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MONTANA GROUND-WATER STATUS REPORT

To

Ground-Water Advisory Council

Prepared by

Department of Natural Resources and Conservation
Montana Bureau of Mines and Geology
Montana Department of Health and Environmental Sciences
Montana Department of State Lands
Montana Environmental Quality Council
Montana State University
Montana University Joint Water Resources Research Center
University of Montana
U.S. Environmental Protection Agency
U.S. Geological Survey

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This report represents the efforts of individuals from the various state/federal agencies and state university departments that work with ground-water resource issues in Montana. As such, the sections that comprise the report were written by various individuals and are as follows:

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Other ground-water professionals from the various agencies and university departments also provided technical assistance for this report. These include:

Richard Brustkern	Montana State University
Al Cunningham	Montana State University
Stephen Custer	Montana State University
Howard Johnson	Environmental Quality Council
Joe Moreland	U.S. Geological Survey
Howard Peavy	Montana State University
William Hunt	Montana University Joint Water Resources Research Center

The report was compiled and edited by staff from the Department of Natural Resources and Conservation's Water Resources Division, which included:

Wayne Wetzel	Supervisor, Hydrosciences Section
Paul Lemire	Geohydrologist
Debra Hanneman	Geohydrologist

Additional DNRC personnel participated in the critical review of the report:

Frank Culver	Special Staff
Gary Fritz	Administrator, Water Resources Division
Gerhard Knudsen	Supervisor, Water Planning Section
Carole Massman	Special Staff
Richard Moy	Chief, Water Management Bureau
Peggy Todd	Editor, Publications Bureau

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INTRODUCTION

Ground water comprises a significant and growing percentage of the water used in Montana. During the first year following enactment of the 1973 Montana Water Use Act, 501 ground-water appropriations were filed; by 1981 the yearly total had increased to 7,557. Most of these appropriations involve relatively small volumes of ground water for domestic or stock water use. For all appropriations of water since 1973 with withdrawal rates over 100 gallons per minute, ground water represents only 17 percent of the total appropriations but accounts for 49 percent of the volume for all uses and 34 percent of the volume for irrigation use.

Major ground-water users in Montana include rural households, municipalities, industry, and agriculture. The actual amount of ground water withdrawn is difficult to tabulate since rural, agricultural, and industrial diversion are generally only estimated. However, a cumulative ground-water withdrawal rate of 261 million gallons per day has recently been estimated (Department of Health and Environmental Sciences 1982). As such, this constitutes about five percent of all water diverted in the state. A graphical presentation of ground-water use in Montana is presented in Figure 1. Table 1 lists state wells by use and by county.

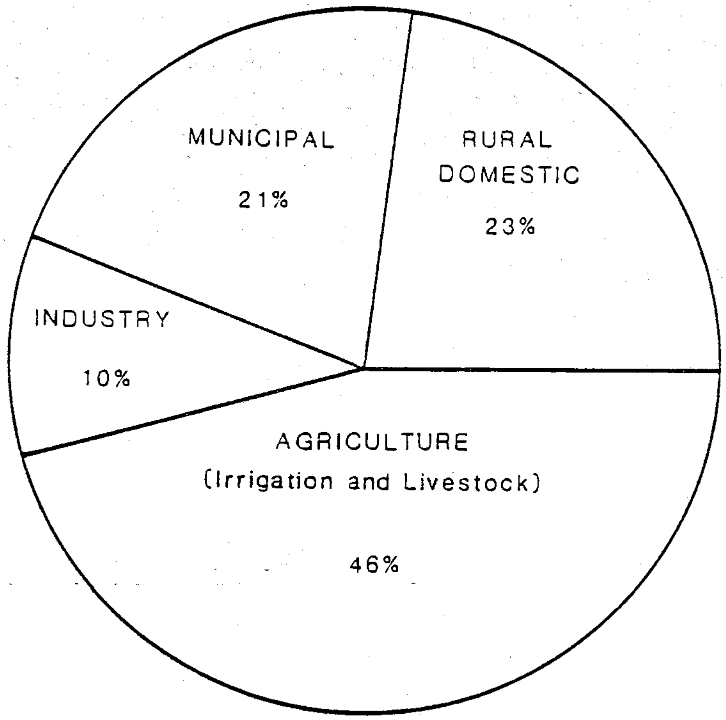


Figure 1. Ground-water use by volume in Montana.
Source: Montana Water Quality--305b Report,
DHES, 1982.

Table 1. Montana wells by use and by county. *I--Municipal, II--Other Public (Subdivisions and Trailer Courts), III--Domestic, IV--Agricultural (Irrigation and Livestock), V--Industrial, VI--Other, VII--Total number of wells, VIII--Municipal Water Use (mgd), IX--Self-supplied Industrial Use (mgd).

	*I	II	III	IV	V	VI	VII	VIII	IX
Beaverhead	11	14	831	300	4	89	1249	0.52	0.08
Big Horn	3	10	379	384	18	93	887	0.26	
Blaine	1	8	342	397	6	32	786	0.04	
Broadwater	0	8	453	234	1	62	758	0.97	
Carbon	1	13	880	215	2	126	1237	0.59	
Carter	0	2	185	648	0	19	854	0.08	
Cascade	22	11	1321	247	5	116	1722	0.80	
Chouteau	0	28	491	344	0	121	984	0.26	
Custer	12	9	443	704	3	122	1293	0.20	
Daniels	1	6	261	193	2	91	554	0.25	
Dawson	13	14	700	710	17	123	1577	0.37	
Deer Lodge	3	4	591	39	6	38	681	4.15	
Fallon	0	7	297	571	8	42	925	0.42	
Fergus	1	7	725	459	13	165	1370	2.14	0.27
Flathead	19	34	3327	122	37	323	3862	3.60	4.57
Gallatin	15	27	2669	237	37	192	3158	1.92	0.56
Garfield	0	2	218	689	2	40	951	0.06	
Glacier	8	4	283	105	20	20	440	0.86	0.24
Golden Valley	0	0	165	279	0	20	464	0.01	
Granite	4	4	420	45	1	43	517	0	
Hill	0	21	664	238	9	99	1031	1.06	
Jefferson	1	25	646	100	6	70	848	1.67	0.21
Judith Basin	2	8	325	323	3	76	737	0.06	
Lake	2	20	1322	70	3	122	1539	0.66	
Lewis & Clark	10	36	2418	216	15	281	2976	1.57	0.08
Liberty	0	3	168	118	0	41	330	0.01	
Lincoln	11	15	1180	21	6	72	1305	0.78	0.08
McCone	2	7	300	496	0	46	851	0.12	
Madison	2	14	904	176	3	54	1153	0.19	
Meagher	0	5	150	54	2	33	244	0.06	
Mineral	5	8	235	12	3	32	295	0.34	2.31
Missoula	14	60	2646	94	65	304	3183	13.27	17.50
Musselshell	0	9	546	829	2	68	1454	0.91	
Park	1	11	747	90	9	103	961	2.55	
Petroleum	1	1	71	193	47	30	343	0.01	
Phillips	2	7	597	496	8	54	1164	0.39	
Pondera	0	13	184	85	0	28	310	0.12	
Powder River	1	9	442	1605	3	27	2087	0.25	
Powell	1	6	463	86	3	38	597	1.12	
Prairie	4	5	211	590	9	25	844	0	
Ravalli	10	30	3686	288	18	1033	5065	2.12	0.02
Richland	1	20	635	834	23	73	1586	1.45	
Roosevelt	1	10	405	372	13	67	868	1.06	0.03
Rosebud	0	21	316	672	17	62	1088	0.57	
Sanders	5	8	672	104	2	108	899	0.65	
Sheridan	0	12	336	190	6	49	593	0.65	
Silver Bow	5	4	610	56	10	47	732	0.02	0.78
Stillwater	3	6	668	401	5	71	1154	0.65	
Sweet Grass	0	2	341	180	2	34	559	0.31	
Teton	5	10	758	310	2	97	1172	1.03	
Toole	0	11	111	127	1	63	313	0.97	
Treasure	0	2	71	223	0	10	306	0	
Valley	0	24	708	574	6	149	1461	1.16	
Wheatland	1	2	121	396	2	36	458	0.13	0.06
Wibaux	0	7	239	410	2	36	694	0.06	
Yellowstone	4	18	2255	889	17	281	3464	0.84	0.28
TOTAL	208	682	41132	18731	485	5696	66934	54.57	26.97

Source: Water Resources Division, Department of Natural Resources and Conservation

The significance of Montana's ground-water resource cannot be measured by these statistics alone. In many areas of the state ground water is the <u>only</u> source of supply, magnifying its importance to those reliant upon it. In fact, according to recent data from the DHES over half of the state's population relies heavily on ground water for domestic and agricultural supplies. Also, as surface water becomes increasingly appropriated, ground water will be looked to as an alternative source. Water use has been increasing in all sectors - industrial, municipal, rural domestic and agricultural - and ground-water use is expected to increase dramatically as the demand for water grows.

Despite the importance of the ground-water resource, both at present and in the future, Montanans have exhibited a certain complacency towards this resource when compared to the interest in surface water. This complacency is fostered by the fact that Montana has not yet experienced on a large scale the aquifer depletion problems (i.e., in Arizona, Texas, California) and contamination problems (i.e., in New York, Rhode Island, New Jersey, North Carolina) experienced by other states. Even though Montana's laws governing the use and protection of ground water are modern and progressive, a general lack of emphasis on ground water problems and development potential has led to the implementation of custodial management programs under our existing laws.

PURPOSE AND OBJECTIVES

The purpose of this report is to identify ground-water issues facing Montana and to suggest options for their resolution. The report is written primarily by ground-water professionals from state and federal agencies and the state university system for use by Governor Schwinden's Ground-Water Advisory Council. The report will also be available to interested persons from the legislature, state, federal, and local agencies, or the general public.

The objectives of this report are to assess the status of ground water in Montana from three perspectives:

(1) To portray, in summary form, the current knowledge about the physical nature of the state's ground-water aquifers, including present and future ground-water availability, usage, contamination, and development potential;

(2) To identify pertinent statutes and rules governing ground water and address areas where statutes could be changed or created;

(3) To examine the ground-water management responsibilities mandated by law for each federal and

state agency and suggest what, if any, measures might be needed to improve management effectiveness of this valuable natural resource.

BACKGROUND

In April of 1982, the Montana Ground Water Conference, sponsored by the Montana Environmental Quality Council (EQC) and the Legislative Council, was held in Great Falls. The conference theme was planning a ground-water strategy for Montana, and suggestions from the conference included the designation of a ground-water advisory council and the compilation of a ground-water strategy report. These suggestions were discussed in subsequent EQC meetings, and in August 1982 the EQC passed a motion requesting the Governor to appoint a ground-water advisory council. The DNRC took the initiative for organizing the strategy report and arranged a meeting in August 1982 of technical representatives involved in ground water from agencies and universities to discuss the present status of ground water in Montana. The agencies and groups represented in these discussions include the Departments of Health and Environmental Sciences (DHES), State Lands (DSL), Natural Resources and Conservation (DNRC), Bureau of Mines and Geology (MBMG), Montana Joint University Water Resources Research Center, University of Montana, Montana State University (MSU), EQC, U.S. Environmental Protection Agency (EPA), and the

U.S. Geological Survey (USGS). This status report is a result of several meeetings of this group and constitutes the first phase of the overall ground-water strategy report.

GENERAL POLICY CONSIDERATIONS

Essential to a discussion of the status of ground water in Montana is the consideration of several policy issues. These include: achieving general recognition of the value of ground water, the coordination and cooperation of various agencies that deal with ground water and the management of ground water as a system for both quantity and quality aspects.

With the increasing use of the state's ground-water resource, definitive statement on the value of ground water to the state becomes important to guide the ensuing management decisions. Obviously, given the ground-water permitting systems of DHES and DNRC, some ground-water value statements already exist. The value of ground water implied by these systems, however, seems somewhat ill defined, and necessitates a more specific, explicit statement.

The future value of ground water is difficult to estimate, particularly since ground water is presently an underutilized resource in Montana. Establishment of ground-water policy is necessarily dependent upon the perceived value of the resource. Ground water, like surface water and air, is a resource that can be used consumptively to supply basic human needs, but which can also be used as a disposal medium for our society. Unfortunately, use of these resources as disposal grounds may limit or preclude any further consumptive use if the quality of the resource is impaired. For surface water and the air that surrounds us, the problem of pollution and contamination is usually visible, is almost always readily measurable, and therefore can usually be dealt with effectively. As a result, strong steps and programs have been implemented by government to ensure continued good air and water quality.

Ground water, however, poses a very different problem. It is, for the most part, an invisible resource accessible to scrutiny only at discrete locations where wells or springs are present. Unlike surface waters and air which have the ability to disperse and dilute contaminants efficiently in a relatively short period of time, ground-water contamination may persist for years, generations, or possibly even millenia. Under such circumstances, contamination of an aquifer, whether planned or inadvertent, can mean an irreversible and irretrievable loss of that resource.

Similarly, where ground-water withdrawal rates exceed rates of recharge over the long-term, aquifer overdraft or mining occurs. While there may be economic incentives for ground-water mining in some instances, it is rare that the future value of the resource being depleted is ever adequately assessed; nor are the many associated problems normally evaluated. Strange (1983), for example, has shown that even with a conservation program to minimize depletion, the present strategy for the

Ogallala aquifer recommended by the High Plains Study Council will result in topsoil losses due to wind erosion, potential desertification, loss of streamflow and riparian habitat, nitrate pollution due to chemical fertilizers, continuing escalation of energy costs, and increased need for and dependence on coal-fired electrical generation. A policy on how overdraft should be handled by the state should ideally be developed before it becomes a significant problem like it has in mid-western states utilizing the Ogalalla Aquifer, and in most of the southwestern United States.

The degree of coordination and cooperation between various agencies that deal with ground-water issues also warrants a policy review. This would ensure that the application of one agency's legal authority does not circumvent the obligations of another agency. This could also provide a mechanism for sharing agency information and for extra-agency review of possible decisions affecting ground water.

The coordination problem extends beyond the bounds of state government. Local government decisions on subdivisions, landfills, industrial zones and even the placement of service stations can have impacts on ground-water quality which can ultimately limit the useable quantity of water in an aquifer. Unfortunately, municipal sewage treatment facilities utilizing percolation and infiltration techniques are often sited where rapid infiltration is possible, usually in the same areas contributing the greatest recharge to a local aquifer.

While it is often convenient to categorize a ground-water concern as strictly either a water supply or a water quality problem, these two aspects often interact and affect each other. For instance, pumping from an aquifer can result in changes in aquifer flow patterns such that a contaminated plume which might normally have never reached the vicinity of the pumping well can be induced to spread in that direction.

It should also be apparent that ground water is suited to a particular use only if the quality of the ground water is also suitable for that use. If ground-water quality decreases, the options available for its use will decrease. Whether a water user needs a great quantity for irrigation or only enough to drink, the water is effectively unavailable if its quality is not suited to either purpose.

In certain situations where surface and ground waters constitute a highly interconnected supply, the distinctions between these become artificial. Thus, where surface water and ground water are hydraulically connected, it may be better to treat them as a system rather than be constrained by arbitrary distinctions between surface and ground water. This aspect is discussed in considerable detail as a specific issue and will not be treated in depth here.

With the increasing pressure on the state's ground-water resource and with the increased decision making load being placed on the various agencies responsible for protecting and developing this resource, the above general policy concerns should be kept in mind as specific ground-water issues are reviewed.

OVERVIEW OF GOVERNMENT AND UNIVERSITY INVOLVEMENT WITH GROUND-WATER RESOURCES

This chapter describes the major ground-water activities of state and federal agencies in Montana; units of the university system are also included. Statutory responsibilities are discussed, along with implementation and enforcement methods. Information is provided on certain data collection and management efforts, and several research projects are mentioned. The purpose of this chapter is to convey a general understanding of the present legal and administrative framework related to ground water.

STATE GOVERNMENT

Department of Health and Environmental Sciences

Solid Waste Management Bureau

This bureau regulates sanitary landfills and hazardous waste facilities, both of which could pollute ground water.

Since 1977, landfills have been licensed by DHES under the Montana Solid Waste Management Act. The Department examines physical characteristics of the site (for example, distance to ground and surface water) and operational plans such as daily application of soil cover to impede infiltration to determine if they meet established criteria.

Most problems arise in landfills which predate the state licensing procedure. The Department's enforcement authority includes requiring the installation of monitoring wells, baseline data collection, and engineering corrections or site closures.

Monitoring is now required at 18 landfills. Data collected concern basic EPA water quality parameters, including iron, total dissolved solids (TDS), coliform, nitrates, sodium, and some metals. Frequency of collection is established by site, and ranges from monthly to annually. Data are available to the public.

The other pertinent statute administered by the bureau is the Montana Hazardous Waste Act, which is based on the federal Resource Conservation and Recovery Act (RCRA). Adopted regulations provide standards for generators, transporters, and storage, treatment, and disposal facilities; establish criteria for siting facilities; govern monitoring; etc. State law may be more lenient than federal law, and Montana law directs that the state program not be more stringent; thus, state regulations are equivalent to the federal program.

The state takes over this program from the federal EPA in phases. DHES is authorized for Phase I and is currently applying for authorization for Phase II, the permitting of storage, treatment, and disposal facilities. This authorization is expected in Spring 1983.

Ground-water monitoring is presently required at eight hazardous waste management facilities. Data collected are those stipulated by EPA for primary drinking water standards. Ground-water quality parameters include chloride, iron, manganese, phenols, sodium, and sulfate; indicators of contamination include pH, specific conductance, total organic carbon, and total organic halogen. Data are first collected quarterly, then semiannually and annually, according to a schedule specified by EPA. Those data are available to the public.

Water Quality Bureau

Community wells, other public water supply systems, and private water systems serving licensed food and lodging establishments are regulated. Siting, construction, operation, and modification of public water supply systems must be approved, including plans and specifications for wells. The primary concerns are the quality of the water and any danger to human health posed by its consumption.

Under the Montana Water Quality Act, the Board of Health and Environmental Sciences must classify all state waters, which include ground water. In addition, classifications and standards of water purity and wastewater discharge must be established to conform to the national system; however, the federal law does not address ground water. Pollution is prohibited, and a permit must be obtained from the Department to construct, modify, or operate a disposal system or to discharge sewage, industrial, or other waste into state waters. For the protection of ground water, the Department also reviews and approves proposed tailings ponds, leaching pads, and holding facilities. An application for a Montana Pollutant Discharge Elimination System (MPDES) permit must provide specified information, including ground-water characteristics, and any approved facility must comply with permit conditions, including effluent limitations and monitoring requirements.

Regulations recently adopted under the Water Quality Act establish water quality standards for state ground water, a classification system for ground waters based on their beneficial use and water quality, a non-degradation policy for ground water, and review procedures and a permit system for sources which may discharge pollutants into state ground waters. Provisions are also made for procedures to be followed in case of unanticipated spills which may affect ground water.

The Department also administers Montana In-Situ Mining of Uranium Control System (MIMUCS) permits designed to protect ground water from degradation associated with solution mining. The introduction of chemicals into a well field for the uranium solution extraction process is regulated, as is the discharge or disposal of pollutants into waste disposal wells. Among the information which must be submitted in a permit application are plans for retaining process water, disposing of waste water, and handling leaks and spills; a detailed monitoring program to determine baseline water quality; and procedures proposed to restore affected ground water.

Finally, the Department is responsible for certain subdivisions regulations, defined to include land divisions creating parcels of less than 20 acres, mobile home and recreational vehicle camping parks, and condominiums. Plans to be reviewed and approved or denied involve the proposed water supply system, sewage treatment, solid waste disposal, and storm water runoff; one criterion for approval is that water pollution will not occur. Under the Sanitation in Subdivisions Act, this review of subdivisions of five or fewer parcels can be delegated to local officials.

No systematic data collection system for ground-water data has been established. However, data are collected in response to specific proposals, problems, or complaints. Generally, these consist of ground-water quality data, which are organized by county and available by the public.

Department of Natural Resources and Conservation

Regulation Responsibilities

DNRC is responsible for the administration of the Water Use Act, which includes issuance of water use permits in Montana. A person desiring to acquire a new water right for surface, subsurface or geothermal water, or additional water must apply for a permit from DNRC. The only exception to this requirement is that outside the boundaries of a controlled ground-water area, a permit is not required for wells or developed springs which will withdraw and beneficially use less than 100 gallons per minute. In that case the appropriator must file a Notice of Completion of Groundwater Development form within 60 days of completion with the Department; a Certificate of Water Right is then issued. Stock watering pits or reservoirs do not require a permit before construction if the impoundment has a capacity of less than 15 acre-feet and if several other criteria are met. A permit application must be filed with DNRC within 60 days after completion before a permit can be issued. Detailed records of water use permits issued since 1973 are kept by the Water Resources Division in Helena.

DNRC also oversees changes in existing water rights. No appropriator may change the place of diversion, place or purpose of use, or place of storage without receiving prior approval.

An appropriator may not sever a water right from land to which it is appurtenant, or sell the appropriation right for other purposes or to other lands, or make the right appurtenant to other lands, without DNRC approval. Persons who purchase property with water rights are required to file a Notification of Transfer of Appropriation Water Right form with DNRC, so ownership of the water right can be updated.

The Water Use Act prohibits granting of a ground-water permit application in excess of 3,000 acre-feet per year without legislative approval, and an appropriator of more than 15 cfs may not change the purpose of use of an appropriation right from an agricultural use to an industrial use.

The Board of Natural Resources and Conservation has the authority to designate controlled ground-water areas when it is shown that ground-water withdrawals exceed recharge; future excessive withdrawals are very likely; significant legal disputes are occurring; or ground-water levels or pressures are declining or have declined excessively. The Board may, with designation of a controlled ground-water area, order necessary corrective action to alleviate the problem.

The Board acts on applications to grant reserve surface and subsurface water for future beneficial use, including instream uses, to any political subdivision or agency of the state or the United States.

DNRC also assists the State Water Courts in the state-wide identification and adjudication of pre-1973 water rights filed with the Department under the state-wide water right adjudication process. Records of all filings are maintained by DNRC.

DNRC may petition the District Court when it ascertains that water is being wasted or being used in a manner interfering with a prior water right. DNRC has the authority to prevent waste, contamination, or leakage from ground-water wells.

Regulation of oil and gas wells to prevent the pollution of fresh water supplies by oil, gas, salt, or brackish water is the responsibility of the Board of Oil and Gas Conservation and is administered by DNRC's Division of Oil and Gas Conservation. Both units are attached to DNRC for administrative purposes.

Planning and Assistance

Coordinated multiple-use water resource planning is an additional duty of DNRC which requires the performance of a variety of studies and investigations of the state's waters.

DNRC, in addition to regulatory and planning functions, also has programs which provide financial and technical assistance for water development, including ground water and geothermal water.

The Water Development Program, created by the 1981 Legislature, provides grants and low-interest loans for water-related projects and activities for both private individuals and public entities. The Renewable Resources Development Program provides loans and grants to units of local or state government. A Rangeland Improvement Loan Program provides low-interest loans to livestock operators desiring to improve range conditions through a number of practices which may include water development projects.

The Geothermal Commercialization Program collects and distributes information about the state's geothermal resource including locations and opportunities, as well as regulations and laws pertaining to geothermal resources. Technical assistance is also provided to potential users of geothermal heat or geothermally heated water.

Bureau of Mines and Geology

The MBMG is a state agency attached to the Montana College of Mineral Science and Technology. It has a non-regulatory role regarding the study of geology within Montana in reference to its ground water and economic mineral resources.

The MBMG is currently conducting 18 hydrogeologic investigations throughout Montana on coal hydrology, geothermal assessment, water quality problems caused by saline seep, surface and ground-water interaction, acid mine water and tailings, and community or rural water problems. The majority of these projects are funded from nonstate sources.

The MBMG also maintains ground-water information files and provides assistance in interpreting these data to the public. These files contain data on aquifer tests, observation well water levels, deep aquifers in eastern Montana, water quality, geologic sources of water, and well inventories. Many of these data are recorded in paper files, but two important portions, the well appropriations and the water quality analyses, have been automated. The MBMG data system involves the acquisition, manipulation, and distribution of these ground-water data.

Water well construction and completion data have been evaluated, coded, and placed in computer files based on more than 80,000 well appropriation documents, or is updated regularly. Data from the well logs (to the extent and accuracy orginally completed by the well driller or owner) include items such as location, owner, depth, yield, static water level, casing size, and driller's license number. Notations in the data include geologic source, water quality data availability, and whether or not the well has been field verified. MBMG has endeavored to improve well location records and to add both geologic (aquifer) and altitude data.

Water quality data are computerized and are entered in the second major ground-water data system at the MBMG. Approximately 5,000 well and spring analyses are included; the quality of the analyses ranges from good to excellent. Considerable effort is expended in correcting and editing the geographic data associated with both historical and new analyses as well as verifying the chemical parameters. Most of the analyses in the system have been generated by field investigations conducted by the MBMG and the USGS. Additional analyses are being added to the system from published reports such as MBMG Bulletins, USGS Water-Supply Papers, and other documents.

Data included in the water quality system are well depth, casing size, location, latitude, longitude, altitude, geologic source, and standard chemical constituents. Where possible, the water quality data are keyed to the well log data.

Ground-water data from the MBMG are organized by geographic location and are available in both map and tabular formats. They are used to answer approximately 2,000 ground-water inquiries a year.

Department of State Lands

DSL enforces the state's reclamation statutes concerning mineral extraction activities; DSL has the authority, among other things, to protect ground-water resources from adverse impacts related to mining. Therefore, under the Strip Mining Act, and in some instances the Metal Mine Reclamation Act, DSL requires that companies desiring to open potentially disruptive mines must conduct site-specific pre-mining ground-water studies and continue to monitor ground water during and after mining until reclamation is complete. Information obtained by the mining companies includes such factors as water quality of affected aquifers, water level information, piezometric surface, and other hydrologic characteristics.

DSL maintains and makes available for public use the mining company reports and all the data contained therein.

DSL may also lease state school trust lands for a variety of purposes, including geothermal resource exploration and development.

FEDERAL GOVERNMENT

Two federal agencies have programs directed to ground water.

Environmental Protection Agency

Under the federal Safe Drinking Water Act, EPA oversees a Drinking Water Program administered by the state and an Injection Control Program. In order to maintain the quality of ground water, EPA regulates the disposal of waste water into deep aquifers. The permitting function now being developed will initially be administered by EPA, and will probably be later delegated to a state agency (DHES) upon application.

In addition, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund Program) authorizes the spending of federal funds to improve and recover the quality of ground water impacted by subsurface disposal. EPA is administering this Superfund Program in coordination with several state agencies. Currently, impacts are being assessed and projects identified; it is anticipated that one or more Montana sites will be involved in the subsequent cleanup phase.

With respect to ground-water data, chemical and biological information is continuously collected on all public water supplies. Data on community supplies are stored at the Montana DHES, while EPA maintains the information pertinent to Indian supplies.

U.S. Geological Survey

The USGS water resources program, in a nonregulatory function, has responsibility for data collection and dissemination, problem-oriented water resource appraisals, interpretive studies, and research in the field of hydrology, including both surface and ground-water resources. Most studies or data collection programs are funded by state, federal, or local agencies. Other federal agencies fully fund studies performed at their request while state and local agencies usually provide 50% of funds for projects under the USGS cooperative program.

A statewide ground-water observation well network (SWON) is maintained to monitor water levels. Most wells in the system have several years of data recorded.

In addition to the SWON data, all ground-water information collected during interpretive and research studies is entered into the national ground-water site inventory (GWSI) computer file. Information stored includes location by both township and range and latitude and longitude, owner, well depth, casing length, perforation interval, aquifers penetrated, production data, well yield, water quality parameters, aquifer characteristics, and borehole lithology.

Although water level data from the SWON wells have not been published recently, the data are available. The USGS maintains its water resources data using the National Water Data Storage and Retrieval System (WATSTORE) located at its central computer facility in Reston, Virginia. Access to this information base system is available from USGS offices or to non-USGS users with compatible computer systems. Data collected by the USGS are available to the public on request. Interpretive studies and research activities are published in various USGS or state reports.

UNIVERSITY SYSTEM

Units of the Montana University system have no ground-water programs per se, although pertinent coursework is offered. Research projects are also conducted, but the data collected are limited geographically and temporally by the particular problem being addressed.

University of Montana

Both a Master's and Doctor of Philosophy degree with an emphasis on hydrogeology are available through the Geology Department. Coursework at the University of Montana includes basic and advanced hydrogeology, a seminar in hydrogeology, and related training in geology, geophysics, chemistry, and hydrology.

Hydrogeologic data are collected in connection with research projects performed by faculty and students. Ground water is the subject of five master's theses which will soon be completed: one deals with arsenic contamination at Milltown, another with oil brine pit reclamation techniques and their impact on ground water in northeastern Montana, a third concerns ground-water/shoreline interactions on Flathead Lake and related salmon spawning success, and two with specific hydrogeologic resources of the Bitterroot Valley. Specific hydrogeologic resources are also the subject of three "senior problems" (research performed by undergraduates).

Montana State University

Students at Montana State University can receive a Master's degree with an emphasis on ground water from the Civil Engineering Department or the Earth Sciences Department. These two programs differ substantially in the approach used. As a result a student has an opportunity to obtain a strong multidisciplinary understanding of the subject.

Research on ground water is also multidisciplinary, and is often funded in cooperation with other state and federal agencies. One current project of the Civil Engineering Department concerns irrigation return flows in the Dillon area; another, a six-year study funded by the EPA, examines the effects of coal mining.

MSU serves as the lead unit in the latter project, with the University of Wyoming and North Dakota State University as cooperators. Pre-mining baseline data were obtained at one site in each of the three states, with the East Decker and Tanner Creek area selected in Montana. Utilizing post-mining data and the disciplines of hydrology, chemistry, and soils, impacts on the quality and quantity of both ground water and surface water are being assessed. Numerous journal articles have resulted from this research, as well as a 1500-page report on the first three years' effort. Publication of the final report is expected in March.

Researchers in the Earth Sciences Department have cooperated with the DHES Solid Waste Bureau and MBMG to study ground-water problems at landfill sites across Montana. A project with the USGS studied geothermal potential in the state, and a study of ground-water potential for laboratory and irrigation use has been completed for the MSU campus.

Montana University Joint Water Resources Research Center

The main office of this organization, which is a part of the university system, is located at MSU in Bozeman, with coordinators in Butte and Missoula. The purpose of the center is to foster research in water resources. Its method is, typically, to work with state government agencies to identify a problem, and then to find faculty members to develop a study design. Graduate students sometimes conduct the research. In the past, funding has been provided by state agencies and the Federal Office of Water Research and Technology; the latter-named source has now been eliminated.

No ongoing research project is directed toward ground water. Past projects, however, have been pertinent, examining such matters as the effects on ground-water quality of rapid infiltration of municipal waste waters.

Montana College of Mineral Science and Technology

Most ground-water activities, other than coursework, are conducted through the MBMG. Because MBMG is actually a state agency located within the college, its research and data management functions are presented in the "State Government" section of this chapter.

