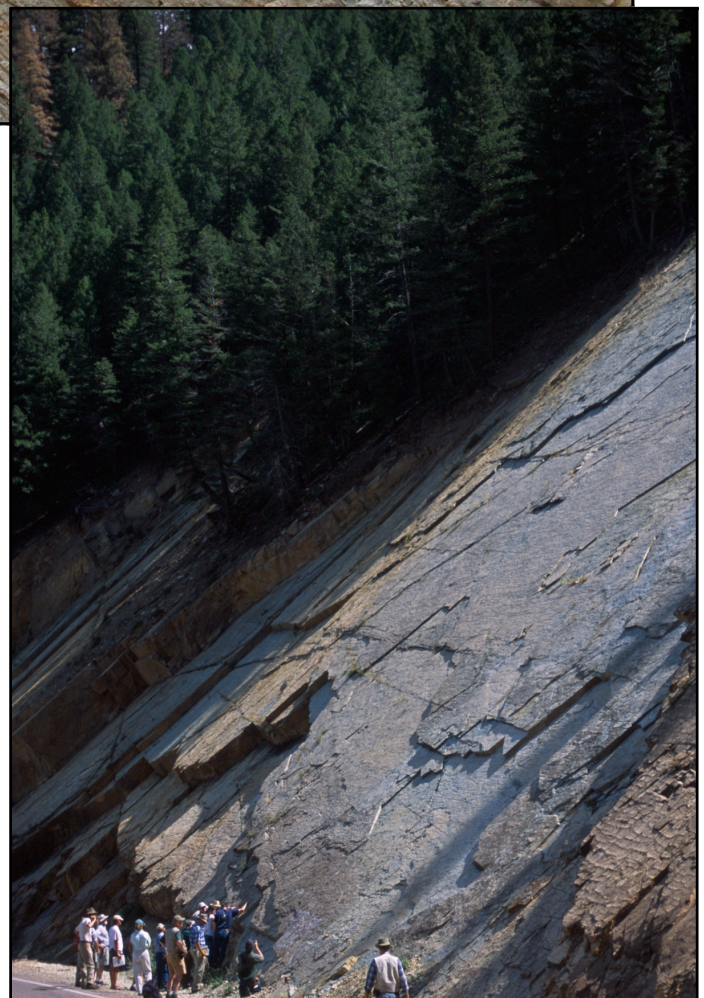
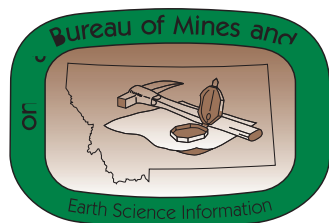


Montana Bureau of Mines and Geology



Biennial Report of Activities and Programs July 1, 2002–June 30, 2004

Compiled by the Staff of the
Montana Bureau of Mines and Geology



Edmond G. Deal
Director and State Geologist

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Director's Introduction

Since 1919 the Montana Bureau of Mines and Geology (MBMG) has provided the citizens of Montana with reliable information on the geology and geologic resources of the State. Through the years our work has grown from an emphasis on hard-rock metals mining to broadly cover all aspects of Montana's diverse geology. Current projects include mapping; applied studies on industrial minerals and metals deposits; energy resources: coal, oil, and natural gas, including coalbed methane; seismic monitoring; and especially, studies on water resources. Perhaps three-quarters of Montana's citizens rely on ground water, but large areas suffer chronic water shortages and recent drought has exacerbated water-supply problems. A significant segment of our research deals with restoration of ground-water supplies and ecosystems damaged during historic resource extraction. In order to understand and solve our geologic problems, new and revised geologic and hydrogeologic maps generated by Bureau staff are widely used by scientists, policy makers, regulators, landowners, and resource managers and developers. Geologic information is crucial for balancing difficult decisions regarding economic growth and the resource needs of society, yet maintaining a high quality of life for future generations.

The MBMG is a non-regulatory, applied-research, and public-service agency and is the State's geological survey. Administratively, we are a department of Montana Tech of The University of Montana. MBMG's main office is located on the campus of Montana Tech and a smaller office is located on the Montana State University-Billings campus. Our staff comprises about 40 full-time research professionals who have wide-ranging experience in the geosciences. Other sections of the Bureau, including Publications, the Analytical Lab, the GIS Lab, and the Administrative section provide support that enables the researchers to successfully carry out their work. The Bureau also employs 20–25 students on a part-time basis. These students gain practical experience in conducting applied research projects and form an inexpensive labor pool for accomplishing many routine duties.

MBMG's funding is provided through a combination of a general fund appropriation from the State, designated State funding for the Ground Water Assessment Program (GWAP), and contracts and grants with outside organizations. The general fund appropriation is used to maintain core programs, primarily in mapping and mineral resource studies, that form the foundation for much of our work. Excepting GWAP, funding for most other projects relies mainly on grants and contracts. Most contracts and grants require matching dollars, and our State funding is highly leveraged. For the 2003–2004 fiscal years contracts and grants income slightly exceeded total State funds.

Partnerships with other agencies, local governments, university faculty, and the general public are critical to our success. Staff spend many hours with collaborators discussing problems and developing proposals to solve problems that come to our attention, commonly resulting in an investigation that is carried out cooperatively. Changing land-use patterns and resource extraction frequently result in disagreements over priorities and proper stewardship. Property development may require an assessment of existing or potential geologic hazards. As a non-regulatory agency, MBMG provides unbiased information and objective analyses of data. Our

researchers bring expertise in various fields to a project, resulting in an integrated study that can help bridge the gap between proponents on all sides.

An equally critical part of our mission is to compile and disseminate the information that we collect. During the past biennium, MBMG released over 60 publications, in addition to project reports, articles published in outside journals, presentations to various groups, and thousands of contacts from walk-in visitors, and written, telephone, and e-mail requests. Additionally, we maintain extensive records and databases containing both historic and modern data. Some of these require a visit to the Bureau for review, but where possible we are converting to online delivery of reports, data, and maps in order to provide better services and cut production costs. We now offer digital geologic map coverage of about three-fourths of the State; these maps can be viewed and downloaded from our website. Through a project with the U.S. Geological Survey, near-real-time seismic records also can be viewed. By far the most popular database is the Ground Water Information Center (GWIC), which contains data for more than 190,000 water wells across the State. Over 7000 registered users now visit the website and average about 30,000 data queries monthly. Users range from individuals seeking information about their well to those concerned with locating ground-water supplies or ground-water protection.

MBMG's mission continues to be one of applied research, service, outreach, and education. In order to best manage and protect our resources, Montana's citizens must have accurate and understandable geologic information. The following sections of this biennial report provide short summaries of many of our projects in the past 2 years. We hope that this will be useful, and if you need further information please drop by and visit us at either the Butte or Billings office, call us at (406) 496-4180, or visit our website at <http://www.mbm.mtech.edu>.



Edmond G. Deal
Director and State Geologist
Montana Bureau of Mines and Geology

Research Division

Wayne A. Van Voast
Division Chief

Introduction

Water and mineral resources across Montana are directly touched by the mapping and evaluation done by the Montana Bureau of Mines and Geology (MBMG). Our work enhances the State's information base, encourages responsible development and environmental protection, and provides key assessments of resource problems. Many of the MBMG's programs and projects are highlighted on the following pages, topically arranged under broad categories. The parts of Montana affected or involved are annotated for each project.

Broad progress was made in the MBMG's stellar geologic program, STATEMAP. This work will lead ultimately to a new geologic map of the entire State, replacing an out-of-print version completed in 1955. Final results will also include a series of special maps that focus on areas of rapid urban growth. During the 2002–2004 biennium, large areas of new mapping were completed in preparation for the final (digital) statewide version, anticipated by December 2005.

Special geologic studies were continued on Cretaceous stratigraphy, sapphires, industrial minerals, and precious metals, as were special characterizations of earthquake conditions and landslide occurrences and potential. More esthetic elements of geology were also covered this biennium through development of educational geological exhibits, tracking of geological features noted by Lewis and Clark, and maintenance of the Montana Tech Mineral Museum. Mining and mine impacts held a strong focus as usual, as the ongoing Small Mine Operators Assistance Program and the Mineral Information and Statistics Program continued steadily, and a handbook on placer mining techniques was completed. Numerous investigations were under way on the impacts of mining, most of these in the Butte area. Special focus was on the Berkeley Pit and on area soils impacted by mining or ancillary activities. Evaluations of abandoned underground coal mines near Belt were begun, with the objective of reducing or eliminating acidic drainage from the workings.

Research into energy development was strong during the biennium. Evaluations of natural gas potential in eastern Montana sandstone beds were completed. Ongoing programs of coal-resource evaluations and coal database construction continued, and results of new research on the availability of coalbed methane were published. Special work on coalbed-methane potential on the Northern Cheyenne Reservation was also completed.

Ground water supplies drinking water to more than 60% of Montanans, and appropriately was the object of numerous programs to characterize, evaluate, and protect the resource. The Montana Groundwater Assessment Program advanced strongly these past 2 years with completion of characterization of the Lower Yellowstone River and Flathead Lake areas. Data collection continued in the Middle Yellowstone River, Lolo-Bitterroot, Upper Clark Fork River, and Clark's Fork of the Yellowstone areas. These studies require extensive cooperative work between the MBMG's Butte and Billings offices. Included in the Assessment Program is the establishment of a statewide ground-water monitoring program (now about 90% completed),

and companion studies of carbon and oxygen isotopes to assess ground-water ages, recharge rates, and flow paths.

Concerns over development of Montana ground water near Yellowstone Park has prompted two programs conducted by the MBMG in cooperation with the National Park Service and the Montana Department of Natural Resources and Conservation. One is a program of well and spring inventory and baseline water sampling that was completed this biennium. The other is directed at water rights of the area, and is a detailed study of ground and surface water in the Soda Butte drainage, northeast of the Park.

As always, MBMG hydrogeologists are very active in assessments of ground-water occurrence and conditions. During the biennium, these programs included appraisals of ground-water conditions and quality in the Sage Creek watershed and in the Greenfields and Burton Bench areas. Chronic streamflow shortages in the Big Hole Basin, ground-water and land uses, and ground water for irrigation in northeastern Montana were also objects of research.

Numerous ground-water investigations pertinent to public health are being performed each year by MBMG staff. Important to drinking water protection are the evaluations of ground-water supplies under the influence of surface water; local assistance to wellhead protection for community water systems; delineations of wellhead protection areas at rural schools, and evaluations of radon, pesticides, and septic nutrients in public ground-water supplies.

Research under way in the 2002–2004 biennium has been the broadest and most comprehensive in the history of the Montana Bureau of Mines and Geology, and the most responsive to the needs of Montana. The following pages include only short summaries, but requests for detailed information on any project would be welcomed by the listed Project Leaders.

Geologic Projects

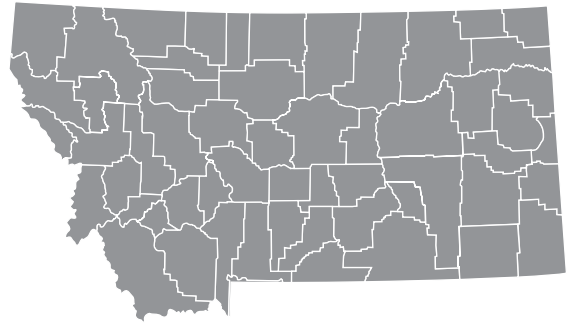
Project Title: Geologic Mapping Program

Location: Statewide

Project Period: Ongoing since 1986 in competitive cooperative programs with the U.S. Geological Survey; since 1992, under the USGS's National Cooperative Geologic Mapping Program (NCGMP). The STATEMAP and EDMAP components of the NCGMP partially support field mapping by State geologists and graduate students, respectively.

Project Leader: Karen Porter

Project Staff: Bureau personnel and graduate students



Issue

A modern geologic map base for the State at a useful scale (minimum of 1:100,000; 0.1"=1.6 mi) does not exist, although new information from many sources is available. The digital geologic map base being constructed in this project is essential to effectively execute many MBMG programs, including evaluation of (1) ground-water, mineral, and fossil fuel resources, (2) seismic hazards, (3) radon contamination, (4) abandoned and inactive mine status, and (5) geothermal resources. Additionally, an accurate geologic base is essential for areas of the State that are undergoing rapid population growth and development without adequate information concerning slope stability, swelling clays, water resources, aquifer contamination, flood-prone areas, and sites of potentially economic materials.

Objectives

The objectives of the geologic mapping program are:

- (1) to provide digitally based, accurate, updated geologic maps at the 1:100,000 scale for the entire State and
- (2) to prepare larger scale maps (1:50,000 or larger) for designated areas of rapid urban or rural growth.

These maps reflect modern structural and stratigraphic concepts and include a significant amount of new mapping.

Approach

Geologic maps are prepared by:

- (1) compiling all available geologic map information for the area,
- (2) field-checking the compilation, and
- (3) conducting new field mapping and revision of earlier mapping.

Data are integrated at the desired scale, maps are finalized through a strict review process, geologic data are entered in the MBMG geographic information system (GIS) database, and the hard-copy and digital products are made available to the public. Copies of many maps are submitted to the USGS in fulfillment of funding contracts. Most maps require 2 to 3 years to complete; nine Bureau geologists work part or full time on this program. In addition to digitally producing new geologic maps, geologists and GIS staff are bringing older, non-digital maps into digital form.

Work with Graduate Students

In addition to conducting our own geologic mapping, each year MBMG staff work with several graduate students doing field theses in Montana, funded by the EDMAP component of the NCGMP. MBMG has responsibility for recommending projects to be funded and production of the final maps for those that are successful.

Progress during the 2002–2004 Biennium

The following geologic maps were completed between July 1, 2002 and June 30, 2004 and are available to the public:

At the 1:100,000 scale (30' x 60' quadrangles):

Angela, Hysham, Dubois (MT part), Fort Peck Lake East, Fort Peck Lake West, Ringling (eastern part)

At the 1:50,000 or 1:24,000 scale:

Western and Northern Gallatin Valley, Hellgate Gulch, Columbia Mountain Area, Ruby Dam Area, Caboose Canyon, Dixon Mountain, East Bay, Arlee Area, Kelly Lake, Dickie Hills, Divide Area, Upper Jefferson Valley, Upper Clark Fork Valley, Deer Lodge Valley

Plans for the 2004–2006 Biennium

Field mapping will continue in several areas of the State, including work that will:

- (1) complete our 1:100,000-scale digital coverage of the State east of 112° west longitude,
- (2) provide detailed geology for the State's areas of fastest growth and development, and
- (3) integrate geologic map data for western Montana.

STATEMAP Advisory Committee

Betsy Campen, Consulting Geologist /Billings
Mike Cannon, U.S. Geological Survey, Water Resources Division/Helena
Steve J. Czehura, Montana Resources, Inc./Butte
Michael Garverich, USDA-Natural Resources Conservation Service/Bozeman
James Gruber, U.S. Bureau of Land Management/Billings
James W. Halvorson, Montana Board of Oil and Gas Conservation/Billings
Marc Hendrix, The University of Montana/Missoula
Bonnie K. Lovelace, Montana Dept. of Environmental Quality/Helena
John Montagne, Montana State University (emeritus)/Bozeman
Larry Monson, Fort Peck Tribes/Poplar
Edward T. Ruppel, Former State Geologist of Montana/Twin Bridges
James Sheldon, U.S. Forest Service, Region 1/Missoula
Rick Stefanic, U.S. Bureau of Indian Affairs/Billings
Donald W. Wirth, Consulting Geologist /Billings

Project Title: Stratigraphic Research

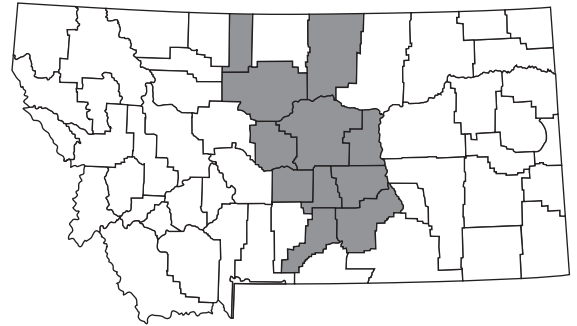
Location: Central Montana (Liberty, Choteau, Fergus, Petroleum, Musselshell, Golden Valley, Wheatland, Yellowstone, Blaine, Stillwater, Judith Basin)

Project Period: Ongoing since 1992

Project Leader: Karen Porter

Project Staff: Bureau personnel and outside research colleagues

Funding Sources: Montana Bureau of Mines and Geology, U.S. Geological Survey



Issue

The occurrence and distribution of sedimentary rock units in the subsurface of central Montana is important because these rocks contain oil and natural gas in numerous fields throughout the Rocky Mountain and High Plains region, from southern Colorado into Canada. Understanding how the rock units of central Montana relate to the same intervals elsewhere in the region will increase our ability to recognize stratigraphic details affecting the occurrence and trapping of producible hydrocarbons.

Objectives

Develop models for improved prediction of the occurrence of oil and gas in the subsurface.

Approach

Detailed field studies are conducted on rock outcrops of those sedimentary rock intervals known to produce hydrocarbons in the subsurface. Important aspects of these outcrops are:

- specific rock types such as sandstones, shales, and limestones;
- thicknesses;
- vertical and lateral changes in the stratigraphic layers; and
- correlation of the units at one locality with those at another.

Correlations are also made between the outcrops and well logs of oil and/or water wells.

These surface and subsurface correlations allow the geologist to make maps of the subsurface distribution of the rock types. The combined surface and subsurface information leads to the development of a geologic model: a three-dimensional picture of how these rocks were first laid down as sediment, then compressed into rock, and finally became hosts to oil and gas.

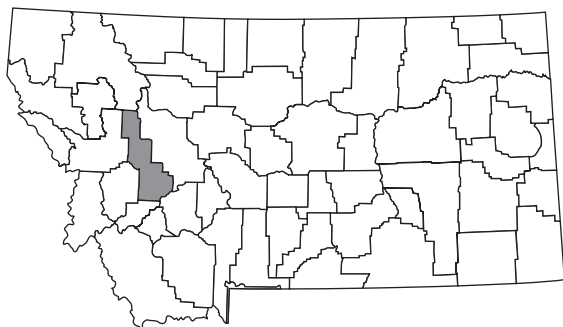
Progress during the 2002–2004 Biennium

Studies of the marine Lower Cretaceous rocks have led to the development of models of these rocks as ancient marine deposits and of the ancient erosion surfaces that have modified these deposits. Ability to predict oil and gas occurrence in these intervals in the subsurface has been improved.

Information Products

Cobban, W.A., Dyman, T.S., and Porter, K.W., in press, Late Cretaceous (upper Coniacian–middle Santonian) ammonite zones and erosional surfaces, Montana and Alberta.

Hale, E.S., Cobban, W.A., Dyman, T.S., Nichols, D., and Porter, K.W., in press, Cretaceous complexities: the stratigraphic intricacies of Mount Everts.



Project Title: Geologic Maps of the Conleys Lake and Deer Lodge 7.5' Quadrangles

Location: Northern part of the Deer Lodge Valley including the Grant Kohrs Ranch National Historic Site

Project Period: October 2003–June 2004

Project Leader: Richard B. Berg

Funding Sources: National Park Service and the Montana Bureau of Mines and Geology

Objective

To provide information on the geology of the Grant Kohrs Ranch National Historic Site and the surrounding area.

Approach

Mapping of bedrock and surficial geology of this area was undertaken.

Progress during the 2002-2004 Biennium

Project completed.

Information Products

Digital version of the map in ArcView was provided to the National Park Service and the following map is available on open file:

Berg, R.B., 2004, Geologic map of the Deer Lodge and Conleys Lake 7.5' quadrangles, Powell County, southwestern Montana: Montana Bureau of Mines Open-File Report 509, scale 1:24,000 with 12 p. text (mapped and compiled by R.B. Berg).

Project Title: Montana Sapphires

Location: Southwestern Montana counties

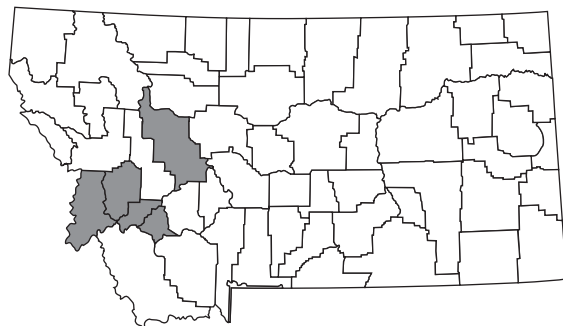
Project Leader: Richard B. Berg

Project Period: Ongoing

Funding sources: Montana Bureau of Mines and Geology

Objective

To provide information about Montana's sapphire deposits that will be interesting to the general public and aid in developing this significant mineral resource. Although these deposits have produced more than 50 tons of sapphires, the bedrock sources have not yet been recognized.



Approach

Sample selected sapphire occurrences and examine reported but unverified occurrences in an effort to determine the source bedrock of the large, alluvial sapphire deposits in western Montana. Study selected sapphires from these deposits to identify mineral inclusions and surface features that can provide clues about their sources.

Progress during the 2002–2004 Biennium

- Sampled gravels (both sapphire-bearing and those lacking sapphires) and bedrock from areas of sapphire deposits north of Butte
- Worked with graduate student in study of sapphire deposit near Ramsay
- Examined surfaces of sapphires from these alluvial deposits at high magnification by scanning electron microscopy, to determine differences between the surfaces of sapphires from the three major deposits in western Montana
- Identified mineral inclusions in selected sapphires by optical and energy-dispersive x-ray techniques

Plans for the 2004–2006 Biennium

Complete writing a detailed report on sapphire deposits north and west of Butte to be submitted for formal publication by the Montana Bureau of Mines and Geology. Although this report will contain detailed information and many illustrations, it is intended for the non-geologist. A Sapphire Symposium, discussing the history, occurrence, and gemology of sapphires, will be held in the Museum in July 2004.

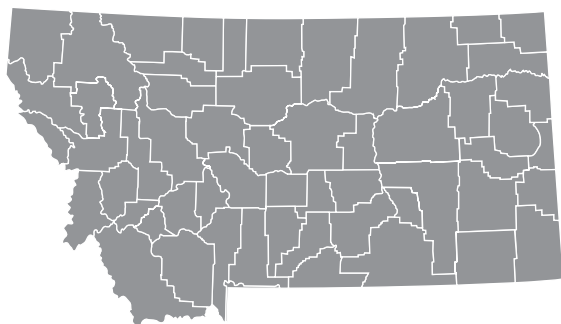
Information Products

Berg, R.B., 2004, Probable bedrock source of sapphires in alluvial deposits north of Butte, Montana, *in* Castor, S.B., Papke, K.G., and Meeuwig, R.O., eds., *Betting on Industrial Minerals*, Proceedings of the 39th Forum on the Geology of Industrial Minerals, Nevada Bureau of Mines and Geology Special Publication 33, p. 23–30.

Berg, R.B., and Equall, N., 2004, Scanning electron micrographs of sapphires from alluvial deposits in southwest Montana: Montana Bureau of Mines and Geology Open-File Report 491, photos and text on CD.

Users of this Information

- The many citizens of Montana and tourists who are interested in sapphires from a recreational viewpoint
- Those commercially involved in the production of Montana sapphires
- The international gemstone community



Project Title: Industrial Minerals of Montana

Location: Statewide

Project Period: Ongoing

Project Leader: Richard B. Berg

Funding Sources: Montana Bureau of Mines and Geology

Objective

Provide information that will aid in developing Montana's industrial mineral resources. Provide information about industrial minerals to the general public.

Approach

Conduct field and laboratory investigations of Montana's industrial mineral resources and release this information through MBMG publications or open-file reports, and articles in other publications. Methods range from grass-roots exploration, as was accomplished in recent years for zeolite deposits, to detailed analyses, as in the investigation of sapphires. Provide technical information, obtained primarily through petrographic analysis and mineralogical determinations, to prospectors and those involved in developing industrial mineral deposits. Provide information about markets for specific industrial minerals and recent industry developments.

Progress during the 2002–2004 Biennium

See *Montana Sapphires* project for specific information.

Together with Chris Gammons submitted a proposal to NSF for research on Montana talc deposits.

Plans for the 2004–2006 Biennium

If our talc proposal is funded we will continue research on Montana talc deposits.

Additional funding sources for further study of Montana's industrial minerals need to be found.

Users of this Information

- Companies considering development of a Montana deposit or looking for a specific industrial mineral
- Industrial mineral producers in Montana
- Individuals who have a Montana deposit they are interested in developing
- Landowners (private or public) who are interested in the mineral resources on their land
- The general public who are simply curious about some aspect of industrial minerals

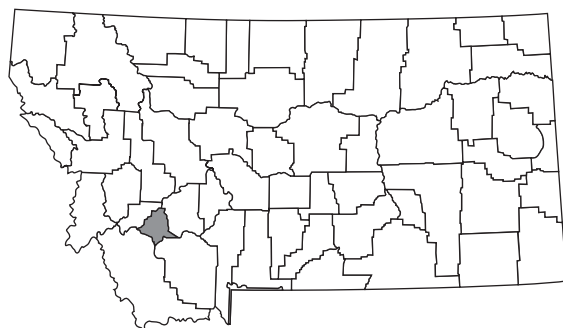
Project Title: Mineral Museum

Location: Montana Tech Campus

Project Period: Since 1901

Project Leaders: Ginette Abdo, Dick Berg

Funding Source: Montana Bureau of Mines and Geology,
Private donations



Objective

To create educational activities that enhance an understanding of the earth sciences and our natural resources; provide interesting and informative displays of mineral specimens, with particular emphasis on specimens from the Northern Rocky Mountains. The Museum has over 1,300 mineral specimens on display and an additional 15,000 specimens in storage. The accessioned collection is in a computerized database that facilitates information acquisition.

Approach

- Display varied and aesthetically intriguing fine mineral specimens
- Conduct informative tours and workshops, and involve the community in geology-related activities
- Provide information to visitors on subjects ranging from the identification of rocks and minerals to descriptions of the mining history of Butte and locations of points of interest for tourists

Progress during the 2002–2004 Biennium

Group tours are an important activity of the Museum, and during the past biennium about 2,000 individuals in over 80 groups were guided through the Mineral Museum. Students were given exercises that required them to find specimens in the Museum and that emphasized the uses of minerals. In addition to tour groups, there were over 22,500 visitors during the 2002–2004 biennium.

An interpretive dimension was added to several of the displays, including: Sapphires and Agates—Montana's State Stones, The Boulder Batholith, Montana sapphires, and interpretative signage in the fluorescent mineral room. In addition, workshops and lectures have become part of a spring series to encourage community outreach.

Talks

- What's All This Stuff about Lightning, Anyway?
- Yellowstone Lake—Craters, Landslides, Faults and More!
- The Montana Sapphire Puzzle

Activities

- Geology Rocks!
- Flint knapping
- Dig it with an archaeologist
- Gold and sapphire panning field trip
- Fossil Collecting at the Ruby Reservoir
- Barite crystals near Basin
- Toll Mountain Minerals
- Prepare to prepare dinosaurs

The Mineral Museum received a grant to help fund the production of a DVD entitled “Butte, the Richest Hill on Earth.” The completed DVD consists of a 12-minute presentation discussing Butte’s geology and history, and will be shown in the Museum during the next biennium.

