feeding operations. Under the proposed regulations, facilities with more than 1000 slaughter and feeder cattle, or 750 dairy cattle would be regulated. Similar minimums are set for horses, sheep, turkeys, chickens, and other animals. The proposed regulations do not presently address impoundments that discharge to the ground water of the State.

Agricultural impoundments that do not meet the above minimums are currently subject to regulation by local health departments. However, due to the general perception that they do not constitute a substantial water pollution threat, they are not a priority enforcement item unless complaints are received.

SURFACE IMPOUNDMENTS (RESERVOIRS)

Surface impoundments, such as reservoirs that retain runoff for irrigation or stock watering, are regulated by the State Engineer, Division of Water Rights, if they exceed 20 acre-feet in storage capacity (UCA 73-5-5). Under this law, construction plans must be submitted to the State Engineer for approval. Under certain conditions the State Engineer may also regulate smaller impoundments.

REGULATION OF URBAN RUNOFF

Studies of urban runoff indicate that runoff water may contain both organic and inorganic pollutants, increased levels of bacteria, and biochemical oxygen demand (B.O.D.). Compounds of lead, zinc, copper, cadmium, mercury, arsenic, and phosphorus have been reported; organic pollutants include greases, oils and gasoline components. Water quality standards for B.O.D. and fecal coliform bacteria may also be exceeded. Typically, 30 to 50 percent of the surface of an urban area is covered by an impermeable cover, such as pavement or buildings. About 20 percent of urban runoff is expected to infiltrate into the ground water system.

DETENTION BASINS

Detention basins, either of natural or man-made origin, have found increasing use to store excess storm water and augment ground water recharge in arid areas. The effect of these impoundments on ground water quality depends on the pollutant loads, basin construction, maintenance practices, local soil and geology, and areal relationship to major aquifer recharge areas.

Storage of contaminated storm runoff in detention basins prevents this type of water from reaching lakes and streams. Wetland vegetation facilitates the uptake of contaminants in detention basins. The use of these basins for management of storm water is strongly advocated as the preferred method of handling urban runoff.

When detention basins serve the added purpose of artificial recharge of ground water, pollutants in the storm water present additional problems. In recharge basins, the intent is to maximize infiltration into underlying aquifers. These basins should be closely monitored to determine if pollutants are present and to what degree they are entering the aquifers. Periodic removal of contaminated sediments may be necessary to maintain high infiltration rates and minimize ground water contamination.

The location of storm water detention basins determine the potential for adverse impact on ground water quality. Runoff from industrial areas is more likely to have pollutants present than residential areas. The geology, soil system, basin size, and construction are also significant factors affecting overall impact. Finally, the hydrologic relationship to water supply wells must be considered.

Irrigation Canals

In urban areas where canals have been historically used for distribution of irrigation water, flood control agencies and municipal entities are likely to use them for storm water disposal. Often these open channels are constructed along major contours with very little grade. The result is a drastic reduction in flow velocity with a greater opportunity for infiltration to shallow and deep aquifers. Most irrigation canals are not lined with impervious material, and loss from infiltration to ground water is high. This infiltration may have deleterious effects to ground water quality if water flowing in the canal is contaminated.

The mean concentrations of constituents in storm runoff in Salt Lake County irrigation canals indicate a potential for ground water contamination by these sources. Biochemical Oxygen Demand, nitrogen, ammonia, sediment, and several heavy metals occur in sufficient concentrations as to pose a potential pollution source to either shallow or deep aquifers.

For those canals constructed within recharge zones, management practices to prevent pollution would include lining with impervious material or other contamination prevention strategies. Irrigation canal companies can legally deny use of their canals as storm water conduits if contaminants exceed water quality standards. Company approval of storm water discharge containing contaminants may involve the irrigation canal company as a liable party in the abatement or cleanup of polluted conditions. Therefore, it is in the interest of the canal company and it's stockholders to protect the quality of water in their systems.

CONCLUSIONS

Regulation of surface impoundments that may contribute to ground water pollution varies greatly in approach, degree, and comprehensiveness. The regulations governing sewage lagoons include specific requirements for design, construction, and operation. The regulations governing industrial impoundments use a different approach by establishing a large group of standards the facility must meet. As an alternative to meeting ground water protection requirements, an owner or operator of an industrial impoundment can install a double-lined surface impoundment with a leak detection system.

Neither design requirements nor design goals have been established for agricultural impoundments in the proposed Utah Pollution Discharge Elimination System regulations. Requirements, responsibility, and authorities need better definition for these impoundments.

Although the recognition of storm water runoff as a source of ground water contamination is widespread, methods to diminish it's adverse ground water effects are few. Detention basins find their greatest use in preventing the storm drain system from overloads and consequent flooding, and removal of sediment and debris from storm water. Ground water impact is usually a secondary consideration. Recognition of the problem is an important first step. More study will be necessary to develop better means of handling urban runoff.

RECOMMENDATIONS

1) Current regulations for new surface impoundments, including waste stabilization lagoons, industrial impoundments, and surface storage impoundments, are adequate for ground water quality protection. Further strengthening of these regulations is not indicated at this time.

2) Existing surface impoundments not meeting current regulatory standards should be subject to ground water monitoring to determine if the facility is contributing to pollution of the ground water. Remedial action should be required to clean up existing ground water contamination and prevent further degradation of the ground water.

3) Further study of agricultural impoundments and storm water detention basins needs to be made to develop economic and effective best management practices to minimize or prevent ground water contamination from these sources.

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