MONTANA AQUIFER SYSTEMS

A brief description of major aquifer systems in Montana is presented to provide background for the ground-water issues. Major aquifers are listed in Table 2 along with their accessibility, typical yields, and dissolved solids content. Figure 2 illustrates the aquifers in relation to other geological units and their time of deposition. The general configuration of these aquifer systems is shown in Figures 3 through 11, with both outcrop areas and subsurface presence depicted. The physical characteristics of these aquifers, including lithology and unit thickness, are presented below, along with general information on water quality and well yields.

Other aquifers, such as fractured zones in granitic and Precambrian rocks, occur over significant areas of the state and are of local importance. However, these formations do not always transmit water in sufficient quantities, or yields are so highly variable that these aquifers are not considered separately in the discussion below.

QUATERNARY AQUIFERS

Alluvium/Terrace Deposits

These deposits consist of unconsolidated to semi-consolidated fluvial gravels, sands, silts, and clays

Table 2. Major aquifers in Montana

Aquifer	*Aquifer Accessibility (feet below surface) <500	500-1000	>1000	Well Yields (gallons/minute)	Dissolved Solids (milligrams/liter)
Quaternary					
Alluvium	X			15-1,000	300-2,500
Terrace deposits	X			up to 30	300-2,500
High level gravels	X			15-1,000	<500
Glacial Deposits					
Till	X			5-200	100-800
Outwash	X			10-1,500	100-800
Tertiary					
Flaxville gravels	X			up to 1,200	250-1,430
Western basins	X			10-125	300-1,500
Fort Union	X			50	159-6,450
Cretaceous					
Fox Hills-Hell Creek	X	X	X	9-200	461-3,260
Judith River	X	X		up to 100	up to 27,500
Eagle	X			50-500	<1,500
Kootenai	X			10-300	204-14,000
Jurassic					
Swift	X	X		<50	<500 near outcrop >4,000 at depth
Mississippian					
Madison	X	X	X	20-1,000	<500 near outcrop >1,000 at depth

Sources: Miller, W.R., 1981, Water Resources of the Southern Powder River area, Southeastern Montana, MBMG Memoir 47, 53p.

Noble, R.A. and others, 1982, Occurrence and characteristics of ground water in Montana, MBMG 99, Vol. 1 and 2, 82p.

Zimmerman, E.A., 1960, Geology and ground-water resources of northern Blaine County, Montana, MBMG, Bulletin 19, 19p.

*Typical well depths to reach adequate water yields.

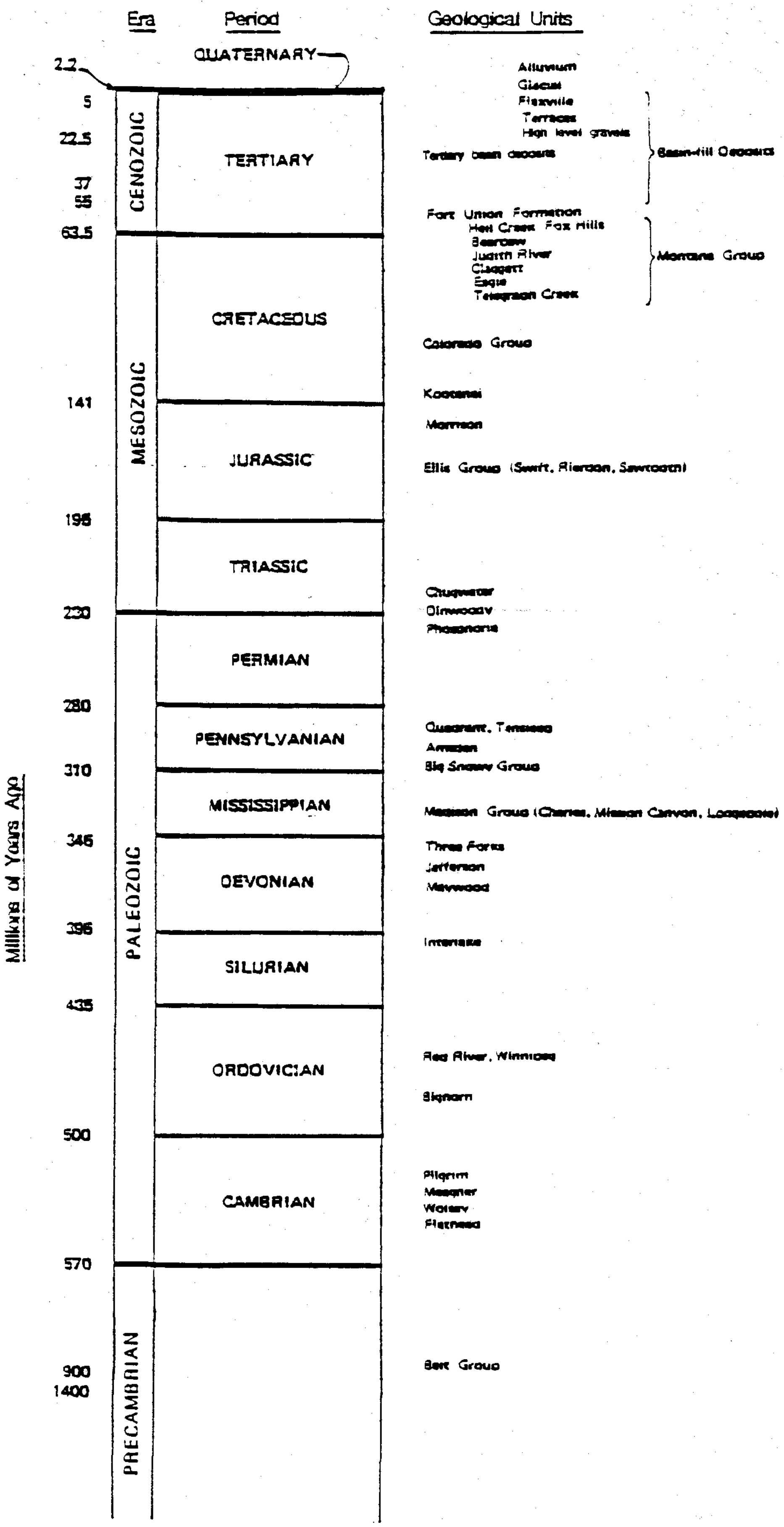


Figure 2. Time-stratigraphic chart of Montana aquifers in relation to other geological units.

Modified from MBMG 99, Vol. 1, 1982

located within and/or adjacent to present drainages (Figure 3). Generally these deposits are less than 30 feet thick, although thicknesses as great as 200 feet have been reported along larger rivers.

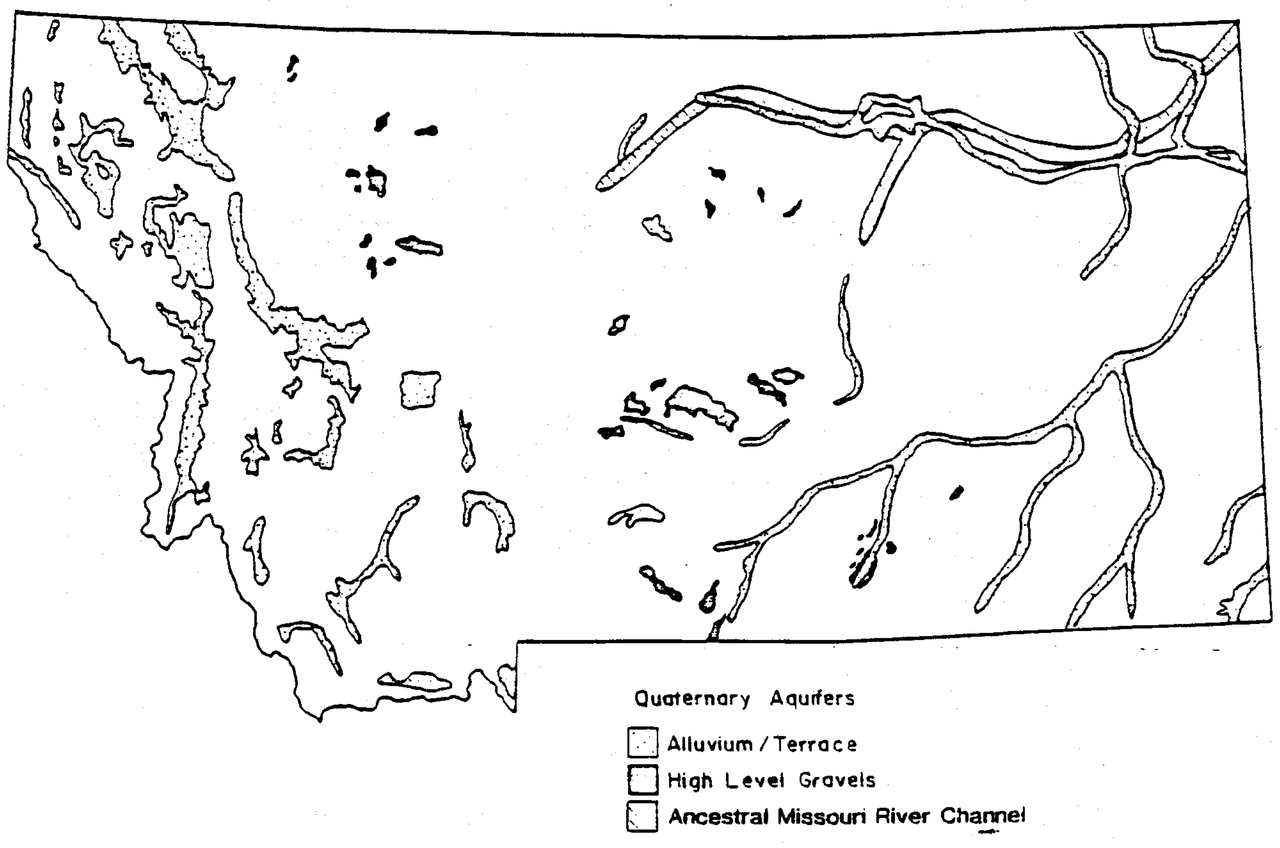
Buried channel deposits, such as the ancestral Missouri River Channel in northeastern Montana (Figure 3), resulted from pre-glacial valleys being covered by glacial material. These buried valleys contain alluvial deposits consisting of gravels, sands, silts, and clays. Distributions and thicknesses of these deposits is irregular.

Alluvium and terrace deposits are some of the most extensively used aquifers in Montana due to the high probability of good well yields and the typical shallowness of wells. Water quality is generally good, with dissolved solids increasing where these deposits overlie Cretaceous shales or pick up additional salts resulting from irrigation practices.

High Level Gravels

This unit is comprised of unconsolidated to semi-consolidated gravels. These gravels are probably primarily Quaternary in age, although some may be as old as late Tertiary. The locations of these gravel units are shown in Figure 3.

Figure 3. Quaternary aquifers.



The gravels are predominantly of fluvial origin, although gravel deposits which are adjacent to the Beartooth, Bighorn and central Montana mountains may have resulted from processes related to uplift or climatic change. These deposits are typically less than 50 feet, but do range up to 100 feet in thickness.

Water yields from these gravels range up to 1,000 gallons per minute (gpm) with the water being typically low in dissolved solids.

Glacial Deposits

Glacial deposits are present throughout much of Montana, resulting from both alpine and continental glaciation (Figure 4). These glacial units are typically less than 50 feet thick, but can be greater than 100 feet thick in areas where extensive terminal and recessional moraines have developed. Included in these deposits are outwash sediments and glacial tills, such as ground, lateral, and end moraines.

Glacial deposits are important aquifers in northwestern Montana because of both their quantity and quality. Well yields range from 5-20 gpm in the till and can be as much as 1,500 gpm in outwash deposits. Water quality is generally good, but may vary with aquifer depth and location.

Figure 4. Glacial aquifers.

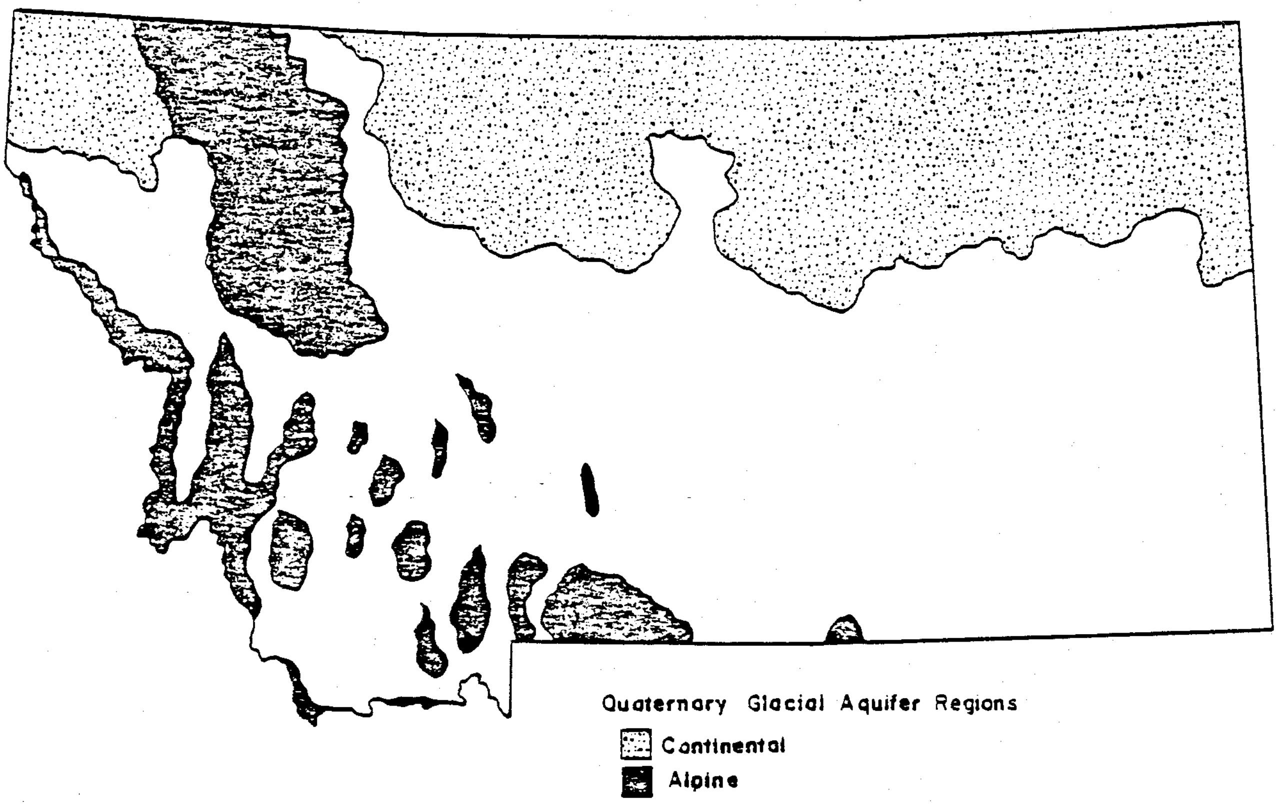
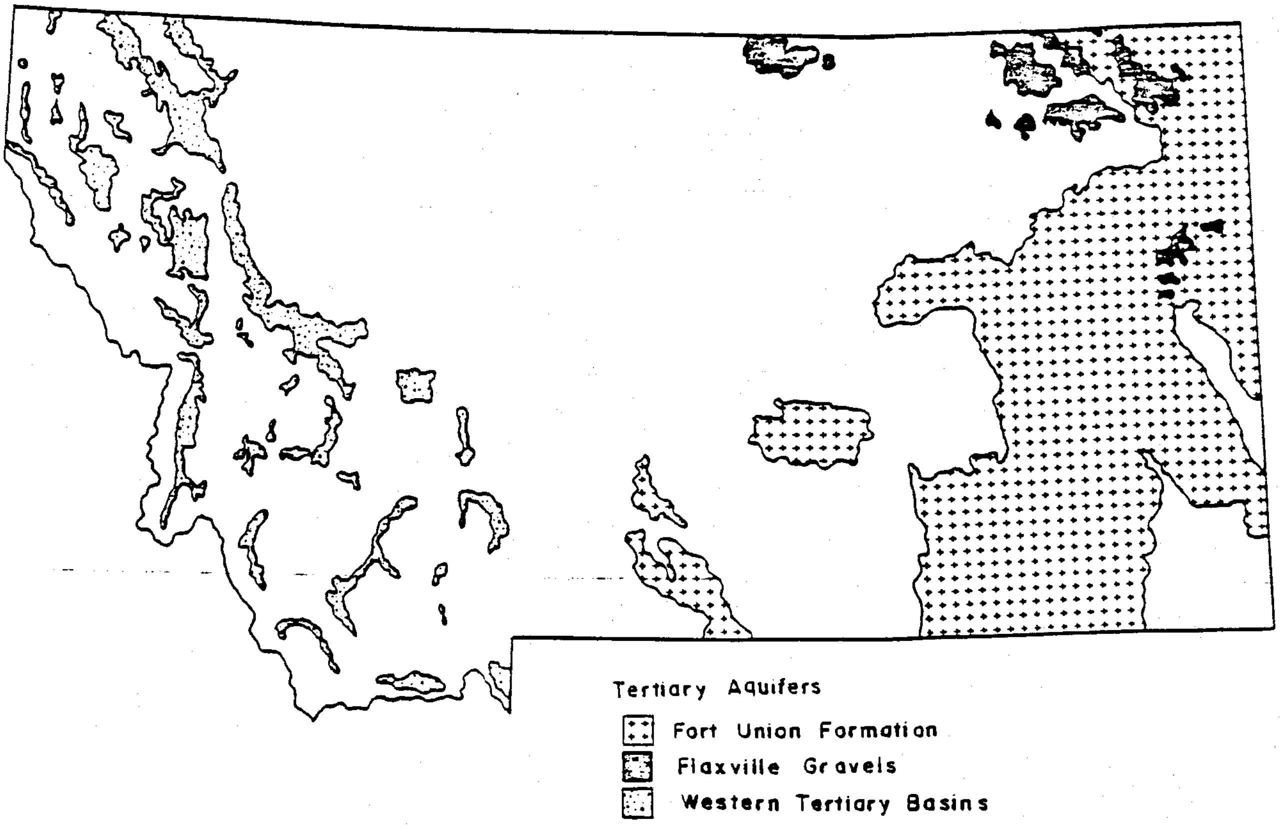


Figure 5. Tertiary aquifers.



TERTIARY AQUIFERS

Flaxville Gravels

These gravels are late Tertiary in age and generally consist of unconsolidated, well rounded quartzite/argillite pebbles in a sand matrix (Figure 5). Boulders up to 12 inches in diameter are also present in the Flaxville. The gravel to sand proportion varies throughout this unit, and in places these beds are semi-consolidated by calcite cement. Maximum thickness of these gravels is about 75 feet.

These gravels have been one of the more productive aquifers in parts of northeastern Montana, particularly in the Turner-Hogeland area. Well yields up to 1,200 gpm have been reported from the Flaxville, and water quality is generally good.

Western Tertiary Basins

Most intermontane valleys in the western part of the state, particularly in southwestern Montana, are filled with Tertiary continental deposits (Figure 5). These deposits consist of fluvial sediments and localized lake bed sediments which are interbedded in some areas with wind-blown volcanic ash and water deposited volcanic detrital material. Total thickness of Tertiary fill is reported to be in excess of 16,000 feet in some basins.

Well yields are variable in these deposits. The upper part of the basin fill generally consists of coarse grained sediments (sandstones and conglomerates), and as such is a reasonable source of ground water. Sediments in the lower part are fine-grained and usually are found at depth, thus precluding much aquifer development. Water quality in the upper basin fill is fair to good.

Fort Union Formation

The Fort Union Formation consists of a sequence of fluvial sandstones, siltstones, shales, and coal and is divided, from base to the top, into the Tullock, Lebo Shale, and Tongue River members. Limestone also occurs locally within this sequence. This formation is present over most of the Great Plains (Figure 5). Total thickness is less than 1,500 feet over most of this area, but is greater than 8,000 feet in parts of the Bighorn and Powder River basins.

The Fort Union aquifer is one of the principal aquifers of eastern Montana. Ground water is primarily taken from the coal and sandstone beds, and in many areas is often found within 250 feet of the surface. Water quality is variable and probably reflects the numerous lithologic changes present.

CRETACEOUS AQUIFERS

Fox Hills/Hell Creek

The Fox Hills Sandstone is an upper Cretaceous marine deposit which is comprised primarily of sandstone, but does contain some siltstone and shale units. Throughout most of eastern Montana it is approximately 300 feet thick, although it has been extensively eroded and in some cases completely removed from east central Montana (Figure 6).

The Hell Creek Formation overlies the Fox Hills Sandstone and consists of a sequence of fluvial sandstone, silt, and clay, in addition to some carbonaceous shale lenses. This formation is present over much of eastern Montana and ranges from 500 feet to 1,100 feet in thickness. It should be noted that only the lower part of the Hell Creek Formation is considered part of the Fox Hills/Hell Creek aquifer.

The Fox Hills/Hell Creek aquifer is considered to be a good water source in eastern Montana. Water from this aquifer is usually preferred over that from aquifers nearer the surface since this water is softer and well yields are generally higher.

Judith River Formation

The Judith River Formation is basically a wedge-shaped deposit (if viewed in a west to east cross-section of the state)

Figure 6. Fox Hills/Hell Creek aquifer.

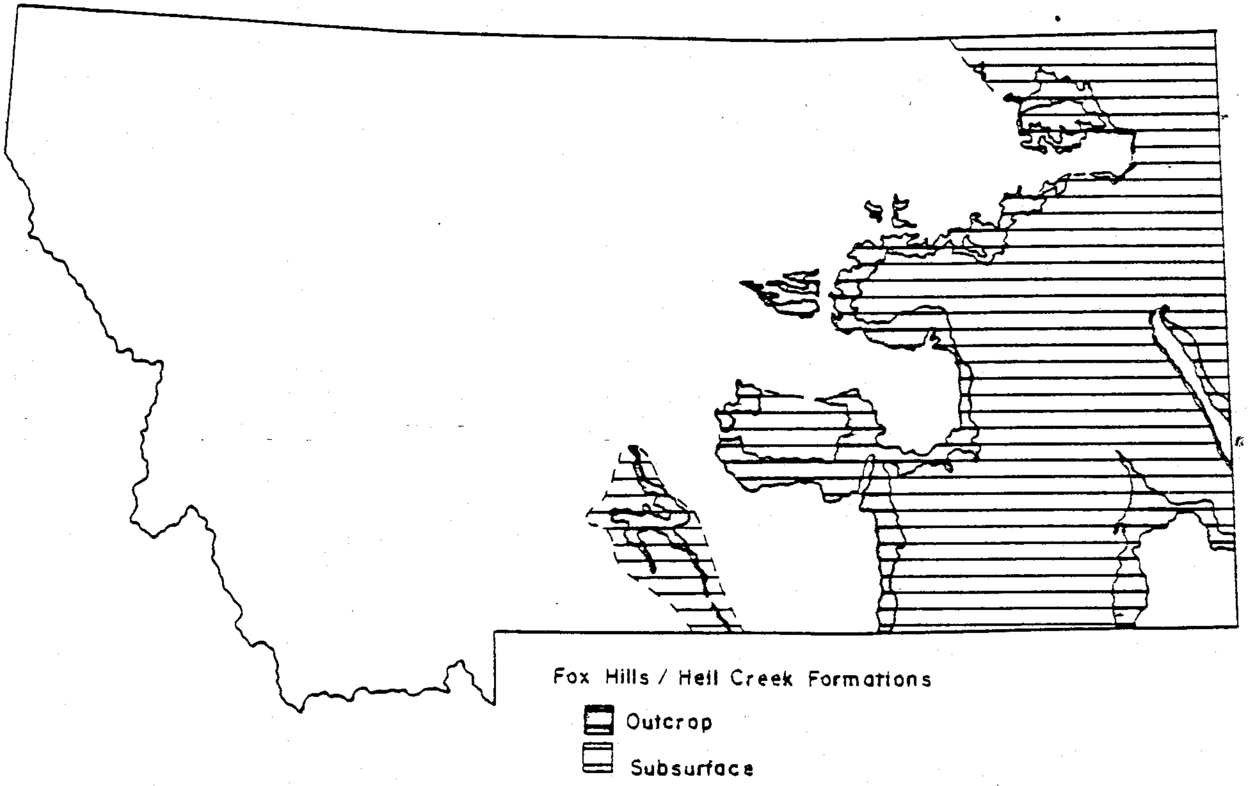
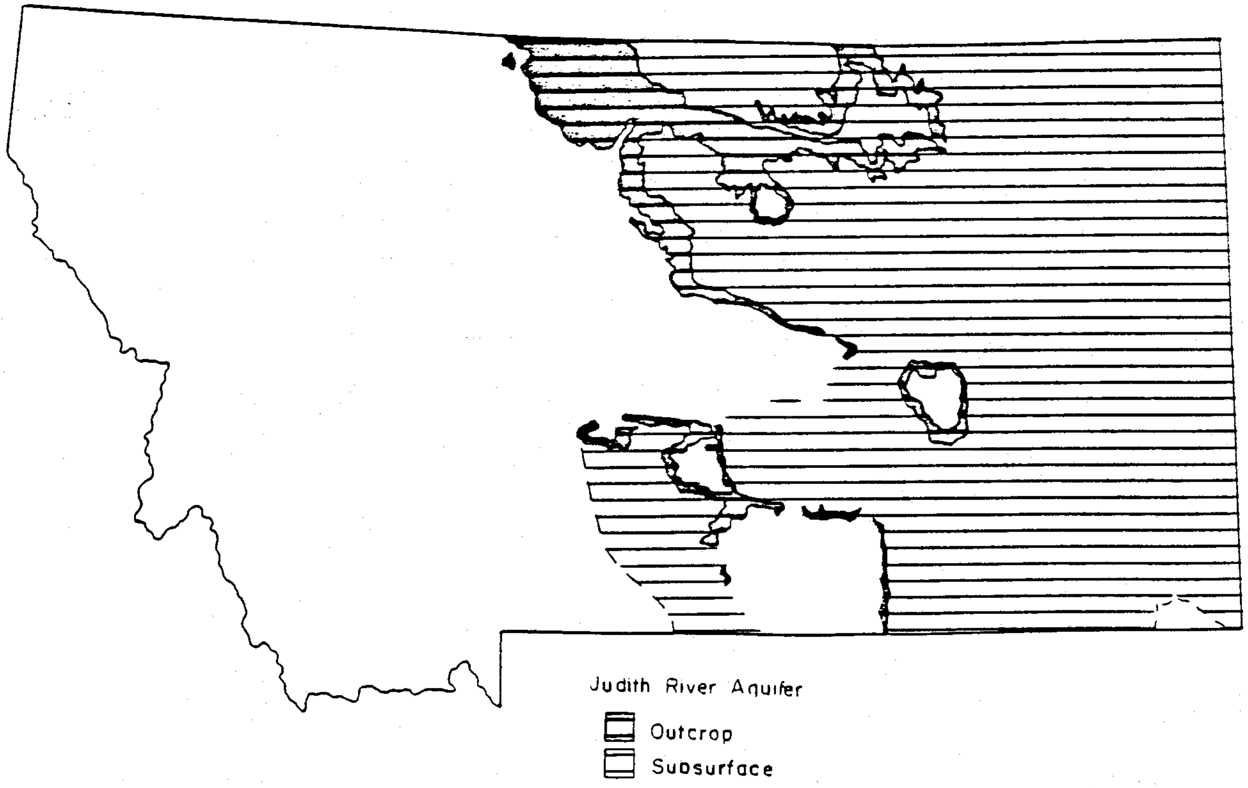


Figure 7. Judith River aquifer.



of sandstone, siltstone, and silty shale (Figure 7). This formation is greater than 700 feet thick at the western margin of the Great Plains where it grades into the Two Medicine Formation, but thins to less than 50 feet near the eastern border of Montana. In south-central Montana, the lower part of the formation is marine in origin, whereas in north-central Montana, it is a fluvial deposit. From its westernmost occurrence to the eastern Montana border, the upper part of the formation is transitional from continental to marine.

This aquifer is used throughout much of eastern Montana, except where it is over 500 feet below the surface. At these depths, drilling costs and low yields have prohibited further aquifer development. Well yields as high as 100 gpm have been documented. Water quality is variable with dissolved solids increasing with distance from the recharge area.

Eagle Formation

Near the western edge of the Great Plains, the Eagle Formation is primarily sandstone. It grades eastward into predominantly siltstone and shale lithologies. The formation is thickest near the Rocky Mountain Front, although even here it rarely exceeds 400 feet in thickness.

This is one of the principal aquifers in the northwestern region of the Montana Great Plains, with its primary use corresponding to its outcrop area and where it is less than 300 feet below the surface (Figure 8). Yields are generally less than 50 gpm, but some as high as 500 gpm have been reported from the Cut Bank area. Water quality is generally good in the areas of utilization.

Kootenai Formation

The basal part of the Kootenai Formation is a fluvial sandstone, with the upper part being marine green and red shale with local bodies of sandstone. Localized limestone deposits also occur within this formation. The basal sandstone is the principal aquifer; however, in some areas the upper sandstone and limestone produce some water.

This aquifer is utilized throughout most of the western and central Montana plains where the formation is within 500 feet of the surface (Figure 9). Well yields range from 10 gpm in the upper portion of the Kootenai to 300 gpm from the basal sandstone. Dissolved solids content is low near the outcrop areas.

JURASSIC AQUIFER

Swift Formation

The Swift Formation is a marine deposit consisting primarily of shale, but with some sandstone beds, particularly in western

Figure 8. Eagle aquifer.