Plans for the 2004–2006 Biennium

Continued educational outreach to the schools and the community, and improvement in the mineral displays. Funds were obtained to develop a traveling display discussing geologic and navigational aspects of the Lewis and Clark Expedition in Montana. The Museum also will host a Sapphire Symposium during the summer of 2004 to coincide with the opening of a temporary display devoted to sapphires and rubies of the world.

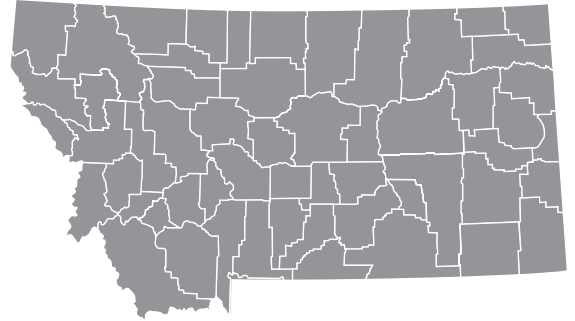
Project Title: A Rock by Any Other Name: Understanding Lewis and Clark’s Geography, Geology, and Navigation in Montana

Location: Statewide

Project Period: June 2004–June 2006

Project Leader: Ginette Abdo, Bob Bergantino

Funding Source: National Park Service, Montana Lewis and Clark Bicentennial Commission



Objective

The objective of this project is to develop a traveling exhibit that features important detailed geographic and geologic observations that Lewis and Clark made in Montana. Included in these products will be illustrations of their navigation equipment and techniques.

Approach

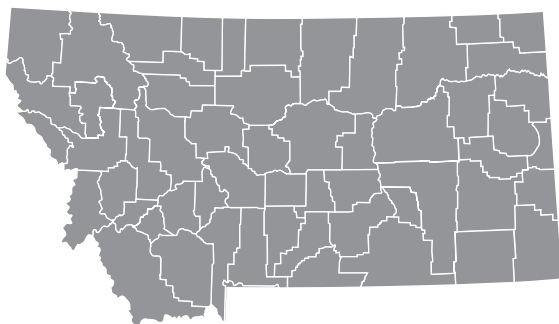
- (1) Develop a list of sites that Lewis and Clark visited and/or described
- (2) Visit selected sites and take photographs and collect samples where appropriate
- (3) Compile information on each site, including the Expedition’s journal entries
- (4) Prepare the traveling exhibit

Progress during the 2002–2004 Biennium

This is a new project and geologic/geographic information relating to the expedition was synthesized. Navigational information had been previously compiled.

Plans for the 2004–2006 Biennium

The plans for this biennium include visiting up to 8 geologic/geomorphic sites related to the Lewis and Clark Expedition, compiling all information, and completing the traveling display.



Project Title: Montana Seismograph Network and Earthquake Studies Office

Location: Statewide; a total of 38 seismograph stations collect ground motion data in western Montana.

Project Period: Operation of the Montana seismograph network is an ongoing project initiated in 1980.

Project Leader: Michael Stickney

Project Staff: One or two part-time student assistants

Funding Sources: MBMG, Confederated Salish and Kootenai Tribes (CSKT), U.S. Geological Survey, National

Institute of Safety and Health, and Incorporated Research Institutions for Seismology

Issue

Western Montana has a history of large, damaging earthquakes and remains seismically active. Many of these earthquakes (including the magnitude 6.8 quake north of Three Forks in 1925 and the 1935 magnitude 6.3 and 6.0 quakes that badly damaged Helena) occur at depth along faults that do not extend to the earth's surface. The seismic hazards associated with earthquakes on these "blind" faults cannot be evaluated with traditional geologic studies of faults and are best studied with data from a permanent network of seismograph stations. As the population and infrastructure of earthquake-prone western Montana continue to grow, the exposure to seismic hazards increases.

Objective

Monitor, analyze, and report on Montana earthquakes and use these data to evaluate seismic hazards. A better understanding of earthquake processes here in Montana and the faults along which they occur will increase our ability to prepare for and protect against the effects of future earthquakes.

Approach

A network consisting of 38 seismic monitoring stations is operated throughout western Montana, the most seismically active region of the State. Signals from 22 remote seismograph stations are transmitted directly to the MBMG using low-power FM radio links while signals from 12 other stations are transmitted to two remote nodes and sent to the MBMG via the Internet. Signals from regional U.S. National Network Stations, including four Montana stations operated cooperatively by the U.S. Geological Survey and the MBMG, are retrieved via satellite link and the Internet. Additional seismic data from stations in the surrounding region (Yellowstone Park, central Idaho, and southern Canada) are provided by other regional seismic monitoring centers. In total, the MBMG records 131 channels of seismic data from 71 local and regional stations. Using the data from this extensive seismograph network, the times, locations, and magnitudes of earthquakes are determined and cataloged. Significant local and regional earthquakes are reported to appropriate State and Federal agencies (Montana Disaster and Emergency Services, Montana Dam Safety Program, Confederated Kootenai and Salish Tribes Dam Safety Program, and U.S. Geological Survey), the public, and the media. A listing of recent earthquakes is available via the Bureau's Earthquake Studies Office website (<http://mbmgquake.mtech.edu/>).

Progress during the 2002-2004 Biennium

- (1) Data from the Montana seismograph network were used to locate and catalog over 2060 earthquakes with magnitudes ranging from less than 1.0 to 3.7 in western

Montana between January 2003 and September 2004. The largest Montana earthquake during this period was of magnitude 3.7 on January 9, 2003, centered in the Crazy Mountains northwest of Big Timber. No damage was reported. A total of 20 earthquakes had magnitudes of 3.0 or greater during this time period and 12 earthquakes were reported to the MBMG as being felt.

- (2) The collaborative effort between MBMG and the CSKT continues to successfully operate the Flathead seismic network, representing the northwestern segment of the Montana seismograph network. Data from this seven-station network vastly improve seismic monitoring coverage in northwest Montana. The CSKT also provide generous support for operation of seismic stations in the Missoula region and analysis of northwest Montana seismicity. A site in the central Mission Valley is currently being permitted for a second digital seismograph station, with installation planned for as soon as possible after receiving the permit.
- (3) Installed a new, telemetered seismograph station in the Bitterroot Valley near Victor on September 16–17, 2004.
- (4) The Earthquake Studies Office continues to use the Earthworm data acquisition system. Using this PC-based system, seismic data from the Flathead Valley, Missoula area, and southwest Montana are continuously recorded at the Earthquake Studies Office in Butte. Seismic data are shared in real-time with other seismic monitoring centers including the U.S. Geological Survey, the University of Utah (which operates the Yellowstone network), BYU Idaho, Idaho National Engineering and Environmental Laboratory, University of Washington, and the Canadian Geological Survey. Seismic waveforms and automatically determined event locations are posted to the MBMG website, updated every 5 minutes.
- (5) Completed a cooperative project with the U.S. Geological Survey and the Incorporated Research Institutions for Seismology to install two modern broadband seismographs in eastern Montana as part of the U.S. National Seismic Network. A station in extreme northeastern Montana near Dagmar was installed in June 2003 and became operational in July 2004. A seismic station in southeast Montana near Miles City was reopened in July 2004. The Miles City station was part of the Large Aperture Seismic Array operated by the US Air Force in the 1960s and early 1970s to detect underground nuclear explosions. The old seismic vault needed extensive renovation before it was suitable for use as a modern broadband seismic recording site.

Plans for 2004–2006 Biennium

The Earthquake Studies Office will continue to study and report on Montana earthquakes using data from the Montana seismograph network and provide information about earthquakes, faults, and seismic hazards in Montana. We plan to implement new data analysis software that will make earthquake analysis more timely and efficient. We will continue to cooperate with the U.S. Geological Survey to establish two additional high-quality U.S. National Seismic Network stations in central Montana, where seismic monitoring coverage is currently limited. Strong motion seismographs operated by the U.S. Geological Survey's National Strong Motion Program will be integrated into the Montana seismograph network. We plan to submit new probabilistic Montana ground motion maps and the accompanying report for publication by MBMG.

Information Products

- Bartholomew, M.J., Greene, R.A., Wasklewicz, T.A., and Stickney, M.C., in press, Alluvial fans: sensitive tectonic indicators of fault-segmentation and stress-field partitioning along the Red Rock fault, southwestern Montana, USA: submitted to Geological Society of America Bulletin.
- Denton, D., Stickney, M., Williams, T., and Langston, R., 2003, Remote monitoring of mine seismicity and earthquakes using radio telemetry, computers and the Internet; *in* Singhal, R., Fytas, K., and Chiwetelu, C., eds., Proceedings of the Fourth International Conference on Computer Applications in the Minerals Industries (CAMI2003), published on CD (URL: <http://www.mpes-cami-swemp.com/ordercd.html>).
- Derkey, R.E., Watson, S.M., Bartholomew, M.J., Stickney, M.C., and Downey P.J., 2004, Geologic map of the Deer Lodge 15' quadrangle, southwest Montana: Montana Bureau of Mines and Geology Open-File Report 271 (digital version of 1993 map), 2 plates, 23 p.
- Stickney, M.C., and Lageson, D.R., 2004, Active tectonics and strain partitioning in the northern Intermountain Seismic Belt: Basin and Range Province Seismic Hazards Summit II Program and Abstracts, p. 140–143.
- Wong, I., Olig, S., Dober, M., Wright, D., Nemser, E., Lageson, D., Silva, W., Stickney, M., Lemieux, M., and Anderson, L., (2004), Probabilistic earthquake ground motion hazard maps for Montana: Proceedings of the Basin and Range Province Seismic Hazards Summit, 2004.

Project Title: Compilation and Publication of a Landslide Location Map and Index

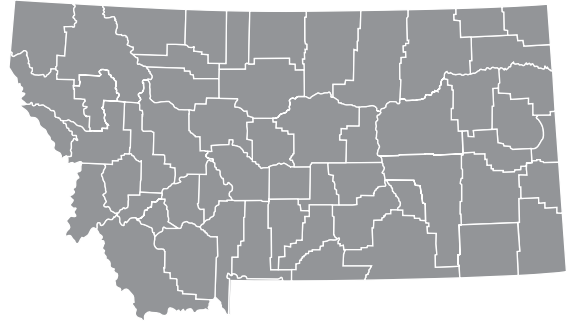
Location: Statewide

Project Period: 2000–2003

Project Leader: Edith M. Wilde

Project Staff: Pat Kennelly, GIS Specialist; David Lopez, Geologist

Funding Sources: Montana Department of Transportation (MDT), Montana Bureau of Mines and Geology (MBMG)



Issue

Many areas of Montana are prone to earth movement. Where these events occur in proximity to human-made structures, remediation can be expensive. Anything affecting slope stability, including seismic activity and construction, can activate sliding. Many areas of Montana are undergoing rapid development and growth, and information about hazards facing developers is needed. In past work, MBMG has plotted landslide locations at various scales, but funding has never permitted development of a systematic index and database.

Objectives

The primary goal of the program is to convert existing landslide data into a published format useful to the public. This project is an initial step to accomplish a systematic statewide compilation.

Approach

Data from multiple sources were compiled into a digital database that provides a catalog of each landslide location, from which digital maps can be created. We will identify formations or lithologies prone to earth movements, and underlying mechanisms of movement where possible.

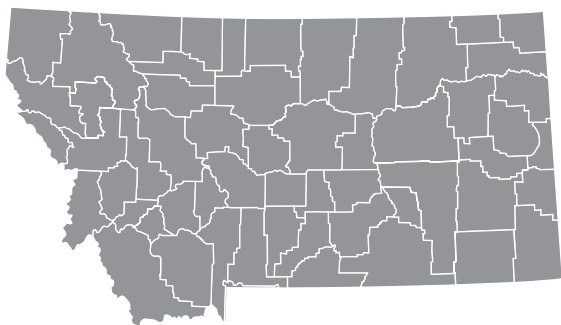
Progress during the 2002–2004 Biennium

Work began on July 1, 2000. Work for MDT's District 2 has been completed.

Information Products

- Public release of a database that enables interactive creation of maps showing locations and types of earth movements for MDT District 2. Copies of the database are housed at MDT and MBMG, and will continue to be updated by MBMG as new data become available. Maps can be generated to readily identify high-risk areas where earth movement is currently active or has been active in the past.
- A summary describing the project and the results was published in 2002 by MDT as Report of Investigation FHWA/MT-02-007/8150, and by MBMG in 2003 as Open-File Report 472.

Mines and Mining Impacts



Project Title: Small Mine Operators Assistance Program

Location: Statewide

Project Period: Ongoing since the 1950s

Project Leader: Robin McCulloch

Project Staff: Robin McCulloch, assisted by Bureau staff as needed

Funding Sources: Montana Bureau of Mines and Geology and private donations

Issue

Small mine operations lack sufficient cash flow to support technical staff. This often leads to inefficient operation, premature closure, and environmental problems.

Objective

Provide technical assistance, contacts, and guidance to ensure the wise use of resources and minimize environmental problems. The priority is strengthening the economic health of small mining enterprises without damage to the environment.

Approach

The Staff Mining Engineer regularly visits mining operations across the State. Contacts are typically made as referrals from other miners or State and Federal regulatory agencies. Technical services typically include operational instruction, feasibility assistance, geologic mapping, surveying, sampling instruction, mine design, reclamation planning, permitting guidance, and contacts to qualified consultants.

Progress during the 2002–2004 Biennium

Properties were visited throughout western Montana. The main focus of the field time was the mineral belt north and south of Butte. In Montana larger scale gold placer operations have dwindled for many years, while interest at the hobby scale has increased dramatically. A number of instructional talks have been given to groups of recreational miners, reaching approximately 700 miners per year. Numerous individuals were assisted with writing permits for exploration and development of mine plans, and many miners have received assistance in understanding permitting, data collection, claim staking, and many other aspects of the mineral industry.

A new book on placer evaluation was completed (MBMG Special Publication 115). This publication is aimed at providing systematic methods to standardize the analysis of placer deposits.

Plans for the 2004–2006 Biennium

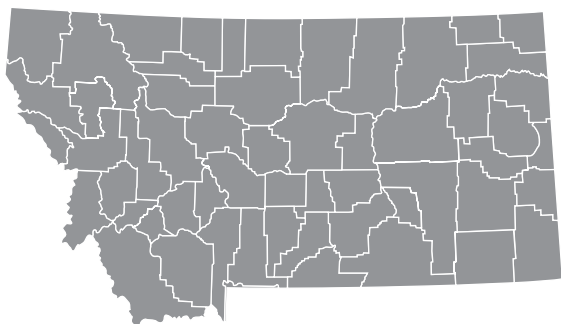
Demand for these services will accelerate with increasing commodity prices and the requirements for more stringent permitting. The workload increased by 20% in the past year and is projected to continue to grow.

Information Products

McCulloch, Robin, Lewis, Bob, Keill, Don, and Shumaker, Matthew, 2004, Applied gold placer exploration and evaluation techniques: Montana Bureau of Mines and Geology Special Publication 115, 267 p.

Users of this Information

- Mine operators
- Prospectors
- Hobbyists
- State and Federal agencies



Project Title: Mineral Information and Statistics Program

Location: Statewide

Project Period: Ongoing

Project Leader: Robin McCulloch

Project Staff: One part-time research aide

Funding Sources: Montana Bureau of Mines and Geology

Issue

Mineral information and statistical data are needed by State and Federal agencies, industry, industry support companies, and private citizens.

Objective

To gather and compile data that provide statistics on Montana's mineral industry.

Approach

Data are secured from companies and individuals where available; mine maps are generated on properties as access is secured; production records on the larger companies are gathered by the U.S. Geological Survey and shared with the MBMG; and data on smaller operations are gathered by the MBMG. Files of both current and historic data are gathered and maintained in an archive. Staff members publish reports on the industry, present papers, and answer specific requests for mineral data.

Progress during the 2002–2004 Biennium

The historic mine map collection and the mineral property files have been inventoried. Extensive collections of data, representing millions of dollars of expenditures, have been received as donations on various and sundry properties across the State. Although letters and visits are still common (over 300 of each), the trend in requesting data is rapidly going to computer-related inquiries. Hundreds of telephone requests and over a thousand e-mail requests for data were processed. Mineral-potential reports for conservation easements were completed for Montana Fish Wildlife and Parks as well as for Federal agencies and organizations such as the Rocky Mountain Elk Foundation. With many Federal agencies updating their planning documents, a new series of GIS maps were prepared outlining locations of mineral potential of metal, industrial, and placer deposits, as well as leaseable commodities, in southwestern Montana.

Plans for the 2004–2006 Biennium

The focus of activities will continue to be in gathering data as it becomes available. More effort will be put into converting paper files into electronic files in easily retrievable databases. Requests for information are expected to increase significantly in the biennium.

Information Products

McCulloch, R., 2003, Annual Review 2002, State Activities, Montana: Mining Engineering, v. 55, no. 5, p. 80–81.

McCulloch, R., 2004, Annual Review 2003, State Activities, Montana: Mining Engineering, v. 56, no. 5, p. 75–76.

Project Title: Post-Mine Reclamation Monitoring on High Ore Creek, Southwestern Montana

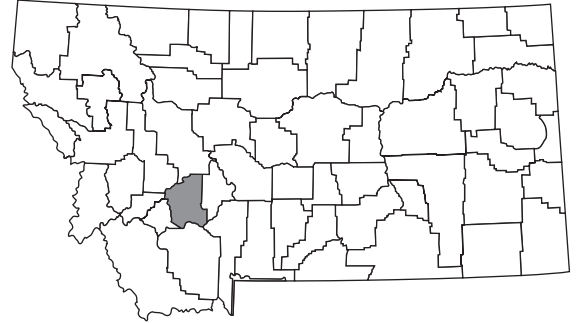
Location: High Ore Creek, Jefferson County

Project Period: April 1999–May 2003

Project Leader: James Madison and Butch Gerbrandt (Montana Tech)

Project Staff: Mike Kerschen and graduate student research assistants

Funding Sources: U.S. Bureau of Land Management (BLM), Montana Department of Environmental Quality (DEQ)



Issue

The BLM and DEQ completed extensive land reclamation of mill tailings and waste dumps at the Comet Mine and along High Ore Creek that were impairing the water quality in High Ore Creek. The reclamation, however, did not result in the removal of all tailings and waste. The BLM and DEQ are interested in documenting the effectiveness of the reclamation and identifying any other areas that may have deteriorating water quality and that may need reclaiming.

Objective

Post-reclamation water-quality monitoring of High Ore Creek is the primary objective of this project. Another objective is the training of Montana Tech graduate students in concepts of water-quality monitoring. With this experience graduate students are able to obtain applied geoscience experience and complete the necessary requirements for their graduate degrees.

Approach

Collect water samples during spring runoff and late summer base flow and analyze them for major ions and trace elements. Measure stream flow at each sampling location and calculate loading for the constituents of concern. Prepare a report summarizing the findings.

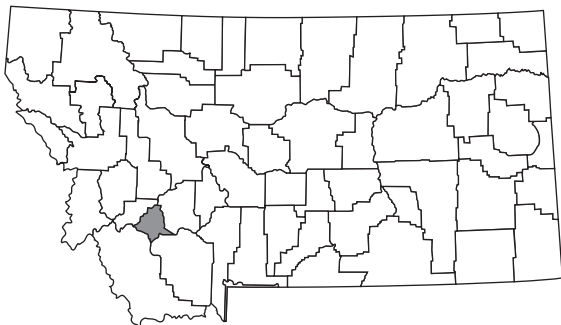
Progress during the 2002–2004 Biennium

Field investigations and data collection have been completed in this biennium. Final reports were completed for the 2002 and 2003 field seasons.

Information Products

Horne, D., Gerbrandt, B., and Madison, J., 2003. High Ore Creek post-reclamation water sampling and analyses: Letter report to BLM, 136 p.

Woods, J., Gerbrandt, B., and Madison, J., 2004. High Ore Creek post-reclamation surface water sampling data summary report: Letter report to BLM, 198 p.



Project Title: Natural Resource Damage Assessment—Butte Area

Location: Butte, Montana

Project Period: Ongoing since May 1991

Project Leaders: Ted Duaime, John Metesh, and James Madison

Funding Source: Montana Department of Justice
Issue

There have been multiple and continuous releases of hazardous substances from mining, milling, and other industrial sources to the upper Clark Fork River basin. The resources affected by these releases include air, surface water, ground water, soils, benthic macroinvertebrates, fish, wildlife, and wildlife habitat.

Objective

To provide the State with the best available information pertaining to ground-water flow and quality related to the Butte Area Superfund site and the Montana Pole Treatment Plant Superfund site.

Approach

The MBMG participated in the assessment of injury to ground water in the Butte area related to mining and at the Montana Pole Treatment Plant in Butte. The MBMG further participated in preparation of restoration alternatives for the Butte area.

Progress during the 2002–2004 Biennium

A recent report by the U.S. EPA has made claims as to the rate of ground-water flow and the migration of contaminated ground water through the alluvial aquifer in the upper Silver Bow Creek drainage. The Montana Department of Environmental Quality and the Montana Department of Justice solicited comments from the MBMG as to these claims; written comments were provided to the agencies in December of 2003. In those comments, the MBMG expressed great concern as to the interpretation of ground-water and geochemistry data. Specific areas of concern include:

- historic ground-water flow patterns before and after the Berkeley Pit was mined,
- ground-water travel rates which are based on the physical properties of the aquifer material (hydraulic conductivity, hydraulic gradient, and porosity),
- migration rates of contaminants which are based largely on the ground-water travel rates, and
- the ability of the natural aquifer to recover with respect to water quality should there be a complete removal of contaminant sources (tailings)

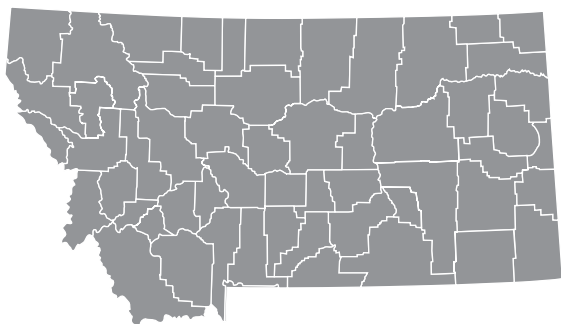
Plans for the 2004–2006 Biennium

The MBMG will be collecting additional data on the Butte Area, Silver Bow Creek portion of the claim.

Information Products

Metesh, J. J., 1995, Clark Fork natural resource damage assessment—groundwater: Montana Pole Treatment Plant ground water injury assessment, Butte, Montana: Montana Department of Health and Environmental Sciences (now DEQ), January 1995, 40 p.

- Maest, A. S., and Metesh, J. J., 1995, Butte groundwater injury assessment report—Clark Fork River Basin NPL sites, Montana: Montana Department of Health and Environmental Sciences (now DEQ), January 1995, 120 p.
- Metesh, J.J., and Madison, J.P., 2004, Summary of investigation, Upper Silver Bow Creek, Butte, Montana: Montana Bureau of Mines and Geology Open-File Report 507, 6 p.



Project Title: Abandoned and Inactive Mines Inventory and Preliminary Assessment

Location: U.S. Forest Service (USFS) lands and U.S. Bureau of Land Management (BLM) lands statewide

Project Period: USFS: May 1992–ongoing; BLM: October 1, 1993–ongoing

Project Leader: John Metesh

Project Staff: Phyllis Hargrave, Ted Duaime, Mike Ker-shen, Katie McDonald

Funding Sources: USFS, BLM

Issue

The abandoned and inactive mines on USFS and BLM lands in Montana need to be inventoried, and preliminary screening and assessments conducted.

Objectives

To collect accurate location, water, and solid chemistry data; to conduct a preliminary screening of sites on USFS and BLM lands; and to compile existing and new data in a database.

Approach

- (1) Use existing information from other databases, the literature, and MBMG files to identify sites for investigation.
- (2) Conduct a field inventory and preliminary screening of sites on USFS and BLM lands.
- (3) Conduct a preliminary assessment, including sampling, of all sites identified in the preliminary screening as having a potential for health or environmental impacts.
- (4) Compile all information into a database.
- (5) Prepare reports for each drainage in each forest (USFS) and resource area (BLM).

Progress during the 2002–2004 Biennium

The inventories of all mines and mills that are on or affecting USFS- and BLM-administered lands are complete. Final reports for all the National Forests and BLM Resource areas in Montana are available.

Plans for the 2004–2006 Biennium

Preliminary work has begun on the compilation of information related to placer mines. A field inventory may be initiated during this biennium. The database of mine and mill sites, as well as site characteristics, will be maintained.

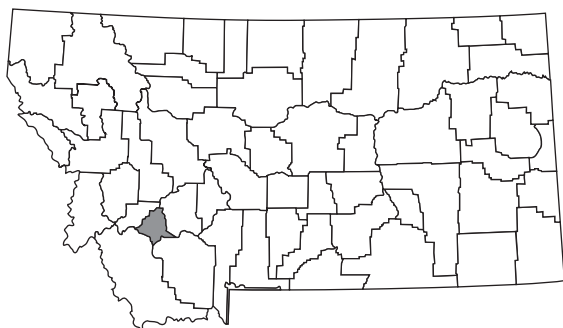
Information Products

Metesh, J.J., Lonn, J., Duaime, T.E., and Wintergerst, R., 1994, Abandoned-inactive mines in the Deerlodge National Forest, v. I: Basin Creek drainage, April 1994: Montana Bureau of Mines and Geology Open-File Report 321, 123 p.

Metesh, J.J., Lonn, J., Duaime, T.E., Marvin, R.K., and Wintergerst, R., 1995, Abandoned-inactive mines in the Deerlodge National Forest, v. II: Cataract Creek drainage, May 1995: Montana Bureau of Mines and Geology Open-File Report 344, 163 p.

Marvin, R.K., Metesh, J.J., Lonn, J., Madison, J.P., and Wintergerst, R., 1995, Abandoned-inactive mines in the Deerlodge National Forest, v. III: Flint Creek and Rock Creek drainages, December 1995: Montana Bureau of Mines and Geology Open-File Report 345, 173 p.

