earthquakes, geomorphology, and landslides. Today, the Survey has strong programs covering an ever widening spectrum of research and service in economic geology, geologic mapping, seismicity and geologic hazards, and earth science education.

The staff continues to monitor mining, to evaluate minerals, and to develop a statewide integrated database of geologic maps. As the state's population grows and the natural resource-based economy changes, land managers and the general public have begun to address a host of new resource problems. Federal statutes like the Clean Water and Air acts, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Endangered Species Act have changed the way we manage the federal land that accounts for two-thirds of Idaho's 84,000 square miles. Basic to understanding ecosystems and watershed management is a fundamental understanding of the state's geology. The Survey is restructuring its database management and field programs to help solve current problems like dwindling salmon runs and the identification and reclamation of inactive mine sites.

Also basic to the Survey's evolving mission is the ongoing work to address the environmental geology of the state's larger urban areas and sprawling housing developments in counties. The need to commit staff resources to an urban geology program has become more readily apparent these past few years. As the second fastest growing state in 1993-1994 (Nevada's the first), Idaho continues to prosper beyond expectations. The economy and state's population are projected to increase at an accelerated rate ahead of the national average well into the next century. This growth is certainly evident in the state's largest urban corridor along the Boise Valley. In other parts of the state, pockets of rapid development, for instance Coeur d'Alene in Kootenai County, are keeping local planners busy. Paradoxically for one of the nation's largest but sparsely populated
states, Idaho is bursting at its municipal seams.

It will be in the cities and towns that most of Idaho's citizens experience the challenges of the geologic environment. Geology interacts with urban infrastructure in ways not always predictable or favorable. Rapid change puts an urgency on gaining immediate knowledge of the earth's resources and tectonics. Communities face pressing operational issues such as waste disposal, potable water, locally available building materials like sand and gravel, and potential hazards from earthquakes and landslides. These domestic issues are inseparable from geology. Decisions affecting, for example, a new landfill site must take into account the region's underground structure so that public waste is kept from contaminating surface and subsurface water. The Survey supplies vital information regarding matters such as these. Because of this important role, the agency has intensified its research in urban geology.

The Survey's current emphasis on urban geology also underscores a change in the mineral industry. The annual value of Idaho's sand and gravel (S&G) production in 1992 exceeded for the first time that for silver and in 1993 almost bettered that for gold. This is a reversal of fortunes for the traditional hierarchy of mining operations in the state and indicates the emergence recently of other resources important to the mineral industry. In addition to research directed at metal miners, the Survey now reports on all mineral commodities produced in Idaho, of which many are important to a much broader group of city and county planners, commercial and industrial interests, and residential landowners. For example, most everyone would agree that plentiful long-term supplies of S&G are crucial to all forms of construction. To maintain this supply means that the areas containing these resources must be identified and preserved before the rush of progress unwittingly builds or paves over them. Such a problem arose this year in Kootenai County and probably will confront other communities very soon.

In seventy-five years, the Idaho Geological Survey has compiled a solid list of research. Over this time the need and purpose for geologic information has changed. What has not changed is the agency's commitment to the state's interest. The Survey remains dedicated to providing citizens of the state with thorough and reliable information.
More emphasis is being directed today toward environmental geology. In addition to traditional applied research programs, the Survey has also been studying the geologic problems society confronts in its cities and those it creates as urban growth impacts surrounding areas. Whether it is to find new resources, preserve old ones, dispose safely of wastes, or guard human development from tectonic forces, the issue has become one to maintain a reasonable quality of life. Will, for instance, sand and gravel be readily available for tomorrow's buildings and roads? Will water always be fit for drinking and will there be enough of it? Will construction in our towns and cities be confined to stable ground and designed to withstand anticipated geologic hazards? How we wisely use the land cannot ignore geology. The Survey is providing geologic information for planning into the 21st century.