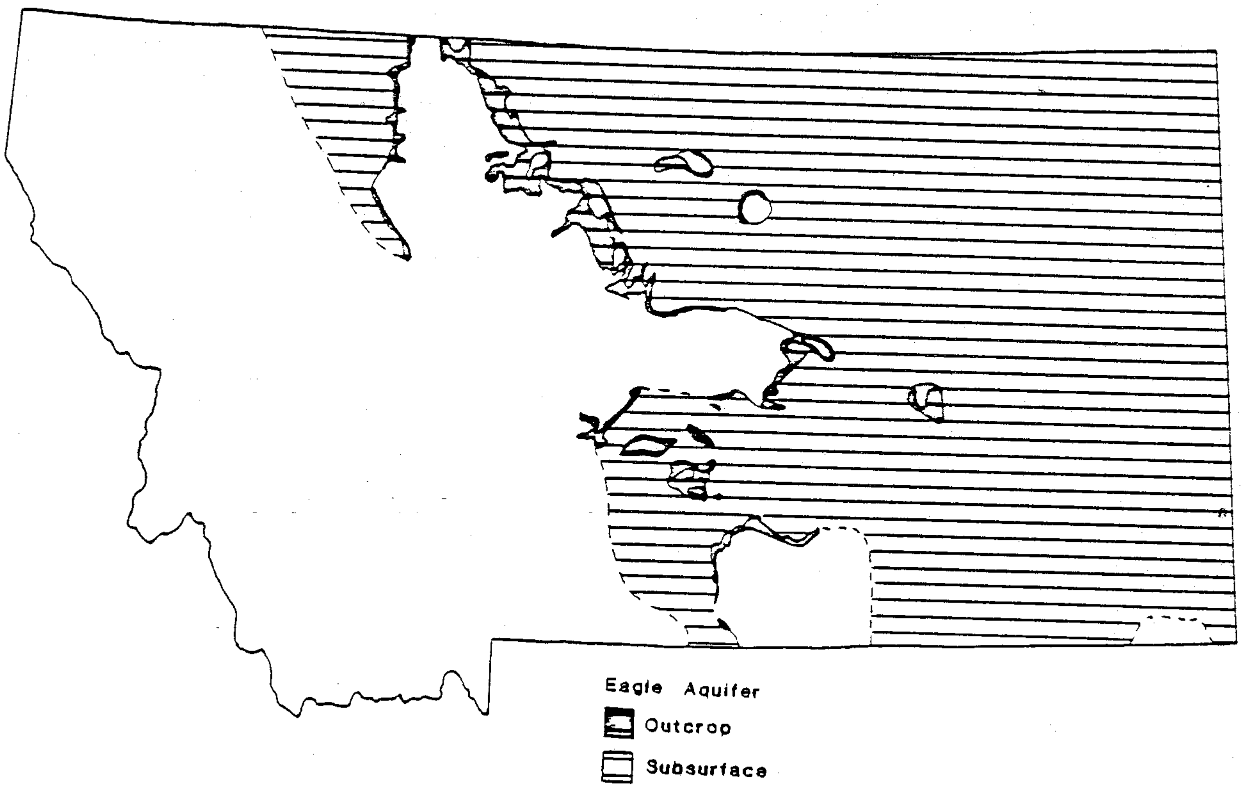
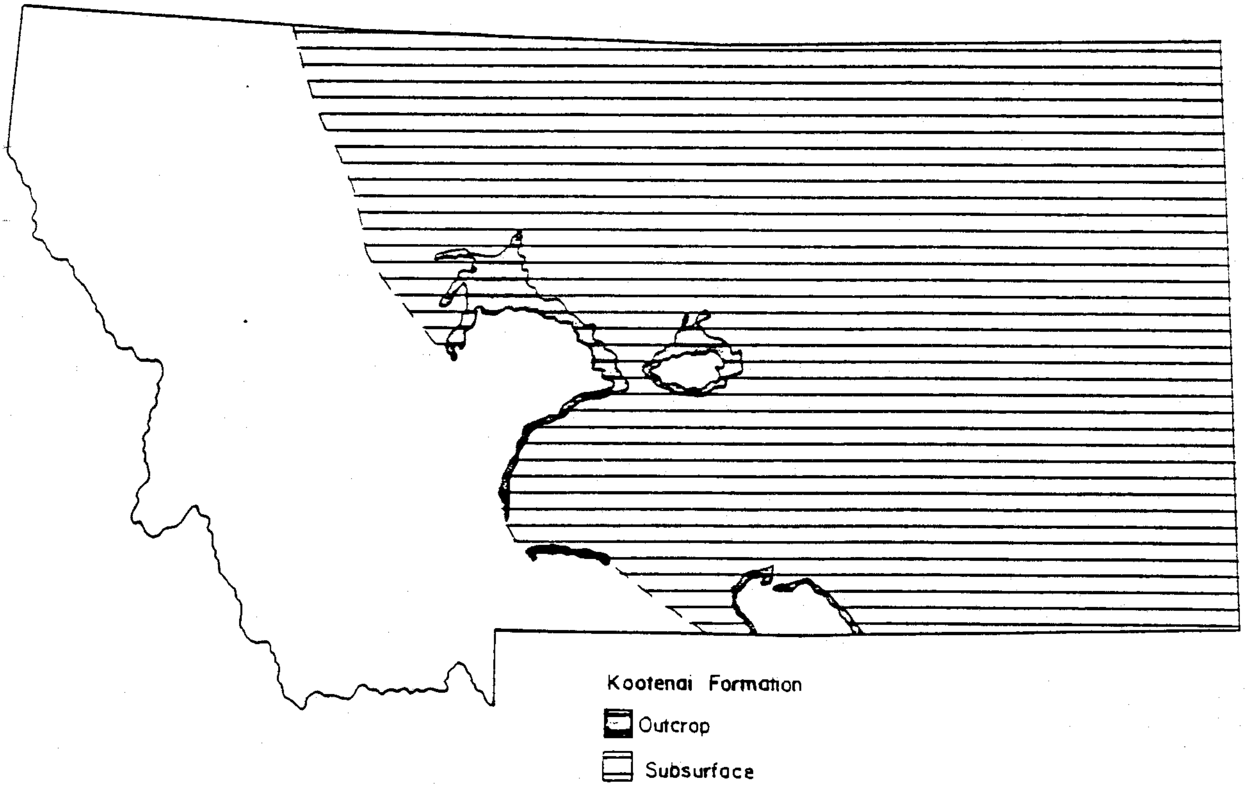


Figure 9. Kootenai aquifer.



Montana. This formation occurs at depth over most of the Great Plains region except for the central plains area where it has been eroded (Figure 10). Total thickness of the formation ranges from approximately 100 feet at the western edge of the Great Plains to 600 feet near the eastern Montana border. Sandstone thickness ranges from 40-150 feet in western Montana, to less than 50 feet in eastern Montana.

Because the Swift Formation usually occurs at depth below the surface, it has not been extensively utilized as an aquifer. Thus, most of the water information available on the aquifer has come from oil wells. According to this information, well yields can be as great as 50 gpm where sandstone thickness exceeds 100 feet. Water quality is variable, with a low amount of dissolved solids present near the outcrop, but increasing rapidly with distance from the outcrop.

MISSISSIPPIAN AQUIFER

Madison Group

This group consists primarily of marine limestone, (dolomitized in places) with the uppermost formation grading into anhydrite. This aquifer is present throughout most of the state, outcropping in numerous locations in western and central Montana, and is found at depth in eastern Montana (Figure 11). Thickness of this group is variable, with a maximum thickness of

Figure 10. Swift aquifer.

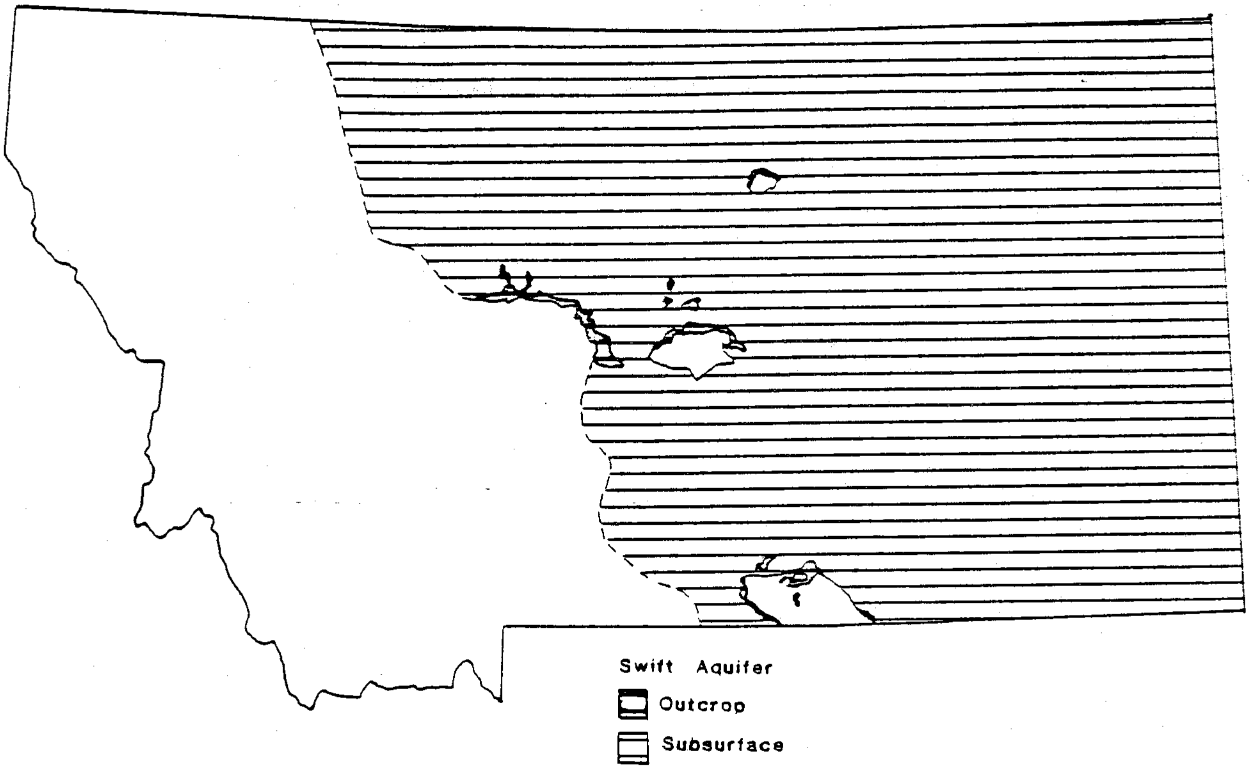
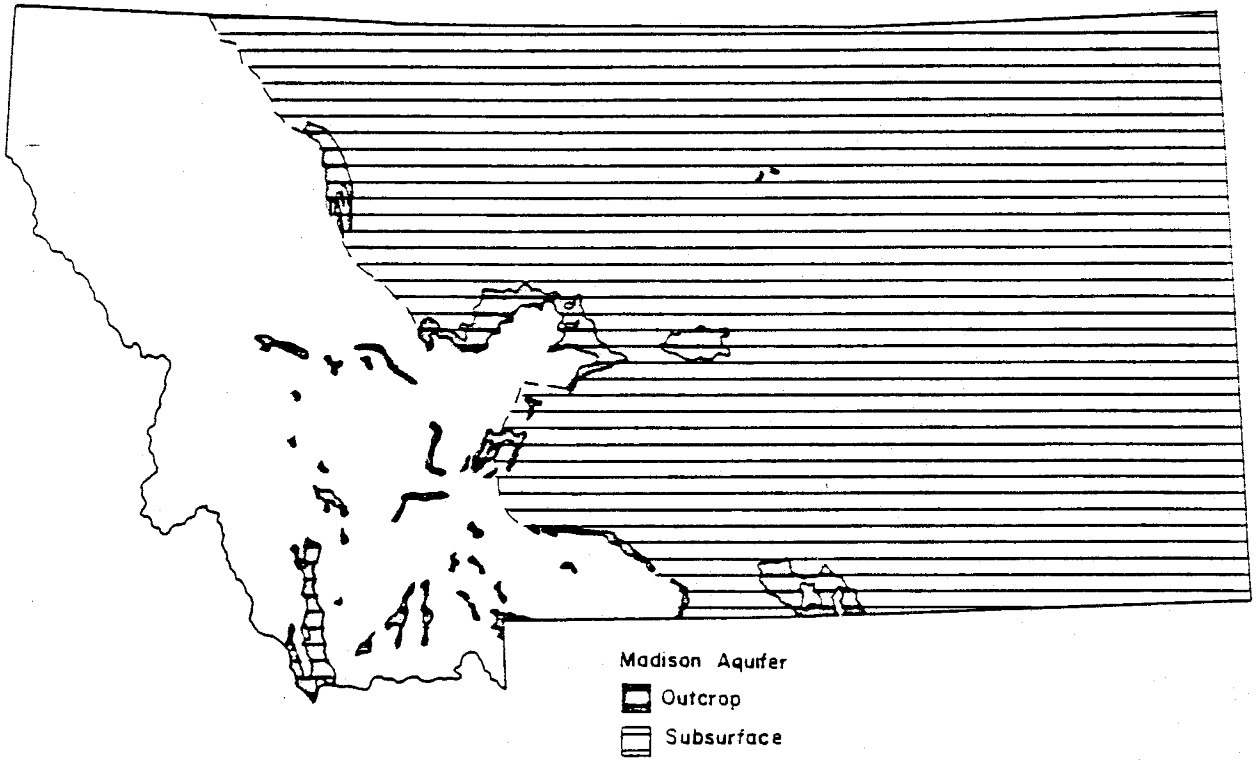


Figure 11. Madison aquifer.



1,000 feet occurring along a trough extending from the Big Snowy Mountains northeastward to the Williston basin.

The Madison Group appears to have high potential as an aquifer. Because of this, several test wells have recently been drilled in the northern Great Plains, with results indicating that well yields can be extremely variable. Water quality is also variable, with dissolved solids content dependent upon outcrop proximity.

GROUND-WATER ISSUES

The final part of this report includes a brief discussion of fifteen issues concerning ground-water quality and quantity in Montana. These issues are not presented in order of importance; all will have an impact on the future of ground-water development in the state. The issue sections were written by individuals from various state and federal agencies, and universities in Montana. As such, these sections do not necessarily reflect the views of the DNRC administration. The author of each issue section represents the agency that deals with the particular issue and as such is capable of presenting the issue and its ramifications.

A. SURFACE WATER/GROUND-WATER INTERACTIONS -- Bill Woessner, University of Montana

Issue Identification

As surface water resources become appropriated and possibly degrade in quality, new and some existing water users will shift to ground-water in order to meet new water demands. The interaction of ground water and surface water will bring surface water and shallow ground-water appropriators into conflict and create difficulties for regulatory agencies involved with water rights and water management. The following is a brief review of the hydrologic principles involved in surface water/ground-water interaction. This is included to give the reader a technical understanding of stream-aquifer systems.

Streams, rivers, lakes, reservoirs and irrigation canals can all interact with ground-water flow systems. A ground-water flow system consists of recharge water which percolates into the saturated earth materials, the natural movement of water through porous earth material and discharge or out flow of ground water either to a surface water system or to another ground-water system (Figure 12). Surface water has the potential to add water by downward seepage to an underlying ground-water system or receive ground-water inflow which is added to the total water in the surface system, (Figure 13).

The interaction-interconnection of ground-water and surface water systems is evidenced by the continued stream flow seen in the late fall and winter when all precipitation is stored on the ground as snow pack. Streams which are receiving ground-water inflow continue to flow. Those streams that are not connected to the local ground-water system for all or even part of the year do not flow during this time. In the spring and summer ground-water discharge to streams provides a base flow which is augmented by overland flow of rainfall and snow melt waters (Figure 14).

Streams can also be sources of recharge to the ground-water system when spring runoff occurs and the stream level rises above the ground-water table. As a result, some stream water

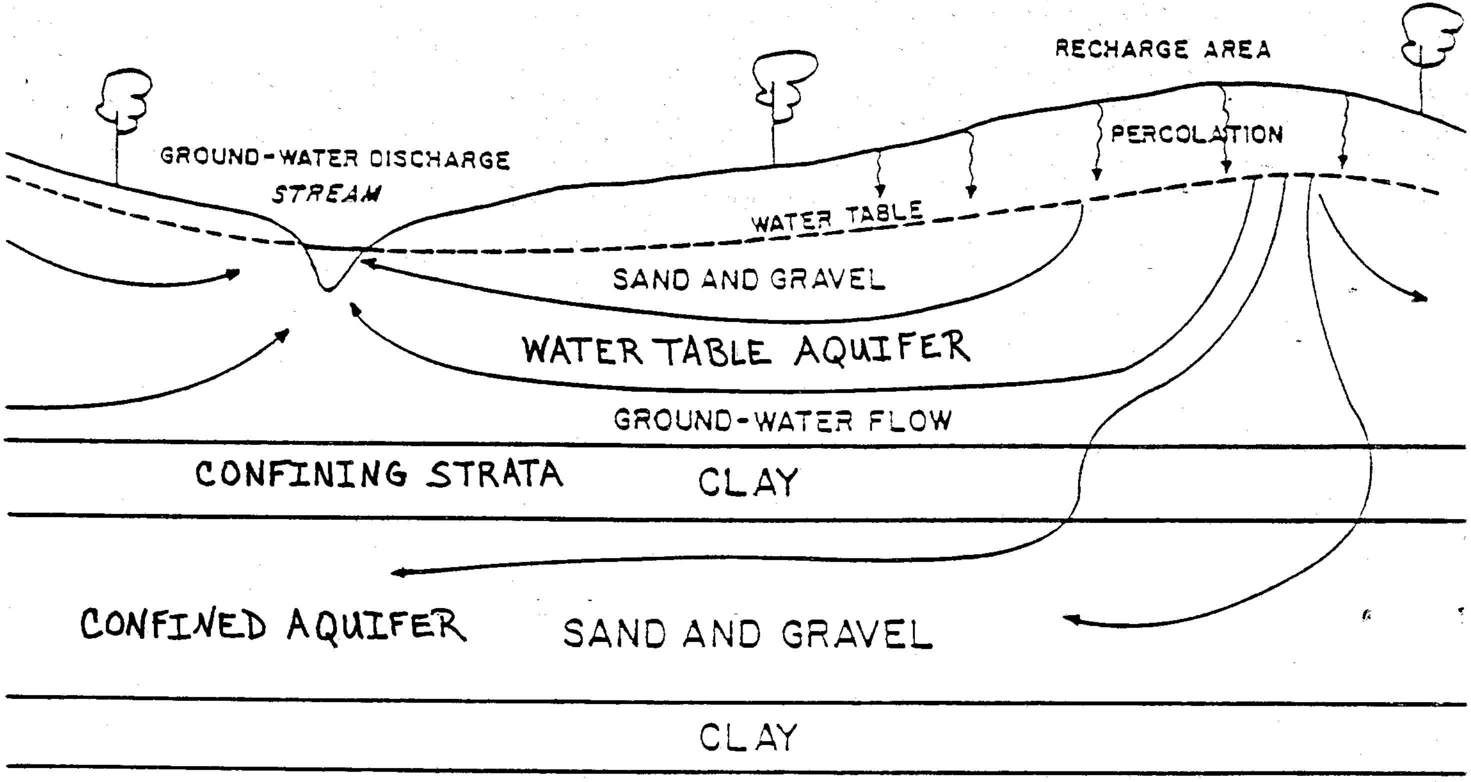


Figure 12. Ground-water flow system in a water table aquifer and in a confined sand and gravel aquifer.

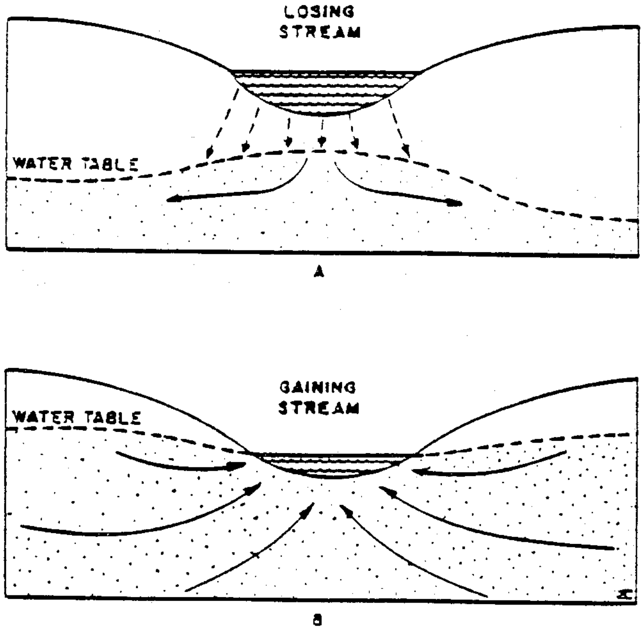


Figure 13. Interaction of a stream and a water table aquifer.

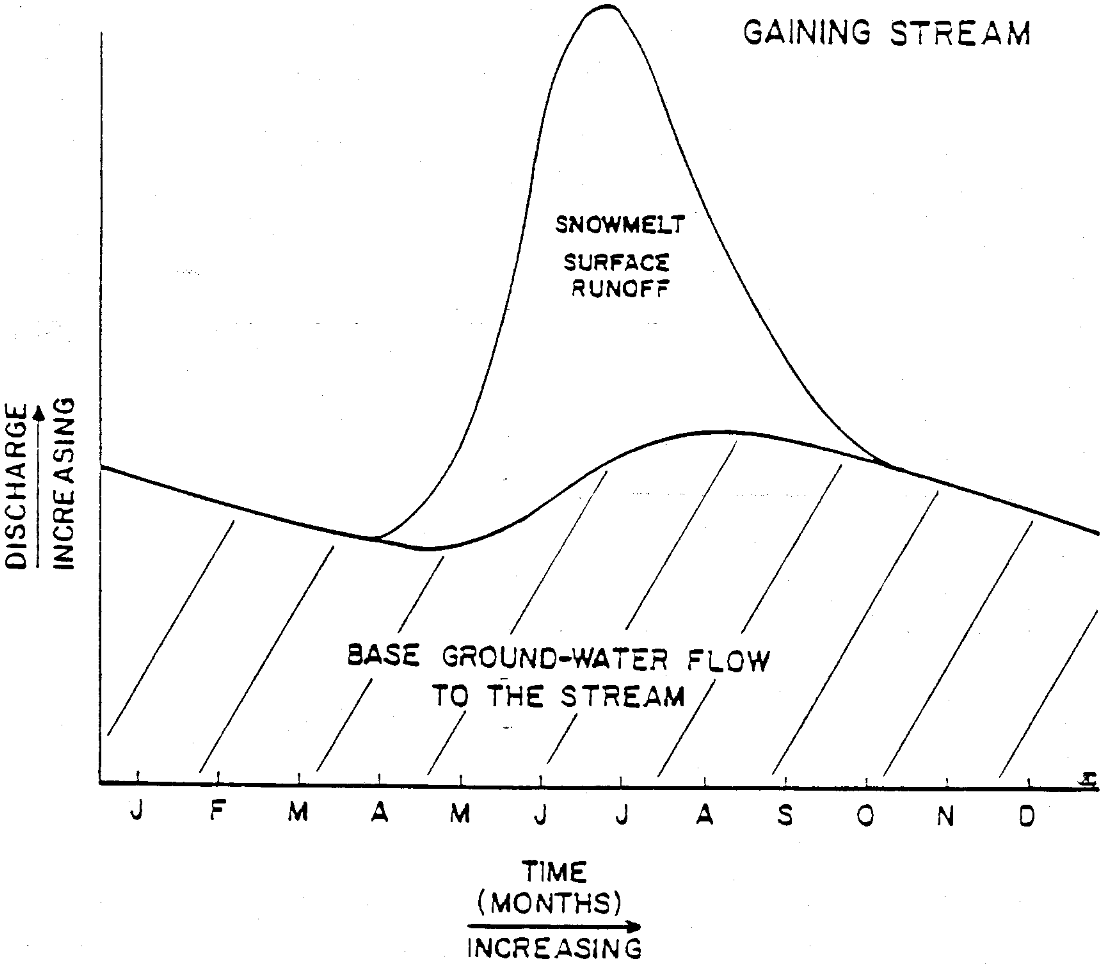


Figure 14. Hydrograph of a gaining stream showing the contribution to stream flow from the ground-water system, base flow, and surface runoff, snowmelt, and precipitation.

seeps into the bank and adds water, called bank storage, to the ground-water which is slowly released back to the stream as the flood stage recedes (Figure 15).

Ground-water interrelationships with lakes and reservoirs are similar to rivers in that under various conditions they can receive ground-water discharge or recharge the ground-water system depending on their position relative to the flow of ground water (Figure 16).

Many kinds of information are critical when attempting to quantify the degree of interaction between various surface water systems and one or more ground-water systems including the annual precipitation, evaporation, use of water by plants, the channel or lake bed surface area, the type of geologic material making up the banks, shoreline and bottom, the hydrologic properties of the ground-water system (such as the ease at which it transmits water), and overlying soil moisture zone. Easiest to visualize is the interaction between the water table ground-water system, which is the first ground-water system encountered below land surface, and surface water. However, deeper ground-water systems separated from the water table by fine-grained or tightly-cemented earth material may be totally or partially connected to the water table system and hence the surface water system (Figure 17).

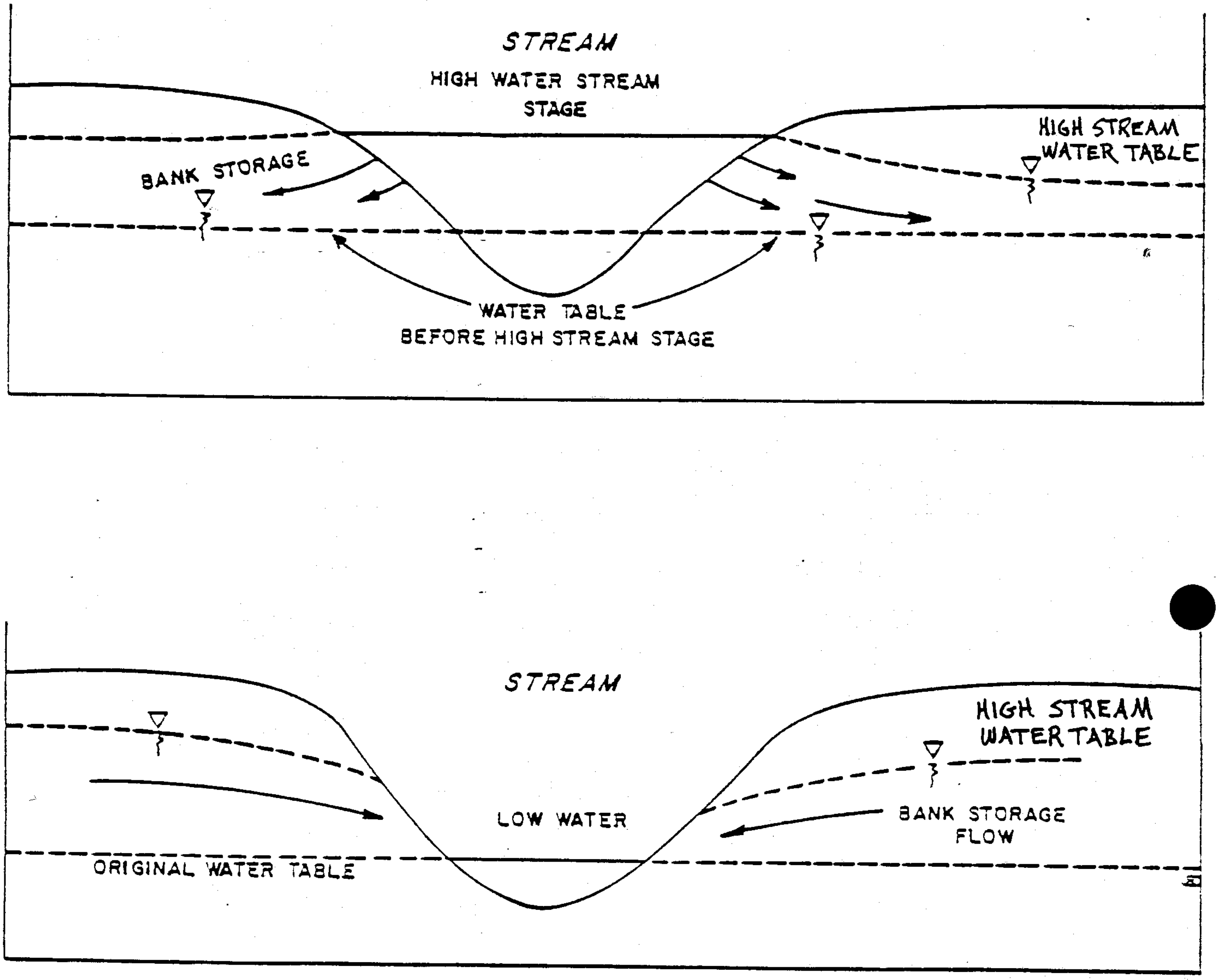
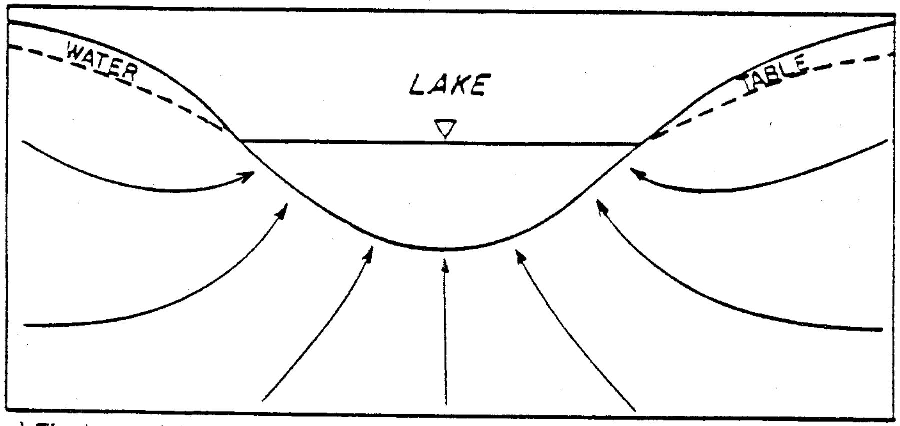
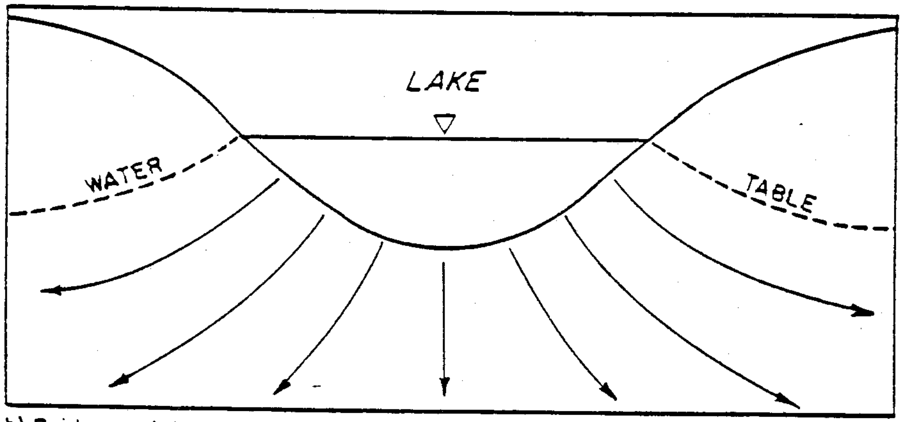


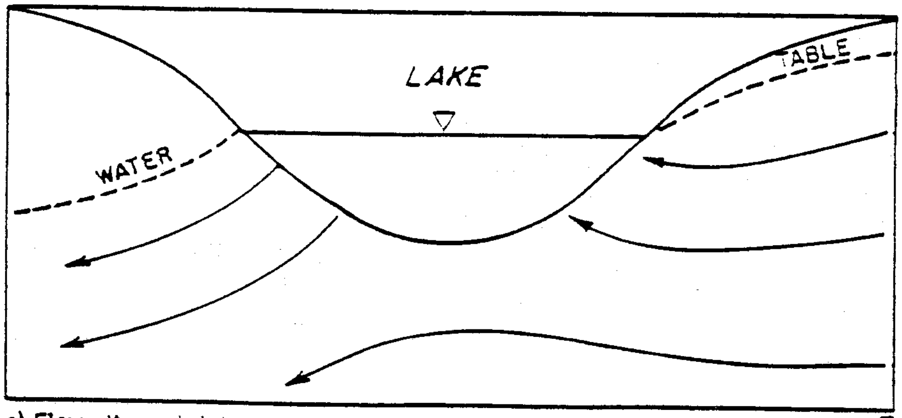
Figure 15. Stream flow recharging the banks and ground-water system during high river stage, and stored bank water, or ground water, recharging the stream during a falling river stage.



a) Discharge lake



b) Recharge lake



c) Flow-through lake

Figure 16. Lake / ground water interaction.