- Madison, J.P., Lonn, J., Marvin, R.K., Metesh, J.J., and Wintergerst, R., 1996, Abandoned-inactive mines in the Deerlodge National Forest, v. IV: Upper Clark Fork River drainage, July 1996: Montana Bureau of Mines and Geology Open-File Report 346, 165 p.
- Metesh, J.J., Lonn, J., Marvin, R.K., Madison, J.P., and Wintergerst, R., 1996, Abandoned-inactive mines in the Deerlodge National Forest, v. V: Jefferson River drainage, July 1996: Montana Bureau of Mines and Geology Open-File Report 347, 157 p.
- Marvin, R.K., Metesh, J.J., Hargrave, P.A., Lonn, J., Watson, J.E., Bowler, T.P., and Madison, J.P., 1997, Abandoned-inactive mines of Montana U.S. Bureau of Land Management, July 1997: Montana Bureau of Mines and Geology Open-File Report 348, 513 p.
- Metesh, J.J., and Duaime, T.E., 1997, Abandoned-inactive mines in Montana—1996, January 1997: Montana Bureau of Mines and Geology Special Publication 111, scale 1:750,000.
- Metesh, J.J., Lonn, J., Marvin, R.K., Hargrave, P.A., and Madison, J.P., 1998, Abandoned-inactive mines in the Helena National Forest, v. I: Upper Missouri River drainage, May 1998: Montana Bureau of Mines and Geology Open-File Report 352, 195 p.
- Hargrave, P.A., Bowler, T.P., Lonn, J., Madison, J.P., Metesh, J.J., and Wintergerst, R., 1998, Abandoned-inactive mines in the Helena National Forest, v. II: Blackfoot and Little Blackfoot River drainages, February 1998: Montana Bureau of Mines and Geology Open-File Report 368, 181 p.
- Marvin, R.K., Hargrave, P.A., Lonn, J., Abdo G.N., Metesh, J.J., and Bump, K., 1998, Abandoned-inactive mines in the southern Beaverhead–Deerlodge National Forest, September 1998: Montana Bureau of Mines and Geology Open-File Report 379, 322 p.
- Hargrave, P.A., Kerschen, M.D., McDonald, Catherine, Metesh, J.J., Norbeck, P.M., and Wintergerst, Robert, 2000, Abandoned-inactive mines on Gallatin National Forest land: Montana Bureau of Mines and Geology Open-File Report 418, 77 p.
- Kerschen, M.D., Hargrave, P.A., McDonald, Catherine, Metesh, J.J., and Wintergerst, Robert, 2000, Abandoned-inactive mines on Custer National Forest-administered land: Montana Bureau of Mines and Geology Open-File Report 421, 59 p.
- Hargrave, P.A., Kerschen, M.D., Liva, G.W., Lonn, J.D., McDonald, Catherine, Metesh, J.J., and Wintergerst, Robert, 2000, Abandoned and inactive mines on Lewis and Clark National Forest-administered land: Montana Bureau of Mines and Geology Open-File Report 413, 132 p.
- McDonald, C., Hargrave, P.A., Kerschen, M.D., Metesh, J.J., and Wintergerst, R., 2002, Abandoned-inactive mines on Flathead National Forest-administered land, July 2002: Montana Bureau of Mines and Geology Open-File Report 462, 68 p.
- Hargrave, P.A., Kerschen, M.D., McDonald, C., Metesh, J.J., and Wintergerst, R., 2003, Abandoned-inactive mines on Lolo National Forest-administered land, April 2003: MBMG Open-File Report 476, 228 p.
- Hargrave, P.A., McDonald, C., Kerschen, M.D., Metesh, J.J., and Wintergerst, R., 2003, Abandoned-inactive mines on Bitterroot National Forest-administered land, October 2003: Montana Bureau of Mines and Geology Open-File Report 484, 93 p.



Project Title: Montana Pole Treatment Plant, Bioremediation of Soils, Environmental Monitoring, and Operation of Water Treatment Plant

Location: Silver Bow County

Project Period: Ongoing since 1995

Project Leaders: Ted Duaime, Tom Bowler

Project Staff: Pam Newbrough, Bill Henne, and James Rose

Funding Source: Montana Department of Environmental Quality (MDEQ)

Issue

The Montana Pole Treatment Plant Superfund site is the location of a former wood-treating facility that operated from 1946 to 1985. Contamination of soils, ground water, and Silver Bow Creek has occurred as a result of discharges of solutions used in the treatment process. Primary chemicals of concern are diesel fuel and pentachlorophenol (PCP). The State of Montana, U.S. Environmental Protection Agency, and Montana Department of Justice have reached a settlement with the responsible parties. Remedial actions on the north portion of the site have been completed and work is underway on the south portion of the site. Potential work to remove formerly inaccessible contaminants beneath the interstate highway bisecting the site is being evaluated. Contaminated soils removed during north side cleanup have been treated to concentrations well below specified levels and have been returned to the north side and covered. The first two lifts of south side soils have also been treated and backfilled and a third is ready for backfilling. Monitoring of contamination levels in air, soil, and water are required to ensure that no additional release of contaminants occurs that might affect adjacent residential homes, Silver Bow Creek, or uncontaminated ground water. Significant improvements in contaminants levels have been measured over the period of treatment.

Objective

Assist the State of Montana in the development and set-up of an environmental monitoring network to ensure there is no off-site migration or release of site contaminants. Operate site water-treatment plant and perform monitoring and sampling activities to establish contaminant levels. Provide all environmental monitoring during site cleanup and construction activities.

Approach

Develop and implement a monitoring plan for the organization and implementation of this remedial action plan. Monitor particulate levels from site construction and demolition activities as well as PCP concentrations. Collect monthly samples of removed soils, residual soil, surface water (Silver Bow Creek), and ground water to test PCP concentrations; collect samples as necessary to aid construction activities. Conduct bi-weekly monitoring of ground-water levels and thickness of free product (PCP and diesel fuel) on top of the water table. Modify the existing carbon-activated treatment plant to handle changes in bioremediation. Monitor influent and effluent flows and PCP levels daily and bi-weekly to ensure ground water being pumped is treated adequately for the removal of organic compounds.

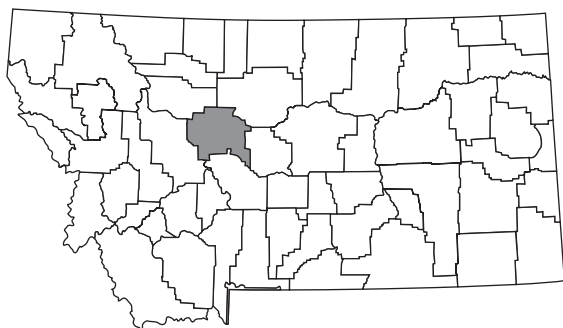
Progress during the 2002-2004 Biennium

Phase III: all planned remedial action construction activities have been completed, and long-term operation and maintenance activities are ongoing. Additional construction work may

take place in 2006 in cooperation with interstate highway improvements on the site. Environmental monitoring continues of site soils, ground water, local surface water, and air quality. Three lifts of treated soils were backfilled and additional excavated soils from south side construction remain on the Land Treatment Unit for treatment. In situ treatment systems for enhanced recovery of residual contaminants were installed on both the north and south portions of the site. This system has been tested and is currently being evaluated for its treatment effectiveness before further operations are conducted.

Information Products

Interim reports (monthly) and data compilations, with results of environmental monitoring and sampling, were submitted to the MDEQ. An electronic database is being constructed for storage of environmental data and to aid in the transfer of data to the MDEQ Clark Fork data management unit. An annual report summarizing monitoring and sampling results has been prepared and under review.



Project Title: Belt, Montana, Acid Mine Drainage Problem: Development of a Three-Dimensional GIS Model and Baseline Monitoring

Location: Cascade County

Project Period: 2003–2006

Project Leader: Ted Duaime

Project Staff: Mike Kerschen, Peter Norbeck, Susan Vuke, Kenneth Sandau

Funding Source: Montana Department of Environmental Quality (MDEQ)

Issue

Drainage of acidic, metal-laden water from abandoned underground coal mines in the Great Falls–Lewistown Coal Fields has been a long-term, ongoing problem. Drainage from the Castner–Anaconda Coal Mine at Belt has caused considerable environmental damage to Belt Creek. Previous methods of mitigation, i.e., adit plugging and construction of wetlands, have failed.

Objective

Develop a three-dimensional model using available information to better understand the local geology, hydrogeology, and extent of the mine workings. Initiate a monitoring program to collect data on mine discharge quality and quantity, along with quality and quantity information for the Box Elder Creek drainage.

Approach

Compile existing information on mine workings, exploration drilling, local and regional geology, and hydrogeology into various coverages for creation of a three-dimensional GIS model. Establish monitoring locations on mine discharges and background sites.

Progress during the 2002–2004 Biennium

Created an initial three-dimensional model, identified areas where additional data are necessary, and collected one full season of water quality and quantity data.

Plans for the 2004–2006 Biennium

Develop and implement a drilling program to collect additional geologic and hydrologic information, i.e., depth to coal, and identify various water-bearing zones above the coal seam. Continue and expand the existing monitoring program for the collection of water level, quality, and quantity information.

Information Products

Duaime, T.E., Sandau, K.L., Vuke, S.M., Hanson, Jay, Reddish, Shawn, Reiten, J.C., 2004, Reevaluation of the hydrologic system in the vicinity of the Anaconda Mine at Belt, Cascade County, Montana: Montana Bureau of Mines and Geology Open-File Report 504, 116 p.

Interim reports (monthly) are submitted to MDEQ and a final report will be completed and submitted.

Project Title: Butte Mine Flooding Long-Term Monitoring Program

Location: Silver Bow County

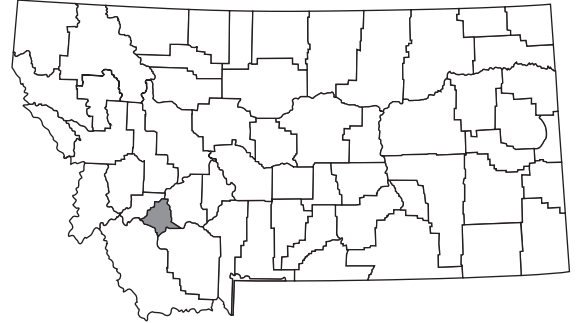
Project Period: Ongoing since 1987

Project Leader: Ted Duaime

Project Staff: John Metesh, James Rose, Mike Kerschen, Pete Norbeck, and Marvin Miller

Funding Source: Montana Department of Environmental Quality (MDEQ) and U.S. Environmental Protection Agency (EPA). The regulatory agencies reached a settle-

ment agreement with British Petroleum/Atlantic Field and Montana Resources Group that provides funding for this continued monitoring.



Issue

Rising ground-water levels in and adjacent to the abandoned underground mines and the Berkeley Pit as a result of the 1982 suspension of mining. The rising ground water is acidic and highly contaminated with trace metals.

A second problem occurred with the suspension of mining by Montana Resources in 2000. Water previously used in mining operations was allowed to flow into the Berkeley Pit, thus increasing its rate of rise. Also, water began to fill the Continental Pit. Montana Resources began mining operations again in the fall of 2003.

Objective

Provide assistance to the State of Montana (Department of Environmental Quality) and the EPA in the collection of water-level and water-quality data, collect additional data associated with the suspension of mining, and provide results of monitoring and sampling activities to the general public. Review and evaluate data, identify changes and trends, and provide an annual update to the State, the EPA, and the public.

Approach

Monitor the flow rate and water quality of the surface water entering the Berkeley Pit as a result of the 2000 suspension of mining.

Maintain a network (over 100 sites) of monitoring wells and mine shafts throughout the Butte basin. Collect weekly and monthly water-level data and semi-annual water-quality data. Compile and evaluate newly collected data for distribution to interested parties, e.g., local government and citizens, and prepare an annual update on water levels, water-quality conditions, and the effects, if any, on local ground water and/or surface water in the area.

Progress during the 2002–2004 Biennium

Assisted the U.S. Department of Justice, EPA, and MDEQ with technical issues during Consent Decree negotiations with potentially responsible parties. Negotiations resulted in a settlement that provides money for the long-term monitoring and sampling costs plus the construction and operation of a water-treatment plant.

Evaluated the integrity of the bedrock-monitoring wells with the intent to provide early identification of potential well corrosion or other casing problems. This can provide the opportunity to refurbish problem wells instead of complete abandonment and replacement with new wells. Incorporated data collected during fiscal year 2002–2003 into existing databases and provided updates to interested parties on a monthly basis. Collected and analyzed water-quality samples from selected wells, surface waters, the Berkeley Pit, and mine shafts. Data were reviewed for changes in trends from previous results and added to the database. Con-

tinued an evaluation on the flow (quantity) and quality of ground water entering the Berkeley Pit. Prepared separate reports evaluating trends in water levels and water quality since flooding began in 1982.

Plans for the 2004–2006 Biennium

With the negotiated Consent Decree, the MBMG assumed responsibility for the long-term water level and water quality-monitoring program. Automated monitoring equipment has been installed at 26 sites. Monitoring of the flow and quantity of water from the Horseshoe Bend drainage will continue.

Continue to review and analyze collected data and prepare annual updates on water levels and water quality. Perform annual evaluation of bedrock well integrity by down-hole camera methods.

Participate in Butte Silver Bow education program for the dissemination of information to the public. Collect bulk water samples from the Berkeley Pit for technology evaluations. New data will be entered into the existing databases.

Information Products

Interim reports (monthly) are submitted to the MDEQ.

Duaime, T.E., Metesh, J.J., 2003, Twenty years of water-level and water quality sampling, Butte underground mines and Berkeley Pit, 1982–2001, Montana Bureau of Mines and Geology Open-File Report 473, 115 p.

Duaime, T.E., Metesh, J.J., 2004, 2002 update of water-level monitoring and water-quality sampling, Butte underground mines and Berkeley Pit, Butte, Montana, 1982–2002: Montana Bureau of Mines and Geology Open-File Report 489, 243 p.

Duaime, T.E., Kennelly, P.J., and Thale, P.R., 2004, Butte, Montana: Richest hill on Earth: 100 years of underground mining: Montana Bureau of Mines and Geology Miscellaneous Contribution 19, scale 1:9,000.

Project Title: Recharge Assessment of the Anaconda Mine near Belt, Montana

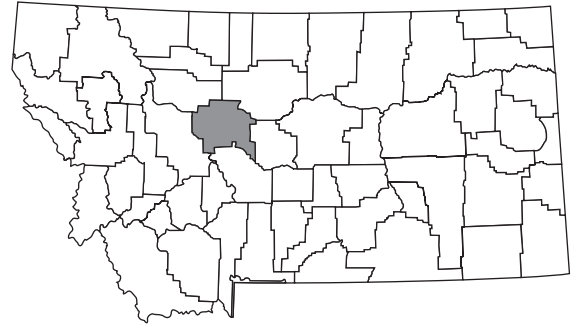
Location: Belt, Montana and nearby area

Project Period: August 1, 2002–December 31, 2004

Project Leader: Jon Reiten

Project Staff: Shawn Reddish, MSU-B students, Town of Belt

Funding Sources: Montana Department of Environmental Quality (DEQ) 319 program, DEQ Abandoned Mine Program, Montana Water Center



Issue

Decades of underground coal mining have resulted in acid mine drainage (AMD), which is contaminating ground-water and surface-water resources at Belt. Although mining ended about 50 years ago, water with a pH of 2.94 is still issuing from mine workings near town. The acid mine drainage is lowering the pH of Belt Creek and increasing trace metals concentration in the stream. The Creek cannot support fish below Belt and is discharging acidic, metal-laden water to the Missouri River.

Objective

By age-dating ground water and mapping ground-water flow, the recharge source entering the mine may be determined. The overall goal is to restore the water quality of Belt Creek by reducing pollution, improving stream habitat, restoring native fish populations, and improving ground-water quality of the alluvial aquifer by improving the quality of the recharge. The goal of this project is to define the hydrogeologic regime in the vicinity of Belt so that recharge to old mine workings, the source of acid mine drainage, can be delineated with a reasonable level of certainty.

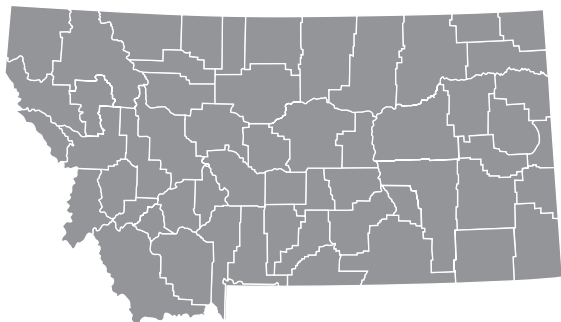
Approach

Age-dating the water by testing for tritium and chlorofluorocarbons will provide useful information for determining the source of recharge to abandoned mine workings so that best-management practices can be developed to reduce generation of acidic discharges. Hydrogeologic data and water-quality information will be used to calculate changes in recharge rates, ground-water flow rates, and AMD discharges under various scenarios and combinations of cropping, dewatering, and other techniques found to be appropriate.

Progress during the 2002–2004 Biennium

Well and spring inventories, streamflow monitoring, water-level monitoring in selected wells, geologic mapping, ground-water flow mapping, water-quality sampling, and age dating of selected water sources have been completed. The data are currently being evaluated for a final report. Recommendations to help mitigate the acid drainage problems are being developed. The most likely option appears to be one that will reduce recharge into the mine workings.

Ground-Water Conditions and Special Studies



Project Title: Montana Ground-Water Monitoring Network

Location: Statewide

Project Period: Ongoing

Project Leader: Tom Patton

Project Staff: Don Mason, Mike Richter, Clay Schwartz, Leonard Rinehart

Funding Sources: Montana Bureau of Mines and Geology, Ground-Water Assessment Program

Issue

Similar to streamflow and precipitation data, ground-water level and water-quality measurements must be collected during long periods of time to be useful. Long-term data allow managers and others to determine normal water levels in wells, changes in water levels relative to climatic conditions, responses of water levels to development, and long-term water-quality trends.

Objective

Create a network of water wells from which water-level and water-quality data can be collected and that will provide information on most areas and aquifers in Montana.

Approach

Strategically located water wells are periodically measured for water levels and sampled for water quality. In October 2004, there were 856 wells in the network and 90 operating water-level recorders. Water-level data are placed in the Ground-Water Information Center (GWIC) database shortly after measurements are made and are easily retrievable by the citizens of Montana.

Progress during the 2002–2004 Biennium

Quarterly water-level data were obtained for fiscal years 2002 and 2004 and water-level recorders were maintained. Water-quality samples were collected and processed from 159 wells. Water-level and water-quality data were placed in the Ground-Water Information Center database. Between July 1, 2002 and June 30, 2004 about 1,100 hydrographs were downloaded monthly from GWIC.

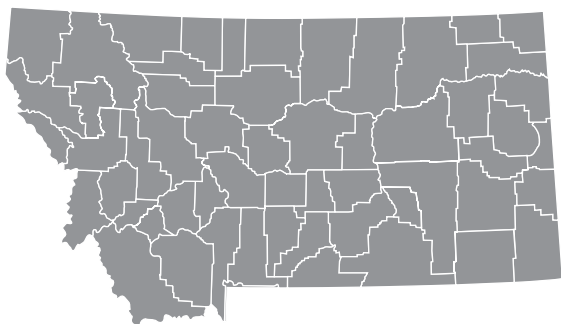
Plans for the 2004–2006 Biennium

Wells within the monitoring network will be measured quarterly and water-level recorders will be serviced. Between 70 and 100 water-quality samples will be collected each year. Samples will be collected from selected water-level routes so that the chosen routes will have a common sampling date. Normalizing sampling dates by route will make future re-sampling of network wells more efficient. Data collected will be placed in the Ground-Water Information Center database and be retrievable through the GWIC website.

Information Products

Data collected from the monitoring network can be retrieved from the GWIC databases at <http://mbmggwic.mtech.edu>, by sending an email note to gwic@mtech.edu, or by contacting the Information Center by telephone at 406-496-4336.

- Patton, T.W., 2002, Water level monitoring and drought: April–June 2002: Montana Bureau of Mines and Geology Ground-Water Information Center water-level monitoring report.
- Patton, T.W., 2002, Water level monitoring and drought: July–September 2002: Montana Bureau of Mines and Geology Ground-Water Information Center water-level monitoring report.
- Patton, T.W., 2002, Water level monitoring and drought: October–December 2002: Montana Bureau of Mines and Geology Ground-Water Information Center water-level monitoring report.
- Patton, T.W., 2003, Water level monitoring and drought: January–March 2003. Montana Bureau of Mines and Geology Ground-Water Information Center water-level monitoring report.
- Patton, T.W., 2003, Water level monitoring and drought: July–October 2003. Montana Bureau of Mines and Geology Ground-Water Information Center water-level monitoring report.
- Patton, T.W., 2004, Water level monitoring and drought: January–March 2004. Montana Bureau of Mines and Geology Ground-Water Information Center water-level monitoring report.



Project Title: Montana Ground-Water Information Center (GWIC)

Location: Statewide

Project Period: Ongoing

Project Leader: Tom Patton

Project Staff: Luke Buckley, student assistants

Funding Sources: Montana Bureau of Mines and Geology, Ground-Water Assessment Program

Issue

Ground-water information generated by projects, water-well drilling, water-quality sampling, and other activities must be accurately stored but easily accessible. There is increasing demand for ground-water data by government agencies, private industry, and the public. Each of these constituencies requires that the data be easily obtainable.

Objective

In the most efficient way possible, make ground-water data available to those who need it. Store and maintain information about well construction, water levels, water chemistry, and the materials encountered during drilling.

Approach

Information about ground-water resources derived from driller's logs, published reports, field measurements, laboratory analyses, and other sources are placed in computer storage for retrieval by interested citizens, government agencies, and private industry. In October 2004, GWIC contained information on more than 190,000 wells, 16,300 water-quality analyses from ground-water sources, 773,700 water-level measurements from more than 9,600 locations, and records of materials encountered during drilling at more than 135,900 locations. The Bureau also offers interpretative services to people who need depth, yield, and water-quality information at potential well locations. Information from the database is available in a variety of formats, ranging from photocopies of water-well logs to retrievals of thousands of well records delivered over the Internet.

Progress during the 2002–2004 Biennium

More than 19,200 new water-well and monitoring-well records were added to the database. An additional 11,000 paper well logs, forwarded to GWIC from the Department of Natural Resources and Conservation, were examined and if not already in GWIC were included in the database. The Ground-Water Information Center website went online in January 1999 and there are now more than 7,000 registered users. In July–December 2002, customers logged in about 2,800 times each month to make approximately 19,000 queries. By January–June 2004, GWIC usage had increased to about 4,100 logins and 33,000 queries monthly.

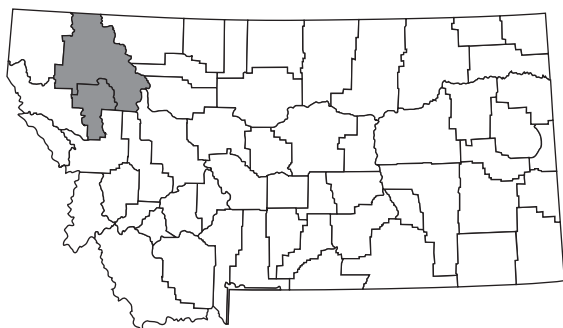
The 2001 legislature changed statute so that water-well drillers must now file water-well logs directly with the Montana Bureau of Mines and Geology. The change also allowed drillers to file electronic copies of the water-well log. In March 2004, the Montana Bureau of Mines and Geology implemented "DrillerWeb," an online filing system for the water-well log. By June 30, 2004, 35 drilling contractors had certified more than 230 well logs through the "DrillerWeb" system.

Plans for the 2004–2006 Biennium

The MBMG will continue to add new well-log, water-quality, water-level, Characterization Program products, and other ground-water information to the GWIC database. The website will continue to be enhanced to make additional reports and data available.

Information Products

The Ground-Water Information Center can be reached through the internet at <http://mbmaggw.wic.mtech.edu>, by mail at the Montana Bureau of Mines and Geology, 1300 West Park Street, Butte, Montana 59701-8997; by calling 406-496-4336; or by e-mail at gwic@mtech.edu.



Project Title: Flathead Lake Area Ground-Water Characterization Study

Location: Flathead and Lake Counties

Project Period: July 1994–December 1998 (field work); 2004 (maps and atlas completed)

Project Leader: Tom Patton

Project Staff: John LaFave, Larry Smith, Camela Carstarphen, Don Mason, James Rose

Funding Sources: Montana Bureau of Mines and Geology, Ground-Water Assessment Program

Issue

Insufficient information is hampering efforts to properly manage, protect, and develop ground-water resources.

Objective

Provide information to landowners and decision makers about the management, protection, and development of ground-water resources by systematically assessing and documenting the hydrogeology and water quality of individual aquifers.

Approach

Compile information on the geology and ground-water resources, map aquifer distributions, visit selected wells to measure water levels and basic water-quality parameters, conduct additional testing to determine aquifer properties, and collect and analyze ground-water samples to evaluate water quality and better understand ground-water flow systems.

Progress during the 2002–2004 Biennium

Ground-Water Assessment Atlas 2 Part A—Ground-water resources of the Flathead Lake Area: Flathead, Lake, Missoula, and Sanders Counties, Montana, descriptive overview and water-quality data, was submitted to press.

Plans for the 2004–2006 Biennium

Ground-Water Assessment Atlas No. 2 Part A will be published. The project will be completed and no further work is planned.

Information Products

Publications produced by the Flathead Lake Characterization study are listed below. In addition, staff presented numerous talks, led field trips, and participated in groups such as the Flathead Basin Commission's ground-water monitoring committee.

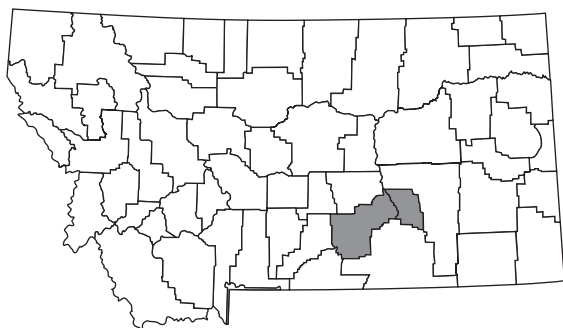
LaFave, J.I., 2000, Status of ground-water level monitoring sites, Kalispell valley (upper Flathead River Valley), Northwest Montana: Montana Ground-Water Assessment Open-File Report 14, 1:200,000.

LaFave, J.I., 2000, Potentiometric surface map of the deep aquifer, Kalispell valley: Flathead County, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-02, scale 1:63,360.

LaFave, J.I., 2000, Dissolved constituents map of the deep aquifer, Kalispell valley, Flathead County, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-03, scale 1:63,360.

LaFave, J.I., 2000, Potentiometric surface map of the southern part of the Flathead Lake Area, Missoula, Lake, and Sanders counties, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-04, scale 1:100,000.