Abandoned Mine Lands

Last year groups concerned about the environmental impact of so-called "abandoned mine lands" (AML) demanded that the sites be identified and action taken. The expression "abandoned" is a misnomer since very few mines with significant past production are truly deserted, but the term has stuck. Nationwide, thousands of old mines are thought to exist with physical hazards in dangerous open shafts and adits or with environmentally contaminating material in metal-rich dumps and acid mine water. Both the U.S. Forest Service (Regions I and IV) and the U.S. Bureau of Land Management decided to inventory mines in the state to determine the magnitude of the problem for Idaho. Plans called for using the Survey's mines and prospects' digital database to screen possible sites by their production figures. The operating hypothesis was that the larger the mine production, the more likelihood an environmental problem.

The first phase of the AML inventory was nearly complete at the end of FY94. All properties with production greater than 1,000 tons have been identified on USFS and BLM lands in the state. Field checking for the physical problems and hazardous materials at the sites will commence on Region IV forests this summer. All forests within Regions I and IV have been covered with the database of mines and prospects and a map transparency of locations scaled to overlay the forest map. Likewise, all BLM districts have received similar databases and overlays at 1:100,000 scale.

Preliminary evidence suggests the AML problem in Idaho may not be as severe as many have believed. Probably fewer than a hundred sites in Idaho will have a hazardous materials problem. Injuries due to physical hazards in old mines have been minimal over the years, but concern remains for the consequences of urban encroachment in the old mining districts. Funds for cleaning up the unsuitable AML properties will depend on taxes generated under a new mining law. Attempts to rewrite the 1872 law have been stalled in Congress.

Geochemical Maps

Final corrections on maps showing the locations of basalt samples analyzed for whole rock chemistry are being digitized into computer files for the Sheep Creek and Glenns Ferry quadrangles (scale 1:100,000). The maps will accompany reports consisting solely of rock analyses available only on 3.5-inch diskette. Releasing this geochemical information in digital format allows scientists to access the tabulated results directly through the computer medium. The data and photocopied maps should be published this fall.
Grangeville Geology

During the summers of 1992 and 1993, scientists mapped the geology of all or part of the Grangeville, Goodwin Meadows, Dairy Mountain, and Hungary Ridge 7.5-minute quadrangles. This area is under scrutiny because the suture zone between the Blue Mountains Arc accreted terrane and the ancestral North American continent is here. Retrograde ultramafic dikes cross the area and appear to be emplaced along regional faults. The Klapton Creek thrust fault at Pittsburgh Landing on the Snake River to the west probably extends beneath Grangeville and may be in part reactivated as the Mt. Idaho fault. Near Grangeville, this fault separates Seven Devils Volcanics (greenstones) from higher grade Riggins Group metavolcanics. From a more practical standpoint, geologists are correlating the faults with potential landslides (see "Tillie Creek Landslide" in the Research section) that could threaten the fish habitat in the South Fork of the Clearwater River and close transportation routes to Elk City. These landslides are related to the old, reactivated faults.

INEL Oversight Program

The oversight program for the Idaho National Engineering Laboratory (INEL) represents a cooperative effort among government agencies and universities to characterize the subsurface water quality and hydraulic variations in the Snake River Plain Aquifer beneath the facility. A straddle packer testing tool has been used to study three monitoring wells near the chemical processing plant at INEL. These data have provided the first detailed vertical profile of the aquifer's characteristics. Chemical and isotopic variations in the wells reflect the hydrostratigraphic segregations in the aquifer due to the vertical heterogeneity of the system. The study has revealed an inherent difficulty in utilizing open borehole monitoring to characterize waste migration in such an aquifer. With the ground-water monitoring techniques currently being used at INEL, scientists cannot determine depth specific information about the distribution of contaminants.

Kootenai County

Kootenai County is the fastest growing county in Idaho in relation to its size. Recent residential development has been encroaching upon the local sources of construction aggregate like sand and gravel. Only six years of reserves of these commodities are estimated to be available at the current pace of expansion. Unless plans are developed soon for new aggregate sources, the resulting shortage of these building materials will lead to costly supply problems. Several other urban areas in Idaho face the same dilemma (see "Urban Geology," below).

The Survey has anticipated the logistical problem imposed on Kootenai County in the clash between housing and industrial needs. Staff geologists have already been mapping the geology of the greater Coeur d'Alene area at 1:24,000 scale. Next year the agency will focus on the Rathdrum quadrangle. Only resource mapping of this kind that delineates, for example, the county's sand and gravel and crushed rock assets will enable city and county planners to avoid irreversible and probably expensive mistakes. These studies are also important for other issues affecting the county, including water quality, waste disposal, and slope stability.