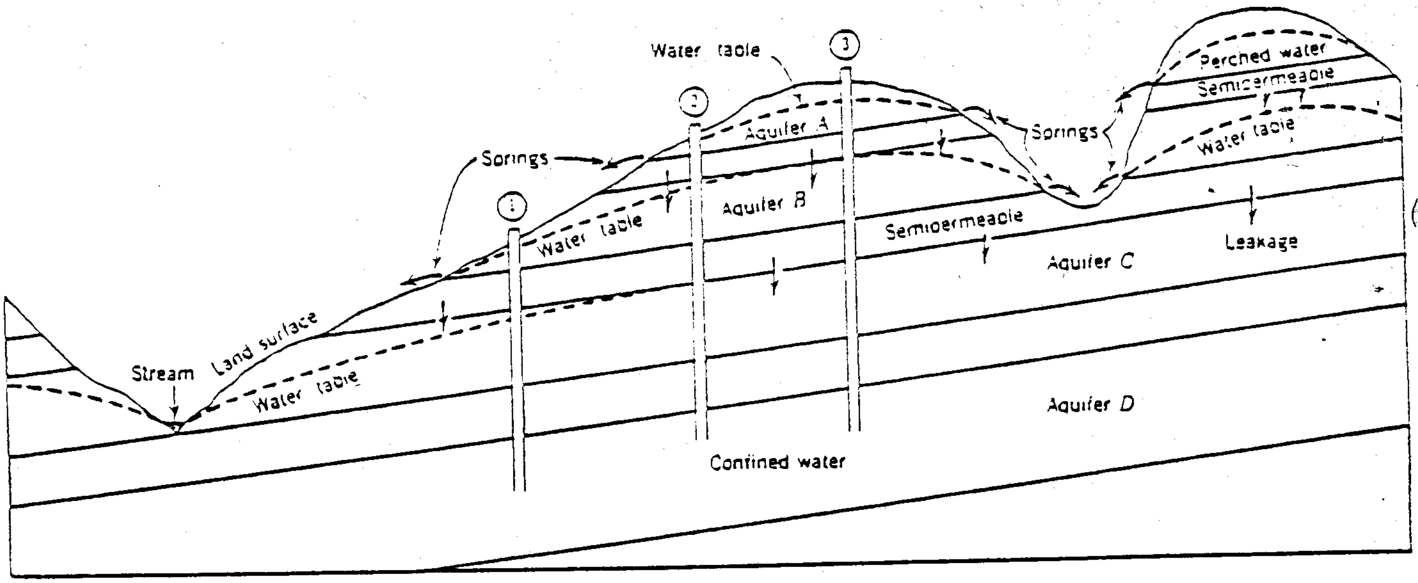


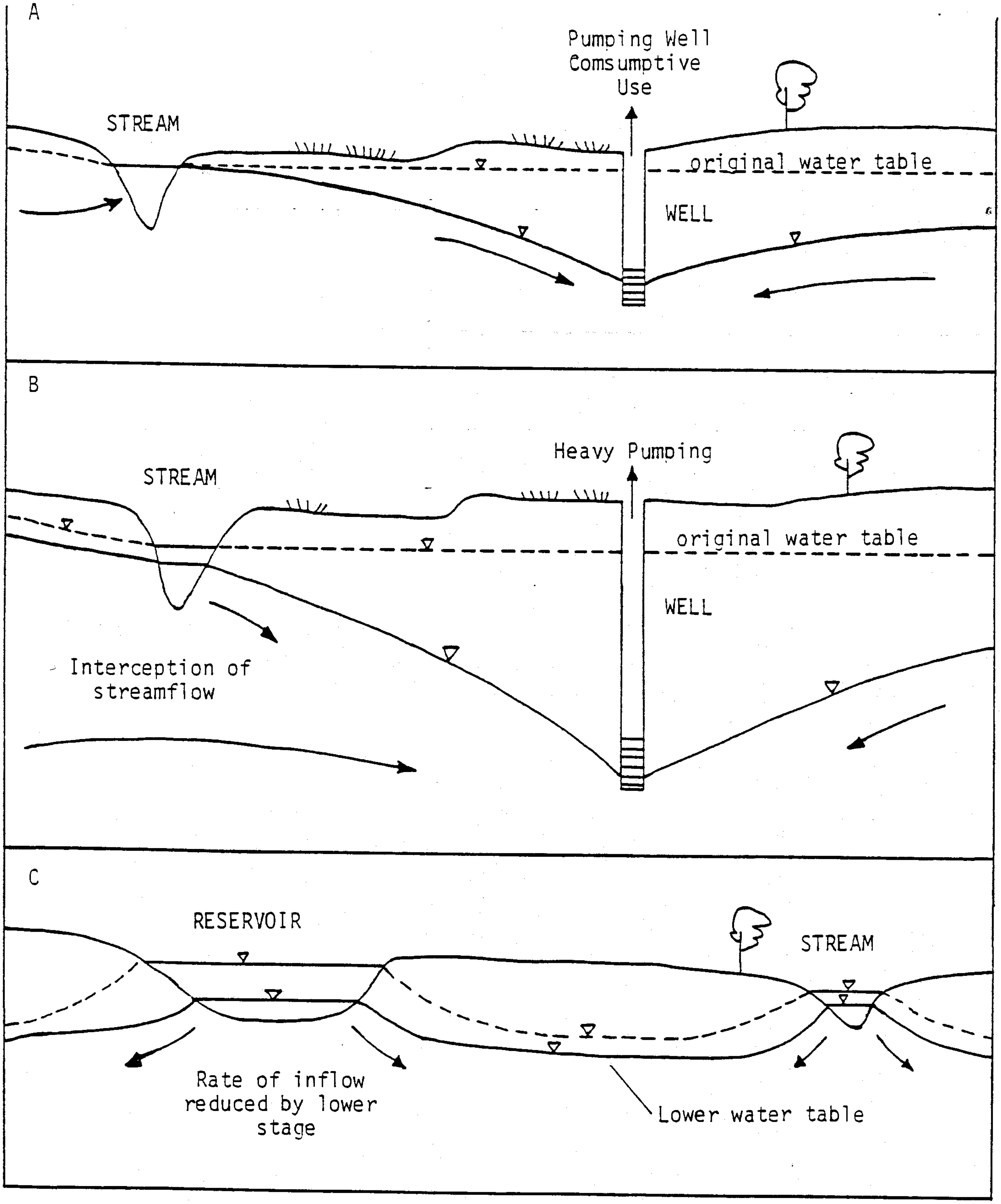
Figure 17. Cross-section showing the stacked nature of ground-water systems and the possible connection of deeper aquifer systems (Aquifer C) to the surface water.

Ground-water systems should be viewed as a stack of systems. Unless fractures extending through a thick portion of the stack exist and thus permit ground-water flow from great depths to the surface as at Giant Springs at Great Falls, large quantities of ground water will not easily migrate upward to discharge to surface water. Surface water will not directly recharge the deeper ground-water systems unless it seeps into an area at which the conductive earth material outcrops.

In Montana, the pumping and consumption of a portion of water from shallow ground-water systems for consumptive irrigation, municipal, or industrial use can in some situations reduce the surface flow of hydraulically connected surface water resources (Figure 18). Conversely, the reduction of a reservoir or a stream water level when these bodies of water are recharging the ground-water system can reduce the recharge to associated ground-water systems (Figure 18).

As the quantity of surface water and ground water is interconnected so is the quality. Construction of unlined sewage treatment lagoons, industrial storage ponds, mill tailing ponds and fly ash ponds, for example, may recharge poor quality water to the ground-water system. Poor quality ground water such as created by industrial waste disposal, chemical spillage, and mining operations, may discharge to a surface water system

Figure 18. The effect of pumping wells on the rate of ground-water flow to a gaining stream (A). Heavy pumping intercepting stream flow (B). Change in the ground-water recharge results in a reduction of the water table in a connected reservoir and stream system.



thus changing surface water quality. Conversely, polluted streams can in some cases recharge ground water which is being utilized for water supplies.

Statutes

Ground water under section 85-2-501, MCA, is defined as "...any water beneath the land surface or beneath the bed of a stream, lake, reservoir or other body of surface water, and which is not a part of that surface water." The DNRC Water Rights Bureau uses this definition of ground water in its regulatory program. This is different from a technical definition which would define ground water as all water which occurs in the zone of saturation which is at greater than atmospheric pressure. This would include all water below the water table. From the previous section, it is evident that the shallow water table ground-water system and sometimes deeper ground-water systems are connected to the surface water either by providing it with a source of inflow or by receiving recharge during all or part of the year.

Currently, DNRC notices existing appropriators of both ground water and surface water in situations where an application for ground water over 100 gallons per minute (gpm) appears to be connected to a surface water source. This application, if granted, is considered a ground-water appropriation.

In support of this procedure to notice both surface water and ground-water appropriators in applicants where ground water is hydraulically connected to a stream, DNRC refers to the decision in the matter of permit No. 14,965-g41E (the Boone Case) proposed by R.S. Sandquist. In this case, the applicant for the permit intended to pump ground water from a sump which was located in a slough adjacent to the Boulder River, Jefferson County, for irrigation purposes. The application was denied on the basis that the applicant would actually be depleting surface water and thus adversely affecting prior surface rights. DNRC recognizes the physical connection of shallow ground water to surface water and treats new ground-water applications accordingly, but when the application is approved, the permit is filed as a ground-water application. But, this procedure is in contradiction to the Title 85, MCA, Water Use definition of ground water, where only water flowing in deeper confined aquifers not discharging to surface water at any point would legally be defined as ground water.

This definition of ground water (section 85-2-501, MCA) also may prevent water resource management opportunities such as conjunctive use of ground water and surface water. Conjunctive use could become a valuable water management method to create new water development in basins where surface water and ground water are currently developed separately.

Ground-water appropriation requests for less than 100 gpm which may be withdrawing water from a shallow surface-water connected ground-water system are excluded by law (85-2-306, MCA) from the standard permit requirements. However, the DNRC does have the procedure described in the above paragraph to protect existing surface water users and manage the hydrologic system. Even though the procedure to protect surface water users exists (e.g. the Boone Case), ground-water appropriations less than 100 gpm are in most cases approved without determining if the well has any hydraulic connection to a surface water source.

DHES's Water Quality Bureau and Solid Waste Management Bureau and DSL use technical definitions of ground water very similar to the previously described technical definition. The Water Quality Bureau uses "water occupying voids within geologic strata and within the zone of saturation" for their new proposed ground-water regulations (Montana Ground Water Pollution Control System Rule 16.20.1001(5)). DSL defines ground water as "subsurface water that fills void openings in a rock or soil material to the extent that they are considered water saturated" (Strip and Underground Mine Rules and Regulations, Rule 26.4.301(25)). The Solid Waste Management Bureau basically uses Water Quality's ground-water definition. These agencies are primarily concerned about ground-water quality and recognize the interconnection of surface and ground-water resources in interpretation and enforcement of their rules. The basic difference between the DNRC ground-water definition (85-2-501, MCA) versus other state agency definitions is that, under the DNRC definition, some ground water is considered as surface water when it is technically ground water, whereas the other agencies treat the surface water system and near surface ground-water system as part of a hydrologic system, not as disjointed units.

Options

1. Maintain the status quo.

2. Define ground water for DNRC in Section 85-2-501, MCA, along technical lines as previously discussed. This would resolve the contradiction between the DNRC procedure on ground water/surface water interaction and the legal ground-water definition.

3. DNRC could treat all appropriation of shallow ground water which would reasonably be connected to surface water as surface water appropriations. Each application could be tested by hydrogeologic setting, specific hydrogeologic testing and surface flow data to determine if it should be treated as a surface water appropriation or a ground-water appropriation.

4. Initiate legal research into whether conjunctive use is possible under present statutes. If this is not possible, legislation could then be introduced which recognizes that

ground water and surface water are often directly linked and that when such linkage exists or is likely to exist, the two could be dealt with conjunctively instead of separately.

5. A study on the degree of surface water/ground-water interconnection in various hydrologic settings in the state, such as alluvial valleys in the western basins and in the Fort Union region, could be undertaken. Information gathered by this study would be helpful in the administration of various state agencies' duties. This information could also be used to point out areas where ground-water opportunities could be developed.

6(a). Amend the Water Use law to eliminate the 100 gpm exclusion.

(b). Amend the Water Use law to reduce the 100 gpm exclusion to some lesser rate.

(c). Require through legislation or procedure changes that the DNRC Water Rights Bureau screen all ground-water applications under 100 gpm to determine if wells are hydraulically connected to a surface water source.

B. GROUND-WATER OPPORTUNITIES -- Marvin Miller, MBMG

Issue Identification

Ground water is a resource that potentially has tremendous economic value to Montana, and yet is under-utilized. For some agricultural, municipal, and industrial needs, ground water is often overlooked in favor of more common engineering solutions of developing or extending surface water resources. Using surface water alone in some cases can be substantially more expensive and less dependable than utilizing ground water either by itself or in conjunction with surface water.

Examples of potential ground-water opportunities that are being overlooked are numerous.

In northeastern Montana (Sheridan, Daniels, and Roosevelt counties), an ancient abandoned channel of the Missouri River lies hidden underneath glacial deposits. Gravel beds in the channel can provide large yields of water to wells, but development of the aquifer for irrigation has proceeded slowly on a haphazard basis, discouraged by a lack of information on the aquifer's geographic extent, storage and water quality, as well as by fears of over-development.

Along the lower Big Hole River, irrigators using surface water face severe and unpredictable shortages during late-season periods. The engineering remedy considerd was to construct a reservoir in the upper reach (or tributaries) to store runoff for such times.

An alternative to reservoir construction may be the installation and use of high-capacity wells along the upper reach to augment the river during times of low flow. The aquifer in the upper reach could then serve as a natural reservoir that would be recharged during periods of high runoff. This conjunctive use of surface and ground water has not been seriously considered probably because of the lack of hydrogeologic data needed to determine its feasibility. In most water resources feasibility studies, large sums of money are often allocated for surface storage alternatives, however, funds to examine potential ground-water solutions have not always been sought or available.

Sediment from irrigation practices on the Greenfield Bench along Muddy Creek (Teton and Chouteau counties) is creating a severe problem in the Sun River. This has been classified as Montana's number one water quality problem in the Water Quality Bureau's 1982 305-B study (DHES 1982).

Possible remedies being considered for this problem include construction of a sedimentation reservoir on Muddy Creek and the lining of irrigation ditches on the Greenfield Bench to reduce the ground-water discharge to Muddy Creek. Another possible solution is to leave the upstream ditches unlined, encourage recharge to the ground-water system rather than runoff from excess irrigation water, and install high capacity wells or ground-water drains to provide irrigation water on the lower portions of the Greenfield Bench. The re-use of ground water may reduce irrigation return flows and associated sediment to Muddy Creek and the Sun River.

A major source of municipal water for the City of Helena is the Ten Mile Creek system. Much of the time, turbidity of the water exceeds EPA's minimum acceptable standards.

The proposed remedy is the construction of a costly treatment plant. An alternative, not given serious consideration because of lack of conclusive data, would be the construction of high-capacity wells to withdraw water from the aquifers underlying the Helena Valley. This water probably would not require treatment. Despite promising hydrogeological indications, additional data are needed to determine the availability of water, its quality, any potential impacts of increased withdrawals on existing users, and the cost of wells and associated waterlines compared to a treatment plant.

The City of Bozeman also has a water shortage problem and a water pollution problem in the spring season. The City is currently using nearly all the surface water rights available to it. One of the water supply reservoirs (Mystic Lake) was breached this year for safety reasons. Each spring there is a turbidity problem which produces a potential health hazard. To respond to this problem a new water plant is being constructed. Overall, the water supply strategy for the city has revolved around surface water. Research at Montana State University during the past year suggests that ground water may be a viable part of the water supply picture for Bozeman. Sources might include water from subsurface Quaternary valleys or alluvial valleys if adequate recharge can be identified. One source of recharge might be water spreading of spring-flood water. The Madison Aquifer may also be a potential ground-water source for the city. Ground water could augment the city's water supply, decrease the water shortfall, and reduce or eliminate the spring season contamination problems. Thus, ground water needs to be seriously studied as a water source in Bozeman.

Utilization of ground-water heat pumps is a special ground-water opportunity in Montana. Over much of the state, ample ground water is available (5 to 10 gallons per minute) to satisfy this new concept in home heating. Heat pumps are now available that can extract enough heat from relatively cold ground water (45° to 50°F) to handle many home heating requirements even with Montana's cold winter temperatures.

Heat from ground water is relatively economical compared with conventional systems, particularly in rural areas where electricity or LP gas are utilized. Despite the economic advantages, only a few ground-water heat pumps have been installed in Montana, most of those being in commercial buildings. The lack of widespread use of the ground-water heat pump can be attributed to lack of information about heat pumps, ground-water availability, quality, temperatures, and regulations concerning return wells and water disposal.

Deep gravels which are artesian aquifers in the Kalispell valley are known to provide up to 2,000 gallons per minute to wells. This resource is being increasingly used to support agricultural and subdivision development. Although little specific information is known about these aquifers, selected wells indicate the potential to supply most water needs in portions of the valley. This resource needs to be explored to discover any problems with development which could include potentially large drawdowns, decreased subsurface flows to Flathead Lake, and whether or not large scale development is economically viable.

The intermontane basins (valleys) of western Montana contain many of Montana's larger population centers for instance, Missoula in the Missoula Valley, and Bozeman in the Gallatin Valley. As surface water resources become more appropriated and water treatment costs rise, more attention will need to be paid to alternative water sources. The deeper sediments in these valleys are unexplored but may represent a potential resource that could produce large supplies of water.

Statutes

There are no state statutes that specify the development of ground-water opportunities in Montana. However, existing legislation such as HB 705 and HJR 54 (Fort Union Ground-Water Study) and HB 733 (Artesian Basin study) direct MBMG to undertake studies of the ground-water resources of Montana. These studies are done in cooperation, where practical, with the USGS, DNRC, DSL, DHES and other like agencies.

Options

1. Continue on the present course of little or no action.

2. Try to anticipate and study areas where ground-water development can have strong social and economic benefits. Under this option, encouragement of wise and prudent development would also be desirable.

3. Undertake a detailed statewide ground-water study program. This could be done on an aquifer basis, county basis, or watershed basis. Data from these studies would supplement data in the ground-water information center.

4. Mandate that ground water be considered as an alternative whenever feasibility studies for water resource availability are done.

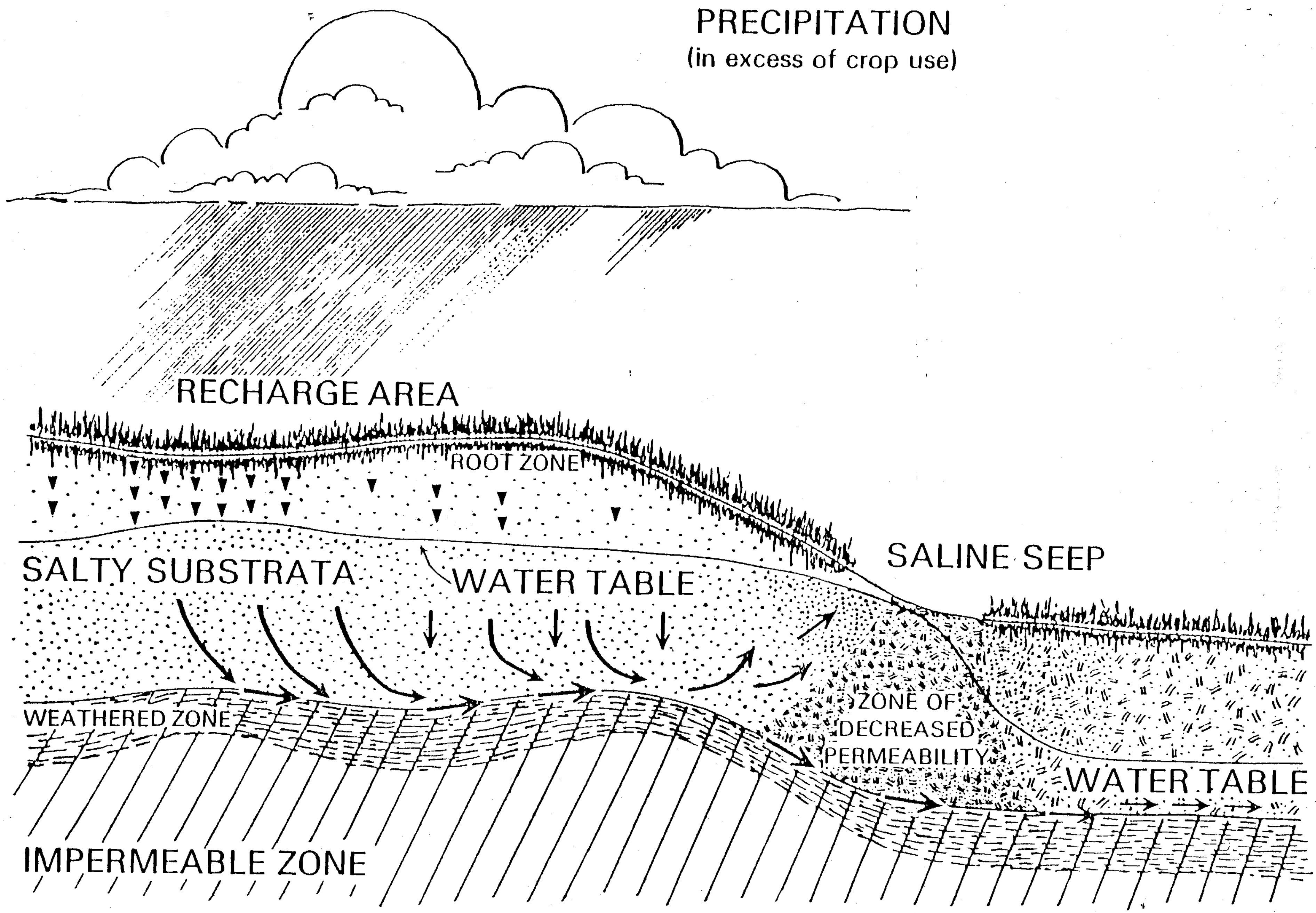
C. SALINE SEEP - Marvin Miller, MBMG

Issue Identification

The widespread occurrence and rapid growth of saline seeps on or adjacent to cultivated drylands has become one of the most serious conservation problems in the Great Plains region of North America (Ferguson, et al. 1972). Dryland salinity, hardly recognized 35 years ago, has now taken approximately 2 million acres out of crop production in the United States and Canada (Vander Pluym 1978). Equally serious as the loss of arable land is the local and potential regional deterioration of surface and shallow ground-water resources which, in many areas, are the primary sources of potable water. Significant concentrations of trace metals, as well as high nutrient levels, have been found in many ground-water and surface water samples (Donovan, et al. 1979). A number of livestock, wildlife, and fish kills have been noted and are believed to be directly related to the saline-seep problem.

A schematic diagram illustrating the formation of a typical saline seep is shown in Figure 19. Dryland salinity is caused by a combination of cultural, climatic, and hydrogeological conditions. The importance of any one of these factors may vary significantly from area to area, but the formation of saline seep follows the same general process throughout the region. This process starts with excess water percolating downward beneath the root zone, picking up soluable salts, accumulating on shallow, less-permeable layers (typically shale) and forming a local ground-water flow system. The flow system moves saline water from the recharge to the discharge area (seep) where it evaporates, depositing the salts on the surface.

Figure 19. Schematic diagram illustrating the typical formation of saline seep.



Any land-use practice which allows excess moisture to migrate downward through the soil profile beneath the root zone, can contribute to the formation and growth of dryland salinity. A number of land-use practices have been noted as contributing to saline seep, but by far the most important change in the northern plains is the widespread use of the alternate crop-fallow (summer-fallow) farming system. Most soils store only 4 to 8 inches of water in the root zone during a fallow period. Once recharged by precipitation, any additional water entering the soil moves to the water table and may resurface downslope as a saline seep. Sandy soils which have very limited holding capacity and allow water to infiltrate rapidly, can readily recharge the local ground-water flow system. Because of the widespread use of the summer-fallow system (tabulated by the U.S. Dept. of Agriculture - Agricultural Stabilization Conservation Service (ASCS) to be 12.3 million acres in Montana alone) relative to other land-use practices, it becomes apparent why it is the dominant cause.

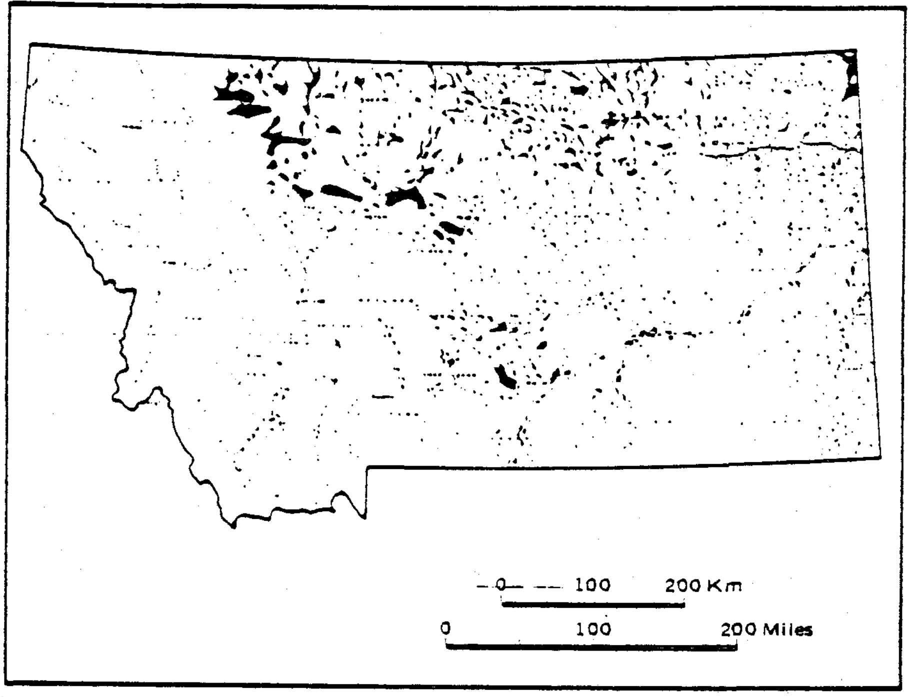
Hydrogeological conditions conducive to the formation of saline seep exist over more than 228,000 square miles in the North American Great Plains (Miller 1971; Miller, et al. 1979). The dominant cropping system over this entire region is the alternate crop-fallow farming system. Accurate estimates of seep development are difficult to obtain, particularly for the earlier days when the problem was much smaller and farmers were unaware of its existence.

The general distribution of saline seeps in Montana is shown in Figure 20. The map and the estimate of 200,000 acres are based on an aerial and field reconnaissance survey conducted by the MBMG in 1978 (Miller, et al. 1978).

On a regionwide basis, the acreage of saline seep appears to be expanding at an average rate of about 10% a year (Figure 21) (Miller 1971; Bahls and Miller 1973; Miller, et al. 1981). The rate varies substantially from year to year, depending upon climate, but the general trend is toward significant increase. After each wet cycle (years with average to above average spring precipitation), expansion of seep areas by 20 to 200 percent is not uncommon (Halverson and Black 1974; observation by personnel from the ASCS, MBMG, and Triangle Conservation District). On the other hand, very little or no expansion may occur during dry cycles.

As noted earlier, the regional deterioration of surface and shallow ground-water resources are equally as serious as the loss of available land. Seep water commonly contains ground water of more than 25,000 milligrams per liter (mg/l) total dissolved solids (TDS) with some samples exceeding 50,000 mg/l TDS, considerably more saline than sea water at an average of 36,000 mg/l TDS (Miller 1971; Miller, et al. 1978; Donovan and Miller 1980). The predominant constituents are sodium, magnesium, sulfate and nitrate with unusually high concentrations of trace elements, particularly selenium. Saline

Figure 20. General distribution of saline seeps in Montana (Miller, et al. 1978).