- LaFave, J.I., 2001, Dissolved-constituents map of the southern part of the Flathead Lake Area, Lake, Missoula, and Sanders counties, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-05, scale 1:100,000.
- LaFave, J.I., Smith, L.N., and Patton, T.W., 2004, Ground-water resources of the Flathead Lake Area: Flathead, Lake, Missoula, and Sanders Counties, Montana, Part A—Descriptive overview and water-quality data: Montana Bureau of Mines and Geology Ground-water Assessment Atlas 2A, 132 p.
- McDonald, Catherine, and LaFave, J.I., 2004, Ground-water assessment of selected shallow aquifers in the north Flathead Valley and Flathead Lake perimeter, northwest Montana, Montana Bureau of Mines and Geology Open-File Report 492, 40 p. (Report was partially funded by Flathead Basin Commission 319 project).
- Patton, T.W., Smith, L.N., and LaFave, J.I., 2003, Ground-water resources of the Flathead Lake area: Flathead, Lake, Sanders, and Missoula counties, Montana: Montana Bureau of Mines and Geology Information Pamphlet 4, 4 p.
- Smith, L.N., LaFave, J.I., Carstarphen, C.A., Mason, D.J., and Richter, M.J., 2000, Data for water wells visited during the Flathead Lake Area Ground-Water Characterization Study: Flathead, Lake, Sanders, and Missoula Counties, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-01, scale 1:250,000.
- Smith, L.N., 2000, Surficial geologic map of the upper Flathead River valley (Kalispell valley) area, Flathead County, northwestern Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-06, scale 1:70,000.
- Smith, L.N., 2000, Altitude of and depth to the bedrock surface: Flathead Lake Area, Flathead and Lake Counties, Montana (open-file version), Montana Bureau of Mines and Geology Ground-water Assessment Atlas 2B-07, scale 1:150,000.
- Smith, L.N., 2000, Depth to the deep alluvium of the deep aquifer in the Kalispell valley: Flathead County, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-08, scale 1:63,360.
- Smith, L.N., 2000, Thickness of the confining unit in the Kalispell valley, Flathead County, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-09, scale 1:100,000.
- Smith, L.N., 2001, Hydrogeologic framework of the southern part of the Flathead Lake Area, Flathead, Lake, Missoula, and Sanders counties, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-10, scale 1:300,000.
- Smith, L.N., 2000, Thickness of shallow alluvium, Flathead Lake Area, Flathead, Lake, Missoula, and Sanders counties, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2B-11, scale 1:100,000.



Project Title: Middle Yellowstone River Area Ground-Water Characterization Study

Location: Yellowstone and Treasure counties, exclusive of the Crow Reservation

Project Period: July 1996–June 1999 (field work); 2001–present (map and atlas production)

Project Leader: Tom Patton

Project Staff: John LaFave, Larry Smith, Camela Carstarphen, Don Mason, James Rose, Jon Reiten, John Olsen, Joe Lalley, Clarence Schwartz

Funding Sources: Montana Bureau of Mines and Geology, Ground-Water Assessment Program

Issue

Insufficient information is hampering efforts to properly manage, protect, and develop ground-water resources.

Objective

Provide information to landowners and decision makers about management, protection, and development of ground-water resources by systematically assessing and documenting the hydrogeology and quality of individual aquifers.

Approach

Compile information on the geology and ground-water resources, map aquifer distributions, visit selected wells to measure water levels and basic water-quality parameters, conduct additional testing to determine aquifer properties, and collect and analyze ground-water samples to evaluate water quality and better understand ground-water flow systems.

Progress during the 2002–2004 Biennium

Work continued on seven maps for Ground-Water Assessment Atlas 3. A basic data map and a map describing the hydrogeology of the Eagle Formation were released. Maps interpreting the hydrogeology of the Judith River Formation and alluvial aquifers and describing ground-water availability by depth and quality were in review.

Plans for the 2004–2006 Biennium

All maps for Ground-Water Assessment Atlas 3, Ground-water resources of the Middle Yellowstone River Area, Treasure and Yellowstone counties, Montana, Part A—Descriptive overview and water-quality data, will be released.

Information Products

Hydrogeologic data obtained from the visitation of wells and static-water level data for monitored wells are available to the citizens of Montana from the Ground-Water Information Center database.

Olson, J.L., and Reiten, J.C., 2002, Data for water wells visited during the Middle Yellowstone River Area ground-water characterization study: Treasure and Yellowstone counties, Montana (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 3B-01, scale 1:200,000.

Olson, J.L., and Reiten, J.C., 2003, Characterization of the Eagle Aquifer in Yellowstone County, Middle Yellowstone River Area, Montana: Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 3B-07, scale 1:150,000.

Project Title: Lolo-Bitterroot Area Ground-Water Characterization Study

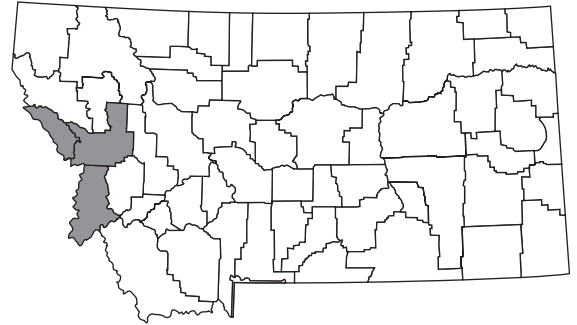
Location: Mineral, Missoula, and Ravalli counties

Project Period: July 1998–June 2001 (field work); 2001–present (map and atlas production)

Project Leader: Tom Patton

Project Staff: John LaFave, Larry Smith, Camela Carstarphen, Don Mason, Mike Richter, Karl Pracht

Funding Sources: Montana Bureau of Mines and Geology, Ground-Water Assessment Program



Issue

Insufficient information is hampering efforts to properly manage, protect, and develop ground-water resources.

Objective

Provide information to landowners and decision makers about management, protection, and development of ground-water resources by systematically assessing and documenting the hydrogeology and quality of individual aquifers.

Approach

Compile information on the geology and ground-water resources, map aquifer distributions, visit selected wells to measure water levels and basic water-quality parameters, conduct additional testing to determine aquifer properties, and collect and analyze ground-water samples to evaluate water quality and better understand ground-water flow systems.

Progress during the 2002–2004 Biennium

Field data were compiled and checked for accuracy and completeness. Montana Ground-Water Assessment Atlas 4, Part B, Map 1, Data for water wells visited during the Lolo-Bitterroot ground-water characterization study, Mineral, Missoula, and Ravalli Counties, Montana was released. Four of the seven maps planned for the Lolo-Bitterroot area were ready for MBMG review.

Plans for the 2004–2006 Biennium

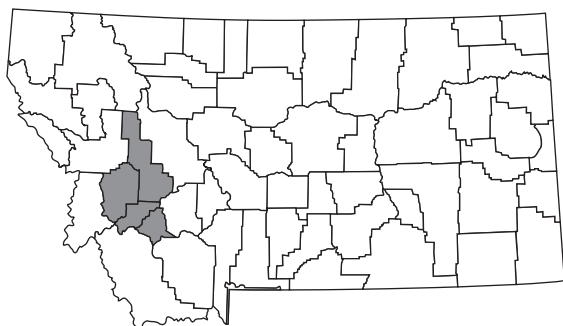
All eight Ground-Water Assessment Atlas 4 Part B maps will be completed. Ground-Water Assessment Atlas 4, Part A—Ground-water resources of the Lolo-Bitterroot Area, Mineral, Missoula, and Sanders counties, Montana, descriptive overview and water-quality data, will be completed.

Information Products

Hydrogeologic data obtained from the visitation of wells and static-water level data for monitored wells are available to the citizens of Montana from the Ground-Water Information Center database.

Carstarphen, C.A., Mason, D.M., Smith, L.N., LaFave, J.I., and Richter, M.G., 2003, Data for water wells visited during the Lolo-Bitterroot Area ground-water characterization study (open-file version): Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 4B-01.

LaFave, J.I., 2002, Tracing ground-water flow in the Missoula valley aquifer, southwest Montana: Montana Bureau of Mines and Geology Ground-Water Open-File Report 17, 16 p (partly funded by the Montana Water Center).



Project Title: Upper Clark Fork River Area Ground-Water Characterization Study

Location: Deer Lodge, Granite, Powell, and Silver Bow counties

Project Period: July 2000–June 2003 (field work); 2003–present (map and atlas production)

Project Leader: Tom Patton

Project Staff: John LaFave, Larry Smith, Camela Carstarphen, Don Mason, Mike Richter, and Leonard Rinehart

Funding Sources: Montana Bureau of Mines and Geology,

Ground-Water Assessment Program

Issue

Insufficient information is hampering efforts to properly manage, protect, and develop ground-water resources.

Objective

Provide information to landowners and decision makers about management, protection, and development of ground-water resources by systematically assessing and documenting the hydrogeology and quality of individual aquifers.

Approach

Compile information on the geology and ground-water resources, map aquifer distributions, visit selected wells to measure water levels and basic water-quality parameters, conduct additional testing to determine aquifer properties, and collect and analyze ground-water samples to evaluate water quality and better understand ground-water flow systems.

Progress during the 2002–2004 Biennium

Field work in the Upper Clark Fork River area was completed. An additional 55 wells were visited and 35 water-quality samples collected to bring the total number of wells visited to 970 and sampled to 291. Data were verified and stored in the Ground-Water Information Center database and Ground-Water Assessment Atlas 5, Part B, Map 1, was released. An open-file report describing water levels and water quality in Warne Heights was completed. The monthly monitoring network was discontinued and selected wells from that network included in the long-term statewide monitoring network.

Plans for the 2004–2006 Biennium

Preparation of Ground-Water Assessment Atlas 5 Part B maps will begin when work is completed on the Middle Yellowstone River and Lolo-Bitterroot area atlases.

Information Products

Hydrogeologic data obtained from the visitation of wells and current static-water level data for monitored wells are available to the citizens of Montana from the Ground-Water Information Center database.

Carstarphen, C.A., Mason, D.C., Smith, L.N., LaFave, J.I., and Richter, M.G., 2004, Data for water wells visited during the Upper Clark Fork River area Ground-Water Characterization study: Deer Lodge, Granite, and Silver Bow Counties (open-file version): Montana Bureau of Mines and Geology Ground-water Assessment Atlas 5B-01.

Carstarphen, C.A., LaFave, J.I., and Patton, T.W., 2004, Water levels and Nitrate in Warne Heights, Upper Summit Valley, Silver Bow County, Montana: Montana Bureau of Mines and Geology Ground-Water Open-File Report 18, 50 p.

Project Title: Clark's Fork of the Yellowstone River
Ground-Water Characterization Study

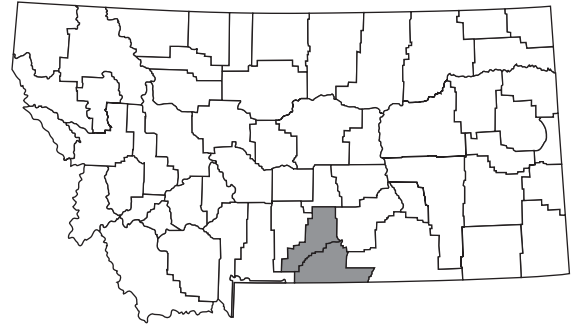
Location: Carbon and Stillwater counties

Project Period: July 2002–June 2005 (field work).

Project Leader: Tom Patton

Project Staff: John LaFave, Larry Smith, Camela Carstarphen, Don Mason, Mike Richter, John Olson, Jon Reiten

Funding Sources: Montana Bureau of Mines and Geology,
Ground-Water Assessment Program



Issue

Insufficient information is hampering efforts to properly manage, protect, and develop ground-water resources.

Objective

Provide information to landowners and decision makers about management, protection, and development of ground-water resources by systematically assessing and documenting the hydrogeology and quality of individual aquifers.

Approach

Compile information on the geology and ground-water resources, map aquifer distributions, visit selected wells to measure water levels and basic water-quality parameters, conduct additional testing to determine aquifer properties, and collect and analyze ground-water samples to evaluate water quality and to better understand ground-water flow systems.

Progress during the 2002–2004 Biennium

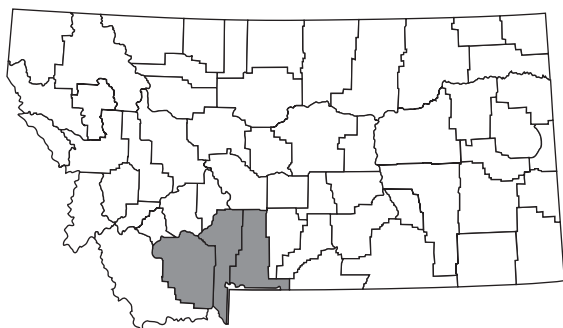
Field staff visited 437 wells to collect location, water level, and field chemistry information. Water levels in about 80 wells have been measured monthly. Of the 437 wells visited, 114 have been sampled for inorganic constituents and trace metals.

Plans for the 2004–2006 Biennium

A basic data map will be released in 2005. Preparation of Ground-Water Assessment Atlas 6 Part B maps will begin when work is completed on the Middle Yellowstone River, Lolo-Bitterroot, and Upper Clark Fork River area atlases.

Information Products

Hydrogeologic data obtained from the visitation of wells and current static-water level data for monitored wells are available to the citizens of Montana from the Ground-Water Information Center database.



Project Title: Yellowstone Controlled Groundwater Area

Location: Southwest Montana, near Yellowstone Park

Project Period: Specific task agreement: 1998–2004

Project Leader: John Metesh

Project Staff: James Rose, Jody Kougioulis, Alan English

Funding Source: National Park Service

Issue

Development of ground-water resources near Yellowstone Park may adversely affect the geothermal resources of the park. In 1994, the State of Montana and

the National Park Service established a controlled ground-water area within Montana. The National Park Service has entered into a cooperative agreement with the MBMG to conduct several investigations, which include: an inventory of wells and springs and evaluation of ground-water resources in the Soda Butte Creek drainage, and an evaluation of watersheds within the controlled ground-water area, including mapping of surficial and bedrock geology. About 330 spring sites were visited and documented; site location and chemistry data from the latest study and from previous investigations were compiled and are listed in the MBMG Ground Water Information Center database. In a related study, the MBMG has mapped and compiled data on bedrock and surficial deposits within the controlled ground-water area; these data, in map form, are published separately. Chemistry from springs and wells throughout the study area reflect a complex system of ground-water recharge, deep circulation near the Yellowstone caldera, and geothermal discharge through a wide variety of rock types. Mixing of geothermal waters with shallow colder water is evident in the chemistry and isotope analytical results. Hydrogeologic and geochemical changes in the geothermal system of Yellowstone National Park and the greater Yellowstone area are inevitable. Distinctions between man-induced changes and natural processes cannot be made without comprehensive surface-water and ground-water monitoring both inside and outside the Park.

Objectives

To collect location and field chemistry data for all existing wells and springs, and collect baseline water-quality data for the eight major watersheds within the Yellowstone controlled groundwater area. Compile a geologic map of the controlled ground-water area.

Approach

- (1) Update information for each spring contained in the MBMG Groundwater Information Center database
- (2) Inventory all active springs in the area
- (3) Select and sample springs for water quality and isotope analysis throughout the area
- (4) Compile existing geologic data and conduct field work to complete the geologic database

Progress during the 2002–2004 Biennium

The spring inventory has been completed; a final report was completed in 2004. Data collection for the watershed analysis has been completed, including geologic mapping of surficial deposits and bedrock geology.

Plans for the 2004–2006 Biennium

A final map and pamphlet will be completed in late 2004.

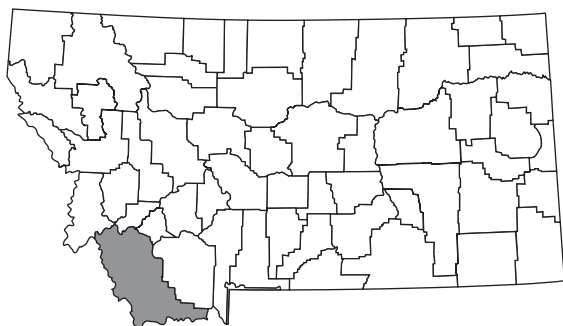
Information Products

Metesh, J.J., English, A.E., Lonn, J.D., Kendy, E., and Parrett, C., 1999, Hydrogeology of the Upper Soda Butte Creek Basin, Montana: Montana Bureau of Mines and Geology Report of Investigation 7, 66 p.

Metesh J.J., and Kougioulis, J., 2000, Well inventory and baseline sampling, Yellowstone National Park controlled ground water area, Montana: Montana Bureau of Mines and Geology Report of Investigations 8, 25 p.

Metesh, J.J., 2004, Spring inventory and baseline sampling of the Yellowstone controlled ground water area: Montana Bureau of Mines and Geology Open-File Report 510, 54 p.

All inventory and chemistry data are available through the MBMG Ground Water Information Center.



Project Title: Big Hole Watershed Management Project

Location: Upper Big Hole Basin, Wisdom–Jackson Area

Project Period: September 2003–September 2006

Project Leaders: Ginette Abdo, John Metesh

Funding Source: Montana Department of Natural Resources and Conservation

Issue

Natural and human-induced changes in water-resource availability have caused increased concern about how to best manage the limited water resources of the Big Hole

River basin. Hay pastures near Wisdom and Jackson that used to be irrigated only in the spring and early summer are now irrigated throughout the summer to support increased grazing. Forestry and agricultural practices have altered vegetation patterns and thus altered the hydrology of the basin. Recent droughts and elevated summer temperatures have heightened concerns about the survival of fluvial Arctic grayling and other fishery resources in the river.

Objective

This project supports the Big Hole Watershed Committee (BHWC) by providing a hydrologic assessment to evaluate how various land- and water-management strategies may affect the upper basin's hydrology. The hydrologic-modeling component of the project is an outgrowth of an increasing need to understand the pathways by which water enters, moves through, and exits the basin. The BHWC, planners, and scientists need this information to better manage the water resources of the basin and to potentially improve river flows in the summer and fall.

Approach

The hydrologic assessment will build on the Irrigation Return Flow and Water Budget Study completed in January 2001. Computer modeling is needed to evaluate how possible changes in irrigation practices, recharge patterns, evapotranspiration, and ground-water use are likely to affect the hydrologic budget of the upper basin and the flow in the river. Development of the model will require additional ground-water and surface-water data collection.

Progress during the 2002-2004 Biennium

A smaller field area was selected on the east side of the basin and ground-water and surface-water flows were monitored. Seepage runs were performed along the ditch system. The MBMG finished collecting ground-water and surface-water data in the study area in the Upper Big Hole Basin. Data are being analyzed and a computer model will be used to simulate ground-water and surface-water interactions. A draft report that will incorporate the modeling component of the study is being written.

Plans for the 2004–2006 Biennium

Complete the computer modeling effort and final report for the project.

Information Products

The project will produce a report summarizing the field efforts and results. The hydrologic model(s) will also be discussed and recommendations for further work will be presented.

Project Title: Big Hole Watershed Management Project, Part II

Location: Upper Big Hole Basin, Wisdom–Jackson Area

Project Period: September 2003–September 2006

Project Leaders: Ginette Abdo, John Metesh

Funding Source: U.S. Bureau of Reclamation

Issue

This project is a continuation of the work described in the Big Hole Watershed Management Project. A field site was selected on the west side of the basin to help further understand the hydrologic framework of the upper basin of the Big Hole River.

Objective

The objective is to increase the understanding of the basin's hydrology with respect to how ground water and surface water interact, and to assess the influence of using tributary stream flow to irrigate fields. Computer modeling will be used as part of the project to evaluate how possible changes in irrigation practices, recharge patterns, evapotranspiration, and ground-water use are likely to affect the hydrologic budget.

Approach

Ground-water and surface-water measurements will be made and climatic data will be collected. These data will be used to determine the water balance for the study area. A computer model will be developed after the summer 2005 field season.

Progress during the 2002–2004 Biennium

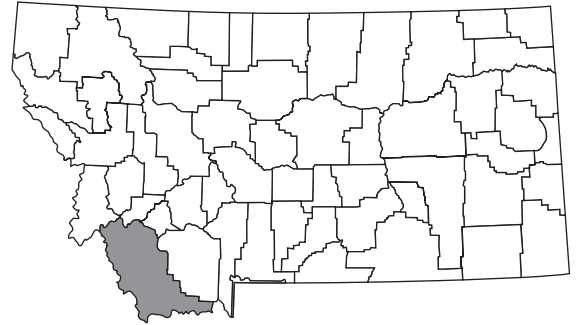
A well inventory was completed and a ground-water monitoring network was established. Surface water measuring locations were also determined.

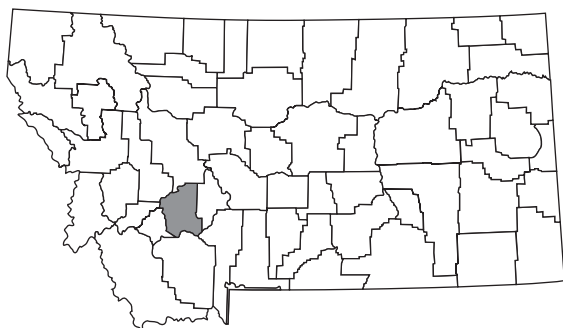
Plans for the 2004–2006 Biennium

Collect data during the summer 2005 field season and complete the computer modeling portion of the project. Several piezometers will be installed to supplement the pre-existing monitoring network.

Information Products

The project will produce a report summarizing the field efforts and results. The hydrologic model(s) will also be discussed and recommendations for further work will be presented.





Project Title: Vegetation and Watersheds—Moving towards a Healthy Ecosystem

Location: Hay Canyon Creek, Whitehall, Montana

Project Period: September 2002–September 2003

Project Leader: Ginette Abdo

Funding Source: Montana Department of Natural Resources and Conservation and the Grazing Lands Conservation Initiative

Issue

Local concern about diminished water quantity in the upper and lower Jefferson Watershed has led to investigating conifer encroachment as a possible cause. While conifers provide important benefits to the ecological sites in which they belong, literature indicates that reduced water flow results when they encroach into sagebrush-steppe and wetland vegetation communities because they have relatively high evapotranspiration rates. In addition, they contribute to soil erosion, declining stream function, increased stream sediment, reduced wildlife habitat, reduced livestock forage, and increased risk of catastrophic fire.

Objective

Conifers from the Bureau of Land Management portion of the Hay Canyon Creek drainage will be removed within several years. The objective of this project is to collect background literature and surface-water information on Hay Canyon Creek prior to conifer removal that can be compared with similar data collected after the removal in order to evaluate the effectiveness of the procedure.

Approach

- Obtain historic aerial photographs and historic descriptions of the drainage
- Compile any prior hydrologic data collected in the drainage
- Compile a list of references on existing studies and methodologies that have investigated conifer encroachment
- Install a surface-water measurement device on the lower reach of the study area and collect continuous flow readings
- Collect two surface-water-quality samples
- Summary report of findings
- Present a talk to the Jefferson River Watershed Council that is open to the public

Progress during the 2002–2004 Biennium

This project was completed in 2003. Historic aerial photographs were obtained and current photos were taken. Background information was compiled and surface-water flow and quality in the Hay Canyon Drainage were measured. A final report, with a comprehensive list of references attached in an appendix, was prepared for the project and submitted to the granting agency.

Information Products

A final report was submitted to the granting agency.

Project Title: Hydrologic Assessment for the Tongue River and Powder River Watersheds and Ashland District of the Custer National Forest

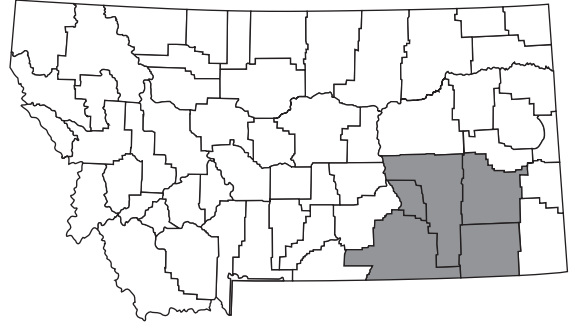
Location: Powder River Structural Basin, southeastern Montana

Project Period: May 2002 through September 2004

Project Leaders: John Wheaton

Project Staff: Teresa Donato

Funding Source: U.S. Environmental Protection Agency (EPA), U.S. Department of Interior Forest Service, Powder River Conservation District, Rosebud Conservation District, Montana Bureau of Mines and Geology



Issue

The U.S. Forest Service and the Powder River and Rosebud Conservation Districts wish to expand their understanding of the scale and location of critical water resources, particularly springs, in the region, and the hydraulic relationships among springs, wells, and coal aquifers where coalbed-methane (CBM) development is being proposed. Wells have typically been documented; however, records of springs are incomplete. Springs are susceptible to the potential impacts of CBM development, and baseline data need to be recorded prior to CBM development in order to evaluate potential changes that may occur.

Objective

The objectives of this research are to:

- (1) record the location, discharge, specific conductivity, and pH of springs and flowing artesian wells considered to be critical water resources for private landowners,
- (2) update records of existing research wells on private land, and
- (3) make all data accessible to the public.

Approach

Landowners and Forest Service personnel will guide MBMG staff to water resources considered to be of critical importance to their operations. Site locations will be recorded using a handheld GPS receiver. Discharge of springs and flowing artesian wells will be determined using a portable Parshall flume or watch and bucket method. Static water levels and total depths of research wells will be determined using a sounder or steel tape. Specific conductivity, temperature, and pH will be measured with field instruments. Site data will be entered in the Montana Ground Water Information Center (GWIC) database for public access and a report and map will be completed for the entire study area.

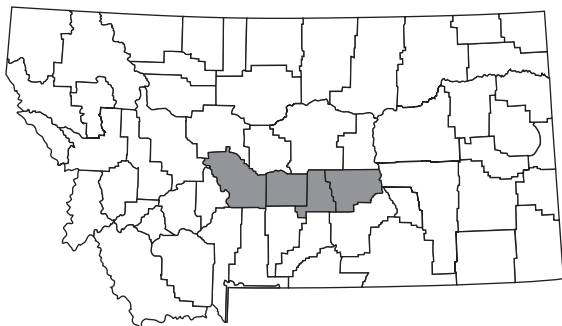
Progress during the 2002–2004 Biennium

A total of 688 springs and 154 wells were inventoried during these projects. Data describing the water resources have been entered in the GWIC and two publications have been released. This project is now complete.

Information Products

Donato, T.A., and Wheaton, J.R., 2004, Spring inventory and other water data, Custer National Forest-Ashland Ranger District, Montana (photos available on CD only): Montana Bureau of Mines and Geology Open-File Report 493A, 84 p.

Donato, T.A., and Wheaton, J.R., 2004, Spring and well inventory for the Powder River and Tongue River watersheds, southeastern Montana: Montana Bureau of Mines and Geology Open-File Report 493B, 53 p. Scale 1:100,000.



Project Title: Upper Musselshell Source-Water Protection as a Watershed Management Tool

Location: Upper Musselshell River Basin

Project Period: August 2004

Project Leader: Kathleen J. Miller

Project Staff: M.L. Hendrickson, L.G. O'Connell (student)

Funding Sources: Department of Environmental Quality (DEQ), Montana Rural Water Systems, Inc. (MRWS), Montana Watercourse

Issue

Use watershed evaluation techniques to provide source-water delineation and assessment products for 15 public water supplies in the Upper Musselshell. As described on the Montana 303(d) list, the water resources of the Upper Musselshell River Basin are predominantly affected by agricultural land-use practices. Agricultural practices that may contribute to NPS degradation include the crop-fallow farming system, crop-irrigation practices, and agrichemical application.

Objective

Integrate source-water protection (SWP) educational activities in small, rural communities in the Upper Musselshell River Basin with the watershed's critical 1A priority assessment needs.