Murphy 30' x 60' Quadrangle

During the fall of 1993, staff geologists finished their mapping of the Walter's Butte, Dorsey Butte, and Jackass Butte 7.5-minute quadrangles in Owyhee County. This work completes the mapping in the Murphy 30' x 60' quadrangle. The field data from all of the 7.5-minute maps in the Murphy quadrangle have now been digitized and are being reduced and correlated for compilation at a scale of 1:100,000. This work will be done during the remainder of 1994.
National Science Foundation (EPSCoR) Research

A major research project began late this year with the award of a three-year EPSCoR grant to the Survey by the National Science Foundation. The grant will be used to develop a capability for stable isotope analysis and to build a field-based ground-water research laboratory to study recharge and transport mechanisms in shallow aquifers.

Paleomagnetism Laboratory

After developing new data reduction and plotting programs, the Paleomagnetism Laboratory now has standard procedures for efficiently studying rocks and sediments. Stratigraphic and chronologic interpretations can be determined from the paleomagnetic directions and polarities derived from rock and sediment samples. The laboratory is operated jointly by the Survey and the College of Mines and Earth Resources at the University of Idaho. During 1993, researchers analyzed samples from the following projects: glacial lake and flood sediments near Priest River, Palouse Formation loess, glacial till on Railroad Ridge in Custer County, and Columbia River Basalt and related sediments near Clarkia in Latah County.

The laboratory has been effective in unraveling problems in stratigraphy, correlation, and geochronology. For example, the pattern of geomagnetic secular variation recorded in over 100 samples of Priest River glacial sediments indicates much longer periods between the catastrophic Missoula Flood events than previously thought. The remanent magnetism in the interflood deposits suggests accumulation times at least ten times greater than those estimated by varve counts. These data support the nearly instantaneous deposition of the coarse flood deposits caused by the failure of the prehistoric Clark Fork ice dam. Initial results of the study are so encouraging that sampling is now planned for several adjacent sections. On another project, two paleomagnetic reversals were tentatively identified in the Palouse loess. The finding could mean that the older part of the wind-blown dust is at least 1 million years old. Scientists are also using paleomagnetic directions and polarities in basalts to correlate individual flows in Latah County.

Pocatello Hazards

The Survey has begun assessing the earthquake hazards of the Pocatello area. Pocatello is the largest urban area in Idaho close to the active Intermountain Seismic Zone. Maps showing the extent of possible ground shaking, the areas that may be affected by liquefaction, and the actual and potential landslide hazards will be produced during the 2-year study. The project is supported by the Idaho Bureau of Disaster Services.

Pocatello Municipal Aquifer

Several independent but closely related ground-water studies are underway in the Pocatello area. These studies, begun in 1992 and funded by the Idaho Water Resources Research Institute (IWRRI) and the Environmental Protection Agency, have focused on the Pocatello aquifer's hydrogeology, water balance, and vulnerability to contamination. The work has provided much of the technical foundation and hydrogeologic data for related site characterization and remediation projects undertaken by Pocatello, Chubbuck, and Bannock County in contaminated parts of the aquifer. The Survey has provided geologic and hydrologic data to state and federal consultants, municipal public works departments, and the county.

The Ground Water Technical Forum was established in 1993 by Pocatello on the Survey's recommendation. The forum promotes the exchange of ground water-related information between the area's municipalities, the county, private contractors, and local industry. A new study on the bedrock and Tertiary base of the aquifer and funded by Pocatello and IWRRI is developing an integrated hydrogeologic
model of the aquifer system based on surface and subsurface geologic data, gravity modeling, and hydraulic data.

Quaternary and Environmental Geology of the Sawtooth National Recreation Area

Survey geologists have mapped the Quaternary geology of parts of four 7.5-minute quadrangles around the Livingston mine in Custer County. The work has revealed evidence of several glaciations. The oldest glacial deposits are typified by the till that caps Railroad Ridge. Paleomagnetic analysis of the till indicates a probable age of less than 790,000 years (middle Pleistocene). River valleys have become deeply incised since the Railroad Ridge glaciation, and the till may have been deposited on a high plateau adjacent to the ancestral White Cloud Mountains, which were then much higher.