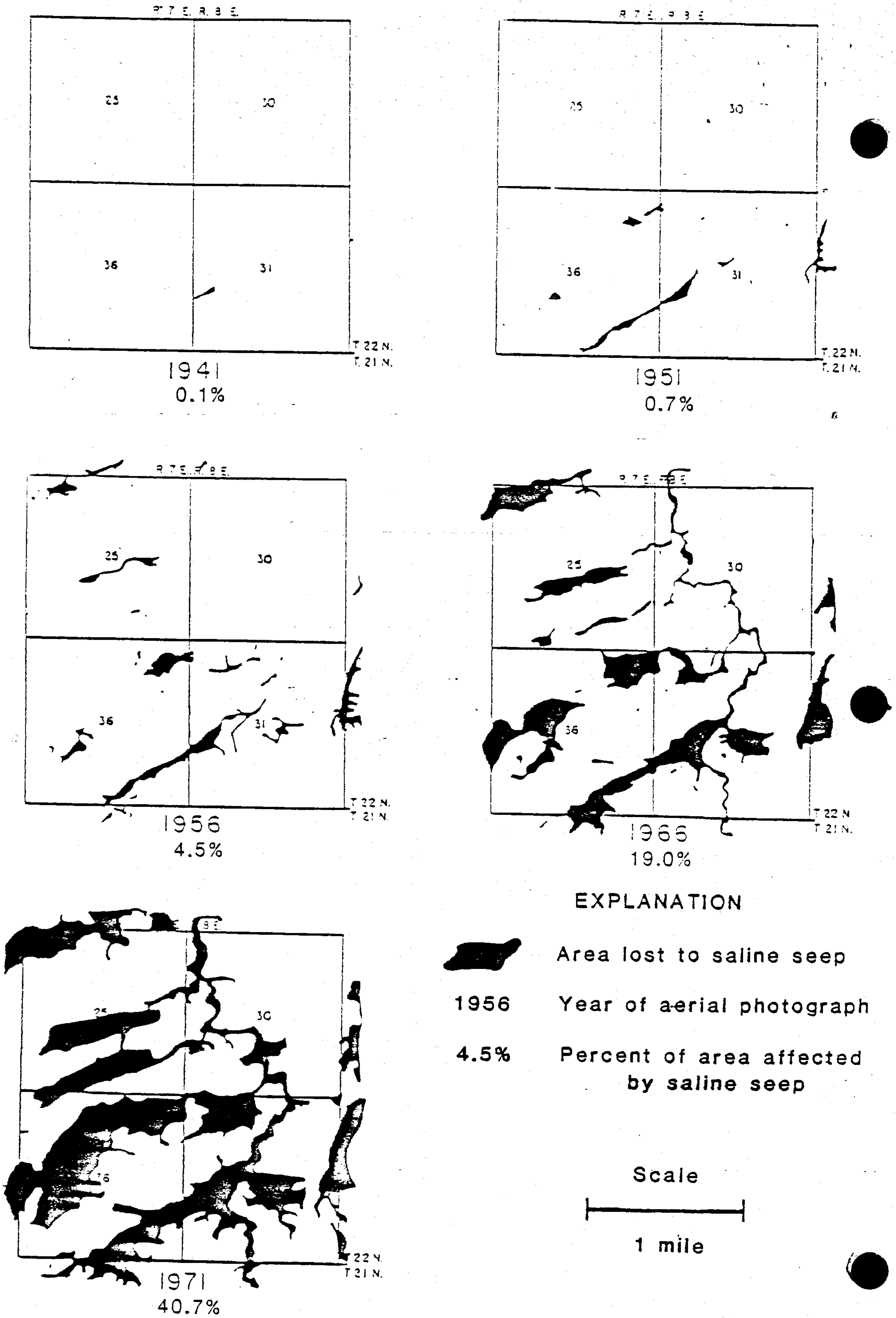


Figure 21. Demonstration of saline-seep growth over a 30-year period (1941-1971), Highwood Bench, Chouteau County, Montana (Miller, et al. 1981).

seep is responsible in part for increasing saline pollution of Montana's water. The growing unpalatability of several community water supplies has been attributed to saline seep and nitrate poisoning of livestock from salinized farm reservoirs has been reported in a number of areas (Miller, et al. 1978; field observation and samples collected by MBMG and DHES Water Quality Bureau personnel). Seeps are developing particularly in areas underlain by Colorado and Bearpaw shales (northern Montana) having no alternate source of fresh water for household, livestock, or wildlife purposes. The demise of tens and possibly hundreds of reservoirs has been linked to the saline-seep problem (Bahls and Miller 1973; Miller, et al. 1978). The implications of seep-caused water pollution are clear. Montana is the headwater state for the entire Missouri River Basin, and any significant degradation of water quality here will affect downstream uses. Unless saline seep is checked, present water uses such as drinking, recreation, and fish and wildlife, will be seriously degraded and water treatment will become more expensive.

The best solution to the problem is to utilize precipitation where it falls, before it moves beneath the root zone. Three of the most successful control practices are: a) growing deep-rooted perennial crops, such as alfalfa; b) switching to flexible intensive cropping systems (for further information see: Jackson and Krull 1978; Brown and Miller 1978; Black, et al. 1981; Miller, et al. 1981); and c) draining selected upland freshwater potholes (U.S. Fish and Wildlife 1970). On one research site (Highwood Bench, Choteau County) where these practices were applied during the past 10 years, significant results include: lowering the ground-water table an average of 8.2 feet; a decrease in salinity of ground water by approximately 25 percent; a 75 percent reduction in soil salinity from the upper 2 feet in the seep area; and a decrease in the salt-affected area from 30 acres to less than 1 acre (Brown and Miller 1978; Miller, *et al*. 1981).

Saline-seep investigations in Montana began in 1969 by the MBMG, MSU, SCS, and U.S. Department of Agriculture - Agriculture Research Station at the request of the Highwood Alkali Control Association (HACA - a group of about 75 farmers in Choteau County). Funding from the above organizations provided initial research findings which were presented at the first Saline-Seep Workshop sponsored by HACA in 1971, that strongly suggested that the saline-seep problem was regional in scope and a much more serious environmental problem than previously thought.

The saline-seep program was enlarged after the 1973 Montana Legislature passed a joint resolution (SJR 33) asking the Governor to marshall all state resources and seek emergency aid to halt seep. Funds administered by DSL and approved by the Governor's emergency saline-seep committee, began a coordinated program to get control of the problem. Since then information relating to all aspects of the problem have been disseminated in publications, conferences, symposiums, workshops, field tours, meetings, and classrooms.

Through close cooperation and coordination among researchers, farmers, and agencies; the origin and development of seep has been evaluated and effective saline-seep control strategies have been developed and applied to small research sites to demonstrate that the problem could be controlled by utilizing the practices mentioned in the previous section. To disseminate research findings and to apply the control practices over a large area, the 1979 Legislature approved funding through DNRC renewable resource account to create the Triangle Conservation District (TCD) involving 9 counties in northcentral Montana. The TCD goal is to provide technical assistance to farmers to implement saline-seep control practices throughout the area. Since 1980 over 200 farm plans have been implemented and based upon the farmers tremendous enthusiasm and acceptance for the program, it is currently being considered for expansion to other areas of the state. Other indications of interest for the seep-control programs are: a) the formation of a number of local saline-seep organizations within the region; b) the SCS is considering applying saline-seep control practices (the first in the nation) to an entire watershed in northern Liberty county and; c) the community of Geraldine has formed a saline-seep association and has applied to DNRC Water Development Bureau for funding to work in the saline-seep problem within the town as well as the surrounding area.

Statutes

Title 85-9-101 and 102 provides for the establishment of conservancy districts whose purpose is to "prevent or control floods, erosion, and sedimentation; provide for regulation of stream flows and lake levels; improve drainage and reclaim wet or overflowed lands...". The title also creates a Board of Supervisors whose duty is to operate the conservancy district according to the purpose of the law. The organizational setup of the TCD is modeled after the conservancy district law and it appears very functional.

The BLM has no formal rules or regulations regarding saline seep, but does exercise control over farming practices through its stewardship authority. Land which is prone to saline-seep is not allowed to be broken, and land which is already farmed and showing signs of saline seep is to be managed in a manner to halt saline seep.

DSL also approaches the saline-seep problem on state-owned land in the same manner as the BLM, except with cultivated lands with saline-seep problems, the DSL requests the farmers contact his local conservation district for advice, rather than the DSL acting directly.

Options

1. DSL and federal land management agencies could: a) take the lead in initiating intensive cropping practices on state or federal lands leases in saline-seep prone areas; b) provide incentives to lessees in carrying out saline-seep reclamation plans (in planning and implementation); and c) disallow breaking of rangelands in saline-seep prone areas until above programs are well underway.

2. Breaking of marginal rangelands into croplands in saline-seep prone areas should be discouraged possibly by taxation or exclusion from state or federal programs, or some other method.

3. Continue existing TCD's education, extension, and demonstration program.

4. Expand the present TCD saline-seep program with an appropriate increase in funding into other areas of Montana.

5. Increase funding for research in intensive (flexible) cropping systems to overcome economic and management problems associated with current farming technology.

6. Initiate a program to evaluate regional water quality trends which will assist communities and landowners in obtaining

potable water supplies. Currently, the DNRC Water Development Bureau have limited funds for improvement of community water supplies.

D. OIL AND GAS EXPLORATION AND DEVELOPMENT -- Debra Hanneman, DNRC

Issue Identification

According to recently released figures by the Montana Board of Oil and Gas Conservation, a record 1,149 wells were drilled in search of oil and natural gas in Montana in 1981. Approximately 60 seismograph companies were bonded for work throughout the state during this time (Pers. Comm., DNRC Oil and Gas Division 1982). With this amount of oil and gas activity occurring in the state, the potential for resulting aquifer deterioration is greatly enhanced.

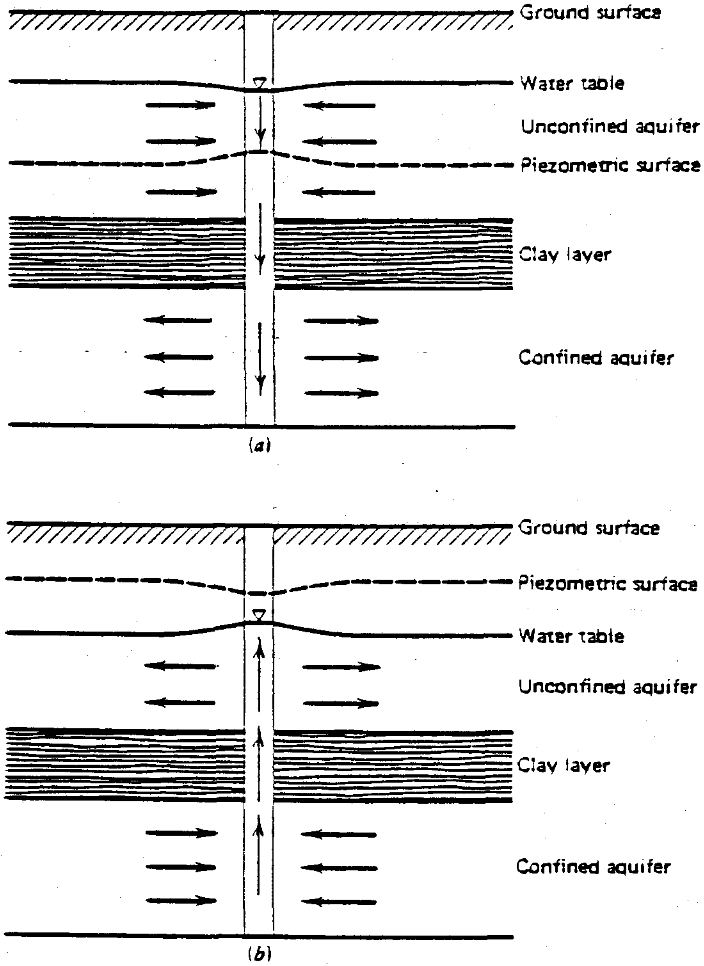
Seismic drilling programs have been in effect in Montana for over the past twenty-five years. It is estimated that there have been over a million exploration shot holes drilled in the state during this time (Bond 1975). Aquifer damage can result from both the drilling and shooting of seismic shot holes. Holes drilled by air-rotary equipment are fairly clean, and in some cases the air actually develops the aquifer, thus maximizing any potential interaquifer mixing. Seismic shooting can cause a change in aquifer structure, which would be characterized by a change in aquifer permeability. This structural change could result from a modification in either the arrangement of aquifer materials or in the cement that holds the material together.

The plugging of seismic shot holes is critical in deterring aquifer deterioration. Depending upon the type of geological material present, the shot holes may seal themselves since the holes are uncased and are prone to collapse. However, in other cases, the holes will not seal themselves, and could cause significant hydrological changes if they are not properly plugged. Figure 22 illustrates the interaquifer mixing which could occur in seismic shot holes.

The total extent of ground-water problems that result from seismic activity is not known. The MBMG has studied the influence of these holes on ground water in eastern Montana. Although no aquifer damage or contamination has yet been detected at the study sites, the MBMG recommended that all seismic holes be plugged (MBMG 1978).

The development and production stages of oil and gas wells are significant in terms of possible ground-water contamination. By the end of 1981, more than 4,000 producing oil and gas wells existed in the state, with approximately 85 percent of these located in the northern and Williston Basin areas of Montana (DHES 1982). Oil and gas exploration is

Figure 22. Diagrams showing aquifer leakage by vertical movement of water through a nonpumping well. (a) Water table above the piezometric surface. (b) Piezometric surface above the water table. SOURCE: Todd, et.al., "Monitoring ground-water quality: Monitoring methodology", Report EPA-60014-76-026, U.S. Environmental Protection Agency, Las Vegas, 1976.

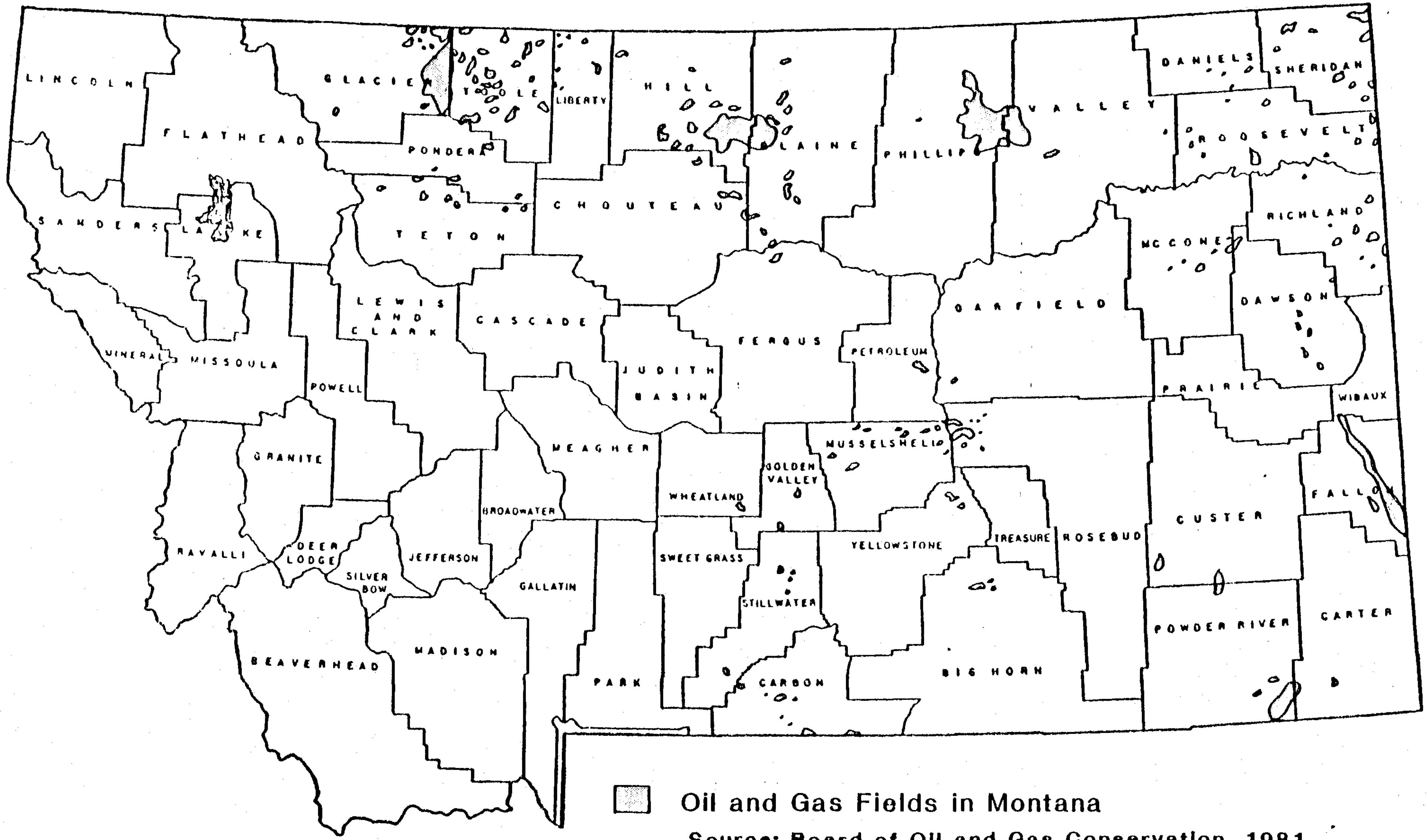


escalating in western Montana, in association with the Overthrust Belt and Tertiary basin areas. Drilling operations in the western part of the state pose an increased hazard to ground-water contamination since the strata are more intensely fractured here than in the eastern part of the state. Figure 23 depicts state oil and gas production areas.

The type of drilling procedures used are important in preventing interaquifer exchange. The prevention of aquifer mixing can be accomplished by various techniques, such as by placing packers and plugs between the casing and drill hole. In addition, the handling of saline drilling fluids and muds is a major concern in deterring shallow aquifer contamination during this stage of well development.

An assortment of recovery techniques are used in oil and gas production. The more common techniques used in this state include: primary recovery--oil and gas recovery under natural pressure conditions; secondary recovery--the injection of water or gas into the reservoir to increase pressure in the reservoir and thus increase production; tertiary recovery--the injection of steam or chemicals into the reservoir in order to lower oil viscosity; and formation fracturing--the injection of a fluid under high hydraulic pressure so that the fluid is forced through the perforated casing and further fractures the production zone. Figure 24 depicts the first three of these recovery methods. Ground-water contamination is again a

Figure 23. Location of oil and gas fields in Montana.

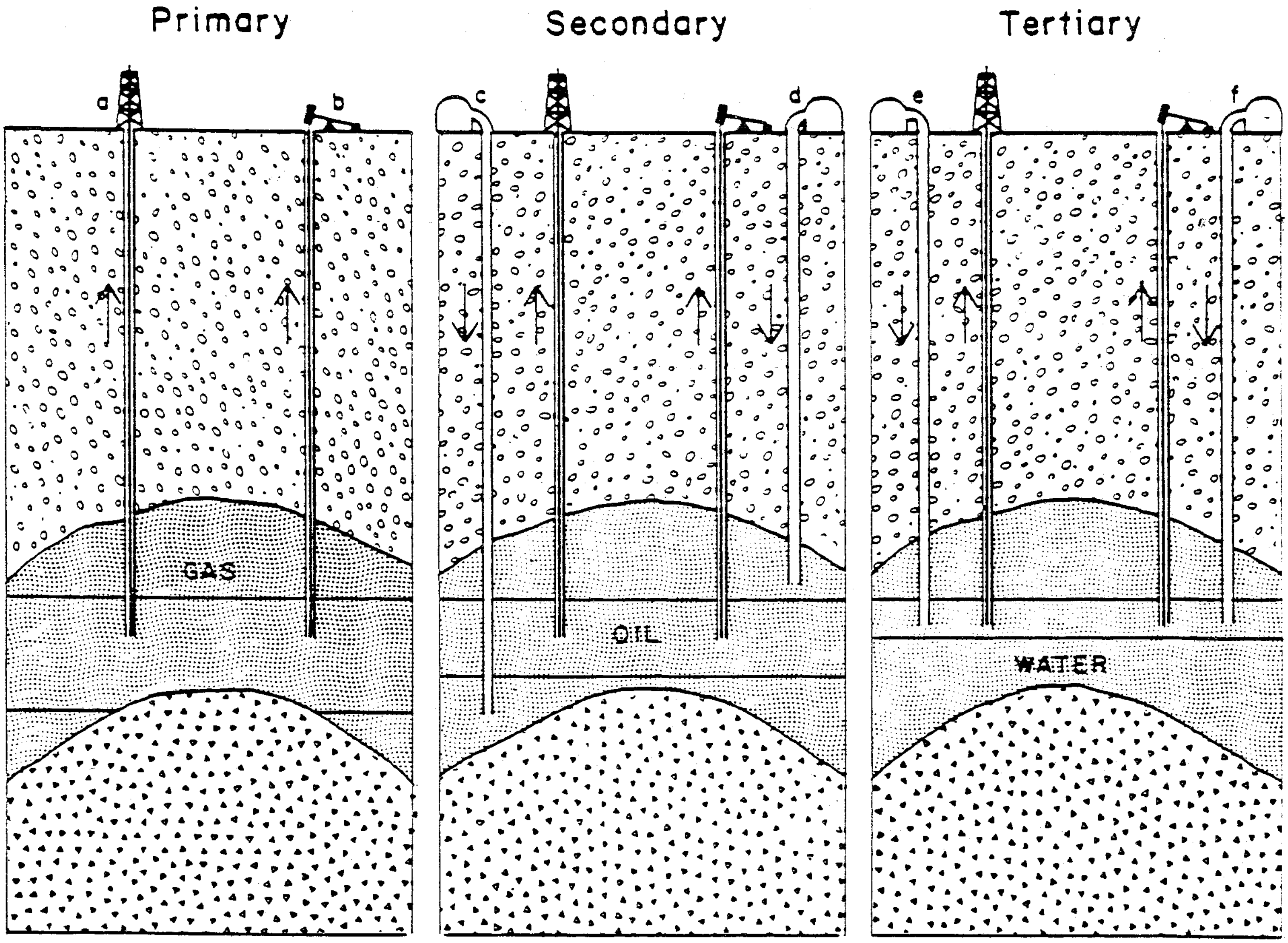


▨ Oil and Gas Fields in Montana

Source: Board of Oil and Gas Conservation, 1981

Figure 24.

METHODS OF OIL RECOVERY



Oil is generally found under pressure in porous rock, often in a geological structure such as the one shown here. Drilling a well into the oil-bearing stratum releases the pressure, and in primary production the oil flows to the surface (a) or is pumped out (b). When the natural pressure is too low to bring the oil to the well, secondary recovery may be achieved by pumping water (c) or gas (d) into the field to increase the pressure. In tertiary recovery the oil's viscosity is lowe ed by injecting steam, which heats it (e), or by injecting a chemical (f).

Source: Scientific American, vol. 238, no. 38, March 1978.

potential problem during the recovery stage, and can result from faulty well development and from subsurface geological features that would allow for the migration of injection fluids from the injection zone.

Reserve pits are also potential sites of ground-water contamination, not only as this relates to their construction, but also in terms of their reclamation. A recent study (Dewey 1982) indicated that during the squeezing and trenching done for pit reclamation, pit liners are easily torn and in some places are removed. Thus saline fluids are trenched into the soil and will eventually enter the ground-water regime.

Another problem noted by this study is the common practice of spreading reserve pit fluids and produced brines on county roadways for dust control. The continual addition of these solutions to roadways results in a buildup of salts in area soils and eventually an increased salt load in the ground-water system.

The extent of ground-water problems associated with oil and gas development and production is difficult to estimate. Drilling operations are regulated by the Board of Oil and Gas Conservation, but enforcement of these regulations is a problem. Thus, the number of reported contamination incidents may be small in comparison to actual contamination occurrences. This also applies to ground-water problems associated with recovery and reclamation techniques, particularly in respect to injection wells, since these will be largely unmonitored until the implementation of the EPA Underground Injection Control program.

Statutes

Department of Natural Resources and Conservation (DNRC)

The regulation of exploration, development, and production of oil and gas in Montana is the responsibility of the Board of Oil and Gas Conservation (Title 82, Ch. 2 and 11, MCA) and is administered by DNRC's Oil and Gas Conservation Division. The purposes of the regulations include: 1) prevention of waste in oil and gas exploration and production; 2) reclamation of disturbed lands, and 3) prevention of water pollution problems related to oil and gas activities.

Overall, the present rules and regulations appear to be adequate in covering state oil and gas activities. The primary problem that currently exists with some of these rules and regulations is that the Oil and Gas Conservation Division lacks the authority necessary to enforce them.

One of the rules previously in contention, Rule 36.22.502, pertaining to the plugging and abandonment procedures for seismic shot holes, has recently been amended so that the holes must be filled with bentonite water slurry upwards from the maximum attainable depth.

State/Federal Land Leases

State and federal lands are leased for oil and gas activity by the DSL and the BLM, respectively. U.S. Forest Service lands are leased through the BLM upon recommendation by the Forest Service. In terms of ground-water protection, these agencies' leases have stipulations which require lessees to abide by the Montana Oil and Gas Board rules and regulations, but leases may have additional stipulations for preventing ground-water pollution. If the lease stipulations are not upheld, the involved agency has the power to cancel the lease agreement.

U.S. Environmental Protection Agency

Under the Safe Drinking Water Act, EPA is currently developing a permitting system for the Underground Injection Control (UIC) Program. This program regulates the uses of underground injection wells to protect drinking water aquifers.

There are five classes of injection wells, with Class II wells being those associated with the recovery of oil or natural gas. Although the use of these wells for oil and gas recovery, waste material disposal, and hydrocarbon storage is common in the state, it is for the most part unmonitored. Thus, EPA will implement this program, with the permitting process estimated to be on line by May 1983.

U.S. Minerals Management Service (formerly the Conservation Division of the U.S. Geological Survey)

U.S. Minerals Management Service also has a permit program to regulate injection wells which only applies to wells on federally leased lands. This program differs from the EPA UIC program in many respects. However, a joint EPA/USGS Committee has been set up to review both programs and to establish cooperation in the mutual conduct of these programs.

Options

1. Limited, or no action could be taken on this issue.

2. Although rule 36.22.502, Chapt. 22, ARM, (plugging and abandonment of seismic shot holes) has recently been amended, there is still some question as to whether this rule should instead specify that the holes be plugged from the total depth of the hole upwards. There are two alternatives for further dealing with this point: a) the Board of Oil and Gas Conservation would reconsider this matter, or b) legislative action would be taken.

3(a). It may be necessary to introduce legislation to broaden existing enforcement authority of the DNRC Oil and Gas Conservation Division, as in the case of allowing the Division to regulate the UIC program's Class II wells instead of EPA.

(b). The UIC program's Class II wells could be regulated by the DHES Water Quality Bureau.

4. Legal remedies for resolving problems through incentives for rapid corrections of infractions, such as stop-work authority, could also be considered.

5. An increase in funding and personnel for enforcement of existing statutes governing production wells and associated operations may be necessary.

E. WASTE WATER DISCHARGES TO GROUND WATER -- Fred Shewman, DHES

Issue Identification

Waste water or other pollutants may be discharged to ground water intentionally, using the soil/ground-water system as a waste treatment or assimilation system, or inadvertently, by spills or leaks. Errors in judgment about how much pollution the system can tolerate without adverse effects or unintentional loss of pollutants can have the same end result--ground water with long-lasting degradation and impairment of beneficial use.

Ground-water pollution is, by its nature, much more complex than surface water pollution. A contaminant which enters the ground-water system generally moves slowly with little mixing (Figures 25 and 26). Slugs of pollutants can be very difficult to locate and often require the use of a number of monitoring wells at various distances and depths from the suspected source of contamination. These monitoring wells and the associated water quality sampling needed to locate the pollutants are often expensive.

Chemical and physical interactions between contaminants transported by ground water and soil and rock that has intimate contact with the ground water can further alter the polluted ground water. Pollution can be very persistent both because of very slow movement of ground water and because of various adsorption (adhesion of ions or molecules in solution to solid body surfaces) - desorption (removal of adsorbed material) and ion exchange reactions that may occur within the soil/rock mass.

Two avenues of wastewater discharge into ground water are possible. The first, deliberate injection through wells, is not presently significant in Montana except for the oil and gas industry. Injection is regulated by the Underground Injection Control (UIC) program of the EPA; those concerns are discussed elsewhere in this report. The other avenue, percolation, is discussed here. Percolation of pollutants into shallow ground

Figure 25. Effect of differences in geology on the shapes of contamination plumes. SOURCE: Miller, 1977.

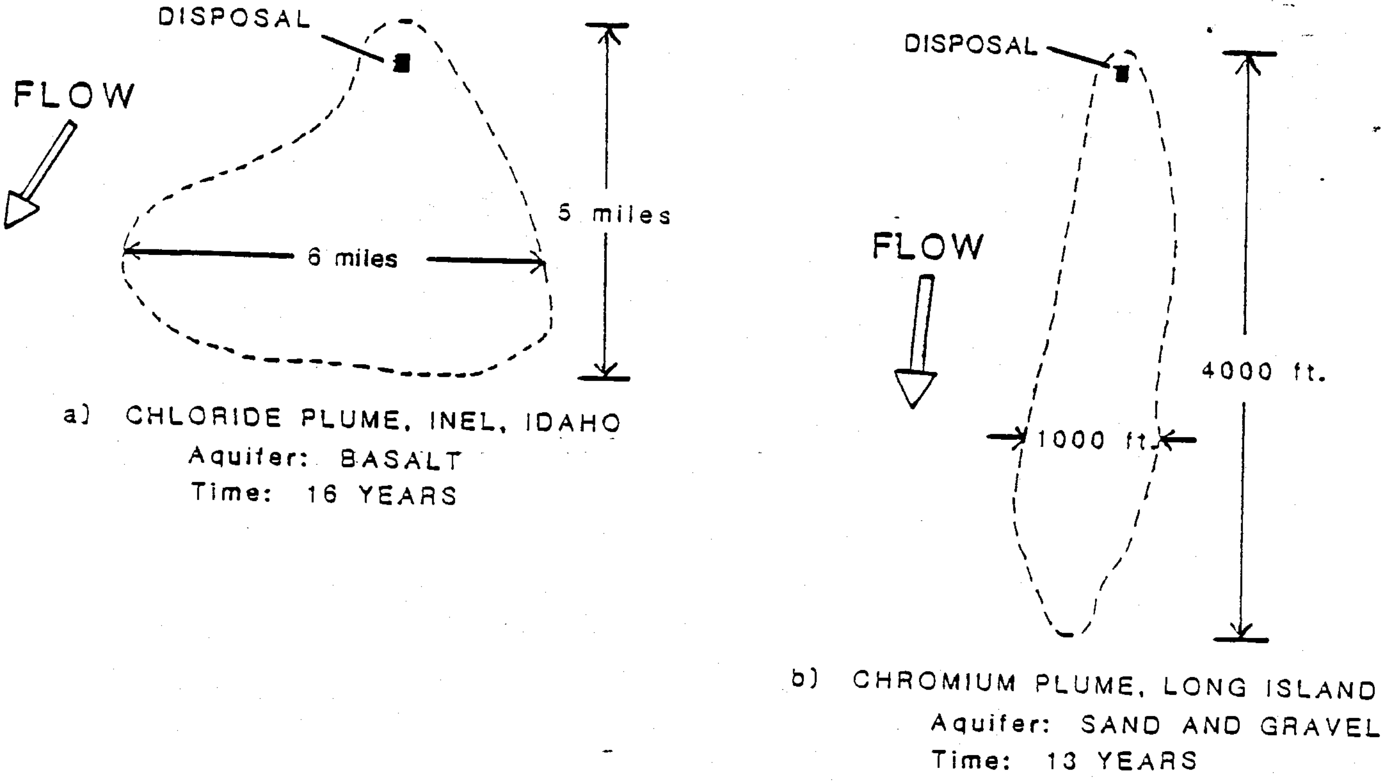
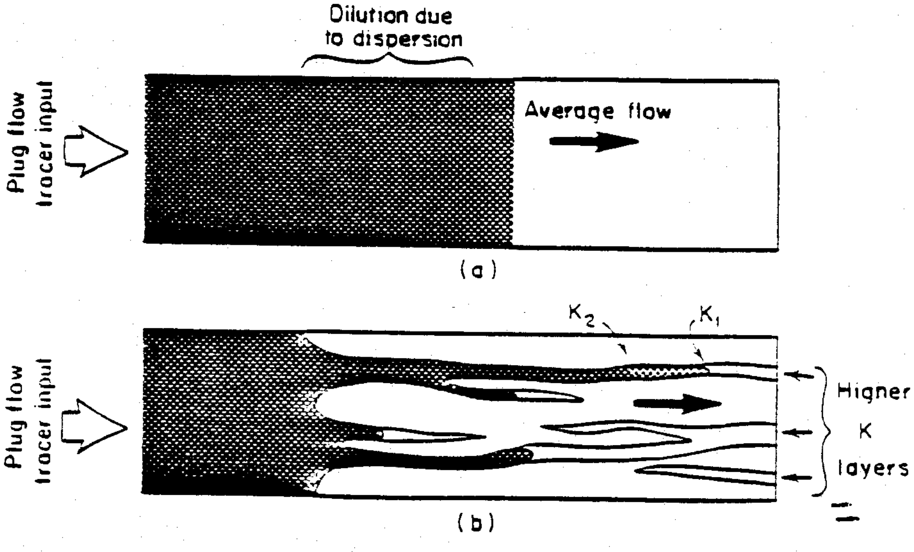


Figure 26. Comparison of the effect on the migration of tracer or contaminant zones in a granular porous media. (a) The pattern of dispersion is regular and predictable in a medium with homogeneous or uniform permeability. (b) Layers of porous media with higher permeability cause the tracer to advance in an irregular pattern. (K is the permeability.) SOURCE: Freeze and Cherry, 1979.



waters from various activities on or near the surface is by far the most common avenue of ground-water pollution in Montana, and occurs statewide.