Approach

This project provided source-water assessment and protection at the community level as well as watershed education related to all potential sources of non-point source (NPS) degradation, including agricultural activities. The MRWS provided specific training to public water supply operators and assisted the operators in completing all the steps required to achieve a DEQ-certified SWP plan. The Montana Watercourse provided "Know Your Source Water" watershed workshops to facilitate the reporting of new information gathered under this project and to provide follow-up to their watershed coordination efforts originally begun with the 1997 Musselshell "Know Your Watershed" workshop. The Watercourse emphasized local efforts to improve resource management in the Upper Musselshell Basin. The MBMG collected, interpreted, and reported hydrogeological information for the delineation of SWP boundaries for the 15 public water supply operators and also collected baseline water-quality information for the entire watershed using private ground-water wells and selected surface-water sampling sites. To further characterize NPS issues in the basin, two permanent monitoring wells were installed for inclusion in the Montana Department of Agriculture's long-term statewide pesticide-monitoring network. This project integrated activities that are often associated with a "ground water" or "watershed" type 319 proposal with I&E activities.

Progress during the 2002–2004 Biennium

Project completed, final report prepared.

Information Products

Final report by O'Connell, maps, educational materials.

Project Title: Ground-Water and Surface-Water Quality, Herbicide Transport, and Irrigation Practices: Greenfields Bench Aquifer, Teton County, Montana

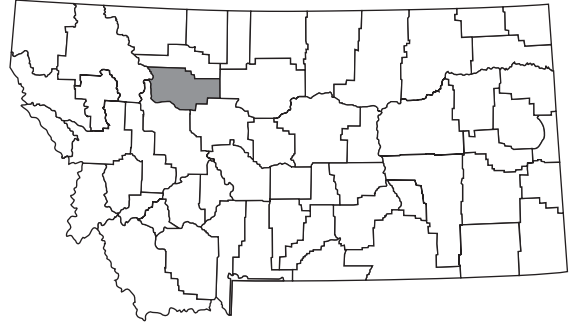
Location: West-central Montana, Teton County

Project Period: 2002

Project Leader: Kathleen J. Miller

Project Staff: K. McDonald, M.L. Hendrickson

Funding Sources: Department of Natural Resources and Conservation, Department of Environmental Quality, American Cyanamid, Teton County Conservation District, Montana Department of Agriculture



Issue

The farming practices on the Greenfields Bench include irrigation of malting barley and the yearly application of herbicides for the control of weeds. The most commonly used herbicide (imazamethabenz-methyl, U.S. trade name Assert®) has been found in the ground water on the Bench. In addition to Assert and its acid metabolite, eight other pesticides have been detected in wells serving the Town of Fairfield and the Tri-County Water District, and in numerous private wells. The Montana water-quality standards have not been exceeded for any of the pesticides. However, the variety of pesticides found and the frequency of pesticide detections in area wells was indicative of aquifer vulnerability and elucidated the need for additional data collection to better understand the hydrogeological processes and to develop appropriate management strategies.

Objective

The purpose of the projects was to:

- (1) determine whether Montana water-quality standards were being exceeded in private water supplies or in the other two public water supplies on the Bench,
- (2) characterize the magnitude and extent of Assert contamination in ground water and in ground-water discharge to surface-water bodies, and
- (3) evaluate the influence of flood and sprinkler irrigation on the transport (leaching) of the herbicide Assert from the organic soil zone to the saturated zone.

Approach

Results from 91 ground-water samples show that Assert (or its metabolite) concentrations in domestic wells range from 0.2 to 5.0 µg/L. The Montana water-quality standard for Assert is 400 µg/L. Water-quality samples were collected from various ground-water discharge sites to assist in the development of total maximum daily loads for the receiving streams and to assess surface-water quality for human health and ecological impacts. Data indicate that Assert concentrations remain essentially unchanged through the flow system as ground water discharges to the streams. Concentrations of Assert in surface water ranged from 0.2 to 1.5 µg/L (37 samples).

Using 20 observation wells, an experimental study was conducted in 2000 and 2001 to evaluate the influence of flood and sprinkler irrigation on the transport (leaching) of the herbicide Assert from the organic soil zone to the saturated zone.

Progress during the 2002–2004 Biennium

Completed 2002.

Information Products

Miller, K.J., Rise, D.S., and McDonald, C., 2002, Ground-water and surface-water quality, herbicide transport, and irrigation practices: Greenfields Bench aquifer, Teton County, Montana: Montana Bureau of Mines and Geology Open-File Report 463, 177 p.

Numerous presentations to the Town of Fairfield, agricultural producers, and local, state, national, and international water professionals.

Project Title: Salt Loads in an Intermittent Prairie Stream:
Sage Creek Hydrogeologic Basin, Northern Montana

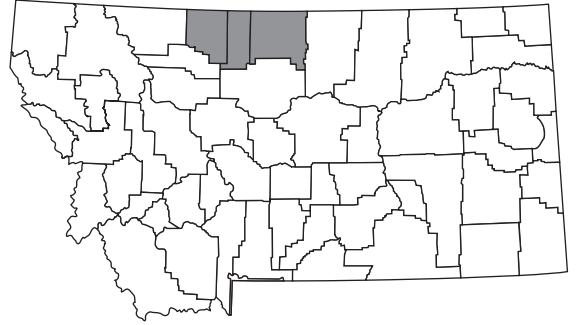
Location: Sage Creek Watershed, north-central Montana

Project Period: 2004

Project Leader: Kathleen J. Miller

Project Staff: K. McDonald, P.M. Norbeck

Funding Sources: Montana Department of Environmental Quality (DEQ), Montana Department of Natural Resources and Conservation (DNRC), Liberty Conservation District, Toole Conservation District



Issue

Ground-water discharge to Sage Creek controls water quality over the long term and causes the presence of perennial pools in the stream channel. This has ramifications for Total Maximum Daily Load development and implementation, because it calls into question the value of using surface-water samples (runoff) from Sage Creek as a metric for judging the effectiveness of remedial strategies or evaluating whether beneficial uses are met.

Objective

To describe surface and subsurface hydrology and evaluate ground-water quality/quantity effects in the Sage Creek watershed, an area comprising over 1,200 square miles. This work will provide a foundation for a more complete understanding of the role of ground-water quantity and quality in water and nutrient budgets and will help clarify objectives when designing water-quality targets and remedial strategies.

Approach

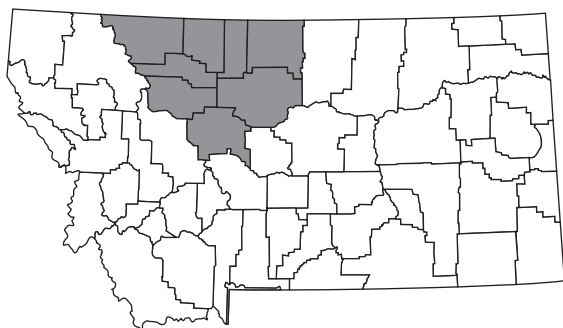
Ground-water and surface-water data collection was begun in 1993 in the upper portion of the watershed under a DNRC grant to evaluate the ground-water resources of the East Butte of the Sweet Grass Hills. Subsequent data-collection efforts were extended to the middle and lower portions of Sage Creek under DNRC and DEQ/U.S Environmental Protection Agency Section 319 grants, all of which were sponsored by the Liberty, Toole, and Hill County Conservation Districts and administered by the Liberty County Conservation District.

Progress during the 2002–2004 Biennium

Completed in 2004.

Information Products

Miller, K.J., 2004, Salt loads in an intermittent prairie stream: Sage Creek hydrogeologic basin, northern Montana: Montana Bureau of Mines and Geology Report of Investigation 13, 37 p.



Project Title: Marias River/Bullhead Area TDS Ground-Water Assessment

Location: Bullhead region of the Marias River watershed

Project Period: July 2004–July 2006

Project Leader: Kathleen J. Miller

Project Staff: Ken Sandau, Paul Thale, Jay Hansen, Jon Reiten

Funding Sources: Montana Department of Environmental Quality

Issue

To address surface-water impairments listed on the 1996 Montana 303(d) list (salinity/total dissolved solids /chlorides, nutrients, suspended solids, pH, siltation, and other habitat alterations) by reducing the amount of salinized baseflow (ground water) from the Bullhead area near the Dry Fork of the Marias River.

Objectives

- Produce a shallow ground-water assessment mapping/planning tool (integrating sustainable agriculture with water-quality protection), which is useful to participating Conservation Districts and is transferable to the rest of the Golden Triangle region and the glaciated Northern Plains region of Montana.
- Provide information and education; initial focus will be on areas ranked as “high” potential for causing water-quality degradation
- Coordinate with agricultural producers on a volunteer basis to implement site-specific Best Management Practices (BMPs) and use the planning maps developed to prioritize sites for BMP implementation

Approach

The first phase uses a shallow ground-water assessment map developed from existing and field-generated information to define high-priority areas for the second- and third-phase activities of information and education, implementation, and monitoring. Evaluation of the accuracy and utility of the map will be accomplished during the site assessment for implementing BMPs. Subsequent ground-water level information at the site will reinforce whether the area truly shows “high” salinity potential as indicated by the ground-water assessment/mapping tool. At this phase an evaluation will be performed to determine if errors were made in the map layer selection or in data interpretation. Adjustments may involve increasing the complexity or number of data layers.

Progress during the 2002–2004 Biennium

Data layers were assembled.

Information Products

Final report, maps, workshops, and brochures will be produced.

Project Title: Demonstration of Somatic and F+ Coliphage, *E. coli*, and Enterococci as Indicators of Fecal Contamination in Small Public Water Supplies in Southwestern Montana

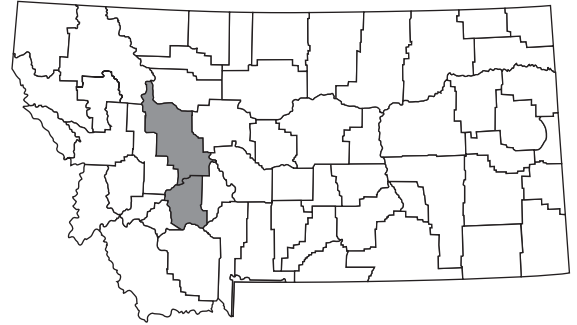
Location: Helena Valley

Project Period: October 2004–December 2005

Project Leader: Kathleen J. Miller

Funding Sources: Montana Water Center, Bozeman

Issue



The proposed Ground Water Rule of the National Primary Drinking Water Regulations (40 CFR, Parts 141 and 142, May 10, 2000) recognizes the need for a targeted risk-based regulatory strategy by identifying those systems with source-water contamination and systems deriving ground water from hydrogeologically “sensitive” aquifers. As such, for un-disinfected systems, the U.S. Environmental Protection Agency (EPA) proposes that systems sample for *E. coli*, enterococci, or coliphage within 24 hours of notification of a total coliform positive sample. The system would also be required to conduct routine monthly monitoring of *E. coli*, enterococci, or coliphage.

Preliminary results of microbial sampling by the Montana Department of Environmental Quality (DEQ) and the Lewis and Clark County Water Quality Protection District (LCWQPD) show that 10 of 19 sampled wells serving small public water supplies and private supplies in the Helena Valley contain F+ coliphage in the absence of *E.coli* and enterococci. Both *E.coli* and enterococci are associated with fresh sewage. A drawback to using these two indicators is they may die out more quickly or be less mobile in the subsurface than some waterborne pathogens, thereby rendering them less suitable as indicator organisms than coliphage. Results of this project will assist the DEQ in selecting the most sensitive and cost-effective fecal indicators for public water systems using ground water. The analytical cost of testing for coliphage using the EPA Method 1601: Male Specific (F+) and Somatic Coliphage in Water by Two-Step Enrichment Procedure is currently about \$100 per sample, a significant cost increase to a small water system, especially if routine monthly sampling is required.

Objective

The objective of this research is to demonstrate the appropriateness and effectiveness of using somatic and F+ coliphage, *E. coli*, and enterococci as indicators of fecal contamination of ground water used by small public water supplies in southwestern Montana.

Approach

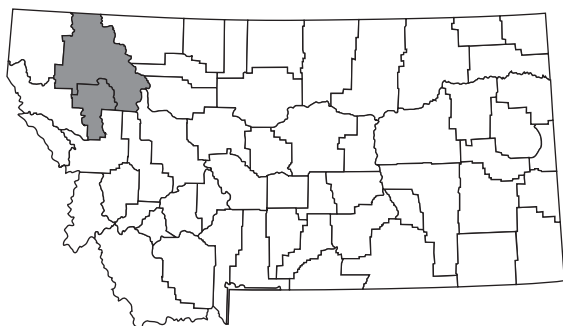
This demonstration project is focused in the Helena Valley and Montana City areas of Montana using collaboration between the MBMG, DEQ, LCWQPD, and the Department of Public Health and Human Services Environmental Laboratory. Project results will be transferable to all parts of Montana with similar geochemistry, hydrogeology, and land use. A Quality Assurance Project Plan (QAPP) will be prepared for review and approval by the EPA within 3 months of grant award and prior to commencement of work on the project. The QAPP will address sample collection, handling and laboratory analysis of inorganic constituents, *E. coli*, enterococci, and coliphage.

Progress during the 2002–2004 Biennium

Contract and QAPP in preparation.

Information Products

Final report and maps will be produced.



Project Title: Ground-Water Quality Assessment and Monitoring Plan for the North Flathead Valley and Flathead Lake Perimeter

Location: Flathead and Lake counties

Project Period: January 2000–December 2003

Project Leaders: Katie McDonald, John LaFave

Funding Source: Montana Department of Environmental Quality 319 Grant to the Flathead Basin Commission

Issues

Nutrient loading from non-point sources has been identified as a significant problem in Flathead Lake, and in January 2002 the U.S. Environmental Protection Agency (EPA) approved a Total Maximum Daily Load (TMDL) for Flathead Lake to reduce nitrogen and phosphorus loading. One source of non-point nutrient loading identified in the TMDL is ground water discharging to the lake. Since shallow aquifers are generally more vulnerable to contamination and, in the North Flathead valley and lake perimeter, more likely to be sources of nutrient loading to the lake, this project will focus on evaluating nutrients in the shallow ground-water systems.

Objective

The primary objective is to evaluate where and how nutrients enter shallow ground-water systems that interact with Flathead Lake. The project will also initiate an evaluation of land-use settings that represent different non-point sources to shallow ground water and specific areas where ground water likely interacts with surface water.

Approach

Existing wells in targeted areas will be used to establish a monitoring network, and ground water will be sampled for a period of 1 year. The results will help characterize the occurrence and distribution of nutrients in the selected shallow aquifers in relation to potential nutrient sources, and to assess seasonal changes in nutrient concentrations. Additionally, the monitoring well network and the project results will provide a foundation for assessing long-term trends in water quality.

Progress during the 2002–2004 Biennium

MBMG established the monitoring well network in May 2002 and, along with the Flathead Lake Biological Station, collected data from June 2001 through March 2003. Data analysis was completed by December 2003.

Information Products

All inventory and water-quality data are available through the MBMG Ground-Water Information Center (<http://mbmggwic.mtech.edu/>).

McDonald, Catherine, and LaFave, J.I., 2004, Groundwater assessment of selected shallow aquifers in the north Flathead Valley and Flathead Lake perimeter, northwest Montana: Montana Bureau of Mines and Geology Open-File Report 492, 40 p.

Craft, J.A., and Ellis, B.K., 2004, Groundwater nutrient assessment of selected shallow aquifers in the North Flathead Valley and Flathead Lake perimeter area, northwest Montana Open-File Report 180-04, Prepared for Flathead Basin Commission, Kalispell, Montana by Flathead Lake Biological Station, Polson, Montana, 45 p.

Project Title: Water-Quality Monitoring in the Big Muddy Watershed, Sheridan County, Montana

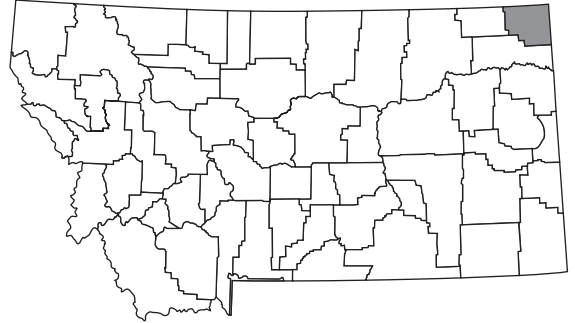
Location: Sheridan County

Project Period: September 2003–December 2006

Project Leader: Jon Reiten

Project Staff: Shawn Reddish, Montana State University-Billings students, Jay Hanson, Sheridan County Conservation District (SCCD) staff

Funding Sources: Department of Environment Quality (DEQ) 319, SCCD, U.S. Fish and Wildlife Services, Montana Bureau of Mines and Geology



Issue

The stream is listed as “Partial Use Support” for aquatic life and warm water fishery. Causes of degradation are listed as trace metals, nutrients, organic enrichment/low dissolved oxygen, sediment, and riparian degradation. Sources of degradation have been identified by the DEQ as dryland farming, grazing, hydromodification, and flow regulation/modification. Sources of degradation suggested by the SCCD are natural ground-water discharge, minor impacts from dryland farming, grazing, feedlots, diversions, and sewage lagoon discharges. Landowners, Fort Peck Tribes, U.S. Fish and Wildlife Service, SCCD, Roosevelt County Conservation District, Natural Resources Conservation Service, and others are in the process of developing a Watershed Group.

Objective

The goal of this project is to gather information needed to characterize the quality of water in the Big Muddy.

Approach

Samples of surface water and ground water will be collected periodically in the Big Muddy drainage, providing an estimate of the proportions of the salt load from major tributaries in the Sheridan County part of the watershed. Geology, land use, soils, surface-water diversions, and agricultural impacts will be compared between tributaries in an attempt to develop an understanding of potential sources of salts, metals, nutrients, suspended sediment, and other contaminants. The information gathered by this project will enable the development of Best Management Practices (BMPs) for land use, diversions, and agricultural development. The SCCD will sponsor workshops and a demonstration tour for local producers, focusing on project results and recommendations.

Progress during the 2002–2004 Biennium

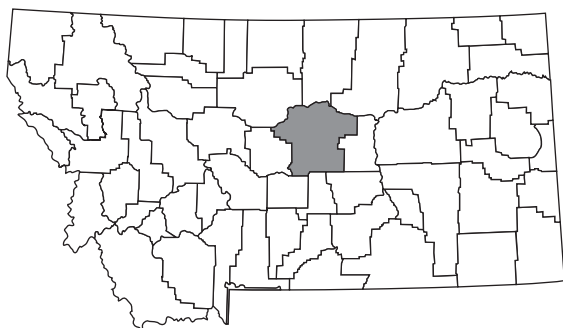
Collected available data and started detailed water-quality monitoring at 15 sites along the Big Muddy.

Plans for the 2004–2006 Biennium

Continue monitoring program and collect water-quality samples along the creek. Evaluate and collect additional data as required. Develop and prepare reports to assist the developing BMPs.

Information Products

Project completion reports and open-file reports. GIS maps are being developed showing extent of contamination, impact on water resources, and status of cleanup.



Project Title: Rehabilitating Flowing Wells in the Big Spring Watershed, Fergus County

Location: Fergus County

Project Period: July 1999–December 2004

Project Leader: Jon Reiten

Project Staff: Fergus County Conservation District staff, Jay Hanson

Funding Sources: Private landowners, Fergus County Conservation District, Montana Department of Natural Resources and Conservation, EPA 319 nonpoint source

pollution grant, Montana Bureau of Mines and Geology

Issue

Landowners have noticed a decline in aquifer pressure and productivity. This decline is caused by allowing wells to flow uncontrolled for many years.

Objective

Document major aquifers and conserve water in the flowing artesian aquifers.

Approach

Reduce flows by rehabilitating wells or plugging unused wells and wells that cannot be economically repaired. Monitor project success by measuring aquifer pressures.

Progress during the 2002–2004 Biennium

Collected data on major aquifers, compiled the data, and developed aquifer and ground-water flow maps.

Plans for the 2004–2006 Biennium

Complete project and write final report. A new NRCS-sponsored project is currently being established to conduct similar work on a statewide basis.

Information Products

Proposed MBMG open-file report or report of investigation.

Project Title: Irrigation Potential of Ground Water Underlying the Lower Yellowstone Valley in Richland County

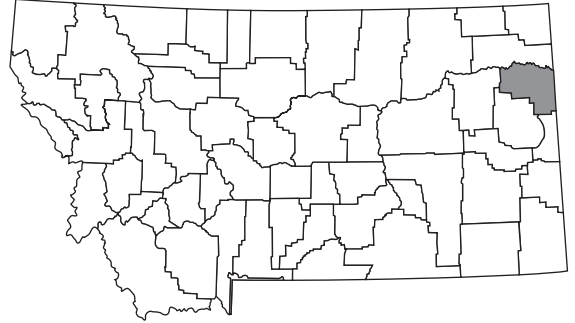
Location: Richland County

Project Period: July 2004–December 2006

Project Leader: Jon Reiten

Project Staff: Justin Brown, Montana State University-Billings students, Jay Hanson, Richland County Conservation District (RCCD) staff

Funding Sources: Montana Department of Natural Resources (DNRC) RRG grant, U.S. Bureau of Reclamation, City of Sidney, Montana Bureau of Mines and Geology, DNRC irrigation-development program



Issue

To identify ground-water resources in a buried-channel aquifer underlying parts of the Yellowstone River Valley in Richland County. The aquifer is best defined near Sidney where it supplies the City with good quality water from seven high-yield wells. Another well field approximately 10 miles to the north supplies water to the City of Fairview. Little is known about the location or character of the aquifer under the Valley between these two water supplies. The aquifer has also been encountered in several wells south of Sidney.

Objective

To define the location and character of this aquifer to facilitate development of this resource for irrigation without significantly impacting other water users in the Valley. Based on water-use records from the City of Sidney, this aquifer has a good potential for additional development. The City of Sidney is concerned that additional water development may impact their existing well field and reduce the potential for expansion. As a result, the City is interested in obtaining information on this aquifer system that would allow it to protect its water resource while promoting economic development through additional irrigation expansion.

Approach

The RCCD proposes to conduct an exploratory test-drilling program, install test wells, sample water quality at many of these wells, and collect additional ground-water data to define the extent of this aquifer. This information will provide the framework to guide future development of this resource and allow partnerships with State and Federal agencies to wisely manage ground-water development.

Progress during the 2002–2004 Biennium

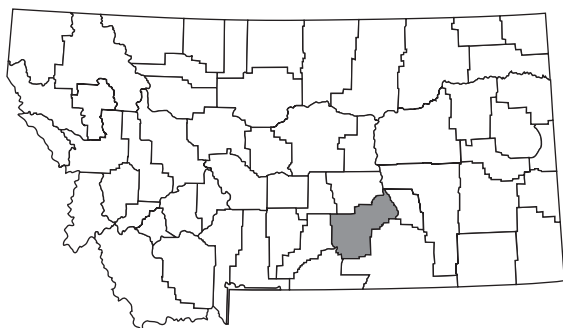
Collected available data and developed aquifer maps to help guide the exploration process.

Plans for the 2004–2006 Biennium

Conduct well inventory, targeting areas believed to be underlain by the aquifer. Install test wells.

Information Products

Project completion reports and open-file reports. [get these report numbers] GIS maps are being developed showing the extent of the aquifer and will be enhanced by new drilling information.



Project Title: Meadowlark Park Wetlands Hydrogeology

Location: Billings Heights in Yellowstone County

Project Period: September 1, 2003–December 31, 2005

Project Leader: Jon Reiten

Project Staff: Jenny Erickson, Justin Brown, Montana State University-Billings students, U.S. Fish and Wildlife Service

Funding Sources: U.S. Bureau of Reclamation, City of Billings Park Department, U.S. Fish and Wildlife Services

Issue

Meadowlark Park is being assessed for development as an enhanced wetland. The wetland is currently undeveloped, but has been partially filled with road sweepings and other fill material. A new subdivision is being developed partially on artificial fill north of the park. Neighbors are concerned about impacts of development on wetland and individual properties.

Objective

The proposed project will assess the hydrology and geology of the wetland. This information will help land managers develop and maintain a healthy wetland based on sound scientific data. Nearby landowners are concerned that wetland development would damage property and reduce property values.

The three major project goals that will focus on determining the wetland hydrology of Meadowland Park are:

- (1) characterizing the hydrogeologic conditions in and around the wetland;
- (2) mapping ground-water/surface-water interconnection and flow through the wetland; and
- (3) monitoring water-level fluctuations and surface-water flow.

Approach

Gather information for a well inventory. This will include visiting all available wells within a few blocks of the wetland and collecting physical hydrologic data including well depth, static water level, pumping rate, and pumping water level. In addition, water quality will be estimated from each well by collecting field parameters that will include water temperature, specific conductance, pH, dissolved oxygen, and nitrate concentration. All of the well inventory data collected will be entered into the Montana Bureau of Mines and Geology statewide database (Ground-Water Information Center, GWIC) and will be available over the internet for public use.

In conjunction with the well inventory, approximately 6–12 wells will be installed in order to develop an understanding of the colluvial/alluvial aquifer that overlies the Claggett shale in this area. The test wells will be used to map ground-water flow and to monitor water-level fluctuations. At least one of the wells will be completed with a water-level recorder to continuously monitor fluctuations. Hydrologic tests will also need to be conducted in order to measure the range of hydraulic conductivity over the site. Monitoring of the water levels will be conducted for approximately one year.

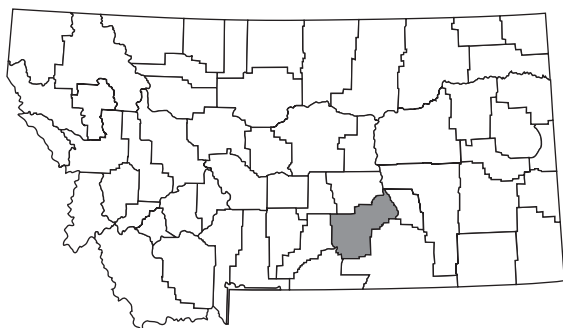
Plans for the 2004–2006 Biennium

Information gathering and testing as described above. Attempts will be made to identify additional funds to continue monitoring for at least another year. Additionally, the elevation of wells and other monitoring points will need to be surveyed. We will try to get assistance from

the city, NRCS, DNRC, or other agencies to accomplish this. All monitoring data will be entered into GWIC for future retrieval and data evaluation.

Information Products

A final report will compile all data and interpretations. The results will be used to help develop plans for an enhanced wetland.



Project Title: Preservation of Rock Art at Pictograph Caves: A Proposal to Restore the Cave Floor to the Original Level by Backfilling and Monitoring Moisture Conditions

Location: Pictograph Cave State Park, Billings, Montana

Project Period: March 2004–September 2005

Project Leader: Jon Reiten

Project Staff: Justin Brown, students from Montana State University-Billings and Montana State University-Billings College of Technology

Funding Source: Montana Fish Wildlife and Parks (FWP)

Issue

Moisture has caused deterioration of the back wall of Pictograph Cave since the archeological site was excavated in the late 1930s. The State of Montana owns the property and the FWP manage the State Park. The site is also listed as a National Historic Site under the oversight of the U.S. National Park Service. FWP has been monitoring and attempting to remediate the moisture problem for many years.