Understanding the Railroad Ridge glaciation will be useful in interpreting the Quaternary tectonics of the entire Sawtooth National Recreation Area.

Seismic Risk Analysis and Tectonic Mapping

Earthquake research has produced two important studies that were released in FY-94: Catalog of Idaho Earthquakes, 1872-1993 and Preliminary Neotectonic Map of Idaho. Both publications were compiled through the services of the Survey’s Digital Mapping and Information Laboratory. The catalog of earthquakes lists the date, time, location, magnitude, intensity, damage, and other seismic information for over 20,000 events. For the neotectonic map, all faults known to be less than 15,000 years old were digitized from existing geologic maps along with the epicenters of all historical earthquakes above magnitude 3 or intensity IV. In the second phase of the map project, additional faults will be evaluated and possibly included in the database on active faults.

Surficial Geology of Jerome

Under a contract with the state Division of Environmental Quality (DEQ), the Survey has been studying the geology near Jerome in Jerome County in relation to the area’s aquifer. Geologists have mapped the surficial geology, described the geology of the unsaturated zone, and developed a general methodology for similar aquifer studies. The DEQ was concerned that a proliferation of dairy farms, septic tanks, and other potential sources of pollution might threaten the unconfined aquifer that supplies the county’s drinking water.

Two geologists spent the field season examining outcrops in six 1:24,000-scale quadrangles to complete a geologic map of western Jerome County. A digital version of the map was provided to the DEQ for integration into a Geographic Information System (GIS) database on ground-water vulnerability. In addition to the fieldwork, geologists also reviewed available water well logs to gain further information about the subsurface geology.

The surface mapping delineated six distinct basalt flows and several structural and lithologic zones that may be important controls on ground-water movement. Variable thicknesses of soil, silty loess, and sand overlie the basalts. Subsurface rocks above the water table are also basalts containing thin, local sediment and cinder layers.

Urban Geology

The Survey is expanding the urban geology program that has been under development for the past few years. Idaho is undergoing a population explosion in its urban areas, spurred mainly by the influx of people from other states. This rapid growth has resulted in a number of geologic-related urban problems. Just a decade ago, the state was thought to have an almost unlimited water supply. Today, however, the urban expansion and the recognition by the public that major aquifers may be vulnerable to contamination have triggered concerns for envi-
ronmental quality in many areas. New regulations regarding landfills, sewage disposal systems, drinking and surface water quality, air pollution, seismic risk, and other geologic hazards find many Idaho cities short on money, expertise, and the capability to properly address these matters. For example, some cities and counties are already hard pressed to supply aggregate (sand and gravel) for construction. Sand and gravel is a commodity thought by many not long ago to be inexhaustible in the state. In response to problems, most major cities and many counties are turning to the Geographic Information System (GIS) to track and analyze current urban expansion and to plan for anticipated growth. The Survey’s geologic maps and other databases provide much needed coverage for planning residential and commercial development. Support for the urban geology program comes not only from the state but also from the STATEMAP component of the National Geologic Mapping Act, which stresses urban mapping and land-use planning.

Of the seven urban-centered counties in Idaho — Ada, Bannock, Bonneville, Canyon, Kootenai, Nez Perce, and Twin Falls — the major impact of the state’s population explosion has been on Ada and Canyon counties, particularly in the greater metropolitan area of Boise. In 1992, under the urban geology program, Survey scientists finished mapping the Boise Valley. The complete study on the geology and geomorphology of the Boise Valley and surrounding area was published in January. This book serves as the companion text to the color geologic map of the same area and the digital composite version of the map published last year. The digital versions of the 7.5-minute geologic maps are currently being used by Ada County and Boise planners as ARC/INFO® coverages, the most widely used GIS in Idaho. The book and the maps are the latest of the Survey’s geologic studies in the area ongoing since 1985. These documents present to an informed public a thorough explanation of the area’s fascinating late Cenozoic geologic history. They provide substantial information about the geologic structure and environment of the region so that planners at every level can direct prudent and resourceful development of the land.