Examples of possible sources of ground-water pollution through percolation would include: leakage from sewage lagoons or industrial ponds containing wastes or process solutions, rapid infiltration or percolation systems used for liquid effluent disposal, leachate from landfills, leachate from fertilizers, pesticides or other pollutants applied to land, leachate from ore or tailings piles on the land, percolate from septic drainfields, and spills from failures of tanks, pipelines, or from transportation accidents. Pollution can occur from management practices such as summer fallowing of agricultural land where excess infiltration of precipitation can then leach excess salts from soils and rocks and transport the salts into the ground water.

Although a serious problem nationwide, numerous relatively minor incidents of pollution of shallow ground-water aquifers have been documented in Montana. These include incidents such as ground-water contamination resulting from septic tank and drainfield problems in the Libby and Kalispell - Evergreen areas and slag piles at the East Helena ASARCO refinery leaching chemicals into the local ground-water system. No major ground-water drinking supplies have been affected however, and potential conflicts have not been widely noted because of the sparse population of the state. Generally, where pollution has been identified, there is currently no use of the impaired ground water. Still, these incidents indicate the fragility of the resource, demonstrate the potential threat to drinking water sources, and illustrate the need to protect ground water.

STATUTES

Ground-water quality management is primarily the responsibility of the Water Quality Bureau of the DHES. Financing for the Bureau's ground-water programs comes from state general funds (25 percent) and EPA 106 grants (75 percent). The Water Quality Bureau administers the state Water Quality Act.

Montana's Water Quality Act, 75-5-101 et seq., MCA, prohibits pollution of state waters, which are defined to include underground waters. The statute requires the State Board of Health and Environmental Sciences to adopt rules governing permits to discharge waste into state waters, and to establish classifications and water quality standards for all state waters.

The Water Quality Bureau prepared draft ground-water permit regulations and quality standards which the Board adopted in September 1982. The ground-water quality standards included in the regulations will improve the possibility of enforcing the

Montana Water Quality Act as it applies to ground water. The regulations and standards are geared to control ground-water degradation, and require permitting of "point-type sources," treatment works, and disposal systems or ponds which might discharge pollutants to ground water. If the source requires a permit under other regulations which address ground-water protection, a duplicate permit is not required and only the ground-water standards will apply. The regulations and standards are based on the concept of protecting beneficial uses rather than prohibiting all constituent-by-constituent changes.

Ground waters of the state are classified into four categories based on their existing quality and suitability for various purposes. These categories range from ground water being suitable for public/private water supplies, livestock, irrigation, and commercial/industrial uses, with little or no treatment, to ground water being satisfactory for some industrial/commercial uses, but unsuitable/untreatable for higher uses. General and numeric standards, based on maximum allowable chemical, radiological, and microbiological contaminant levels, as well as specified levels of dissolved/suspended substances, have been proposed. Point sources will not be allowed to violate these standards in ground water. Where existing ground-water quality is better than the standards, degradation will not be allowed except after a finding of social and economic justification by the State Board of Health. For parameters not contained in the standards, degradation will not be allowed if it will adversely affect the existing or reasonably expected beneficial uses of the water. Nonpoint sources are not allowed to change the quality of usable ground water unless all reasonable best management or conservation practices have been applied.

Although the statutes and regulations appear to be adequate, problems with ground-water pollution are sure to occur. It is expected that many developers will exert heavy pressure to gather minimal information before receiving a permit for a development project. The DHES's requests for prior information will be called unreasonable. However, if DHES does not require adequate hydrologic studies, decisions on permit conditions will necessarily be based on inadequate information. A second problem is that current staffing resources will not permit as thorough a review of proposed projects or as thorough a compliance monitoring of existing projects as DHES would like. Enforcement will also be difficult because of staffing problems. DHES staff expertise may not be sufficient in every case to properly evaluate the information presented, either for proposed projects or enforcement cases. Retention of highly qualified hydrogeologists is a problem at salaries available for program personnel. Where permits do not allow discharge to ground water, unintentional spills and leaks of pollutants will occur. Detection of these problems may be difficult, while cleanup will undoubtedly be even more difficult.

All of these problems apply to point sources of ground-water pollution, but they are magnified in cases of nonpoint source pollution. Nonpoint or areal sources of pollution to ground water no doubt do exist in the state but have for the most part remained unknown and undocumented. Certain activities, such as surface mining of coal and application of pesticides and fertilizers in agriculture, are known or suspected to affect ground-water quality. For practicality however, DHES believes the best way to control such nonpoint sources is by best management practices (practices which minimize the impact of ground-water pollution prescribed by professionals competent in the field) by further studying their effects on ground water. If regulations of agencies (such as those of Department of Agriculture for pesticides application and those of DSL for surface mining) are followed, these nonpoint source problems will probably be controlled as much as possible. Resources simply are not available in DHES to administer permit programs for such activities, nor are such permit programs desirable. If funds were available, a better approach would probably be to refine best management practices.

OPTIONS

1. The present course of action could be continued.

2. Adequate funding for proper implementation of the ground water protection program by the Water Quality Bureau is essential.

3. Some further refinement of management practices to control nonpoint sources of ground-water pollution is desirable.

4. Continued scrutiny of the newly-developed ground-water quality standards will be necessary to assure that they provide sufficient enforceability for protecting ground-water quality. Through use, the newly adopted regulations will be tested and any necessary revisions will probably be apparent.

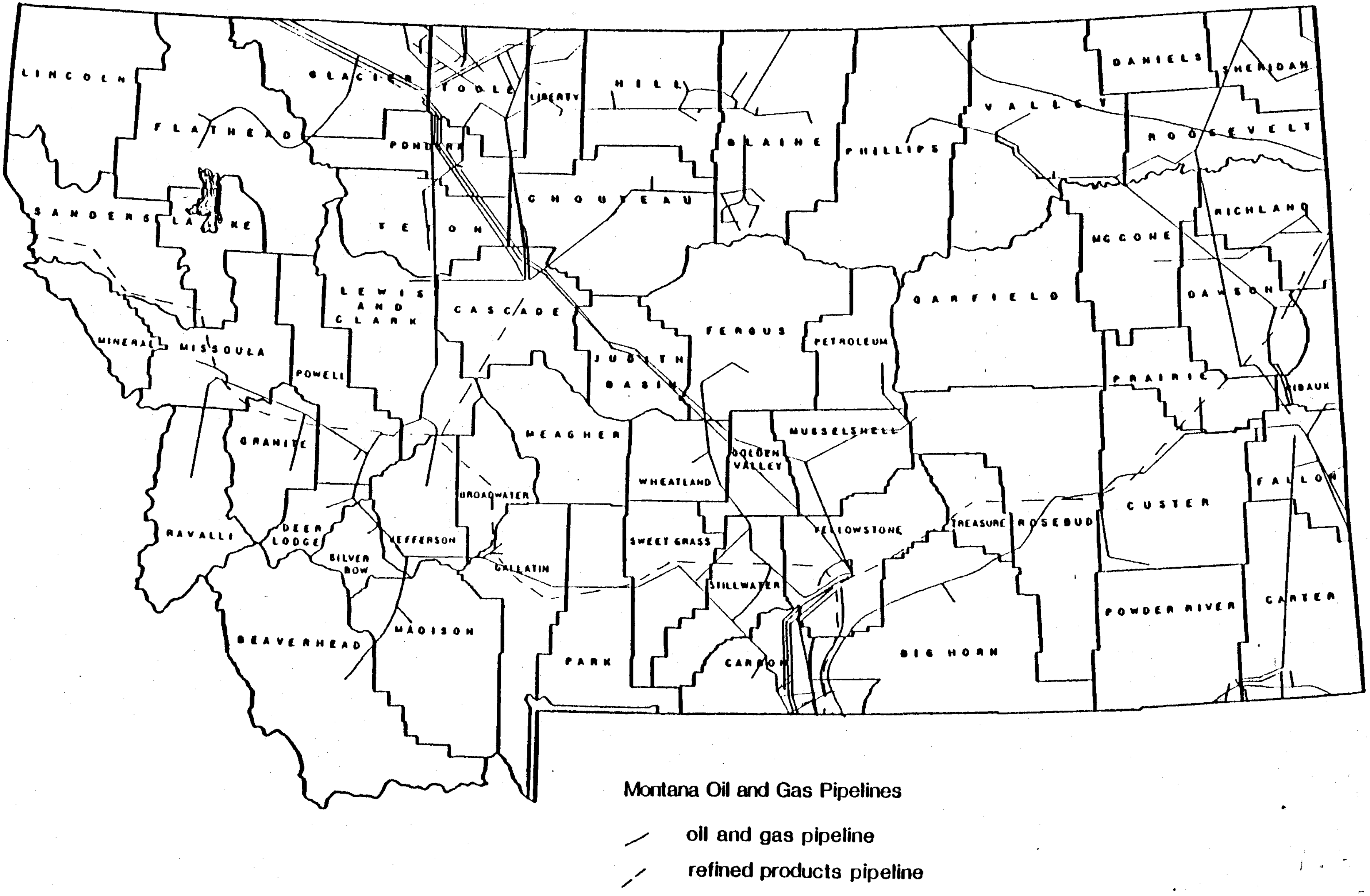
F. FUEL SPILLS AND LEAKS -- Dick Montgomery, EPA

Issue Identification

Fuel spills and leaks occur periodically in the state and thus can contaminate the ground-water resource. These spills and leaks can result from faulty equipment, accidents, or sabotage. The main contaminants from these sources are gasoline and fuel oil products.

There are presently 15 oil pipeline companies and approximately the same number of gas pipelines operating in the state (Botz and Gartner 1978). The pipeline locations are shown in Figure 27. As of 1980, liquid pipeline mileage in Montana exceeded 8,000 miles, and was transporting more than 300,000 barrels of crude and refined products per day (Pers. Comm., DNRC Energy Division, 1983). Even with this amount of pipeline

Figure 27. Location of oil and gas pipeline routes in Montana.



Source: DNRC Board of Oil and Gas Conservation, 1981 mileage, there have been few spills or leaks. However, significant localized impacts such as the line break near Missoula (June 1982) testify to the potential for ground-water impacts.

There are an estimated 3,000-4,000 steel gasoline tanks buried at gas stations, and an associated 20-25 miles of underground pipeline which connect the tanks to the gasoline pumps (Botz and Gartner 1978).

Approximately 726 bulk plants exist in the state, with each having various 150 to 100,000-gallon storage tanks (Botz and Gartner 1978).

There are over 225 oil well operators presently active in 175 well fields in the state of Montana (Pers. Comm., DNRC Oil and Gas Division, 1982). Spills and leaks associated with production facilities occur regularly, usually in remote locations. These incidents involve loss of crude oil or poor quality by-product water, both of which contaminate ground and surface water.

Truck and rail accidents are another source of contamination, but because of their localized impacts they receive little interest unless associated with a population center. However, even these apparently small incidents can render ever-increasing volumes of ground water unfit for consumptive use.

Statutes

Pipelines and other transportation related facilities are regulated by the U.S. Department of Transportation.

Nontransportation related facilities are regulated federally by EPA under 40 CFR 110, 112, 113, and 114; local control over spill cleanup may be assumed under section 40 CFR 109 upon completion and approval of an adequate oil removal contingency plan.

Service station and bulk tank installation and maintenance inspection varies throughout the state. In some areas, industry provides its own check. In other areas, these facilities are periodically inspected by local fire department personnel.

The present statutes appear to sufficiently cover the cleanup of spills and leaks. However, response time capabilities are viewed as somewhat inadequate.

Another seemingly incomplete aspect of the present regulations is facility inspection. The inspection of both old and new operations would help in preventing major leaks and spills.

Options

1. Maintain the status quo.

2. Since existing regulations primarily address cleanup, additional regulations may be needed for inspection of facilities (old and new) so that new ones are properly designed and those at the end of their design life are either upgraded or eliminated before major leaks and pollution can occur.

3. State and local agency emergency response capabilities could be improved through further refinement of the "State Emergency Response Plan" prepared and administered by the Department of Military Affairs in cooperation with other state and local agencies.

4. A further option would be to rely on the federal government to provide emergency response and funding under 40 CFR 111 (k). However, this option cannot provide the rapid response available under option Number 2.

G. COAL MINING - Wayne Van Voast, MBMG

Issue Identification

Montana's strippable coal resource is one of the largest in the nation. However, these coal beds are also some of the most widely used aquifers in the region. The dots on the coal map (Figure 28) illustrate areas of intensive mining development. Although these areas appear relatively small, this interpretation is somewhat misleading since some surface mines cover areas of several square miles, and, at each location, several large mines are in production, or are in some stage of planning. Additional large mines are in planning stages in McCone, Powder River, Big Horn, and Rosebud counties (Figure 28). In Canada, directly north of the Montana border, large surface coal mines and power plants are being constructed or planned in watersheds that drain directly into Montana.

One of these which is being constructed is on the East Fork of the Poplar River Watershed (Daniels County) (Figure 28). The Poplar River watershed is a semi-arid agricultural area where most inhabitants are almost totally dependent upon ground water for stock and domestic supplies. In many places the only easily obtained water is from coal beds that could be removed by mining. Ground water is the lifeblood of the plains region, so the removal or disturbance of aquifers is viewed with great concern.

Another large mine, still in the planning stages, will be on the North Fork of the Flathead River (Flathead County (Figure 28). The Flathead watershed is a highly productive and pristine fishery, and an irreplaceable resource; thus there is some concern regarding possible mining associated impacts occurring in this area.

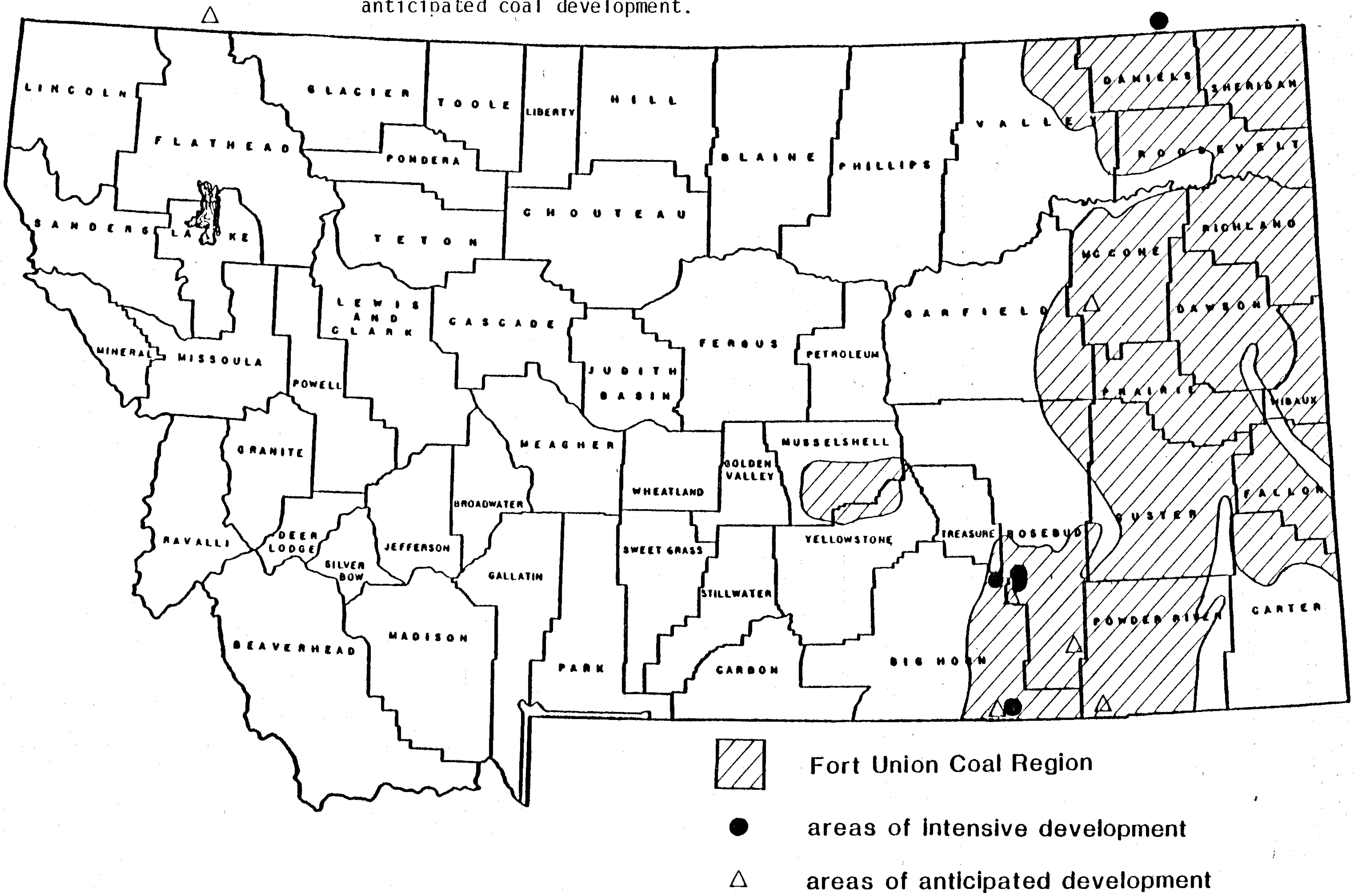


Figure 28. Location of the Fort Union coal region and areas of present and anticipated coal development.

Some impacts on ground water already are being seen. Around the Decker mine, ground-water levels have declined more than 10 feet over an area of more than 6 square miles. Around other mines, water-level changes have been much less severe. At all mines, however, diminished ground-water quality has been documented; dissolved solids contents are increasing by 2 to 4 times and in some cases exceed human or stock tolerances (Van Voast and Hedges, 1975).

Mining-related changes in associated ground-water systems thus far have been undesirable, but not catastrophic. Issues to be addressed are (a) whether the changes thus far documented are the worst that can be expected and (b) whether the cumulative effects of the many mines ultimately to be developed will create increasingly severe problems to the ground-water resource.

Statutes

The DSL administers coal mining reclamation laws under the following acts:

1. Montana Strip and Underground Mine Reclamation Act (Section 82-4-201, MCA). This law applies to coal mining operations which remove greater than 10,000 cubic yards of minerals or overburden and requires

annual permits for mining operations, a comprehensive plan for reclamation, an adequate performance bond, and prohibits mining on certain lands.

2. Strip and Underground Mine Siting (Section 82-4-101, MCA). Under this act, any operator of a new strip or underground mine workings involving the removal of greater than 10,000 cubic yards of overburden or minerals must obtain a mine site location permit from DSL before beginning preparatory work on the mine. This permit is renewable until the operator receives a permit under the Strip and Underground Mine Reclamation Act.

The corresponding federal regulatory agency is the Office of Surface Mining (OSM), whose regulatory power is established under the Surface Mining Control and Reclamation Act of 1977. This act established national standards for coal mining and reclamation and includes regulations for the protection of hydrologic systems, procedures for adopting state laws when they are more stringent than applicable federal laws, and regulations for enforcement and inspection of mine workings.

There are no state statutes or federal (U.S.) codes that cover effects of Canadian mines. Here, international cooperation is relied upon to minimize problems.

To date, protection of ground water afforded under mining rules and regulations results from the requirements that potential hydrologic impacts be identified. At this point in the process, administrators of the statutes must decide whether the impacts would be acceptable, whether modified mining and reclamation techniques would make them more acceptable, or whether the predicted impacts would be totally unacceptable. Decisions among these options can be made to protect the ground-water resource. Subsequent monitoring serves mostly to protect the mining companies, the regulators, and the local water users in deciding claims of water losses or degradation. By the time ground-water problems can be observed through monitoring, they may be essentially irreversible.

Effectiveness of the regulations depends upon the level of understanding that changes in ground water will have on the use of the land. The real hydrologic effects of mining are poorly known and most predictions of impacts are loosely founded. Large amounts of money are spent in providing base-line data and interpretations required by the regulations in Montana, however, the effectiveness of implementing the regulations is limited by the inability to predict the ultimate long-term impacts.

The statutes and their enforcement are adequate under the current levels of knowledge. Unfortunately, understanding of the problem has not kept pace with mining development. In some ways, additional knowledge may make the statutes excessive. More important, critical inadequacies probably will be found that warrant attention.

Options

1. To continue on the present course, not knowing whether the best protection of the ground-water resource is being provided, and not knowing whether the existing protection is adequate over the long term.

2. Initiate a monitoring and study program to monitor strategic wells in areas of coal development.

3. Evaluate and interpret monitoring data currently being submitted by mining companies to the DSL to increase the understanding of mine related hydrologic problems.

4. Initiate an investigative program on ground water in Daniels and Flathead counties near the Canadian border.

5. Work closely with Canadian hydrologists to evaluate and mitigate potential impacts of the Canadian mines.

6. Maintain a basic evaluation program of documented, projected, and potential hydrologic effects of mining.

7. Strive toward the capability of predicting the effects of mining so that regulations can be administered most effectively.

8. Examine the regulations and recommend modifications as the predictive capabilities and understanding of the problems evolve.

H. HARDROCK MINING AND MILLING - Terry Grotbo, DSL

Issue Identification

Most hardrock mines in the state directly or indirectly influence water quality. Waters, intercepted in underground workings or used in the concentration of minerals, are usually discharged to surface water and ground-water systems.

Under the Montana Water Quality Act, active operations are required to meet specific water quality standards before discharging to state waters. In order to meet these standards, various water treatment and containment facilities are utilized.

These impoundment structures are the primary concern in regard to active hardrock mining and water quality. Numerous locations throughout the upper reaches of watersheds in western Montana are being impacted by hardrock mining (Botz and Gartner

1978). A large portion of the pre-Hardrock Mining Act impoundments on active, inactive, and abandoned properties is inadequately designed and constructed for safety and function.

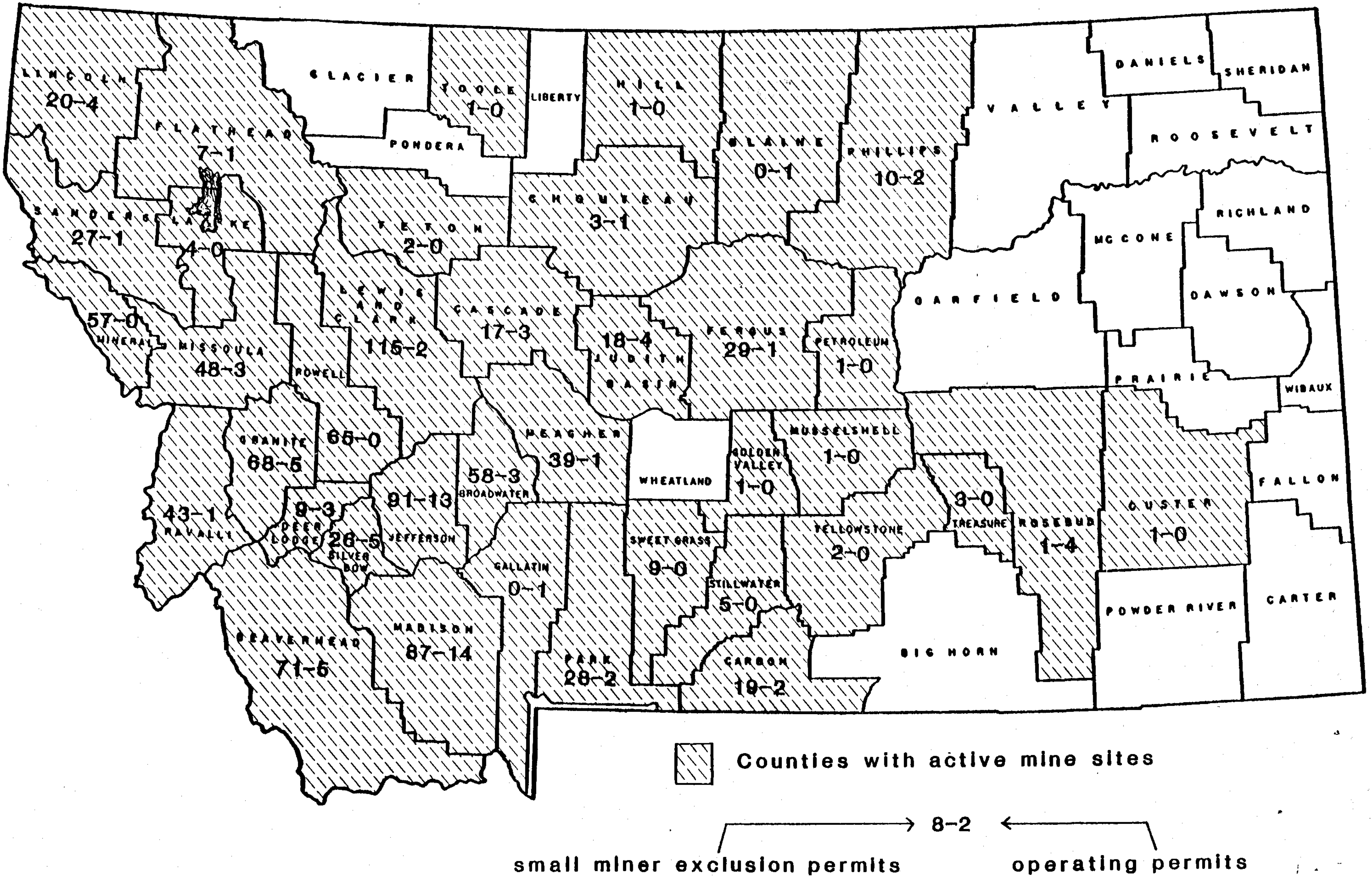
As previously mentioned, ground-water velocity varies depending on the type of alluvium, but is generally very slow. Therefore, pollution problems resulting from impoundment water seepage may go undetected for years. Correction of a ground-water problem can be an insurmountable task, both financially and environmentally.

Figure 29 indicates the number of active mining/milling activities by county in the state.

Statutes

The Hard Rock Mining Act, also called the Metal Mine Reclamation Act, requires licensing of persons engaged in exploration and permits for development of mining properties. It provides for reclamation and is administered by the State Board of Land Commissioners. Minerals covered under this act include any ore, rock, or substance other than oil, gas, bentonite, clay, coal, sand, gravel, phosphate rock, or uranium. An application, bond, and fee are required. A small miner exemption will be granted for quantities less than 36,500 tons per year and less than five acres unreclaimed disturbance per operation.

Figure 29. Number of active hardrock mine sites in Montana by county



The General Mining Law applies to mining activities on federal land. If a miner plans to conduct any activity which might cause surface disturbance, he must file a Letter of Intent with the land management agency's local office. Depending on the nature of the activity and the environment affected, a Plan of Operation may be required. A reclamation bond may also be required.

The Montana Water Quality Act and pursuant regulations adopted provide for classification of surface waters, and establish both surface water quality standards and a permit program to control the discharge of pollutants into state waters. The Act requires that an application be submitted at least 180 days before commencing work that would result in a discharge. The permit is issued by DHES, and must be obtained before any discharge can occur. It will set forth water quality limitations and will require self-monitoring of effluent quality by the permittee.

Before a person can begin a new diversion or impoundment of water for any beneficial use, including a mining venture, he must receive a permit from DNRC. This includes water removed from a stream for dredge mining.

Options

1. Maintain the status quo.

2(a). A formal review of required impoundment engineering designs could be established. The review of the designs may or may not be an approval process, but the review would be an effort to ensure that state of the art design and construction techniques are being utilized. The review could also establish whether or not adequate systems are being incorporated for protection against offsite impacts.

(b). Addition of experienced personnel to inspect the construction of major impoundments would ensure that construction follows the design plan.

(c). Hiring a state engineer would ensure review of design plans for major impoundments.

3. Changes in the Montana Metal Mine Reclamation Act could include a requirement that companies proposing to construct impoundments must submit engineering design details for the impoundment before the operating permit is approved.

I. ABANDONED MINES - Mike Hiel, DSL

Issue Identification

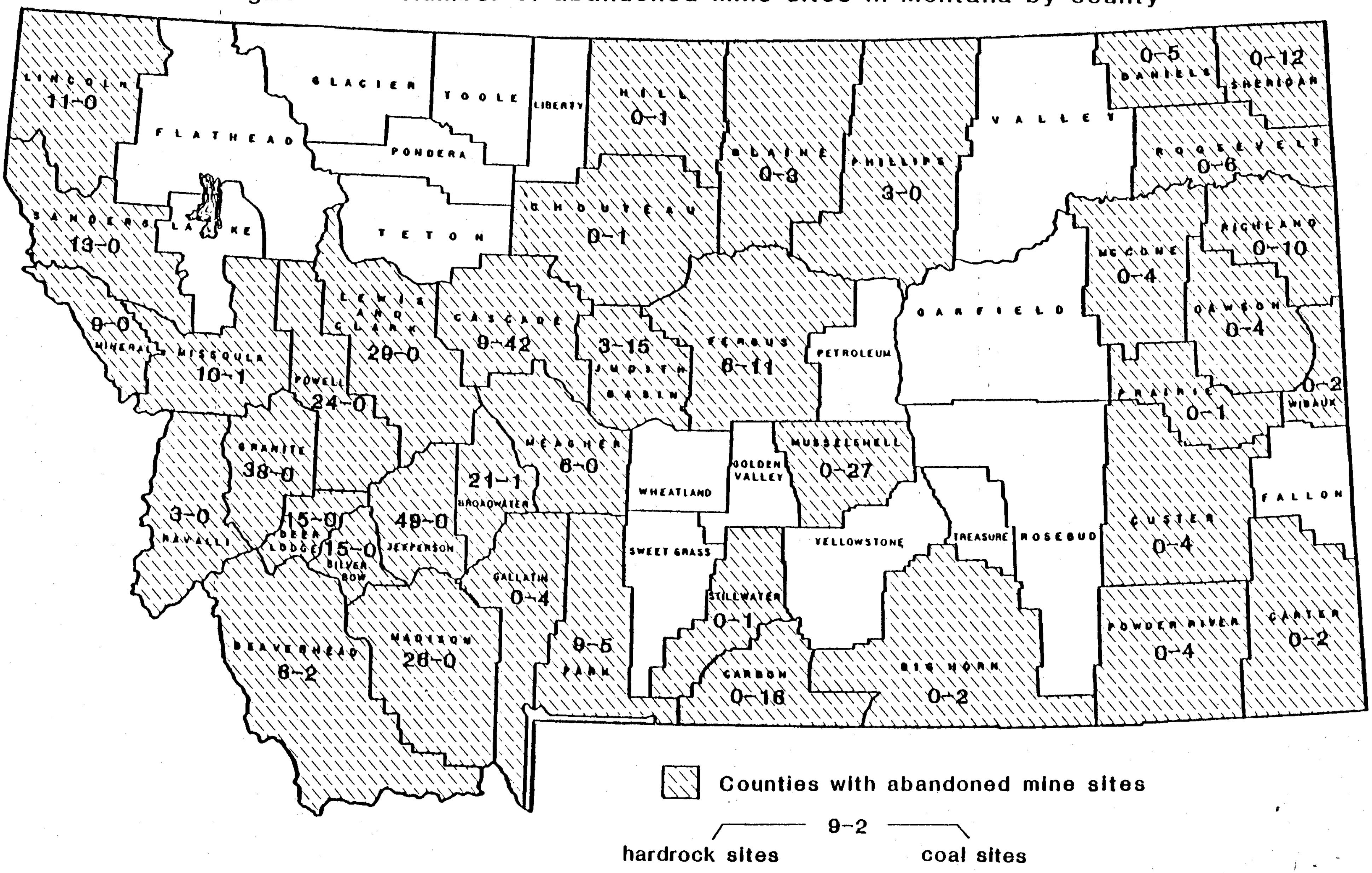
Historical discharge and waters percolating through mine waste and tailings impoundments from abandoned mines pollute the waters of many streams and hydraulically connected aquifers in Montana. The number of abandoned mines for each county is shown on Figure 30.