Objectives

The FWP recently developed a Master Plan to guide park management and research. Based on recommendations in the current Pictograph Cave Management Plan, a project is being proposed to backfill the cave with fine-grained sand and to subsequently monitor moisture movement through the backfill. The Montana Bureau of Mines and Geology was requested by the FWP to assist in designing and monitoring the backfill project.

Approach

A relatively small area was chosen for the initial backfill test and if successful the entire floor below the Pictographs will be backfilled to the original floor level. A moisture-monitoring program will be developed to track moisture movement through the test area. A student intern was hired to conduct this work under the direct supervision of Jon Reiten, Research Professor, Montana Tech of the University of Montana. Moisture monitors were installed to monitor soil moisture fluctuations in the backfill. The student also is compiling past moisture-monitoring records, including photographic documentation and crack monitoring. As part of the proposed moisture monitoring, photographic logging of the pictographs and of the crack monitor were resumed.

Progress during the 2002–2004 Biennium

Jon Reiten and the intern both worked directly on the design and implementation of the backfill project. A wall was constructed and fine-sand backfill placed up to the original floor level of the cave. Periodic monitoring of the 20 moisture monitors in the sand pack has been implemented. Photographic monitoring and crack monitoring was re-established. The project duration will be for 1 year from March 1, 2004 to September 30, 2005.

Plans for the 2004–2006 Biennium

Monitor cave wall stability and monitor moisture through the backfill; advise as necessary on further problems. Develop three-dimensional model of cave and experimental wall.

Information Products

An interim report to the FWP on moisture movement and success of the wall stabilization project will be submitted in fall 2004. A report summarizing the project will be completed within 1 month of the completion date. Additional monitoring may be required to fully evaluate moisture changes in the backfill.

Project Title: Sheridan County Aquifer and Surface-Water Monitoring and Modeling

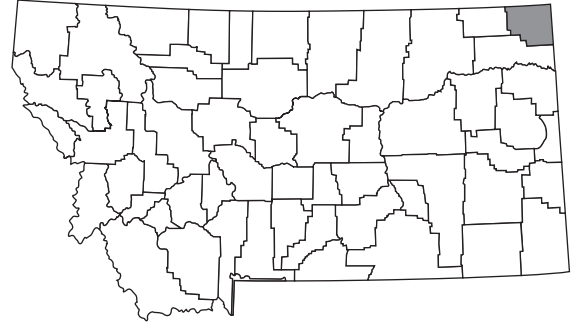
Location: Sheridan County

Project Period: October 30, 1997–June 30, 2005

Project Leader: Jon Reiten

Project Staff: Shawn Reddish, Montana State University-Billings students, Sheridan County Conservation District (SCCD) staff

Funding Sources: Montana Department of Natural Resources (DNRC), Resource Indemnity Trust, SCCD, U.S. Fish and Wildlife Services



Issue

The SCCD has been authorized to develop up to 5809 acre-feet of ground water from the Clear Lake aquifer as part of a Water Reservation. Once this volume of water has been developed an additional 9,800 acre-feet of water may be opened up for future development. A technical advisory committee was established to evaluate permit applications from potential irrigators. The committee requires a large amount of information on water quality, water availability, soil/water compatibility, potential impacts to wetlands, and project engineering to evaluate each permit application. A long-term goal is to develop the water resources without causing significant impacts to other resources in the region.

Objective

Promote economic development in an agricultural region by safely developing the Clear Lake aquifer for irrigation without harming the region's wetlands and water bodies associated with the Medicine Lake Wildlife Refuge.

Approach

To evaluate impacts to other irrigators, lakes, and wetlands, the SCCD has developed a monitoring program to determine causes of water-level fluctuations in the aquifer. Over 100 wells and surface-water sites are monitored on frequencies ranging from continuous to semi-annual. Climatic records and water-use records are compiled to compare to the water-level fluctuations.

Progress during the 2002-2004 Biennium

Continued monitoring water levels, periodically updated monitoring databases, produced hydrographs, produced plots of climatic trends, produced plots of water use, and used these data to evaluate several additional water permit applications. Several reports were written to evaluate impacts of current status of irrigation. Drilled an additional 10 monitoring wells and collected and analyzed water samples from these and several other wells. Conducted several aquifer tests to help evaluate applications for additional water.

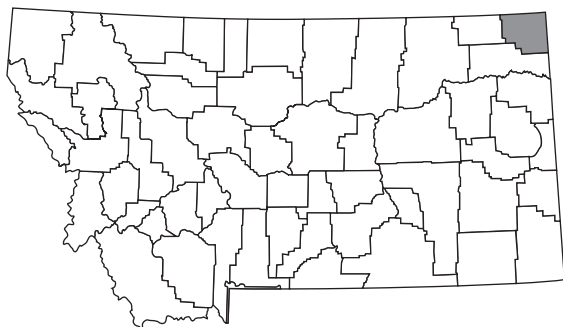
Plans for the 2004–2006 Biennium

Continue monitoring and assessing aquifer conditions with respect to additional irrigation. Evaluate models and collect additional data as required. Develop and prepare reports to assist the Conservation District apply for the additional 9,800 acre-feet of water from DNRC.

Information Products

GIS maps are being developed showing hydrogeology, water resources, and status of ground-water development. Most of this information is available over the internet at the MBMG Ground-Water Information Center under the Sheridan County Reserved Water Project.

Reiten, J.C., 2002, Sheridan County Ground-Water Management Program: Management of water resources from the Clear Lake aquifer: Montana Bureau of Mines and Geology Open-File Report 447, 32 p., 9 plate(s).



Project Title: Sheridan County Impacts of Oilfield Wastes on Natural Resources

Location: Sheridan County

Project Period: September 2003–December 2006

Project Leader: Jon Reiten

Project Staff: Shawn Reddish, Montana State University-Billings students, Jay Hanson, Sheridan County Conservation District (SCCD) staff

Funding Sources: Montana Department of Natural Resources (DNRC), Resource Indemnity Trust, SCCD, U.S.

Fish and Wildlife Services (USFWS)

Issue

The SCCD and USFWS are concerned about the impacts of oilfield wastes on natural resources, including crop land, ground water, wetlands, and wildlife habitat.

Migration of oilfield brines, containing as much as 10 times the salt concentration of seawater, has caused serious problems in Sheridan County. Landowners have reported an increase in contaminated soils and water resources near oilfield sites and a corresponding decrease in the economic vitality of traditional farming practices. Problems include sterile soils, contaminated wells, sinkholes, and accelerated erosion. All of these problems have caused significant economic impacts. Onsite disposals of salt-laden drilling wastes are a common practice in this part of the Williston Basin; there are about 900 drilling sites with onsite disposal pits in Sheridan County. A typical onsite disposal pit contains as much salt as a 260-ton salt block. Landowners have recently reported to the SCCD significant problems at 22 of these sites. Many of these disposal sites appeared stable during the dry times of the 1980s; wetter climatic conditions during the late 1990s mobilized the salts, making the problems more serious and noticeable.

Objective

Promote economic development in an agricultural region by removing or stabilizing contamination. Document the degree of contamination of wetlands and water bodies associated with the Medicine Lake Wildlife Refuge. The SCCD proposes to clean up as many of these sites as possible to regain the lost productivity and reduce further contamination. The USFWS project emphasizes documenting the magnitude and impacts of contamination on the Medicine Lake Wildlife Refuge and Waterfowl Protection Areas in the County.

Approach

Conduct site assessments at potentially impacted areas by EM conductivity surveys, sampling, test drilling, and ground-water monitoring. Results will be used to develop cleanup plans to remove salt water.

Progress during the 2002–2004 Biennium

Initiated site assessments at about 20 sites. Data are currently being evaluated.

Plans for the 2004–2006 Biennium

Continue monitoring and assessing oilfield sites throughout the county. Evaluate and collect additional data as required. Develop and prepare reports to assist the cleanup process.

Information Products

Project completion reports and open-file reports. GIS maps are being developed showing extent of contamination, impact on water resources, and status of cleanup.

Project Title: Improving Soil Productivity and Water Quality in South-Central Montana through Land-Use Changes

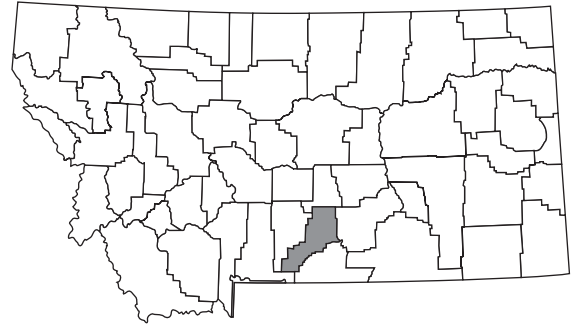
Location: Stillwater County

Project Period: July 1, 2001–December 31, 2004

Project Leader: Jon Reiten

Project Staff: Shawn Reddish, Jay Hanson, Montana State University-Billings students, Stillwater County Commission

Funding Sources: Montana Department of Natural Resources (DNRC), Resource Indemnity Trust, U.S. Fish and Wildlife Services



Issue

Since the 1950s saline-seep conditions have developed in the Lake Basin of south-central Montana. Traditional small-grain cropping patterns result in land being left fallow every other year to enhance soil moisture. This practice can lead to saline seeps because excess water infiltrates into recharge areas and mobilizes salts. These salts can build up in lakes, springs, seeps, sediment, and forage to concentrations that are toxic to livestock and wildlife. The salts contain antagonistic minerals that can block the uptake of required trace metals necessary for healthy livestock and wildlife. With the loss of land productivity and the advent of the Conservation Reserve Program (CRP), much of the salinized land is now being returned to rangeland and saline seeps are shrinking.

Objective

Find methods that will further decrease saline-seep development.

Approach

- Develop potable water supplies to maintain the livestock industry
- Identify sources contributing to the saline-seep problem including surface water, ground water, and sediment
- Document changes caused by CRP and the return to more rangeland, and develop Best Management Practices to further reduce saline-seep growth
- Develop a comprehensive overview that compares current land uses to water quality in the Lake Basin
- Provide local producers with information to help them develop the best mix of land uses to enhance the economy and reduce saline seep

Progress during the 2002–2004 Biennium

A water well and spring inventory was completed. All additional data collected during the inventory were entered into the Ground-water Information Center (GWIC) database maintained by the Montana Bureau of Mines and Geology.

During the late 1970s a private company exploring for uranium drilled a series of boreholes in the Lake Basin area. Excellent sub-surface geophysical data were recorded and logged by the driller and in the geophysical logs. These logs were obtained and locations verified, and they are being used to help identify potential sources of water in the area.

A total of 147 water wells and 46 springs were inventoried in the Lake Basin.

About 40 water samples were collected to evaluate water quality and about 20 samples were collected to evaluate age of the ground water.

Plans for the 2004–2006 Biennium

Complete project and final report. Develop recommendations for water development, and document changes in saline-seep development as a result of changes in land use from crop-fallow to CRP and grazing. Assist producers in evaluating potential water resources in the area.

Information Products

Project completion reports and open-file reports. GIS maps are being developed showing hydrogeology, water resources, and potential for ground-water development.

Project Title: Streamside Tailings Waste Radioactivity Study

Location: Silver Bow County

Project Period: Calendar year 2003

Project Leader: Peter Norbeck

Project Staff: Ted Duaine

Funding Source: Montana Department of Environmental Quality (DEQ)

Issue

Radioactive waste slag from the former Stauffer Chemical site (now Rhodia) overlies and is mixed with mine waste tailings within Reach G of the Streamside Tailings Operable Unit (SSTOU).

Objective

Provide the DEQ with a preliminary evaluation of concentrations and quantities of radioactive waste slag overlying tailings, and potential impacts of the slag on the tailings, to help determine disposal options under Administrative Rules of Montana (ARM) 37.14.

Approach

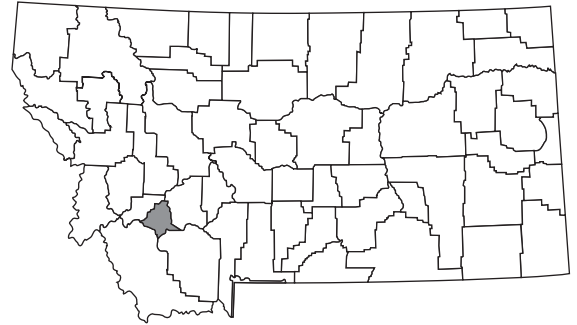
An initial assessment of areas where slag overlies tailings was conducted using a Ludlum Micro R meter. A total of 194 readings were taken at 170 sites with the instrument approximately 1 meter above the surface at sample sites located using a Global Positioning System. Based on the initial assessment, sample sites were selected to confirm the lateral extent and depth of the slag. A small backhoe was used to excavate sample pits through the slag and tailings so radioactivity could be measured and samples collected at discrete depths for laboratory analysis of gross alpha and gross beta activity.

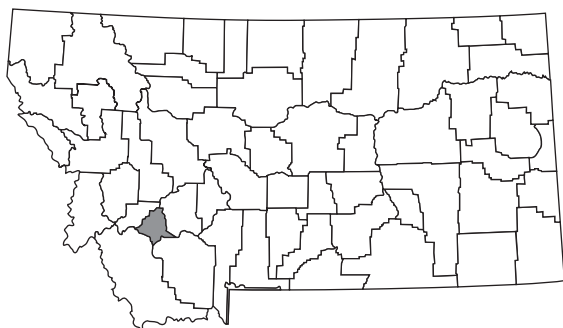
Progress during the 2002–2004 Biennium

The study was completed, and sample results and conclusions were included in a final report.

Information Products

A final report addressing the various subtasks was completed and submitted.





Project Title: Long-term Monitoring and Data Collection, SSTOU

Location: Silver Bow County

Project Period: Calendar year 2004

Project Leader: Peter Norbeck

Project Staff: Ted Duaime

Funding Source: Montana Department of Environmental Quality (DEQ)

Issue

Provide the DEQ with the analytical data and data evaluation needed to (1) identify and locate any continuing contaminant sources and (2) evaluate the effectiveness of stream channel restoration of the Streamside Tailings Operable Unit (SSTOU) of the Silver Bow Creek/Butte Area National Priorities List site.

Objective

Provide assistance to the State of Montana and the U.S. Environmental Protection Agency in the collection of surface-water, streambed, and vadose zone and ground-water samples, compilation and analysis of data, and monthly reporting of analytical results.

Approach

Perform streambed and surface-water sampling during approximate high and low flow conditions each year at sites on Silver Bow Creek. Install lysimeters at repositories and sample vadose zone water.

Progress during the 2002–2004 Biennium

Ground-water and surface samples, stream flows, channel cross sections, vadose zone samples, and streambed sediment samples were collected and the analytical data were entered into project databases and the MBMG's Ground-Water Information Center (GWIC).

Plans for the 2004–2006 Biennium

Continue to collect and analyze data and prepare periodic updates. New data will be entered into the existing databases.

Information Products

Interim reports (monthly) are submitted to the DEQ, and a final report addressing the various subtasks will be completed and submitted.

Project Title: Post-Remediation Monitoring and Data Collection, SSTOU Subarea 1, Reach A

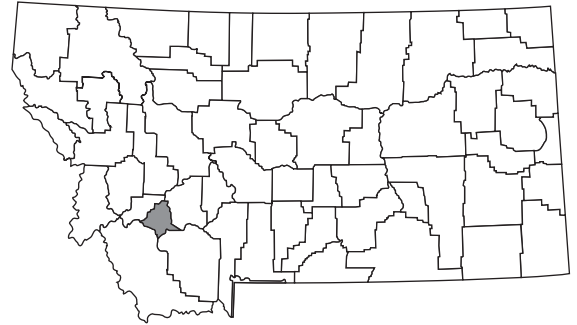
Location: Silver Bow County

Project Period: Calendar year 2004

Project Leader: Peter Norbeck

Project Staff: Ted Duaine

Funding Source: Montana Department of Environmental Quality (DEQ)



Issue

Provide DEQ with the analytical data and data evaluation needed to (1) identify and locate any continuing contaminant sources and (2) evaluate the effectiveness of stream channel restoration for Reach A, Subarea 1 of the Streamside Tailings Operable Unit (SSTOU) of the Silver Bow Creek/Butte Area National Priorities List site.

Objective

Provide assistance to the State of Montana and the U.S. Environmental Protection Agency in the collection of surface-water, streambed, soil, and vadose zone and ground-water samples, compilation and analysis of data, and monthly reporting of analytical results.

Approach

Perform streambed and surface-water sampling during approximate high and low flow conditions each year at two sites on Silver Bow Creek. Collect one soil sample per 10 acres from the restored area. Install lysimeters at repositories and sample vadose zone water.

Progress during the 2002-2004 Biennium

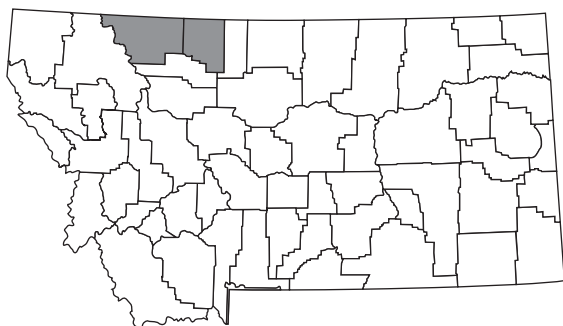
Sample results, stream flows, channel cross sections, and other data were entered into the project database and appropriate data were entered into the MBMG's Ground-Water Information Center (GWIC).

Plans for the 2004-2006 Biennium

Continue to collect and analyze data and prepare periodic updates. New data will be entered into the existing databases.

Information Products

Interim reports (monthly) are submitted to DEQ, and a final report addressing the various subtasks will be completed and submitted.



Project Title: Sunburst Water-Supply Renovation

Location: Toole and Glacier counties

Project Period: Calendar year 2004

Project Leader: Peter Norbeck

Project Staff: Ted Duaime

Funding Source: Montana Department of Natural Resources and Conservation (DNRC)

Issue

The town of Sunburst currently has water rights on 12 wells originally drilled over 50 years ago to provide water from the Virgelle sandstone for Texaco's refinery at Sunburst. Two wells have been used to supply the town. In the summer of 2001, sulfur-reducing bacteria in the water from Well 15 overwhelmed their chlorination system, forcing the town to shut down the well. A preliminary hydrogeologic analysis by MBMG and inspection of the casing using a down-hole camera indicated that a likely source for sulfur bacteria was poor quality water from shallow aquifers entering the well through corroded steel casing. Failure of the casing in Well 15 raises the possibility of casing failures in other wells and possible contamination of the aquifer.

Objective

Unused wells represent a possible source of contamination for the Virgelle aquifer, either because of casing failures or because of introduction of contaminants through open boreholes. Two unused wells will be selected for use as back-up supplies and the remaining unused wells will be plugged and abandoned.

Approach

The remaining pumps will be pulled from the unused wells and all wells will be cleaned, sampled, and inspected. Based on a hydrogeologic analysis, analytical results, and condition of each well, decisions will be made to maintain a well as a back-up source or plug and abandon it.

Progress during the 2002–2004 Biennium

Unused pumps were pulled from wells, boreholes were inspected with a down-hole camera, samples were collected from 4 wells, and a ground-water inventory was begun.

Plans for the 2004–2006 biennium

Complete the inspections and sampling of the Sunburst wells and the ground-water inventory. Select wells for renovation, cement a liner in those wells, and plug and abandon the remaining unused wells.

Information Products

Interim reports (quarterly) are submitted to the DNRC, and a final report addressing the various subtasks will be completed and submitted.

Project Title: Assessment of Impacts of Non-Point Source Pollution to Water Resources in the Yellowstone Alluvial Valley, Yellowstone County, Montana

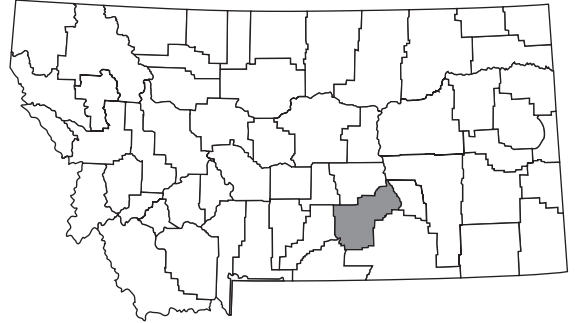
Location: Yellowstone County, Montana

Project Period: September 2001–July 2005

Project Leader: John Olson

Project Staff: Rye Svingen, Kenny Welsh (student), Dave Kuzara (student)

Funding Source: Environmental Protection Agency, Montana Department of Environmental Quality Clean Water Section 319 Grant, supplemental funding from the U.S. Bureau of Reclamation



Issues

Urban fringe and rural areas in and around the communities of Lockwood, Shepherd, Huntley, and areas east of Billings in Yellowstone County are experiencing rapid population growth, with many new homes being built each year. Most of these homes are outside municipal sewer services and must rely on septic drainfields for sanitary disposal. Drainfield sanitary systems have been shown to be sources of nitrate contamination of ground water. Other potential sources of nitrate impacts in the area include feed lots and field fertilizer applications. The extent and distribution of the nitrate-affected ground water in the Middle Yellowstone alluvial valley has not been adequately defined. There are nearly 2000 wells within this area and only a few of these wells have ever been tested for nitrate. Therefore, the possible magnitude of the nitrate problem is unknown.

Ground-water quality is also threatened by large-scale development and urbanization that is occurring across the region. The land in the valley is rapidly transforming from primarily flood-irrigated croplands and pastures to residential and urban uses. Data from west Billings indicate that these land-use changes will likely have significant impacts to future water quality and quantity. The primary source of recharge to the ground-water system is from seasonal flood irrigation, and to a much lesser degree from precipitation. During the irrigation season, ground-water levels and flows substantially increase. Recharge from irrigation water (supplied from the Yellowstone River) acts to dilute the much more mineralized and poorer quality ground water. Increased seasonal ground-water flows from irrigation also dilute nutrient and other NPS contaminant loads. However, urbanization and development of the valley are removing large areas of land out of irrigation for use as residential subdivision. Consequently, the quantity of high-quality recharge will diminish. Results of this loss include increased ground-water salinity and decreased ground-water yields. The effects of land-use changes on the watershed need to be documented to preserve water quality and ensure adequate quantities of the water resources. Baseline conditions need to be established so that the influences from future development can be accurately evaluated.

Objectives

To understand the surface-water and ground-water systems in the Middle Yellowstone alluvial valley in sufficient detail to develop technically sound predictions of the impacts of future land-use changes and development. The project will focus on delineating the distribution, sources, and fate of nitrogen and salinity impacts in ground water and surface water, and on evaluating the water quality and hydrologic interrelationships of ground water, irrigation, and drainage systems in the area. The data generated by this project will be used to develop management plans for the Yellowstone River.

Approach

Data from inventories will be used as starting points for establishing additional sites for installing monitoring wells and surface-water monitoring sites. A monitoring network will be developed using these sites, and water levels and field water-quality parameters will be periodically measured. Water-quality sampling during the 2-year period of this project will provide the background of seasonal changes in water quality during this study. In addition, this sampling will provide background data for monitoring future impacts that we hope will lead to longer term sampling at selected sites. Routine field screening will include measuring field pH, specific conductance, temperature, turbidity, and nitrate concentrations. Water-quality sampling will measure major cations, major anions, selected trace metals, and nutrients. Stable-isotope analyses and radiometric dating will be used to better quantify recharge, flow rates, and nitrogen sources and attenuation in the area. Sites will be established to gage future conditions through future monitoring programs. This work will complement and advance concepts identified in a similar project in the west Billings area. Together the projects will provide landowners and planners with valuable data and insight to manage water resources in the greater Billings area.

Progress during the 2002–2004 Biennium

MBMG staff have inventoried 67 wells and 64 surface water station sites. In addition 26 dedicated monitoring wells have been installed and fitted with continuous water-level recorders. Aquifer pump tests have been conducted at 10 sites to obtain aquifer property data. Stream monitoring has been conducted at 64 sites to evaluate the regional water balance and to estimate nitrate loading rates to ground water and surface water. Water-quality samples have been collected for nutrients, common ions, and trace metals. Routine monitoring for nitrate concentrations have been conducted at selected sites.

Information Products

Detailed interpretive maps of the terrace aquifers, ground-water flow patterns, ground-water quality, and nitrate concentrations have been prepared for publication. Preliminary data have been presented at a number of public forums.

Project Title: Northern Park County, Water Resources Protection and Management Plan

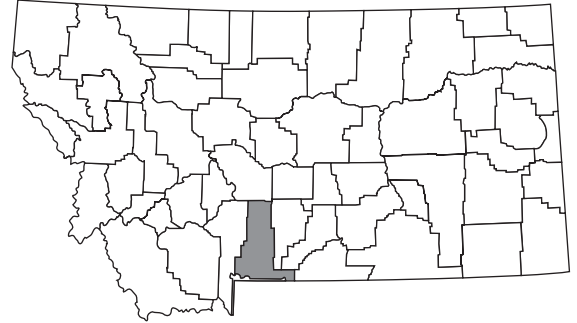
Location: Northern Park County, Montana

Project Period: September 2003–July 2005

Project Leader: John Olson

Project Staff: Rye Svingen, Jimmy Fry (student), Dixie Shopp (student), Shawn Stevens (Student)

Funding Source: Montana Department of Natural Resources, Renewable Resource Grant



Issues

The availability and quality of water resources in northern Park County are under increasing pressures from rapid subdivision developments in areas surrounding Livingston and potentially from coalbed-methane (CBM) development in some areas of northern Park County. Hydrologic data on the aquifers and their interaction with surface water in the northern portion of the county are very limited. Baseline data for water quality and flow data on streams and springs in potential CBM areas are also lacking. These data are essential to develop county growth and land-use plans and policies.

Objectives

To collect and evaluate hydrogeologic data to develop a water resources protection and management plan for northern Park County. This plan will be used by Park County and the Park Conservation District to manage subdivision developments north of Livingston and to evaluate and manage potential coalbed methane development.

Objectives to accomplish these goals include:

- Identify and evaluate ground-water and surface-water systems in the areas of rapid subdivision development;
- Collect baseline ground-water and surface-water data in areas of potential coalbed-methane development; and
- Develop a water resource protection and management plan for northern Park County.

Approach

The project will consist of completing an inventory of wells, springs, and streams. Streams and springs will be measured for flow and stage. Wells will be measured for static and pumping water levels. Surface-water and ground-water samples will be collected for nutrients, common ions, and trace metals analyses. Some samples will be analyzed for tritium, deuterium, and oxygen-18 to provide data on aquifer sensitivity to impacts and recharge settings. All data collected during the project will be available through the MBMG's Ground-Water Information Center database (GWIC).

Data will be used to evaluate yields and suitability of the aquifers underlying the area. These data will be very useful to homeowners, developers, ranchers, and county planners. Recharge sources and relationships between ground water and surface water will be assessed. The end product will be a water resource plan for northern Park County containing a summary report of the project data and findings, and recommendations for future development and protection of the area's water resources.