In a cooperative agreement signed with the U.S. Geological Survey, the Survey will soon be mapping the urban geology of the Pocatello and Twin Falls regions. Moreover, additional research work will be conducted in the Coeur d’Alene area.
Sometimes the times blur between how someone might categorize a "research" or "service" activity. The Survey itself sometimes finds it an arguable distinction. Even activities the agency has deemed a "service" function may entail the exacting methods of "research." Examples in this 1994 Annual Report are the examinations of two recent landslides in the state that required the field investigation and mapping common to applied research. What distinguished them as part of the "service" role, in the Survey’s view, was the need for the agency to respond, after quick visits to the sites, with summaries of existing information on these single geologic incidents. The responses did not undertake a detailed study of the area beyond the event or about other possible geologic hazards, a broad approach that would generally be part of a project the agency defines as "research." The Survey’s work, in these cases, was also in support of other public organizations’ need for timely information. These agencies had to make urgent practical decisions, such as where to reroute obliterated roads.

Bliss Landslide

On July 24, 1993, a large tract of ground southwest of Bliss gave way and slid into the Snake River. The landslide actually dammed the waterway for a while. Over the next few weeks, the initial slide grew by creep and subsequent failure to a size of over 100 acres. The landslide obliterated a road to a bridge over the Snake. Local residents, tourists, and the media quickly turned into enthusiastic geologic spectators as they waited to see when the slide would move again. Local and state officials were more concerned with public safety. The Survey’s geologist in Boise visited the site and worked as part of a geotechnical committee providing expertise to the Idaho Bureau of Disaster Services and other worried officials. Geologic factors presented by the Survey helped convince the Gooding County highway department to reconsider the site of the new road that was eventually built across the landslide.

Boise Branch Office

In August, the Boise office relocated to new quarters in room 229 of the remodeled Math-Geosciences building on the Boise State University campus. While the most notable activity for this office during the past year concerned the Bliss landslide, the Boise office also represented the Survey at meetings on resource issues, participated in a field conference of the Earth Science Teachers Association, assisted the Idaho Department of Transportation, and discussed the relevance of geology in society with children in local school classes.

Digital Databases

The Survey maintains regional and statewide digital databases that are available in various formats to the public. Extensive computer files include a cumulative bibliography of over 11,000 published references on geology and mineral resources (also available in paper copy), production figures on 9,000 mines and prospects (in 1:250,000 scale, 1:100,000 scale, and as forest map overlays), an inventory of major landslides, and an embryonic but growing number of geologic maps. This year, the Survey added a database on earthquakes in Idaho and the surrounding area. This compilation contains over 20,000 events and their seismic parameters for the period from 1872 to 1993. It was gathered from over twenty seismic-net operators in the region.
Digital Mapping and Information Laboratory

The Survey's Digital Mapping and Information (DMI) lab continued to collect, maintain, and produce geologic data. Chief among its accomplishments was the Catalog of Idaho Earthquakes, 1872-1993. This publication released on 3.5-inch disk is designed to meet the needs of researchers and public agencies for information that can interface immediately with computers. The same data were used to produce another publication, the Preliminary Neotectonic Map of Idaho. The lab is currently revising an extensive spatial database of active fault traces in the state.

Other statewide database projects include the expanding file on mines and prospects and the spatial geology at 1:100,000 scale or greater detail. Ten 7.5-minute quadrangles from staff geologists have been added to the geologic database in the past year. Two additional 1:100,000 quadrangles have been converted from hard copy format to digital data. The Murphy 1:100,000 has been compiled digitally, mostly from newly mapped geology by staff geologists, and is now undergoing its first editing.

The DMI lab has improved its capability to generate color maps digitally using specially written Postscript® output routines. With this system, the Survey can reproduce single copies of a map in color using a color copier. The process also allows the Survey to produce through a commercial printer fully digital color maps faster and at less expense than traditional cartographic methods.

AutoCAD® continues to be the software backbone of the lab. Software and hardware improvements have enabled the lab to execute the spatial operations required for modern map making and geographic information manipulation. The lab is now also a PC ARC/INFO® site. Having both software programs allows a smooth exchange of data between the two formats.