In addition to the technical problems associated with acid mine drainage from abandoned mines, a major conflict currently exists between the OSM and the Montana Abandoned Mine Reclamation Bureau (ARMB). After field visits to proposed reclamation sites in Montana, OSM determined that nonlocal acid mine drainage with heavy metal concentrations does not pose a threat to public health and safety. OSM made this determination selectively against proposed hardrock reclamation projects. In this manner OSM has taken away the state's latitude in addressing the highest priority AMRB problems. The AMRB has, however, received funds to address coal related acid mine drainage in the Great Falls coal field.

Statutes

Currently neither the Water Quality Bureau of DHES nor the AMRB of DSL has any statutory authority to address historical

Figure 30. Number of abandoned mine sites in Montana by county



discharge and historical degradation of watersheds. Abandoned mine sites are continually degrading Montana surface and ground waters with little or no action being taken to remedy the situation.

Options

1. Where geologic and mining conditions permit, a hydraulic seal may be placed at the mine opening. The mine workings would flood, thereby removing atmospheric oxygen from the acid mine drainage process. To alleviate a dangerous hydrostatic head, the mine seal would be fitted with a drain pipe to allow drainage to flow into the natural drainage pattern. The water quality of the drainage should be significantly improved if complete flooding is obtained. To achieve a competent hydraulic seal the following conditions must be met:

(a) all mine workings must be below the mine opening,

(b) all mine openings must be sealed to eliminate oxygen exchange, and

(c) the country rock (rock surrounding the ore vein) must be competent (not easily fractured).

In proper conditions, a seal of this type could be formed for approximately $50,000.

2. Funnel all degraded waters into a water treatment plant. This would require a very large initial expense and a continual maintenance program to run the treatment plant.

3. Little or no action. This option would be necessary in some projects.

4. The physical removal of abandoned mine waste dumps and mill tailings ponds from stream channels would go far in abating historical water quality problems.

5. When economically feasible, old mine dumps and tailings ponds could be reprocessed to extract the economic metal content. When reprocessing is not possible, toxic wastes could be removed and disposed of on-site in an environmentally sound manner. The reprocessing could actually pay for itself. A minimal amount of AMRB funds could be used for disposal of any wastes, final grading, and revegetation. Disposing of mine waste piles and tailing ponds in an environmentally sound manner will be expensive, anywhere from $0.85/cubic yard to $7.00/cubic yard.

6. An attempt to change OSM policy on heavy metal acid mine drainage could be made.

J. SOLUTION MINING -- Fred Shewman, DHES

Issue Identification

During the last decade solution mining technology has been developed for uranium mining. This method utilizes chemicals injected into the ore zone to leach uranium and return it into solution. The uranium pregnant solution is then pumped from the ore body to the surface where the uranium component is concentrated.

Uranium is only one element of a number of elements in the radioactive decay series. It is, therefore, possible that following complete removal of the uranium from the ore body a number of radioactive materials may remain. These materials include radon, radium 226, decay products of uranium, thorium, and potassium. However, the general belief is that solution mining does not serve to further concentrate these ions and generally does not dissolve a great number of the radioactive materials. Thus, these ions are usually left in place. It is possible, though, that some of these daughter products can be dissolved and either carried to the surface or left in the aquifer as a result of the solution mining process.

After completion of the solution mining, the aquifer is restored to a condition somewhat equivalent to that which existed before mining by injecting chemical solutions into the aquifer to reverse or balance the chemical reactions caused by the initial injection. During the restoration stage, chemical solutions are injected and recovered in a continuous cycle to replace the ions extracted or to precipitate those ions mobilized. The chemical solutions utilized during the restoration may mobilize other ions, which may or may not remain in solution upon completion of the restoration process. The nature of the chemicals injected and the amount of restoration necessary is typically dependent upon the original water quality.

Frequently the ground-water quality associated with uranium deposits is such that it is not potable by humans or livestock before mining. Therefore, it is thought unnecessary to attempt to make this water potable following solution mining.

If, however, the uranium deposit occurs in an aquifer of potable water that is or may be utilized as a water supply, the degree of restoration is generally greater in an attempt to return the water quality to a potable nature. Following restoration, wells are usually cement-grouted bottom to surface to prevent contamination or the migration of fluids between aquifers.

Concern in Montana for regulation of the solution mining process is evidenced by the moratorium on uranium solution mining passed by the 1977 legislature. In addition, the

Yellowstone-Tongue Areawide Planning Organization staff was asked by its board of directors to investigate potential ground-water contamination involved in solution mining of uranium. It is possible that solution mining might take place in the same geologic formation that supplies most of the water to a portion of southeastern Montana.

Uranium solution mining could lead to degradation of ground-water supplies if proper precautions are not taken in the design and operation of the mining system used. Problems of this type include the possibility of the chemical solutions escaping from the control of the solution mining operator, unanticipated chemical reactions may occur, and uncontrolled leakage of chemicals from one aquifer to another may occur. Improper well completion, and abandoned or faulty well casing in the solution mining field may cause pollution of other aquifers.

Interest in uranium mining in Montana has recently dwindled due to the low price of uranium. Development activity never actually started in Montana, but there has been considerable exploration for uranium in the state.

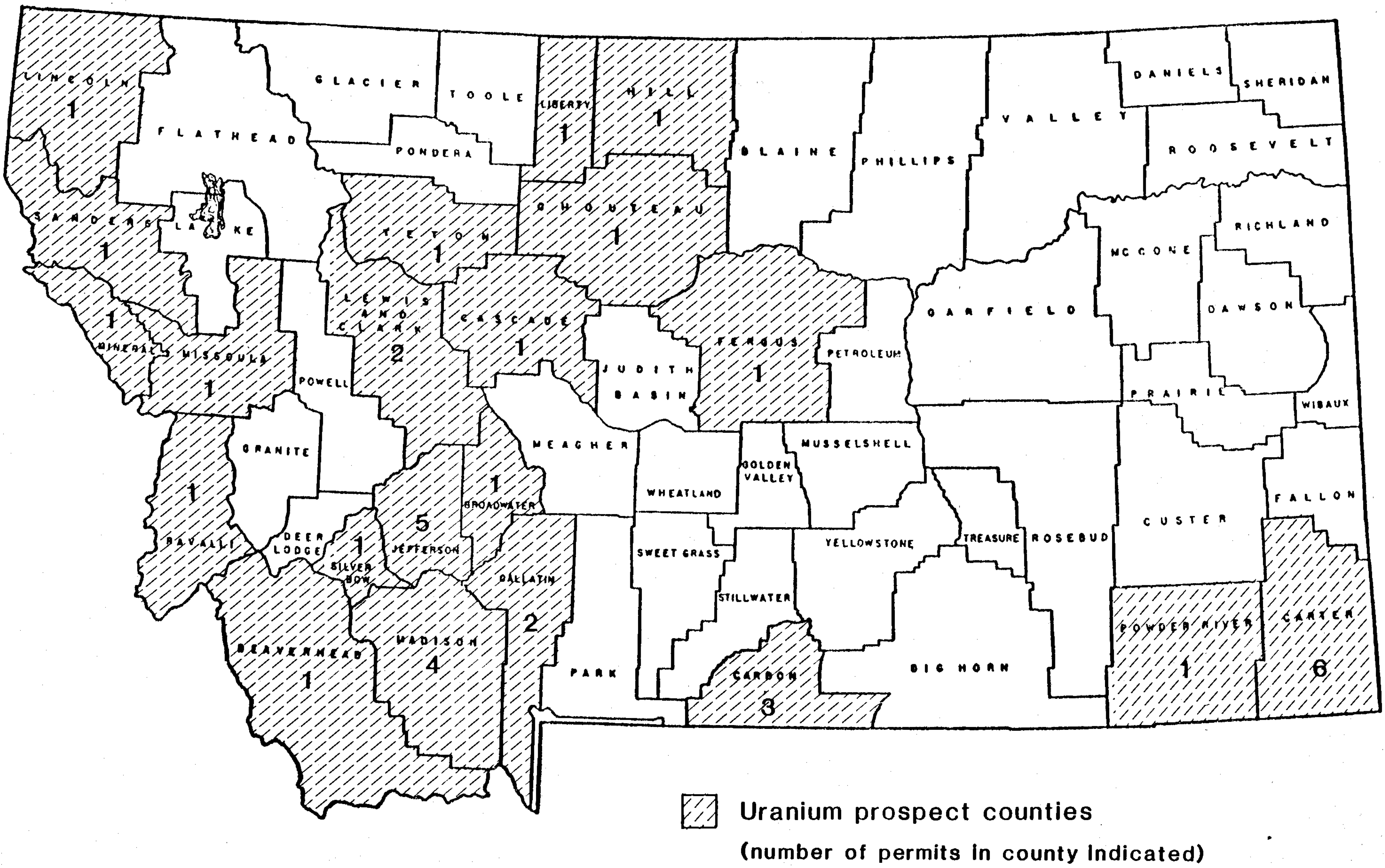
Of the 450 acres under uranium exploration statewide in the fall of 1979, 279 were in Carter County where Kerr-McGee, Amoco Minerals Co., Energy Reserves Group, Exxon, Frontier Resources and Rocky Mountain Energy each had state prospecting permits. The search for the yellow mineral also reached into Lewis and

Clark, Silver Bow, Jefferson, Broadwater, Deer Lodge, Powell and other western Montana counties. (Pers. Comm., DHES Water Quality Bureau 1982). County locations of exploration as of August 1979 are shown in Table 3 and in Figure 31. No mining, however, is now underway.

Table 3
Active uranium prospecting permits in Montana, as of August 1979

Permittee	County
Amoco Minerals Company	Carter
Anschutz Uranium Corporation	Carbon
Anaconda Company	Broadwater Jefferson
Montana Bureau of Mines	Missoula Ravalli
BurWest	Lincoln Sanders
Colorado School of Mines	Cascade, Choteau, Fergus, Hill, Liberty, Teton
Continental Oil	Jefferson Mineral
Energy Reserves Group	Carter
Everest Exploration	Jefferson
Exxon Company, U.S.A.	Beaverhead, Carbon, Carter, Gallatin, Jefferson, Madison, Powder River
Frontier Resources	Carter
G.G.K.	Carbon
Homestake Mining Company	Madison Silver Bow
Kerr-McGee Corporation	Carter
Noranda Exploration, Incorporated	Madison
Pathfinder Mines Corporation	Gallatin Jefferson
Resource Association of Alaska	Lewis & Clark
Rocky Mountain Energy	Carter
St. Joe American Corporation	Lewis & Clark Madison

Figure 31. Counties of active uranium prospecting in 1979



Statutes

Department of Health and Environmental Sciences

In 1978, the Board of Health and Environmental Sciences adopted rules (16.20.1101 Seq., ARM) in response to two legislative acts: 1) the Control of Uranium Solution Extraction Act (Section 50-1704, R.C.M. 1947) which directs the Board to adopt rules regulating the solution extraction of uranium from in-situ deposits; and 2) the Water Pollution Control Act (Section 75-5-201 MCA), which directs the Board to adopt rules for the issuance, denial, modification, or revocation of permits and for the administration of the Act.

Under these rules, the operator/owner of any source which discharges pollutants to the ground water for purposes of in-situ mining must file for a Montana In-Situ Mining of Uranium Control System (MIMUCS) permit. Some of the information required for the permit includes: site definition, plans for disposal of waste water, treatment of waste water, treatment and disposal of leaks and spills from water pumped underground, monitoring programs, and reclamation plans.

Environmental Protection Agency

With the promulgation of federal Underground Injection Control (UIC) regulations, the state has relinquished its control over in-situ mining operations to EPA. EPA will review and process permits for any future solution mining operations, and the 1978 state regulations will be waived.

The UIC regulations were promulgated June 24, 1980, under Section 1421(a)(1) of the Safe Drinking Water Act, PL93-523. Their primary purpose is to protect present and potential underground sources of drinking water (USDW) from contamination as a result of underground injection.

There are five classes of injection wells under these regulations. Of these five classes, Class III wells include all special process injection wells (solution mining, geothermal). The Class III wells are to be permitted for an operator on an area basis, as would be feasible for uranium solution mining.

If uranium solution mining does occur in Montana, it is believed that the federal UIC program should be adequate to control the process to protect ground-water quality for beneficial use.

Options

1. Maintain the status quo. (EPA would administer the UIC regulations for Montana in-situ mining operations.)

2. DHES could take over administrative responsibilities of the EPA UIC regulations for in-situ mining operations.

K. SOLID WASTE -- John Arrigo, DHES

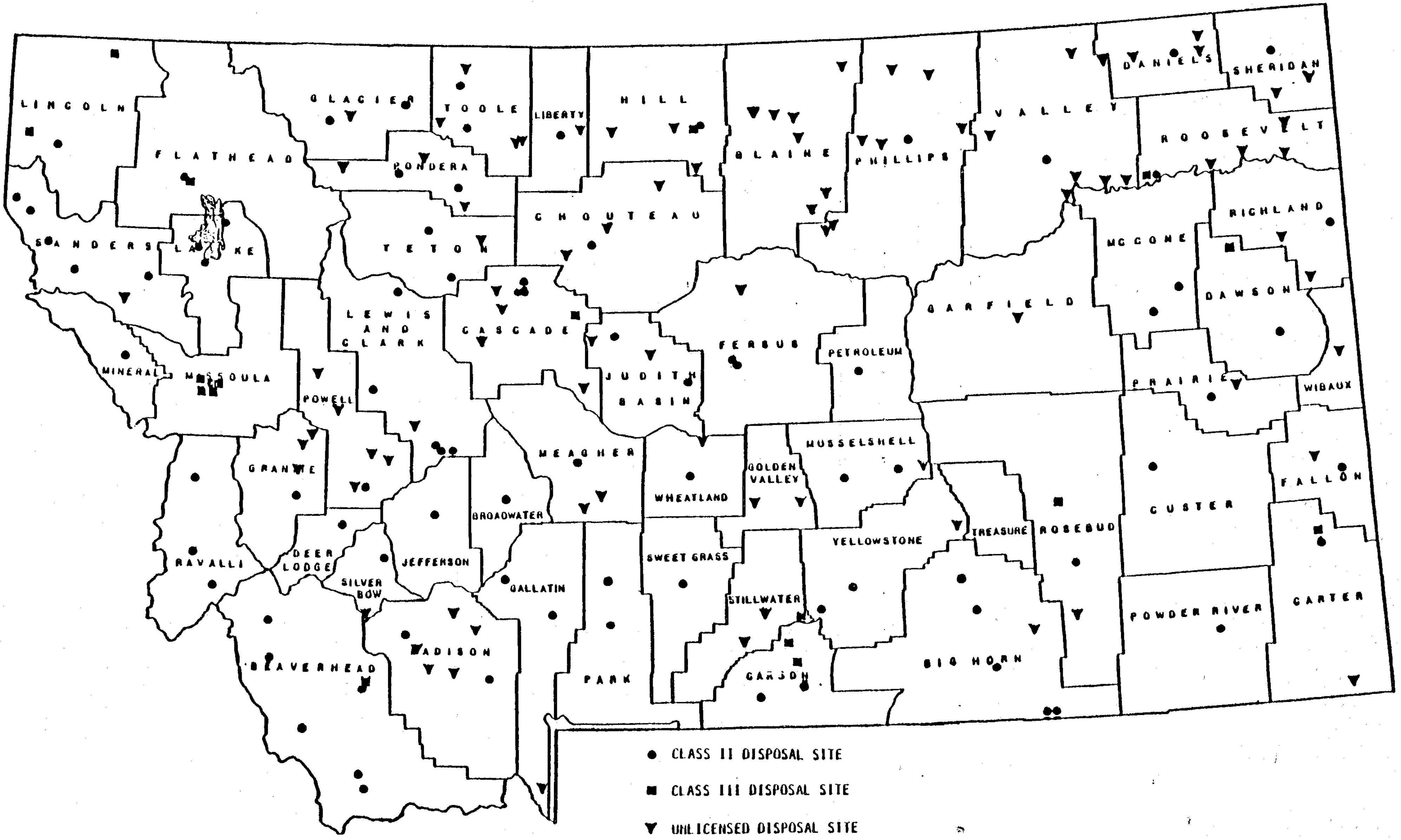
Issue Identification

Precipitation and snowmelt percolating through wastes disposed in landfills or dumps, as well as liquid wastes emplaced in landfills, can pick up contaminants and migrate into the ground-water environment. Contaminated water (leachate) produced by decomposing landfills produces a problem generally associated with abandoned or existing dumps which have been improperly sited or managed. Since 1965, the siting and construction of landfills has been covered by state regulations which attempt to minimize the generation of leachate and the accompanying impacts on ground water and surface water.

There are three types of disposal sites in Montana, Class I, Class II, and Class III, classified according to the type of wastes they are licensed to accept. Wastes are divided into three types, Group I, Group II, and Group III. Group I wastes are those solid wastes classified or identified by EPA as hazardous wastes such as caustics, acids, petroleum wastes, and chemical fertilizers. Group II wastes include decomposable wastes but exclude hazardous wastes. Examples of Group II wastes include the following: 1) municipal and domestic wastes such as garbage, yard and garden wastes, digested sewer and water treatment sludges, dead animals, discarded appliances; and 2) commercial or industrial wastes such as packaging materials and solid or liquid process wastes which are chemically or biologically decomposable. Group III wastes include wood wastes and inert solids that are not water soluable such as brick, concrete, brush, lumber, and tires. Class I landfills can accept Group I, Group II, or Group III wastes, Class II landfills can only accept Group II or Group III wastes, and Class III can accept Group III wastes only.

Since 1967 approximately 210 open dumps have been closed throughout Montana due to unacceptable siting or operating conditions. There are no Class I landfills in Montana. As of September 1982, there were 88 Class II landfills, 17 Class III landfills, and 89 unlicensed dumps in the state (Pers. Comm., DHES Solid Waste Bureau 1982). The locations of these landfills are shown in Figure 32. There are also 92 containerized refuse collection sites in Montana, which eliminate the need for small local dumps by allowing wastes to be collected in containers at several locations. These containers are later transferred to area wide Class II sanitary landfills for disposal. Since Class

Figure 32. Location of Class II, Class III, and unlicensed solid waste disposal sites in Montana.



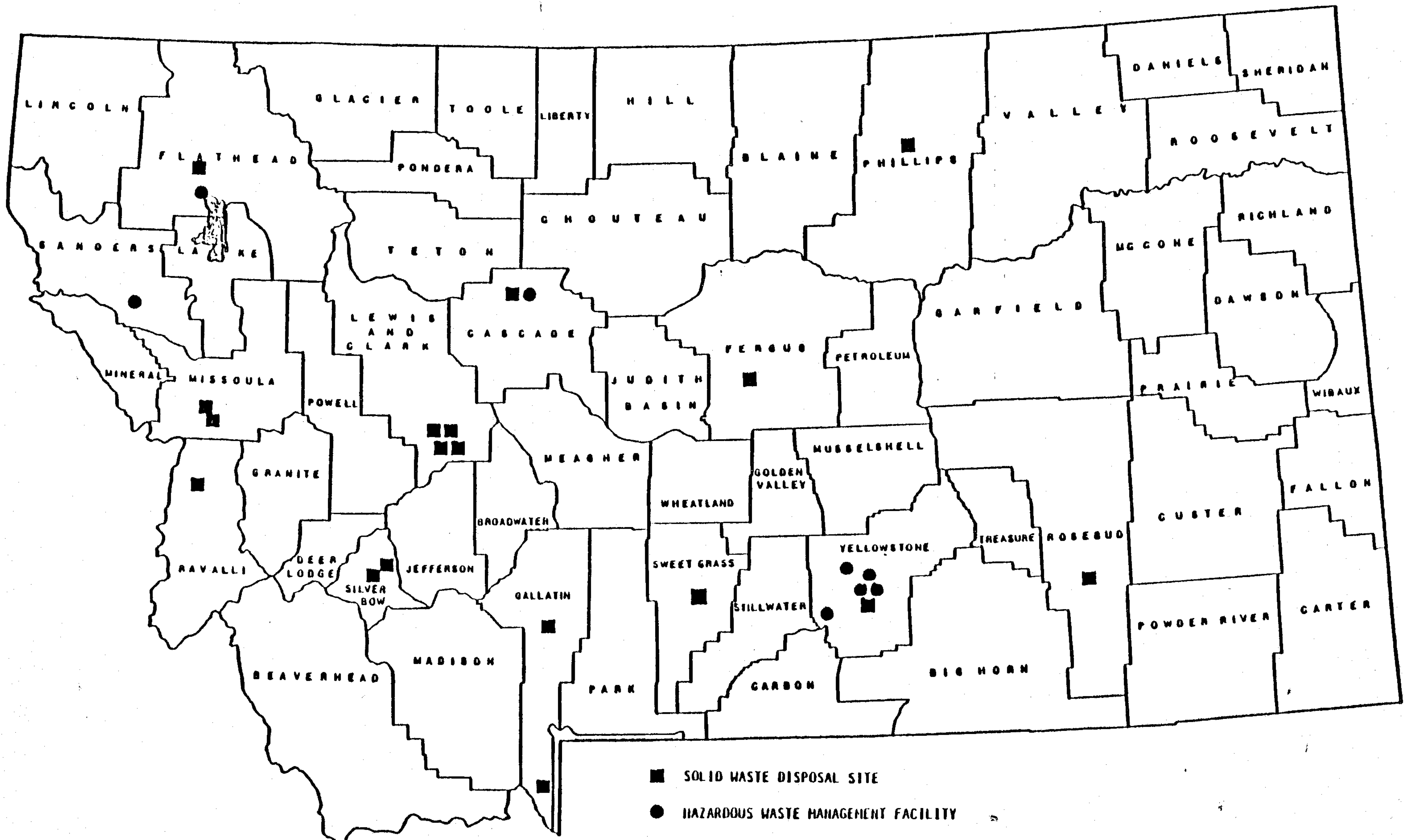
III landfills generally contain only insoluble wastes, the highest potential for leachate generation exists at the Class II landfills and unlicensed dumps.

To document the nature and extent of possible or real contamination resulting from the migration of leachate into the ground water, the monitoring of ground-water quality is ongoing at several landfill sites. State hazardous waste regulations pertaining to the treatment, storage, and disposal of hazardous wastes also require ground-water monitoring systems to be installed at hazardous waste management facilities, such as surface impoundments and land treatment areas. The location of solid waste landfills and hazardous waste management facilities which currently maintain ground-water monitoring networks are presented on Figure 33. The data from these monitoring programs are utilized to determine if leachate has formed and migrated off site. Data from monitoring wells are also used to better describe the hydrogeologic setting of individual disposal sites and to evalute mechanisms involved in the generation and transport of leachate.

Statutes

The management and disposal of solid wastes in Montana is regulated under the Montana Solid Waste Management Act (Section 75-10-201 through Section 75-10-233, MCA). The Act directs DHES to adopt rules governing solid waste management systems

Figure 33. Location of solid waste disposal sites and hazardous waste management facilities with ground-water monitoring networks in Montana.



including construction of sites to contain wastes. The generation, transportation, treatment, storage and disposal of hazardous wastes in Montana are regulated under the Montana Hazardous Waste Act (Section 75-10-401 through 75-10-421, MCA). The Act permits DHES to adopt rules governing the handling of hazardous wastes including standards for generators and transporters of hazardous wastes and hazardous waste treatment, storage, and disposal facilities. The responsibility for administering both acts is granted to DHES, provided for in Title 2, Chapter 15, Part 21, MCA.

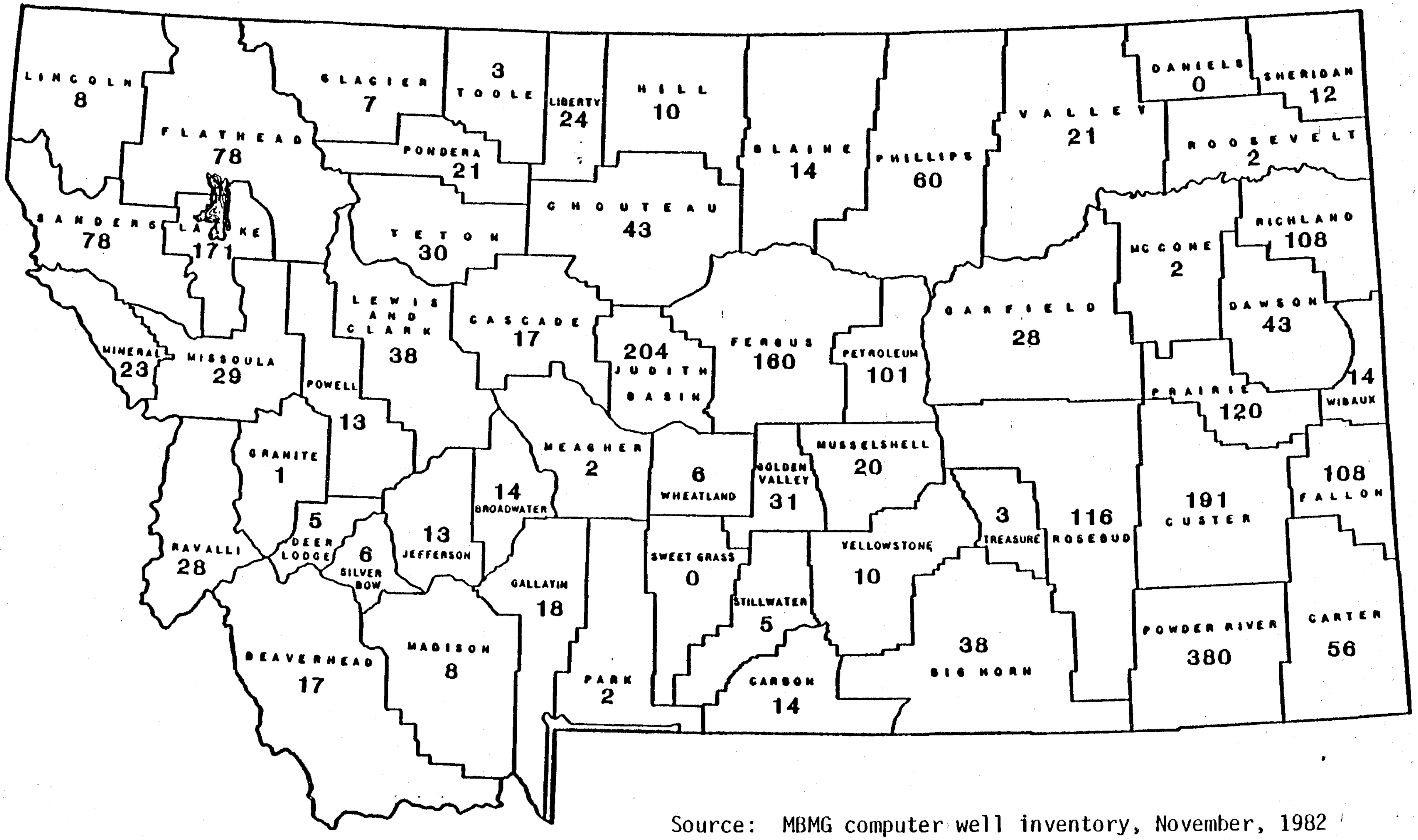
Both the Montana Solid Waste Management Act and the Montana Hazardous Waste Act provide adequate authority to DHES to protect ground water. However, the administrative rules adopted pursuant to each act need amending to address ground-water protection. Specifically, the solid waste rules need updating to address currently exempted small quantity hazardous wastes and incorporation of the new DHES ground-water rules, Montana Groundwater Pollution Control System (MGWPCS), administered by DHES, Water Quality Bureau. The hazardous waste rules need to be expanded to include disposal requirements, financial standards, and permitting procedures.

<u>Options</u>

1. Maintain the status quo.

2(a). Ground-water monitoring could be required on all solid waste disposal sites, land treatment areas, municipal

Figure 34. Number of flowing wells per county in Montana.