Progress during the 2002–2004 Biennium

MBMG staff members have inventoried 96 wells, 10 springs, and 13 stream-monitoring sites since the project was started in September 2003. Ground-water level monitoring is being con-

ducted at 12 wells and surface-water flow and level monitoring is being conducted at 13 sites. All visited wells have been sampled for nitrate and field water-quality parameters. Selected sites have been additionally sampled for nutrients, common ions, trace metals, water isotopes, and tritium.

Project Title: Impacts of Non-Point Source Pollution to Water Resources in the Paradise Valley

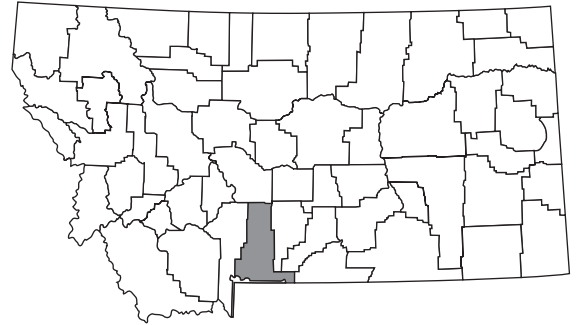
Location: Paradise Valley, Park County, Montana

Project Period: July 2000–February 2005

Project Leader: John Olson

Project Staff: Shawn Reddish, Rye Svingen, Dave Kuzara (student)

Funding Source: Environmental Protection Agency, Montana Department of Environmental Quality Clean Water Act Section 319 Grant, supplemental funding from the U.S. Bureau of Reclamation



Issues

Rapid expansion of residential development into the Paradise Valley has caused new and increasing potential impacts to the ground-water system. Land is being taken out of use as rangeland and irrigated cropland and subdivided into residential and recreational lots and non-producing land. The residential areas are not served by municipal sewers and rely on septic drainfields for waste discharges. Drainfields have been found to degrade underlying ground water through increased nitrate and dissolved solids concentrations. As the number and density of these waste systems increases, contaminant loading to the aquifer may become critical in some areas. The effects of land-use changes on the watershed need to be documented to preserve water quality and ensure adequate quantities of water resources. Baseline conditions needed to be established so that future potential effects from future development can be accurately evaluated.

Objectives

To develop an understanding of the physical hydrogeology of both the surface-water and the ground-water systems in the Paradise Valley with enough detail to develop scientifically sound predictions of the impacts of future land-use changes and development. This project will focus on collecting and interpreting hydrogeologic data with respect to current and future non-point source pollution and the potential impacts to the entire watershed.

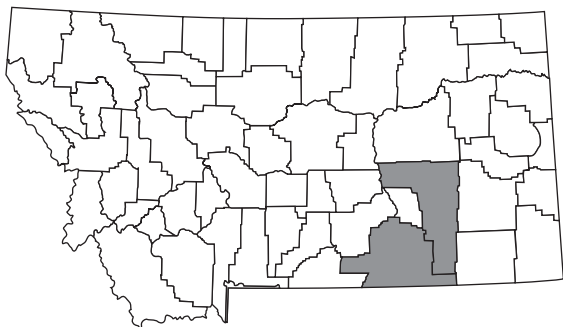
Approach

Data from inventories will be used as starting points for establishing additional sites for installing monitoring wells and surface-water monitoring sites. Additional sites will be inventoried as needed. A monitoring network will be developed out of these sites and water levels and field water-quality parameters will be periodically measured. Water-quality sampling during the 3-year period of this project will provide the background of temporal changes in water quality. In addition, this sampling will provide background data for monitoring future impacts and hopefully lead to longer term sampling. Routine field screening will include measuring field pH, specific conductance, temperature, dissolved oxygen, turbidity, and nitrates. Water-quality sampling will measure major cations, major anions, selected trace metals, stable isotopes, and nutrients.

Progress during the 2002–2004 Biennium

MBMG staff have inventoried 101 wells and 52 stream-monitoring sites in the project areas. Routine level monitoring was conducted at 20 wells and routine level and flow monitoring was conducted at 52 surface water stations. Samples for nutrients, common ions, trace metals, and tritium have been collected. Nine test wells were installed at key locations and pump tests were conducted to evaluate aquifer properties. Pump tests were also conducted by the MBMG at 4 other sites using wells supplied by landowners. Currently the data are being evaluated and final reports are in preparation.

Coal Resources, Hydrology, and Methane



Project Title: Northern Cheyenne Reservation Coalbed Natural Gas Resource Assessment and Analysis of Produced Water Disposal Options

Location: Northern Cheyenne Reservation; Big Horn and Rosebud Counties

Project Period: March 2002–March 2004

Project Leader: David A. Lopez

Project Staff: GIS staff, student research assistants

Funding Source: Contract with Idaho National Engineering and Environmental Laboratory (INEEL); funding

source is National Petroleum Technology Office of U.S. Department of Energy

Issue

The Northern Cheyenne Reservation is in the northern Powder River Basin, a prolific producer of oil and gas. Currently, coalbed natural gas is being developed in Wyoming and to a lesser extent in the Montana portion of the basin. The Reservation is within the area of potential coalbed natural gas development. The main issue with this development is the disposal of produced water associated with coalbed natural gas production. The focus of this project was to evaluate the disposal options available, especially the feasibility of water injection.

Objective

INEEL in conjunction with the MBMG has conducted an analysis of environmentally correct and cost-effective methods for disposal of potentially large volumes of water associated with development of coalbed methane (CBM) on the Northern Cheyenne Reservation. Multiple water handling options were reviewed within the context of the forecasted gas and water rates associated with the CBM development under the Reservation. Production forecasts were acquired via reservoir simulation and were based on actual geologic descriptions of coal assets and all available reservoir property data. Of the possible water disposal options, water disposal by re-injection into a zone that will preserve beneficial uses was the main focus of the project. The ultimate objective of the study is to determine which CBM development scenario and water handling option(s) maximize the beneficial use of produced coal water and the economic return to the Northern Cheyenne Indian Tribe, while minimizing adverse environmental impacts.

MBMG was responsible for the geologic description of the coals, including detailed stratigraphy and distribution of coalbeds and interbedded sandstones of the Tongue River Member of the Fort Union Formation. INEEL was responsible for reservoir engineering and water injection modeling. Both technical and economic criteria were considered.

Approach

Careful correlation of coalbeds and channel sandstones within the Fort Union Formation from all existing subsurface data, both from coal exploration and oil and gas exploration drilling, was utilized to develop as accurate a geologic description as possible of the Northern Cheyenne Reservation. Satellite imagery and aerial photography were used to define fracture systems in the area.

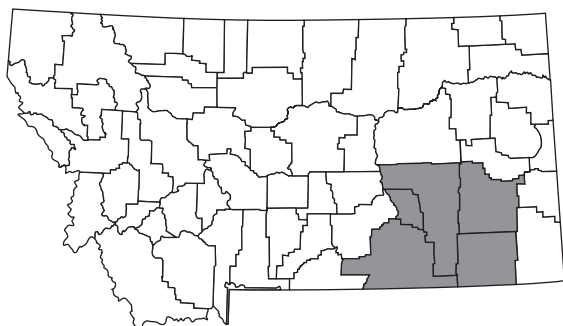
Progress during the 2002–2004 Biennium

Construction of a database for the Northern Cheyenne Reservation area using ARCVIEW GIS was completed. Subsurface stratigraphic and structural maps of the area were completed,

including maps of all Tongue River Member coalbeds and important channel sandstone units. The MBMG portion of the final report (geologic description) was completed in December 2004.

Information Products

The results and recommendations from this project have been published (August, 2004) by INEEL with cooperation and input from the MBMG.



Project Title: Coal Availability Program

Location: Southeastern Montana, Powder River Basin

Project Period: Ongoing since 1995, renewed yearly; current contract period: April 2004–March 2005

Project Leader: Edith M. Wilde

Project Staff: GIS Specialist, two student assistants

Funding Sources: U.S. Geological Survey (USGS) Energy Team, Montana Bureau of Mines and Geology

Issue

Original coal-resource estimates for the nation were made over 25 years ago and in many cases were based on few data locations, with only tentative coalbed correlations. These estimates included all coalbeds at least 30 inches thick and under less than 1,000 feet of overburden. Coal mining restrictions, likely mining methods, and essential economic factors were not considered. Based on these estimates, the nation was believed to have thousands of years of reserves. Differences between these estimates of total resources and the amount of coal that could actually be mined were highlighted by coal availability studies begun in the Eastern Coal Province in 1986. Study of this issue was extended into the remaining coal provinces and began for Montana in 1995.

Objectives

Measuring the magnitude of coal mining restrictions and determining their effect on mining in the economically important Powder River Basin area of Montana are the primary objectives. Results will be used by State and Federal agencies to update estimates of the national and State resources so that a more realistic picture of our energy future can be made.

Approach

Information contained in the National Coal Resources Data System (NCRDS) database, with the addition of other available data, is being used to produce basic coal-reserve estimates at the 1:24,000 scale in five separate study areas of Montana's Powder River Basin. Additionally, two larger study areas at a scale of 1:250,000 are in progress. Study locations were chosen to represent the major coal-producing zones and the various mining conditions of the immediate surrounding areas.

The methodology, developed specifically for this program by the USGS, is unique because it applies restrictions to coal resources before the reserve amount is estimated. Restrictions are placed in two basic categories: technologic and land use. Technologic restrictions consist of physical factors: coal too thin to surface mine, overburden too thick to remove, and beds too close together. Land-use restrictions, established by State and Federal regulations, include National Park locations, alluvial valley floors, public use areas, inhabited buildings, towns, utility lines, cemeteries, etc.

For each study area, the specific restrictions and the area covered by each are determined, and the amount of coal restricted is calculated. The available coal is then determined by removing restricted areas from the resource area, and the remaining tonnage available is calculated.

Progress during the 2002–2004 Biennium

The first and second study areas (Willow Crossing, Colstrip East and Colstrip SW 7.5-minute quadrangle) are complete, and three publications from the study are now available. Results from the two areas indicate that the original coal-resource estimates in the area were low by about 10 percent. However, only 44 percent of the original coal resource in the first area and

73 percent of the original coal resource in the second area could currently be mined due to land-use and technologic restrictions. Land-use conflicts and multiple-use issues cause the greatest impact in these areas. For the first area, the two largest restrictions are the locations of Custer National Forest lands and alluvial valley floors. For the second area, the technological restrictions defined by “too thin to mine” and “prior mining” have the greatest effect. The third study area (Otter and Reanus Cone 7.5-minute quadrangles) is in press. The fourth (Half Moon Hill and Taintor Desert 7.5-minute quadrangles) and fifth (Forks Ranch and Lacey Gulch 7.5-minute quadrangles) areas are in review. The first 1:250,000-scale study (Birney) is nearing completion. Field and bed correlation work is complete; restrictions and mined-out areas have been determined, and GIS work and report writing is under way.

Plans for the 2004–2006 Biennium

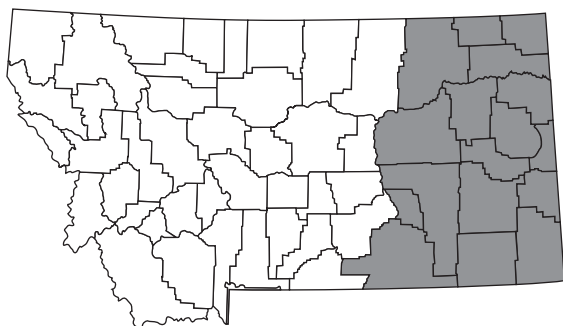
Complete review and publication for the third, fourth, and fifth study areas. Complete work and report writing for the first 1:250,000-scale area. Complete all work for the second 1:250,000 area (Lame Deer).

Information Products

Funding agreements require publication of the results of each study area. Yearly progress reports are presented at the annual meeting of the Coordination and Planning Committee for the Coal Availability program. Results for the first and second study areas (MBMG Report of Investigation 6 and Open-File Report 367; and MBMG Report of Investigation 12, respectively) have been completed.

Wilde, E.M., 2000, Availability of the coal resources of the Willow Crossing 7.5' quadrangle, Rosebud and Powder River counties, Montana: Montana Bureau of Mines and Geology Report of Investigation 6, 26 p.

Wilde, E.M., and Myers, W.H., 2003, Available coal resources of the Colstrip East and Colstrip SW 7.5' quadrangle, Rosebud and Bighorn Counties, Montana: Montana Bureau of Mines and Geology Report of Investigation 11, 163 p.



Project Title: National Coal Resource Assessment Program

Location: National, Southeastern and Eastern Montana, Powder River and Williston Basins

Project Period: Ongoing since 1996

Project Leader: Edith M. Wilde, as representative for Montana beginning 1997

Project Staff: Romeo Flores, USGS, Denver, Program Director; Stephen Roberts, USGS, Denver, Regional Director; one student research assistant

Funding Source: U.S. Geological Survey (USGS) Energy Team

Issue

Recently enacted Federal mining regulations, as well as new air- and water-quality standards, have brought into question the accuracy of reserve estimates currently being used for energy policy decisions. Current reserve estimates are based on data over 25 years old and considerable coal has been mined during that time. Results of recent coal availability studies have emphasized the need for updated reserve estimates based on more current conditions and taking into account restrictions that are imposed on mining.

Objectives

Reevaluate the nation's coal reserves using a basin-by-basin approach, and emphasizing coal-beds/zones currently being mined or likely to be mined in the next 20 years.

Approach

USGS personnel are compiling all available information into databases for each basin under study. The STRATIFACTS software program is being used for data storage and initial bed correlations. MBMG is assisting with data acquisition, determination of significant beds, coalbed correlation, and data interpretation for Montana. Data will be combined into a national database and used to update the national reserve estimates. Derivative products, charts, maps, and tables will be prepared based on the updated information obtained by this program. Data will be made available for policy makers once the study is completed.

Progress during the 2002–2004 Biennium

All work involving Montana has been completed. Regional information has been published by the USGS for the Williston and the Powder River Basins. A finalized version, including the basin-wide results for the entire nation, is pending.

Plans for the 2004–2006 Biennium

Assist with the completion of any pending publications.

Information Products

To date, the results have been published as USGS Open-File Report 99-376 (1 CD-ROM disc) and USGS Professional Paper 1625-A (two CD-ROM discs). Three additional publications are undergoing review.

Project Title: National Coal Resources Data System

Location: Statewide

Project Period: Ongoing since 1982; January 2002–December 2004

Project Leader: Edith M. Wilde

Project Staff: GIS specialist, one student assistant

Funding Sources: U.S. Geological Survey (USGS) Energy Team, Montana Bureau of Mines and Geology

Issue

The USGS established the National Coal Resources Data System (NCRDS) as part of their National Coal Resource Assessment Program. MBMG participation in this project is in its 20th year. The MBMG has considerable information available on all aspects of coal in Montana. Many of these data have been prepared and entered into the NCRDS database, but some remain to be entered. Quality control and verification methods were only recently established for this database; few of the data have been validated.

Objectives

This cooperative agreement provides funds to the MBMG for preparation of a comprehensive database containing information on Montana's coal reserves. NCRDS personnel are charged with using information provided by all participating states to determine the quality and quantity of all United States coal reserves. Reserve assessments are then used to provide consistent data to policy makers in Washington and as a research tool. The primary goal of this project is to validate and correct data from Montana that is currently in the national database, so that NCRDS and the MBMG can provide this data to the public in a timely and efficient manner.

Approach

All Montana data in the NCRDS database are checked against in-house records, necessary corrections are made, and missing information is added. Additional available data are prepared, entered, and verified. The validation process is time-consuming and is proceeding first in areas needed for other projects. Efforts are also being made to add outcrop, production, and chemical data to this database.

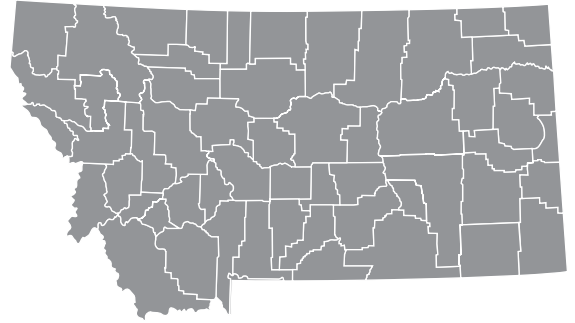
Progress during the 2002–2004 Biennium

The Montana portion of the database contained information for 10,574 data points (locations) from coalfields across the State. Locations for all data are being digitized and added to the database after the initial data entry. At the end of 2003, outcrop locations for all coalbeds in 65 1:24,000-scale map sheets from the Powder River Basin area of Montana had been digitized and added. The validation process has been completed for 74 of the 1:24,000-scale map sheet areas in the Powder River Basin; validation is continuing.

A database for chemical data was created in Microsoft Access format. All publicly available data for Montana from the USGS have been entered and additional data are entered as time permits. Additionally, production statistics have been entered into Microsoft Excel spreadsheets.

Plans for the 2004–2006 Biennium

Continue preparation and entry of any additional data. Continue entry of chemical and production data as time permits. Outcrops from 26 additional quadrangles are expected to be added by the end of 2005. Continuation of the validation process; at least 26 additional quadrangles are expected to be completed by the end of 2005.



Information Products

Currently, an informal report is submitted to NCRDS at the end of each year and a presentation is given before the NCRDS Coordination and Planning Committee at its annual meeting. Data are available to the public in paper copies or in limited digital formats.

Project Title: Evaluation of Coalbed-Methane Infiltration Ponds for Produced-Water Management

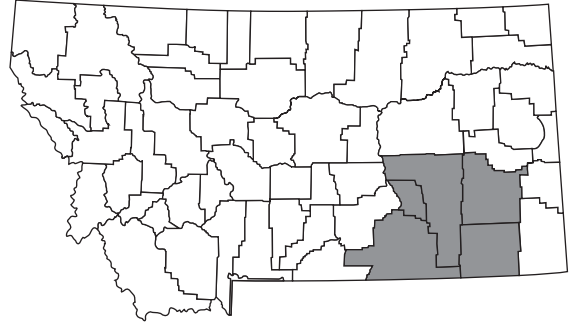
Location: Powder River Basin, southeastern Montana

Project Period: July 2002–November 2006

Project Leader: John Wheaton

Project Staff: Teresa Donato, Licette Hammer, Dan Fox, student assistants

Funding Sources: U.S. Bureau of Land Management, Montana Bureau of Mines and Geology, U.S. Department of Energy, Western Resources Project



Issue

Within the Powder River Basin in southeastern Montana, an area of approximately 5,500 square miles, 7,500 to 26,000 coalbed-methane wells are expected to be drilled and put into production during the next 20 years, according to the Montana Environmental Impact Statement (EIS) on coalbed-methane development. The production of coalbed methane (CBM) requires that significant volumes of coalbed water be pumped to reduce the hydrostatic pressure in the coal aquifer, allowing the methane to desorb from the coal surfaces. During the early stages of production, water is discharged at fairly high rates, often exceeding 20 gallons per minute (gpm). During later stages of production, discharge rates are expected to decrease, possibly to 5 gpm or less. Productive life of individual wells is not yet known for the Powder River Basin, but estimates range from 5 to 20 years. The potential number of wells, the average water production, and the life of the wells demonstrate that carefully designed and implemented water-management plans are crucial to successfully developing CBM in southeastern Montana. Infiltration basins (or holding ponds) are currently the primary method for disposing of produced water.

In Wyoming, 2,900 infiltration ponds are either currently in use or are in the permitting stage. Similar use of infiltration ponds in Montana is expected as CBM development expands. In southeastern Montana where CBM is expected to be developed, coalbed water has high sodium adsorption ratios (SAR) and salinity. Montana CBM-produced water is projected to have an average SAR value of about 47 and specific conductance of 2,200 umhos/cm. Infiltration ponds have several advantages. They are an inexpensive means of disposing of produced water, and allow more flexibility in pumping rates for the companies. Also, the produced water, which comes from primary aquifers in the area, helps recharge the shallow ground-water system. The basins also have several potential disadvantages. The infiltrated water does not move vertically into the original deep aquifers, but rather tends to infiltrate shallowly or move laterally. As the sodium-bicarbonate water moves through the shallow weathered bedrock, a series of chemical reactions (primarily dissolution and oxidation/reduction) may increase the salt load in the water and detrimentally impact shallow aquifers or streams.

Predicting changes in water quality is an integral part of permitting these ponds. Saturated paste-extract data and computer modeling may help define the water-quality changes and provide important tools for companies and permitting agencies.

Objectives

To develop methods to assess proposed CBM infiltration-basin sites, and to test and calibrate those methods with field research. Data will be collected at field sites, and water-flow and water-quality models will be run and calibrated using the field data. It is expected that specific

data needed for modeling, and the correct models, will be identified and documented. This will determine what criteria will be needed for the appropriate siting of infiltration basins. These criteria will allow the expected long-term infiltration rates to be calculated, and ensure that the infiltrated water will recharge bedrock aquifers rather than flowing unexpectedly to surface waters (either as baseflow or through the creation of new and potentially saline springs). The criteria would also be used to assist industry in selection of appropriate sites for infiltration basins, and to assist regulators in evaluating the adequacy of proposed infiltration basin sites. Major factors controlling site adequacy are expected to include the types of soils at the site, the site-specific stratigraphy of the underlying bedrock, and the distance to out-crop.

Approach

Four infiltration ponds that are in use by CBM companies are being used as study sites. At these sites monitoring wells have been installed near the ponds and the rate of water production and quality of CBM water entering the ponds is being documented. In addition to the active CBM sites, several flowing wells in southeastern Montana where sodium-bicarbonate rich water has been discharged across the land surface for a number of years are being studied. Water flowing from these wells is similar to CBM-produced water, and the interaction with soil and subsurface material is projected to duplicate that which occurs at CBM infiltration ponds. At each site a shallow testhole has been drilled upgradient and downgradient of the discharge point. In the discharge area, test holes were cased and are utilized as monitoring wells.

At all sites changes in shallow ground-water levels and water quality are being measured. Paste-extract analyses run on drill cuttings are providing data on chemical reactions in the infiltrating zone. A geochemistry model will be used to provide a general understanding of chemical reactions along flow paths.

Progress during the 2002–2004 Biennium

Monitoring has been established and is ongoing at 4 CBM infiltration ponds and at 15 flowing stock wells. Monitoring wells have been installed and lithologic material collected and analyzed, and water levels are being measured and water-quality samples collected. Additional monitoring will occur for the duration of the project. Preliminary models have been created. Preliminary results have been presented at several scientific conferences.

Plans for the 2004–2006 Biennium

Continue monitoring sites, collect additional water-quality samples. Perform chemical modeling and write formal paper on results. Present technical papers at workshops and scientific conferences.

Information Products

This long-term project has produced several presentations at scientific conferences and the preliminary results are being used as part of the Montana infiltration pond siting criteria.

Project Title: Investigation of Microbial Ecology, Structure, and Function in Coalbed Aquifers: Powder River Basin, Montana

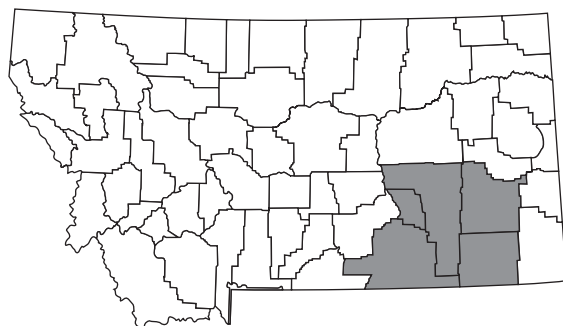
Location: Powder River Basin, southeastern Montana

Project Period: March 2004–February 2005

Project Leader: John Wheaton

Project Staff: Pat Ball, University of Montana

Funding Sources: U.S. Department of Interior Geological Survey—Montana Water Center, Montana Bureau of Mines and Geology, University of Montana



Issue

Coalbed aquifers supply critical water resources to vast regions in southeastern Montana. They support the needs of agricultural, coal mining, domestic, and recreational interests, as well as provide base flow to the Tongue River, the Powder River, and their tributaries. These aquifers are being impacted by conventional coalbed-methane (CBM) development and, as concerns of global warming increase, speculation that these aquifers may serve as waste repositories for sequestering industrial CO₂ suggests that additional impacts are likely in the future.

The origin of CBM in the Powder River Basin is the result of microbial processes (biogenic methanogenesis). The success of CO₂ sequestration strategies will likely be a function of microbial activities as well. The structure, diversity, and presumptive function of the total microbial community within coalbeds in the Powder River Basin needs to be determined and understood in order to maximize CBM production, minimize ground-water impacts, and potentially augment CO₂ sequestration.

Objectives

The goal of this work is to generate data that will support more advanced studies of *in situ* gasification of coal as it relates to methanogenesis, CO₂ sequestration, and the development of technologies appropriate for sustainable methane development. The value of these data are as a means of moving us toward harvesting CBM rather than simply mining this resource at the expense of our ground-water resources.

Information derived from this research will aid in our understanding of the microbial ecology of coalbed aquifers and help identify which microbial populations are likely responsible for acetate fermentation or reduction of CO₂ and the formation of methane. Based on molecular phylogeny data obtained from these analyses, we will gain knowledge that will underpin and inform our culture-based investigations. This is necessary in order to delineate and quantify methanogenesis kinetic rates that are attributable to the microorganisms present in the coalbed aquifers. This also may aid us in the development of biostimulation or bioaugmentation protocols that may lead to increased methane production and CO₂ sequestration based on enhanced microbial activity.

Approach

CBM production water samples have been collected from sampling ports on wellheads. An initial survey of the microbial populations ecology has been performed, including the functional groups present on the samples, based on phylogenetic analysis of 16S rRNA genes and the *mcr* gene (the key enzyme in methane biosynthesis) sequences. Based on the molecular analysis and phylogenetic information, culture-based investigations will be initiated that will

help delineate methanogenesis kinetic rates attributable to the resident microorganisms. Methods used for sampling and analysis will be evaluated.

Progress during the 2002–2004 Biennium

Preliminary analyses of CBM-produced water samples for microbes has shown microbes that have not previously been described in the scientific literature. Initial results have been presented at a scientific conference.

Plans for the 2004–2006 Biennium

Complete analysis of microbe community. Prepare a formal publication for a national journal. Present technical papers at workshops and scientific conferences.

Project Title: Mitigation of Ground-Water Impacts of Coal-bed-Methane Development

Location: Billings and southeastern Montana

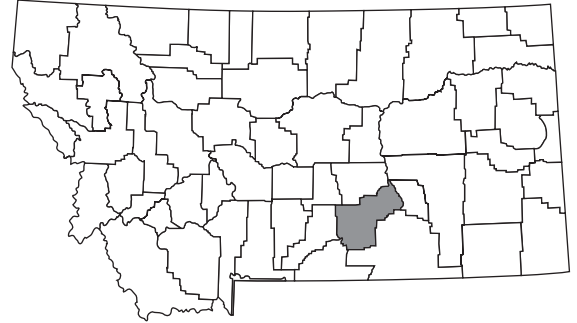
Project Period: Ongoing since 1999

Project Leader: John Wheaton

Project Staff: Teresa Donato, Licette Hammer, student assistants

Funding Sources: U.S. Bureau of Land Management (BLM), Montana Bureau of Mines and Geology, Montana Department of Natural Resources and Conservation

(Resource Development Grants Program), Conservation Districts, U.S. Department of Interior Forest Service



Issue

Coalbed-methane (CBM) development in Montana challenges industry and regulators to provide proper safeguards for water resources. Methane production requires pumping and wasting large volumes of ground water. This method of production will impact water availability over large areas, and will impact water quality in streams that are used for irrigation. The degree of impact will be determined largely by the number of wells being pumped, and the rates of discharge.

Production is accomplished by pumping ground water from the coalbeds to decrease hydrostatic pressure in the aquifer. With sufficiently decreased pressures, methane gas desorbs from the coal and is discharged with the well water. Thus far production is established and expanding in New Mexico, Colorado, Montana, and Wyoming. Development in Montana began in 1999 with 127 wells near Decker producing 8 million cubic feet of methane gas per day, and 3 million gallons of water per day. During August, 2004, 406 wells produced 1.15 billion cubic feet of gas with a combined monthly average of 1,310 gallons per minute of produced water. The gas is a high BTU, clean-burning fuel. The water is useable for human and livestock consumption, but highly unfit for irrigation. In Montana, 718 permits to drill have been filed for CBM wells.

Objectives

Many additional wells are expected, possibly exceeding the several thousand already producing in Wyoming. The objectives are to predict and mitigate the areas of ground-water depletion, and to manage the discharge of high-sodium water to safeguard irrigation uses of the Tongue River.

Approach

The MBMG is conducting research on several aspects of CBM development. The MBMG has assisted the BLM in the preparation of a programmatic Environmental Impact Statement (EIS) of CBM development and continues to expand an Internet-based, comprehensive literature database covering technical aspects of CBM and topics associated with development. MBMG staff serve on a Technical Advisory Committee on ground-water problems related to development, and on several multi-agency (State and Federal) committees to coordinate agency responsibilities.

Through site-specific studies, a large volume of hydrogeologic data exist for the Powder River Basin in Montana. These data can be used for specific calculations of impacts and recovery of hydrogeologic systems based on and limited under assumptions such as the CBM development scenarios. A series of computer modeling efforts has incorporated much of the existing

data. Modeling, using generic single layer and a site-specific 3-D approach with the available data, is the best method to provide an estimation of impact potential. A multi-layered, 3-D model was utilized to provide input on the statewide EIS, and simple models are being used to help evaluate newly proposed CBM fields.

Projections of discharge water quantity and quality are being made based on data collected at monitoring wells. The MBMG's long-established coal-hydrology monitoring program has been maintained and expanded to provide additional data. Additional monitoring wells are being drilled in key locations in the area of intensive CBM development. Older monitoring wells are being located and reactivated. Spring inventories and field analyses are being conducted. These wells and springs will provide additional data and as methane production in Montana increases, the MBMG, in cooperation with other agencies, will document and predict impacts, and will offer mitigation measures where possible.

All investigators on this project are providing technical assistance and informational presentations to BLM, companies, landowners, scientific conferences, and others interested in the progress of CBM development in Montana. A GIS of the Powder River Basin area was completed and includes all known hydrologic features, coal outcrops, and topography. Another GIS showing the Anderson and Knobloch coal horizons and potential for methane development was developed. Both of these GIS projects are being used to interpret and illustrate the impacts of CBM development. An introduction to coalbed methane and the associated hydrologic issues has been published and is available to the public.

Progress during the 2002–2004 Biennium

Programs have been added and additional funding procured for this project. New monitoring wells have been installed and added to the regular monitoring program, and additional wells are being drilled during Fall 2004.

Plans for the 2004–2006 Biennium

Continue monitoring program. Add additional monitoring wells. Present technical papers at workshops and scientific conferences. Collect water-quality samples and perform aquifer tests.

Information Products

- Wheaton, J., and Metesh, J.J., 2002, Potential ground-water drawdown and recovery for coalbed methane development in the Powder River Basin, Montana: Montana Bureau of Mines and Geology Open-File Report 458, 59 p.
- Van Voast, Wayne, 2003, Geochemical signature of formation waters associated with coalbed methane: AAPG Bulletin 87, no. 4, p. 667–676.
- King, L., Wheaton, J., Vance, G., and Ganjegunte, G., 2004, Water issues associated with coalbed methane (natural gas) in the Powder River Basin of Wyoming and Montana: American Society for Mine Reclamation, Reclamation Matters, v. 1, no. 2, Fall, 2004, p. 7–12.
- Wheaton, J.R., and Donato, T.A., 2004, Ground-water monitoring program in prospective coalbed-methane areas of southeastern Montana: Year One: Montana Bureau of Mines and Geology Open-File Report 508, 91 p.
- Wheaton, J.R., and Donato, T.A., 2004, Coalbed-methane basics: Powder River Basin, Montana: Montana Bureau of Mines and Geology Information Pamphlet 5, 20 p.

Project Title: Coal Lands Hydrogeology

Location: Southeastern Montana

Project Period: Ongoing since the early 1970s

Project Leader: Wayne Van Voast

Project Staff: John Wheaton, Teresa Donato

Funding Sources: U.S. Bureau of Land Management,
Montana Bureau of Mines and Geology

Issue

Energy is not the only resource provided by coalbeds in southeastern Montana. In this semi-arid climate, inhabitants almost totally depend on ground water for stock and domestic supplies, and in many places ground water is obtained from coalbeds that will be removed by mining. Mine-spoil aquifers may be of limited value as a water resource and may impact water quality in down-gradient aquifers.

To ensure rational and efficient coal resource decision-making by mining companies and regulators, the impacts of mining on ground water must be well documented and thoroughly understood. Because mining and associated impacts have very long durations, the study of the associated hydrology needs continues to be a long-term commitment.

Objectives

Document hydrologic impacts associated with coal strip mining. Develop models that can be used to predict those impacts using hydrogeologic baseline data and mine plans; and use the information to plan, mine, and reclaim for minimum hydrologic impact.

Approach

- (1) Measure water levels and collect water-quality samples at over 200 wells in and out of mine areas. Wells reflect mining-impacted aquifers as well as aquifers that are not impacted but can provide background data and natural seasonal variations.
- (2) Maintain the data in databases that are easily accessible to the public on the Internet.
- (3) Review the data, analyzing temporal and spatial trends.
- (4) Interpret the information and disseminate it to regulators and industry.

Progress during the 2002–2004 Biennium

Continued data collection at mining areas near Colstrip and Decker. Reviewed data for mining impacts. Data collected and interpretations of those data were used at numerous presentations including public meetings and scientific conferences. The value of the database, due to its longevity and continuity, has been a point of discussion at these meetings.

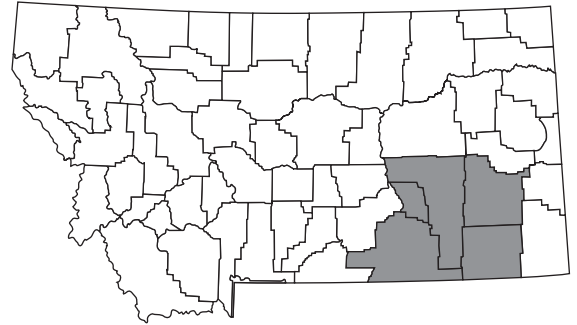
Plans for the 2004–2006 Biennium

Continue monitoring program, and visit older study sites. Present technical papers at workshops and scientific conferences. Collect water-quality samples and perform aquifer tests, with emphasis on the Decker area.

Information Products

This long-term project has produced many formal publications. In this biennium:

Wheaton, J.R., and Donato, T.A., 2004, Ground-water monitoring program in prospective coalbed-methane areas of southeastern Montana: Year One, Montana Bureau of Mines and Geology Open-File Report 508, 91 p.



Grants and Contracts

Marvin R. Miller
Assistant Director

The Montana Bureau of Mines and Geology has continued to expand its grants and contracts program to better serve the needs of Montana citizens and to broaden its overall effectiveness. During the past two years, MBMG professionals in Butte and Billings have been involved in over 100 outside-funded projects cooperating with 105 different local, State, Federal, and private organizations. These projects, evaluating virtually all aspects of Montana's vast water and mineral resources, are distributed throughout Montana. Brief descriptions of most of these investigations are included in other sections of this report.

For many years, the Montana Bureau of Mines and Geology has worked closely with numerous organizations. With increasing concerns related to conservation and careful utilization of our natural resources and escalating regulatory pressures combined with reduced budgets, it is even more critical to work together. Over the biennium the MBMG collaborated with the following organizations:

- Local organizations/communities (17): Belt; Billings; Broadview; Edgar; Fairfield; Great Falls; Hardin; Harlowton; Laurel; Lavina; Martinsdale; Ramsay; Rapelje; Ryegate; Sidney; Sunburst; and Two Dot
- Conservation districts (25): Bighorn; Big Sandy; Cascade; Chouteau; Custer; Daniels; Deer Lodge; Fergus; Glacier; Hill; Jefferson Valley; Judith Basin; Liberty; Lower Musselshell; Park; Pondera; Powder River; Richland; Rosebud; Sheridan; Stillwater; Teton; Toole; Upper Musselshell; and Yellowstone
- Counties (11): Beaverhead; Butte-Silver Bow; Cascade; Flathead; Hill; Lewis & Clark; Missoula; Park; Stillwater; Treasure; and Yellowstone
- State agencies and organizations (13): Departments of: Agriculture; Commerce; Environmental Quality; Fish, Wildlife and Parks; Justice; Natural Resources and Conservation; State Library; Bitterroot Water Forum; Disaster and Emergency Services; Flathead Basin Commission; Montana Arts Council; Montana Salinity Control Association; and Montana Water Resources Center
- Out-of-state organizations (6): Idaho Geological Survey; Idaho National Engineering Laboratory; Incorporated Research Institutions for Seismology; Western Research Institute; Western Research Partnership; and Association of American State Geologists
- Universities and Colleges (8): Colorado School of Mines; Montana Tech, Butte; The University of Montana, Missoula; Montana State University, Billings; Montana State University, Bozeman; Montana State University, Northern; Rocky Mountain College, Billings; and the University of Wyoming

- Indian reservations (3): Crow Tribe; Northern Cheyenne Tribe; and Confederated Salish-Kootenai Tribes
- Federal agencies (14): Forest Service; Natural Resources Conservation Service; Department of Energy; Bureau of Indian Affairs; Bureau of Land Management; Bureau of Reclamation; Fish & Wildlife Service; U.S. Geological Survey; National Park Service; National Science Foundation; Office of Surface Mining; Environmental Protection Agency; Federal Emergency Management Agency; International Joint Commission, United States/Canada
- Private (9): Apache Oil Company; Ballard Petroleum Company; Big Hole River Foundation; Bull Mountain Properties, Inc.; Husky Energy Company; Midwest Assistance Program; Montana Rural Water Systems Association; Trout Unlimited (George Grant Chapter); Western Heritage Center

In addition, MBMG professionals actively participate on approximately 50 technical advisory committees, councils, boards, or study groups for the benefit of public organizations or agencies. Through these contacts, MBMG personnel contribute their expertise and also continue to learn through their participation in and communication with these groups.

Administrative Division

**Lynn Job
Division Chief**

The Administrative Division includes administrative and accounting support personnel. The division is responsible for the overall administrative and fiscal management of the Montana Bureau of Mines and Geology, and directs and administers all of the outside monies that are awarded to the Montana Bureau of Mines and Geology for research, contracts, and creative activities.

Part-time Student Assistants

The Montana Bureau of Mines and Geology augments its staff through the employment of college students as part-time assistants. These students not only contribute to the research effort but also gain experience in organized research as part of their academic training. During all or part of the 2003-2004 biennium, 37 students from various departments were employed.

	July 1, 2002 - June 30, 2003	July 1, 2003 - June 30, 2004
Revenue		
General Fund Appropriation	\$ 1,536,284.00	\$ 1,581,899.00
Sales & Service	29,218.57	35,649.06
Ground Water Assessment	666,000.00	666,000.00
Total Revenue	\$ 2,231,502.57	\$ 2,283,548.06
Expenditures		
Personnel Services	1,835,686.78	1,804,410.93
Operating Expense		
Contracted Services	88,385.13	70,476.17
Supplies & Materials	83,970.87	73,047.75
Communications	37,422.63	33,107.41
Travel	101,565.81	108,252.44
Rent	27,801.00	26,711.40
Utilities	240.50	211.68
Repair and Maintenance	15,954.19	26,120.19
Other Operating	79,632.82	140,153.08
Total Operations	434,972.95	478,080.12
Equipment	20,289.00	-
Transfer	39,289.52	-
Total Expenses	\$ 2,330,238.25	\$ 2,282,491.05

Information Services Division

Susan Barth
Publications Editor

The Montana Bureau of Mines and Geology (MBMG) provides extensive advisory, technical, and informational services on Montana geological, mineral, energy, and water resources to the public and private sectors, and is legislatively mandated to communicate and disseminate the findings of research conducted within the organization. It is the primary responsibility of Information Services (IS) to facilitate adherence to that mandate.

Goals

The central goals of the IS division are to:

- assist MBMG researchers in the preparation, publication, and dissemination of their work;
- ensure the high quality, consistency, and readability of MBMG publications;
- maintain, and continually develop and improve upon, the MBMG website;
- be a resource of information and technical assistance for MBMG staff and the public; and
- promote public awareness of MBMG projects and publications through displays, public outreach, advertising, cooperative agreements with other organizations, and conferences.

Division Organization

The IS division comprises four sections: Editorial, Cartography, Information Systems, and Publication Sales.

Editorial

The editorial staff is responsible for the scientific editing, layout, and pre-press production of a wide variety of publications, as well as management of vendors and printers.

Cartography

The cartographic area handles the research, compilation, and graphic design of maps, technical illustrations, scientific publications, exhibits, presentations, and brochures.

Information Systems

The information systems section holds our link to the outside world via the Internet. Our webmaster is required to develop, deploy, and manage the daily operation of the MBMG's website.

Publication Sales

Our Publication Sales Office distributes MBMG publications and USGS topographic and thematic maps to a diverse array of customers, including: artists (jewelers, potters, etc.); builders; geologists; local, county, State and Federal agencies; miners; researchers; recreationists (amateur gold prospectors, campers, fishermen, gardeners, hikers, hunters, rock hounds, etc.); real estate agencies; students; schools; and other universities and colleges. These materials are used for administration, exploration, earthquake tracking, genealogical studies, search and rescue, spelunking, teaching, thesis and dissertation studies, tourism, water-well potential and location, and zoning.

MBMG publications are issued in the following categories:

Bulletins

Significant data and interpretations with lasting scientific interest

Geologic Map Series

Mapped areas and presentations on various geologic themes; may include some descriptive text or expanded explanations; charts, tables, analytical data, etc.

Ground-Water Assessment Atlas

Descriptive overviews and maps interpreting the ground-water resources of selected areas

Ground-Water Open-file Reports

Manuscripts and maps dealing with various ground-water issues in Montana that have been produced as ancillary documents by the Ground-Water Assessment Program

Hydrogeologic Map Series

Mapped areas and presentations on various hydrogeologic themes; may include some descriptive text or expanded explanations; charts, tables, analytical data, etc.

Information Pamphlet Series

Generalized discussions of variable subject matter on earth science and general interest topics of Montana geology

Memoirs

Comprehensive scientific reports of broad topical or geographic scope that have wide and long-term importance

Miscellaneous Contributions

Administrative reports, primary data tabulations, directories, bibliographies, indexes, and catalogues

Montana Atlas Series

Depicts geology, ground-water resources, mineral resources, and other subjects in a portfolio format

Open-File Reports

The open-file reports and maps are a means by which information is made available to the public on investigations that are preliminary in content, awaiting publication, or for various reasons are unpublished.

Reports of Investigation

Reports about narrowly focused areas of study

Special Publications

Compilation of various works, guidebooks, proceedings volumes, bibliographies, multiple authorship; may include subjects of interest to the non-scientist

Progress during the 2002–2004 Biennium

In the past biennium we have released formal publications on ground-water resources, gold placer exploration, coal resources, a map of the route of the Lewis and Clark Expedition in Montana from a geological perspective, a GIS-based map of the mines under Butte, and our ever-popular annual calendars. We also updated our publications catalogue and released this on a CD with a Montana Geology Screensaver. The MBMG website has been completely redesigned, and a new Kid's Area, with activities and information designed to interest kids in the Earth Sciences, was released in the summer of 2004.

New Publications

Geologic Maps

- GM 61-B Areas of potential landslide hazard in the Billings area, Yellowstone County, Montana, Lopez, D.A., Sims, M., 2003
- GM 61-C Areas of potential rock-fall hazard in the Billings area, Yellowstone County, Montana, Lopez, D.A., Sims, M., 2003
- GM 61-D Areas of potential swelling-clay hazard in the Billings area, Yellowstone County, Montana, Lopez, D.A., Sims, M., 2003
- GM 61A-D CD of GM Series Maps A-D, Lopez, D.A., Sims, M., 2003

Ground-Water Atlas Series

- GWAA 3B-07 Characterization of the Eagle Aquifer in Yellowstone County, Middle Yellowstone River Area, Montana (open-file version), Olson, J.L., Reiten, J.C., 2003
- GWAA 4B-01 Data for water wells visited during the Lolo-Bitterroot Area Ground-Water Characterization Study (open-file version), Carstarphen, C.A., Mason, D.M., Smith, L.N., LaFave, J.I., Richter, M.G., 2003

Information Pamphlets

- IP 4 Ground-water resources of the Flathead Lake area: Flathead, Lake, Sanders, and Missoula counties, Montana, Patton, T.W., Smith, L.N., LaFave, J.I., 2003

Open Files

- MBMG 401T Hydrogeologic assessment of the Em Kayan Village public water supply for ground water under the influence of surface water - PWSID #00540, Libby, Montana, Kerschen, M.D., McDonald, Catherine, 2002
- MBMG 401W Hydrogeologic assessment of the Lions Park Spring for ground water under the direct influence of surface water, Lions and Spring public water supply PWSID #03742, Forsyth, Montana, Duaime, T., Kerschen, M., McDonald, C., 2002
- MBMG 446 Geologic map of the Lonesome Lake 30' x 60' quadrangle, north-central Montana, Lopez, D.A., 2002
- MBMG 447 Sheridan County Ground-Water Management Program: Management of water resources from the Clear Lake aquifer, Reiten, J.C., 2002
- MBMG 449 The potential for a public water supply from the Madison limestone in the eastern Big Snowy Mountains and Little Snowy Mountains, Montana, Porter, K.W., Wheaton, J., Miller, M.R., 2002
- MBMG 450 Geologic map of the Belt 30' x 60' quadrangle, central Montana, Vuke, S.M., Berg, R.B., Colton, R.B., O'Brien, H.E., 2002
- MBMG 451 Geologic map of the Rocky Boy 30' x 60' quadrangle, Bergantino, R., Porter, K.W., 2002
- MBMG 453 Geologic map of the Valier 30' x 60' quadrangle, Berg, R.B., 2002
- MBMG 454 Geologic map of the Cut Bank 30' x 60' quadrangle, Berg, R.B., 2002
- MBMG 457 Preliminary geologic map of the eastern part of the Gallatin Valley, Montana, Lonn, J., English, A., 2002
- MBMG 458 Potential ground-water drawdown and recovery for coalbed methane development in the Powder River Basin, Montana, Wheaton, J., Metesh, J.J., 2002

- MBMG 465 Geologic map of the Wibaux 30' x 60' quadrangle, eastern Montana and adjacent North Dakota, Vuke, S.M., Wilde, E.M., Colton, R.B., Stickney, M.C., 2003
- MBMG 466 Historical Mining Districts of Montana, 1860–1972, Albright, L.D. , 2004
- MBMG 467 Geologic map of the Havre 30' X 60' quadrangle, Bergantino, R.N., Sholes, M., 2002
- MBMG 468 Geologic and structure contour map of the Harlem 30' x 60' quadrangle, north-central Montana, Bergantino, R.N., Patton, T.W., Sholes, M.A., 2003
- MBMG 469 Geologic map of the Bozeman 30' X 60' quadrangle, southwestern Montana, Vuke, S.M., Lonn, J.D., Berg, R.B., Kellogg, K.S., 2002
- MBMG 470 Geologic map of the Circle 30' x 60' quadrangle, eastern Montana, Wilde, E.M., Smith, L.N., 2003
- MBMG 471 Geologic map of the Whitewater 30' X 60' quadrangle Bergantino, R. N., 2002
- MBMG 472 Compilation of landslide locations maps and index for identification of slide-prone areas: A pilot study for the Butte district, Wilde, E. M., Sandau, K.A., Kennelly, P.J., Lopez, D.A., 2002
- MBMG 473 Twenty years of water-level and water quality sampling, Butte underground mines and Berkeley Pit, 1982–2001, Duaime, T.E., Metesh, J.J., 2003
- MBMG 474 Water-quality monitoring of the Butte Metro storm drain during a storm event: June 26–27, 2002, Gammons. C.H., Shope, C., Duaime, T.E., 2003
- MBMG 475 Geologic and structure contour map of the Richey 30' x 60' quadrangle, eastern Montana, Wilde, E. M., Smith, L.N., 2003
- MBMG 476 Abandoned-inactive mines on Lolo National Forest administered lands, Hargrave, P.A., Kerschen, M.D., McDonald, C., Metesh, J.J., Wintergerst, R., 2003
- MBMG 477 Geologic map of the Terry 30' x 60' quadrangle, eastern Montana, Vuke, S.M., Colton, R.B., 2003
- MBMG 478 Geologic and structure contour map of the Sidney 30' x 60' quadrangle, eastern Montana and adjacent North Dakota, Vuke, S.M., Wilde, E.M., Smith, L.N. 2003
- MBMG 479 Coalbed mapping in the Park Coulee 7½ minute quadrangle (partial) near Roundup, Montana, Wilde, E.M., McCleary, S., 2003
- MBMG 480 Preliminary geologic map of Paradise valley, south-central Montana, Lopez, D.A., Reiten, J.C., 2003
- MBMG 481 Geology of western and northern Gallatin Valley, south-western Montana, Vuke, S.M., 2003
- MBMG 482 Preliminary geologic map of Hellgate Gulch 7.5' quadrangle, western Montana, Lonn, J.D., McDonald, C.M., 2003
- MBMG 483 Preliminary geologic map of the Philipsburg 30' x 60' quadrangle, western Montana, Lonn, J.D., McDonald, C.M., Lewis, R.S., Kalakay, T.J., O'Neill, J.M., Berg, R.B., Hargrave, P.A., 29 p., scale 1 1:100,000, 2003
- MBMG 484 Abandoned-inactive mines on Bitterroot National Forest administered lands, Hargrave, P.A., McDonald, Catherine, Kerschen, M.D., Metesh, J.J., Wintergerst, Robert, 2003
- MBMG 485 Geologic map of the Angela 30' x 60' quadrangle, eastern Montana, Vuke, S.M., Wilde, E.M., Bergantino, R.N., 2003
- MBMG 486 Geologic map of the Hysham 30' x 60' quadrangle, eastern Montana, Vuke, S.M., Wilde, E.M., Bergantino, R.N., 2003

- MBMG 487 Geologic map of the Columbia Mountain area, northwest Montana, Clapp, K.K., Smith, L.N., MacLaughlin, M.M., Miller, C.R., 2003
- MBMG 488 Geologic map of the Ruby Dam area, southwest Montana, St. Jean, Z.C., Teeter, D.R., 2004
- MBMG 489 2002 update of water-level monitoring and water-quality sampling, Butte underground mines and Berkeley Pit, Butte, Montana, 1982–2002, Duaine, T.E., Metesh, J.J., 2004
- MBMG 490 Geologic map of the Montana part of the Dubois 30' x 60' quadrangle, southwest Montana, Skipp, Betty, Janecke, S.U., 2004
- MBMG 491 Scanning electron micrographs of sapphires from alluvial deposits in southwestern Montana (full-size SEM images available on CD only), Berg, R.B., Equall, Nancy, 2004
- MBMG 492 Groundwater assessment of selected shallow aquifers in the north Flathead Valley and Flathead Lake perimeter, northwest Montana, McDonald, Catherine, LaFave, J.I., 2004
- MBMG 493A Spring inventory and other water data, Custer National Forest-Ashland Ranger District, Montana (photos available on CD only), Donato, T.A., Wheaton, J.R., 2004
- MBMG 494 Bedrock and surficial geologic map of the Caboose Canyon 7.5' quadrangle, southwest Montana, Harkins, N.W., Newton, Mike, Anastasio, D.J., Pazzaglia, F.J., 2004
- MBMG 495 Surficial and bedrock geologic map of the Dixon Mountain 7.5' quadrangle, southwest Montana, Harkins, N.W., Latta, D.K., Anastasio, D.J., Pazzaglia, F.J., 2004
- MBMG 496 Geologic map of the East Bay 7.5' quadrangle, northwest Montana, Hofmann, M.H., Hendrix, M.S., 2004
- MBMG 497 Geologic map of parts of the Arlee, St. Ignatius, Gold Creek, and St. Marys Lake 7.5' quadrangles, northwestern Montana, Hofmann, M.H., Hendrix, M.S., 2004
- MBMG 498 Geologic map of the Fort Peck East 30' x 60' quadrangle, eastern Montana, Wilde, E.M., Bergantino, R.N., 2004
- MBMG 499 Geologic map of the Fort Peck West 30' x 60' quadrangle, eastern Montana, Wilde, E.M., Bergantino, R.N., 2004
- MBMG 500 Geologic map of the Kelly Lake 7.5' quadrangle, western Montana, Lonn, J.D., McDonald, Catherine, 2004
- MBMG 501 Geologic map of the Dickie Hills 7.5' quadrangle, southwest Montana, Lonn, J.D., McDonald, Catherine, 2004
- MBMG 502 Geologic map of the Divide area, southwest Montana, Vuke, S.M., 2004
- MBMG 503 Geologic map of the East Part of the Ringling 30' x 60' quadrangle, central Montana, Lopez, D.A., Berg, R.B., 2004
- MBMG 504 Reevaluation of the hydrologic system in the vicinity of the Anaconda Mine at Belt, Cascade County, Montana, Duaine, T.E., Sandau K.L., Vuke, S.M., Hanson, Jay, Reddish, Shawn, Reiten, J.C., 2004

Miscellaneous Contributions

- MC 19 Butte, Montana: Richest hill on Earth, 100 years of underground mining, Duaine, T.E., Kennelly, P.J., Thale, P.R., 2004

Reports of Investigation

RI 10 Hydrogeology of the west Billings area: Impacts of land-use changes on water resources, Olson, J.L., Reiten, J.C., 2002

RI 11 Available coal resources of the Colstrip East and Colstrip SW 7.5-minute quadrangle, Rosebud and Bighorn Counties, Montana, Wilde, E.M., Myers, W.H., 2003

Special Publications

SP 115 Applied gold placer exploration and evaluation techniques, McCulloch, R.B., Lewis, Bob, Keill, Don, Shumaker, Matthew, 2003

SP 116 The route and campsites of Lewis and Clark in Montana: A geologic perspective, Bergantino, R.N., Sandau, K.L., 2004