Source: MBMG computer well inventory, November, 1982

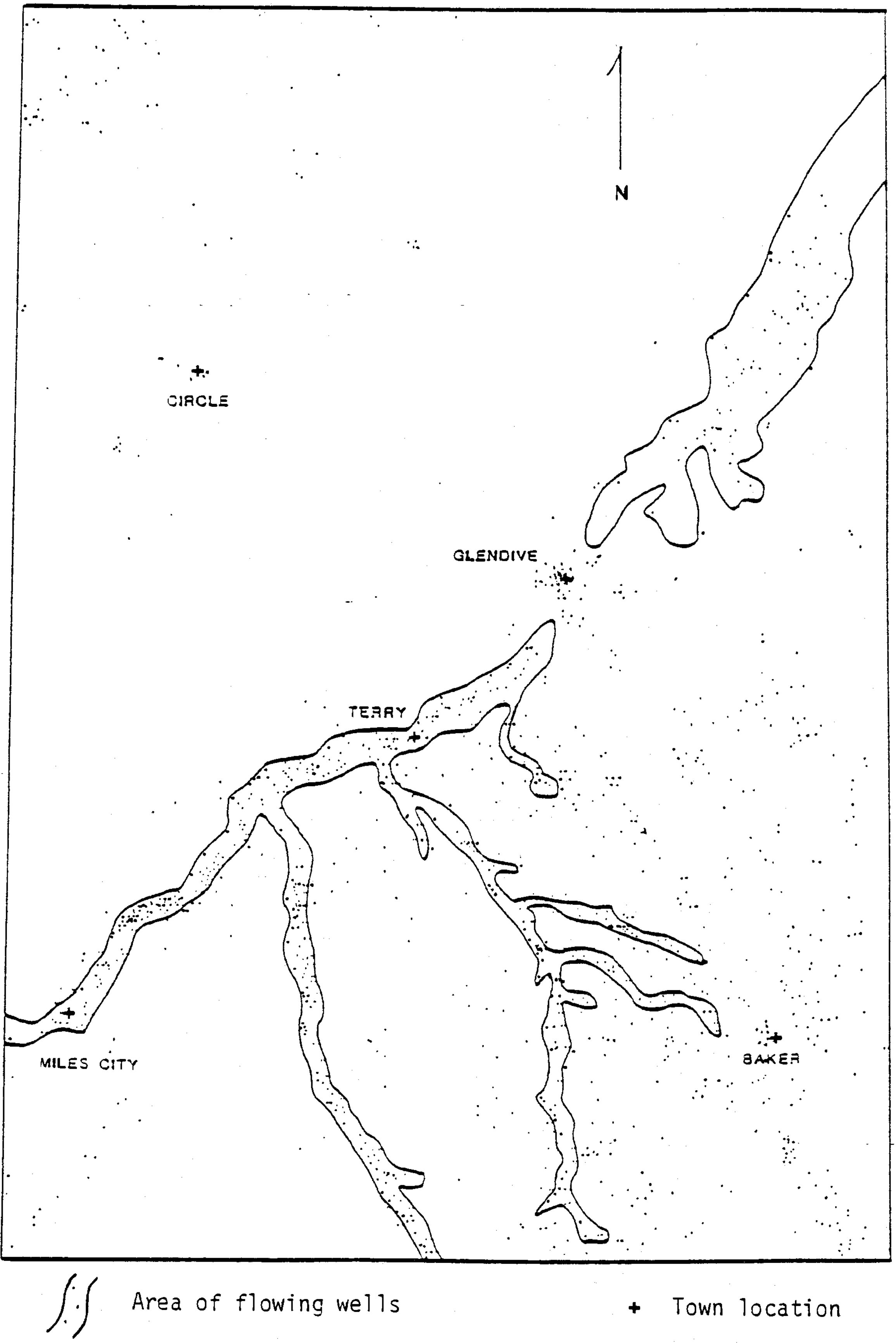
MBMG. Most likely, wells drilled before the 1961 ground-water law were not recorded with MBMG during the re-filing of water rights.

The large number of flowing wells in the southeastern part of Montana is largely attributed to the Fox Hills-Hell Creek aquifer. Figure 35 shows a portion of the aquifer and only those flowing wells listed on the 1982 computer inventory or found during the 1975 USGS field reconnaissance are plotted. It is speculated that there are many more flowing wells in this area which were not found during the field reconnaissance. The area of free-flowing wells was probably much larger in the past but has shrunk to its present size because of the pressure loss on the aquifer. Wells were drilled into this aquifer during the early years of agricultural development because of the aquifer's good water quality, accessibility, and flowing artesian properties. The problem here is that the majority of these wells have no control and flow freely.

Statutes

The ground-water statute of 1961 (R.C.M. 1947, 89-2926) prohibits waste of water and requires a control valve on all wells constructed after January 1, 1962. The Water Use Act of 1973 incorporates this same statute under Section 85-2-505, MCA.

Figure 35. U.S. Geological Survey inventory of wells from the Fox Hills/Hell Creek Formations, 1975. Dots indicate wells completed in the Fox Hills/Hell Creek Formations and only wells located inside the lines are free-flowing as of the 1975 inventory.



The Water Use Act also includes a section on the waste of water in general (85-2-114, MCA). Under this provision DNRC may order persons to stop wasting water, and to take steps to remedy the situation. On post-1961 free-flowing wells, DNRC may require control valves; any person who wastes water may be guilty of a misdemeanor and subject to a fine of not less than $25 nor more than $250 per offense. In addition, post-1973 ground-water permits have section 85-2-505, MCA, attached as one of the conditions; if a permitted well is found to be wasting water, the permit could be revoked.

Two other methods are available to control free-flowing wells. One method is that a representative body of ground-water users can petition DNRC to hold a hearing, and a hearing examiner will act on findings of fact in the hearing. The requirements of the hearing examiner shall be met under penalty of a misdemeanor. The other method is for the individual to petition the district court for relief as provided under Section 85-2-406, MCA.

The statutes appear to be adequate for regulating the waste of ground water since 1962. However, a few items of concern are:

a) If the casing on a free-flowing well has been pulled, then a valve or control device cannot be installed. The well must be plugged or new casing installed (to provide for a valve); this is a very expensive procedure and the law does not specifically address this situation.

b) If ownership of a free-flowing well has changed, then it is questionable as to which party is responsible for the damages, the new owner or the former owner.

c) If a well is leaking up around the casing, even though a control valve is installed, it is essentially wasting ground water. This problem may be the fault of the well driller, although the well driller may not have been aware of this situation. However, it is unclear which party would be responsible, the owner or the well driller.

d) There are no statutes addressing the wasting of ground water from abandoned seismic shot holes drilled by oil and gas exploration firms.

Finally, the major concern is those free-flowing wells which predate the 1961 ground-water statute. It appears DNRC has no legal authority to act on these wells. For example, most of the free-flowing wells shown on Figure 35 predate the 1961 ground-water code.

Options

1. Maintain the status quo.

2. New legislation could be enacted to define which party

is responsible for well plugging in the event a flowing well was abandoned and the well casing removed.

3. Legislation could be enacted to determine which party is responsible for stopping the wasting of water on a free-flowing well when well ownership has changed.

4(a). For free-flowing wells prior to the 1961 ground-water statute, a demonstration plugging program could be conducted by the appropriate state and/or federal agency, with joint financing by state, federal, and local sources. This demonstration could take place in a known problem area, such as the Fox Hills-Hell Creek aquifer region in southeastern Montana. A few free-flowing wells could be selected, plugged by a professional well-plugging firm, and surrounding wells monitored over a reasonable period of time to determine if the program is successful in increasing well pressure. New wells may have to be constructed for the landowners involved because many of these free-flowing wells are presently in use. The economic benefits could be examined in relation to the costs, and a conclusion drawn as to the economic feasibility of a large-scale well-plugging program.

(b). A program could be set up to plug all free-flowing wells in the state that predate the 1961 ground-water statute. This program could be conducted by state and/or federal agencies with funding from one or more of the sources; state, federal or local. This option could be very expensive and time-consuming.

5(a). The statute (Sec. 85-2-505, MCA, "Wasting of groundwater") states that wells no longer put to a beneficial use be capped or plugged. Legislation is needed specifically addressing abandoned nonflowing artesian wells. It should be required that abandoned wells be plugged from the bottom of the hole upwards, not just capped. If the abandoned well was simply capped, and the casing corrodes through time, water would leak upward in the hole and causing damage to the aquifer similar to that caused by free-flowing wells. It is questionable as to who is responsible for the plugging.

(b). Same action as above except have rules adopted by the Board of Natural Resources and Conservation.

6. Responsibility in event of well leakage around casing could be reviewed by water well contractors or determined through legislation.

7. Enact legislation to set aside funds for the enforcement of free-flowing wells.

8. Remove the responsibility from DNRC and put the responsibility of enforcement on the complainants.

M. WELL DRILLERS' QUALIFICATIONS -- Ron Guse, DNRC

Issue Identification

Montana has approximately 260 licensed water well contractors; about 220 are residents practicing in the state. Only about 50 are actively pursuing their occupation full-time (Board of Water Well Contractors, 1982). The remaining licensees drill on an occasional basis. Well log reports filed with DNRC show that about 2,500 new water wells are drilled each year.

Most water well drillers are conscientious and will try to correct any problem that results from an oversight on their part. Others simply avoid settling any complaints. The Board of Water Well Contractors, an administrative arm of the Department of Commerce, which handles complaints from the public against water well drillers, on such matters as improper well construction, dry wells, money settlements, inaccurate well depths, sand in wells, malfunctioning pumps, and falsified well logs. Most of the complaints can be settled by correspondence, sending an inspector out to investigate the problem, or, if necessary, revocation of a driller's license.

Major problems stem from unlicensed or inadequately trained drillers who inaccurately complete well logs, or do not file them at all, or do not use contracts or disclosure forms.

Regulation of the water well drilling industry is complicated by insufficient administrative resources, inadequate statutes, rules and regulations, and lack of enforcement.

Statutes

Montana's existing law (Section 37-43-101, MCA) provides for the licensing of water well contractors and certain regulation of the water well drilling industry. The Board of Water Well Contractors, as created under Section 2-15-1632, MCA, is charged with administering the licensing act. This Board, established by the Legislature in 1961, defined the practice of water well drilling and established qualifications for licensure.

The law was amended in 1974 by changing the composition of the Board and revising the requirement for licensing as a water well contractor. Licensure now requires a mandatory one-year apprenticeship and submittal of a bond.

The Board adopts rules to enforce the Montana Water Well Contractor's License Act (Section 37-43-101, MCA, et seq.). The Board was empowered to set up a training program for applicants, administer competency tests to applicants, and authorize the Department of Commerce to issue licenses as well as revoke, suspend, or re-instate licenses. Disciplinary action by the Board must be conducted as a contested case hearing under the provisions of the Montana Administrative Procedure Act.

As a result of the review of regulatory boards made under the 1977 "Sunset Law," the Legislative Audit Committee voted on May 3, 1982, to recommend to the 1983 Legislature the termination of the Board of Water Well Contractors and the transfer of its functions to DNRC.

Options

1. Maintain the status quo.

2. The recommendations of the Legislative Audit Committee for the transfer of the Board of Water Well Contractors functions to DNRC. Support and supplement could be supported and supplemented.

3. An educational program could be provided to the water well drillers by some agency. The Board of Water Well Contractors has the statutory authority to establish a program for training active or prospective water well contractors and their apprentices, but has not done so.

4. Present water well drillers statutes and/or rules could be amended to require a driller to attend at least one well driller's seminar to be conducted or sponsored by the administering agency. These seminars could be structured to work out problems such as well logs, etc., and other numerous educational topics.

5. Proposed legislation could be drafted to amend present statutes to close loopholes and impose stiffer penalties on unlicensed drillers, and to eliminate the problem of improperly completed or non-existent well logs.

6. Informational material could be made available for present and prospective water well drillers.

N. WELL DEVELOPMENT STANDARDS - Ron Guse, DNRC

Issue Identification

Montanans are facing an ever-increasing problem of waste and contamination of our valuable ground-water resource, which in part is caused by a lack of mandatory minimum standards for water well construction and maintenance. Some problems are caused by the lack of control over water well drilling. This includes wells constructed without supervision which are located as to interfere with existing installations, are improperly constructed and thus result in insufficient yields, or may tap confined aquifers without being properly sealed. Difficulties in some of these areas have resulted from inaccuracies on the part of drillers in compiling and providing data used to determine safe yield, and from the failure of some drillers to keep records.

"Recommended Standards for Preparation of Water Well Construction Specifications" have been prepared, adopted, and published by the Montana Water Well Drillers Association, with its first edition dated January 1970 and the second edition dated 1980. The purpose of the Association's publication is to provide the water well construction industry with an industry-approved guide for the preparation of specifications for the construction of water wells. It is intended for use by the specification writer and may be modified to fit the particular needs and conditions of each case.

The Association's publication of recommended standards is merely a guide. There is no statute that provides regulation or enforcement.

Statutes

adopt improved inspection & const. reg.

Montana presently has statutes enabling the Board of Natural Resources and Conservation and the Board of Water Well Contractors to approve and adopt rules related to water well construction. Other current statutes concerning waste and contamination are also listed here.

1. Enabling Statutes of the Board and Department of Natural Resources and Conservation.

Montana law in Section 85-2-101(3), MCA, encourages the wise use of water resources, to make them available for appropriation. This section also encourages development of ground-water recharge.

Section 85-2-113(2), MCA, titled "Board powers and duties," provides that, "the board may adopt rules necessary to implement and carry out the purposes and provisions of this chapter." Subsection 2d provides that the Board may adopt rules to "regulate the construction, use and sealing of wells to prevent the waste, contamination, or pollution of ground water."

Section 85-2-505, MCA, provides authority to the Department over the waste and contamination of ground water. More specifically, the section provides that DNRC require all producing wells to be plugged, capped, or valved (in the case of flowing wells), and wells be constructed so as to prevent waste, contamination, and pollution of ground water.

2. Board of Water Well Contractors

This Board is attached to Department of Commerce for administrative purposes. The purpose of the Board and Water Well Contractor's Licensing Act is to reduce and minimize the waste of ground-water resources within the state and to protect the health and general welfare by providing a means for the development of the natural resources of ground water in an orderly, sanitary, and reasonable manner.

present rule-making authority. Consideration could be given to amending any portion of its statutory rule-making authority that does not specifically cover areas of needed rules.

3. The Board of Water Well Contractors could expand its existing rules to adequately cover necessary minimum well construction standards. Legislative amendments to existing rule-making authority may also be necessary.

4. A bill could be drafted and introduced to the legislature which would cover all necessary aspects of minimum well construction standards with a designated administering agency.

5. The minimum well construction standards referred to in Option 2 through 4 could be based on:

(a). Recommended standards for preparation of water well construction specifications, as prepared and adopted by the Montana Water Well Drillers Association with the most recent publication dated 1980.

(b). Suggested minimum Water Well Construction Standards, as adopted by the National Water Well Drillers Association, second edition, 1980.

(c). Minimum water well construction and maintenance standards of other western states, more specifically, Idaho, Washington, and Oregon.

(d). A combination of any of the above may be more appropriate than adopting any single existing standard.

O. GROUND-WATER INFORMATION CENTER - Marvin Miller, MBMG

Issue Identification

Because ground-water data are often obtained with little concern for their potential use beyond the original purpose of the collection effort, these data often become difficult to locate and use. For example, ground-water quality data collected specifically for siting a coal mine or power plant are often used for only that specific purpose, published in a document of limited distribution, and commonly misplaced or lost afterwards. Data "managed" in this fashion are difficult for a user to obtain and consequently are rarely used again.

In order to prevent loss of data, Montana needs to support a continuing centralized ground-water information center which will collect, manage, and publish ground-water data. To date, state support for such a system has been low and work accomplished towards this goal has resulted from outside (non-state) funding. Unfortunately, these sources were always inadequate, supporting only portions of the office programs with MBMG, and are no longer available.

The primary product of a compilation of ground-water data is a statewide data base from which many kinds of questions can be answered. For example, the following questions can usually be satisfied quickly and efficiently. What data already exist for a project area? Is the water quality in my well or spring suitable for irrigation use? How deep do I need to drill to complete a well in my area and what can I expect for a yield? Often the data offered the citizen in response to his inquiry have more significance when viewed in the context of wells or springs in similar situations. An inquiry about the concentration of dissolved solids in water produced by a spring discharging from the Fort Union Formation, for example, may show that the spring produces water with higher dissolved solids than the aquifer's average of 1,765 mg/l, which is based on 1,333 samples.

The overall goal of a statewide ground-water information center is not only to address ground-water concerns of the MBMG and its cooperator, the USGS, but also state, federal, and local organizations and the public: namely, DNRC, DSL, DHES, Montana Joint Water Resources Research Center, Cooperative Extension Service, Montana University System, Montana Board of Oil and Gas Conservation, SCS, EPA, BLM, Montana Association of Conservation

Districts, Montana Well Drillers Association, Montana Petroleum Association, Montana Mining Association, landowner groups and citizens of Montana. The need for and importance of this program were clearly expressed by the majority of the above organizations at the first Montana Ground-Water Conference held in April 1982 at Great Falls.

An effective ground-water information center must expand its capability to obtain data beyond the traditional sources of well appropriations and previously published data. Although these sources are important, they are inadequate in providing data for areas of great need and filling gaps in existing knowledge. Consequently, the information center's purpose must be both the maintainance, manipulation, and distribution of existing ground-water data (office program) and the selective acquisition of new, accurate ground-water information in areas of need (field program).

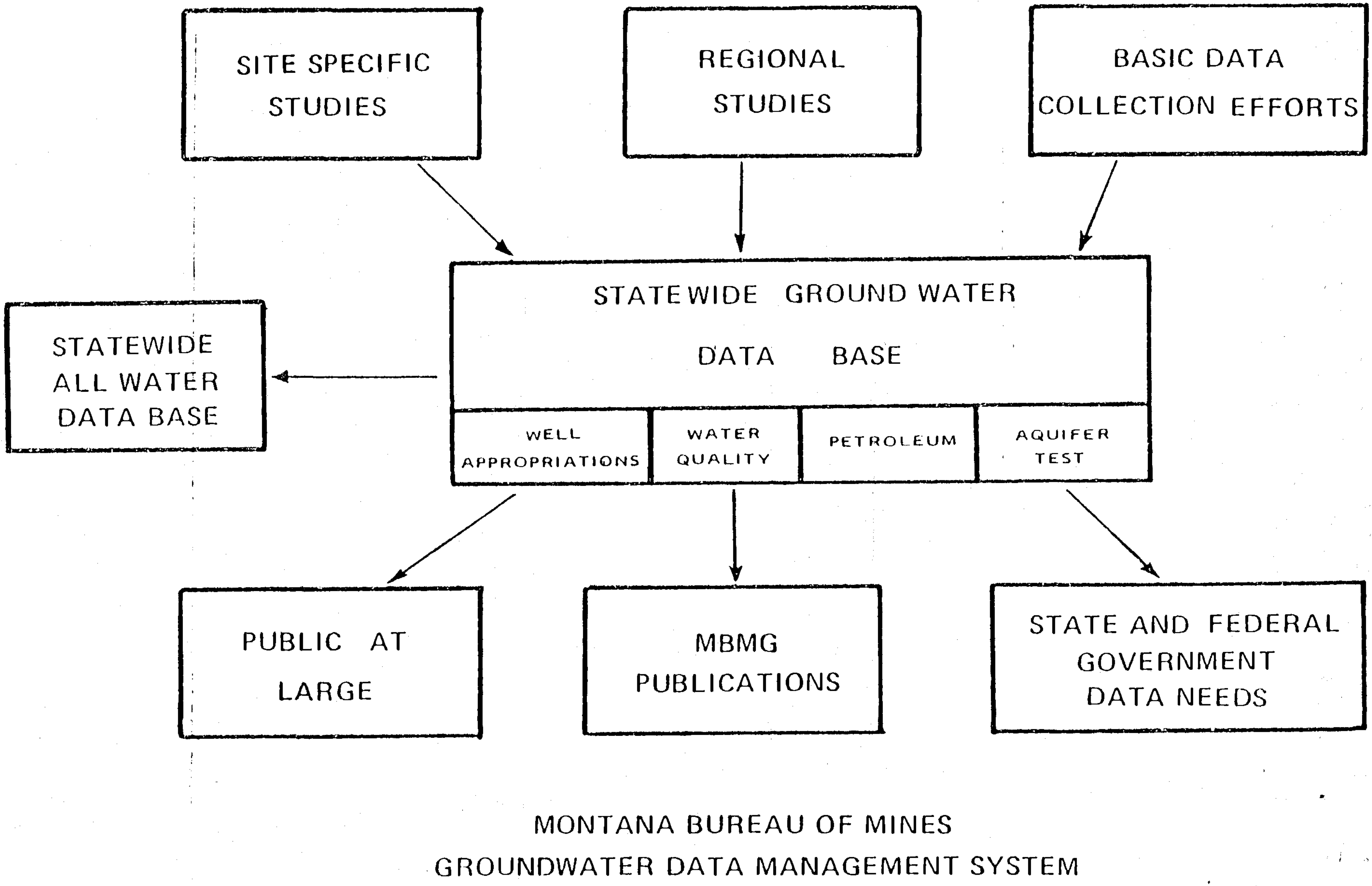
The office program would consist of the following tasks: standardization of data input forms such as field inventory, water quality, aquifer test, and well appropriation to accommodate principal needs of participating agencies; reorganization of existing computer files to allow implementation of a query system and improved accessibility of data; correction of data prior to entry into the data system; publication of basic data reports (example: MBMG ground-water basic data report for the Hardin 1° x 2° sheet); assistance with preparation and publication of hydrogeologic maps or other documents of the MBMG or other agencies (example: MBMG Hardin and Ekalaka 1° x 2° sheets); and maintenance of a library containing published and unpublished hydrogeologic reports on both paper and microfilm.

Field program tasks would include: maintaining, revising, and expanding the statewide monitoring well program as needed with input from other organizations; systematic collecting of water quality samples from selected wells with emphasis on problem areas encountered by DHES, DNRC, Montana State University Cooperative Extension Service, DSL, Montana Board of Oil and Gas Conservation and others; inventorying newly drilled wells in strategic areas to obtain water quality, geophysical logging, and aquifer test data serving as "Bench Mark Data" for correlation of local and regional hydrogeologic characteristics; inventorying existing well appropriations (logs); assisting local communities and state agencies in technical data-gathering problems (aquifer testing, well logging) and instituting a systematic aquifer testing program with specific emphasis on problem areas being evaluated by DNRC or other agencies. The diagram in Figure 36 illustrates some of the components of the information center.

Statutes

The establishment of a ground-water information center is not directly covered by any statute of the State of Montana.

Figure 36. Flow chart illustrating some of the components of the ground-water information center.



However, section 85-2-516 of the Montana Water Use Act does require that Montana water well drillers file water well reports with DNRC and MBMG. This statute appears adequate in that well logs are generally filed by the drillers in a timely manner. An inadequacy of the statute is that it is not specific regarding the data contained on the well log. The most important information on a well log is the geographic location of the well. All other data such as the geologic source, yield, static water level, etc. gain their value from the presence and accuracy of the location. Large numbers of well logs received at the MBMG are placed in the "no location" file so the information contained on them becomes virtually inaccessible. The responsibility for providing accurate geographic locations clearly lies with the well driller and well owner, as they are on site when the well is constructed. Topographic map coverage is available for most of the state and with nominal costs the well drilling industry could provide accurate well locations. MBMG in turn is willing to expend time and effort in preparation of educational materials for presentation at workshops for the Montana drilling industry.

Options

Three options are readily apparent regarding the ground-water information center.

1. Make no changes in the ground-water data system as presently defined or funded and continue the

acquisition in Montana of ground-water data on a piecemeal basis.

2. Provide additional funding for the statewide Ground-Water Information Center allowing maintenance, reorganization, and expansion of the data system.

3. Rearrange priorities in existing funding to allow the benefits of option 1.

Two options pertaining to the well log situation are:

1. Make no changes in the statutes requiring the water well drilling reports.

2. Include in the statute a requirement that accurate geographic locations for water well log data must be provided by the water well driller.

CONCLUSION

The previously discussed issues will undoubtedly have an impact on the future of ground-water development in the state. These issues cover a wide array of topics which range from ground-water opportunities to present and future ground-water problems associated with resource development. Options for resolving these issues are listed in their respective section.

The importance of the issues becomes clear when one considers the fact that over half of the state's population relies heavily on ground water for domestic and agricultural supplies. This ground-water reliance is intensified since, in many areas, ground water is the only source of potable water.

To reiterate, one option that is available in each of the issues is the option of taking no action and maintaining the status quo. During times of fiscal austerity such an option is bound to be popular until the long-term costs of inaction become apparent. Other states, particularly in the eastern and southern United States, have effectively eliminated ground water as a water supply option in a number of important aquifers by choosing to take no action to protect their ground-water supplies from contamination. Such contamination is not easily contained or removed even with elaborate and expensive aquifer restoration techniques. Also, aquifer restoration is rarely, if ever, effective in cleansing an aquifer to pre-contamination quality. As mentioned before, such contamination is not a problem that will plague the state for months or years; it will be a problem for generations.

Similarly, lack of action in doing research on determination of aquifer characteristics, recharge rates and sustainable long term yields from aquifers will reduce the state's ability to manage the use of ground water to avoid depletion. Long-term consequences of aquifer overuse include financial hardships when speculative investments in irrigation equipment fail to produce, rising energy costs with increased pumping lifts, or in some cases complete depletion of a supply.

In comparison, other states, such as North Dakota and Kansas, actively invest in ground-water resource investigations statewide to promote the future use of ground water. Many water districts in southern California pursue the conjunctive use of ground water and surface water by storing excess surface water in ground-water aquifers. Montana could follow a similar course to effectively manage its water resource.

Montana's ground-water resource truly rests in the hands of those in the state who are concerned about our present and future use of this resource. The EPA's recently proposed National Ground Water Policy leaves a clear message, that is, the states will be responsible for protecting their own ground water. If Montana fails to do this, the federal government will not do it for us. The resolution of the issues presented in this report comes back to the question of how much the state values our ground-water resource and how far it is willing to go to ensure that ground water is available and useable as the need to develop water resources increases in the future. It is urged that the options presented be evaluated with these considerations in mind.

REFERENCES CITED

Bahls, L.L., and Miller,M.R., 1973, Saline seeps in Montana. In: Second Annual Report, Montana Environmental Quality Council, pp. 35-44.

Black, A.L., Brown, P.L., Halverson, A.D., and F.H. Siddowage, 1981, Agricultural Water Management, Elsevan Scientific Publishing Company, Amsterdam, Vol. 4, pp. 295-311.

Bond, E.W., 1975, A study of the influence of seismic shotholes on ground water and aquifers in eastern Montana, MBMG Spec. Publ. 67, Butte, Montana.

Botz, M.K., and A. Gartner, 1978, Groundwater quality and pollution assessment for Montana statewide 208 area, Dept. Health and Environmental Sciences statewide 208 program, Helena, Montana.

Brown, P.L., and M.R. Miller, 1978, Soils and crop management practices to control saline seeps in the U.S. northern plains. In: Dryland-Saline-Seep Control, Proceedings Meeting of Subcommission on Salt-Affected Soils at 11th Int. Soil Sci. Soc. Congress, Edmonton, Alberta, Canada, pp. 7-9 to 7-15.

Department of Health and Environmental Sciences, 1982, Montana water quality 305b report, DHES Water Quality Bureau, Helena, Montana.

Dewey, M., 1982, Water quality problems associated with oil and gas development in eastern Montana, MS thesis, Univ. of Montana, Missoula, Montana.

Donavan, J.J., Sonderegger, J.L., Miller, M.R., and F.A. Schmidt, 1979, Saline-seep progress report--investigation of soluble salt loads, controlling mineralogy and some factors affecting the rates and amounts of leached salts: Montana Bureau of Mines and Geology Open-File Report No. 36, 32 pp..

Donovan, J.J., and M.R. Miller, 1980, Saline-seep drainage systems--semi-annual report.: Montana Bureau of Mines and Geology Open-File Report No. 57, 25 pp..

Ferguson, H., Brown, P.L., and M.R. Miller, 1972, Saline seeps on non-irrigated lands of the northern plains. In: Proceedings on Control of Agricultural Related Pollution in the Great Plains, Lincoln, Nebraska: Great Plains Agricultural Council Publication 60, pp. 169-191.

Freeze, R.A., and J.A. Cherry, 1979, Groundwater, p. 399, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Halverson, A.D., and A.L. Black, 1974, Saline-seep development in dryland soils of northeastern Montana: Journal of Soil and Water Conservation, Vol. 29, No. 2, pp. 77-81.

Jackson, G.D., and J.L. Krall, 1978, The flexible method of recropping. In: Dryland-Saline-Seep Control, Proceedings Meeting of the Subcommission on Salt-Affected Soils at the 11th Int. Soil Sci. Soc. Congress, Edmonton, Alberta, Canada, pp.7-23.

Miller, D.W., 1977, Editor, Report to Congress on Waste Disposal Practices and Their Management Program, Office of Water Supply and Office of Solid Waste Management Program, U.S. Environmental Protection Agency.

Miller, M.R., 1971, Hydrogeology of saline-seep spots in dryland farm areas--a preliminary evaluation. In: Proceedings of Saline Seep - Fallow Workshop, Great Falls, Montana, 9 pp..

Miller, M.R., Vander Pluym, H., Holm, H.M., Vasey, E.H., Adams, E.P., and L.L. Bahls, 1976, An overview of saline-seep programs in the states and provinces of the great plains. In: Proceedings on Regional Saline Seep Control Symposium, Bozeman, Montana: Montana Cooperative Extension Service Bulletin 1132, pp. 4-17.

Miller, M.R., Bergantino, R.N., Bermal, W.M., Schmidt, F.A., and M.K. Botz, 1978, Regional assessment of the saline-seep problem and a water quality inventory of the Montana plains: Montana Bureau of Mines and Geology Open-File Report 42, 417 pp..

Montana Bureau of Mines and Geology, 1978, Groundwater of the Fort Union coal region, eastern Montana, MBMG Spec. Publ. 80, Butte, Montana.

Strange, Marty, 1983, Commentary: Of whooping cranes and family farms: Another look at the High Plains study, Journal of Soil and Water Conservation, Vol. 38, No. 1.

U.S. Fish and Wildlife Service, 1970, Wetlands of the United States, Circular 39, 67 pp..

Vander Pluym, H.S.A., 1978, Extent, causes and control of dryland saline seepage in the Northern Great Plains region of North America. In: Dryland-Saline-Seep Control, Proceedings Meeting of the Subcommission on Salt-Affected Soils, 11th Int. Soil Sci. Soc. Congress, Edmonton, Alberta, Canada, pp. 1-4 to 1-58.

Van Voast, W.A. and R.B. Hedges, 1975, Hydrogeologic aspects of existing and proposed strip coal mines near Decker, southeastern Montana, MBMG Bulletin 97, 31 p.

GLOSSARY

Adsorption - The adhesion of ions or molecules in solution to solid body surfaces.

Alluvium - A term referring to clay, silt, sand, and gravel deposited by running water.

Anhydrite - A mineral, anhydrous calcium sulfate, which is found in typically massive beds resulting from extensive or total evaporation of the solvent.

Argillite - A rock which is derived from shale or siltstone, but which has undergone further induration than is present in these rocks.

Base flow - Referring to precipitation being delivered to a stream via a subsurface flow route through saturated materials.

Confined aquifer - Synonymous with artesian. Ground water is confined under pressure greater than atmospheric by overlying relatively impermeable strata.

Conjunctive use - The integration of two water resource systems, such as surface water and ground water, in a management plan which optimizes the different characteristics of each for solving some water problem.

Conglomerate - Rounded, water worn fragments of rocks or pebbles which are cemented together.

Desorption - Removal of adsorbed material.

Dissolved solids - The total dissolved minerals in water expressed as the weight of minerals per unit volume of water, without regard to type of minerals.

Fluvial - Pertaining to a river.

Lithology - The physical character of a rock, such as color, structure, and mineralogic composition.

Moraine - An accumulation of unstratified, unsorted material deposited by direct glacial activity and resulting in a variety of topographic land forms.

Overland flow - Referring to precipitation which is delivered to a stream via the land surface.

Outwash - A deposit of stratified sediments derived from glacial meltwater streams.

Piezometric surface - A surface which represents the water level elevations of an aquifer.

Quartzite - A metamorphic rock consisting primarily of quartz.

Till - Unstratified and unsorted material deposited by a glacier.

Trace metals - Metals that are present in minor amounts.

Water table aquifer - An unconfined aquifer where the pore water pressure is atmospheric.