Disaster Preparedness

The Survey continued to work closely with the Idaho Bureau of Disaster Services (IBDS) in the earthquake program as well as conferring with the agency on shared concerns over other geologic hazards such as landslides and floods. Staff members examined landslides near Bliss and on Tillie Creek. For more information on these geologic events, see the reports on the "Bliss Landslide" and the "Tillie Creek Landslide" in this Service section. The agency also investigated a debris flow near Julietta in which two people perished in June 1993.

The IBDS, with the cooperation of the Survey, hosted a state workshop in October dealing with emergency preparedness for rural earthquakes. The session was held on the 10th anniversary of the state's largest historical seismic event, the 7.3 magnitude Bonah Peak earthquake. Recent major earthquakes in California and Oregon have prompted inquiries from people moving to Idaho about earthquake safety and hazards in the state. A common request is for information about faults near landfills. Survey staff participated in news media interviews and contributed materials for several newspaper articles and television short features about Idaho tremors.

Earthquake Monitoring

The Idaho Bureau of Disaster Services hosted a meeting in Boise to discuss how best to monitor earthquakes using the seismic networks in Idaho. Attendees from Idaho and Montana drafted an agreement calling for all records to be shared through a computer network. The assembly unanimously supported the need to establish a statewide seismic net and an earthquake information center for Idaho, both to be administered by the Survey.

The Survey issued a Staff Report (see explanation of this new publication series in the Publications section) on the sequence of earthquakes near Draney Peak in Caribou County. The sequence in southeastern
Idaho, near the Wyoming border, included a magnitude 5.9 event. This quake was the seventh largest historical temblor recorded in Idaho and was characterized by a series of foreshocks and persistent large aftershocks. Scientists began preparing data for the report as soon as they perceived a pattern emerging in the quakes. The report on Draney Peak was issued two weeks after a period of unusually large aftershocks. Another noteworthy event was the magnitude 4.5 Hoyt Mountain earthquake on March 7 along the St. Joe fault in Shoshone County. This quake was only the fourth historical event above magnitude 3 recorded in the panhandle of northern Idaho. A Staff Report on this event will be released soon.

Earth Science Education

The Survey conducted its ninth, tenth, and eleventh geology workshops for teachers in the summer. In midsummer the Survey co-sponsored a field workshop with the Idaho Earth Science Teachers Association and the Idaho Bureau of Disaster Services (IBDS). Under the theme, “Idaho’s Earthquakes,” the meeting was held appropriately in the Borah Peak area, the site of the state’s last major earthquake. The IBDS provided funds to develop and distribute a packet of teaching materials on earthquakes and also to help defray the lodging and instructional costs of the workshop.

The Survey conducted environmental geology and hydrology workshops in both eastern and western Idaho. The Fremont County School District co-sponsored and hosted the first eastern Idaho workshop at South Fremont High School in St. Anthony. The session was specifically designed for elementary school teachers. Twenty-six participants studied basic landforms, rock types, and soils in part through field trips to features such as Menan Buttes, the sand dunes at St. Anthony, basalt lava tubes in the area, and the Huckleberry Ridge tuff at the former Teton Dam site.

In western Idaho, the Environmental Geology and Hydrology Workshop was again co-sponsored by the Idaho Water Resources Research Institute (IWWRI) and held at the University of Idaho’s McCall field campus. Like last year, this meeting emphasized the application of geology to address natural resource problems created by the impact of rapidly expanding recreational development on the area’s land and water. Twenty-five teachers were given an introduction to Project WET Idaho (Water Education for Teachers) and environmental analysis through the Streamwalk program. In addition to support from the Survey and the IWWRI, funding came from a U.S. Department of Education, Dwight D. Eisenhower Act grant awarded by the Idaho Department of Education. The Survey has applied for and received another IBDS grant and an Eisenhower grant to continue these summer workshops next year.

Mining Industry Review

Due to a combination of factors — depressed metal prices, legislative uncertainty about new mining regulations, and international mining opportunities — activity in the state’s mineral sector was down from last year. Several metal mines stayed closed, and some gold development projects remained on hold. Still, exploration projects in the Salmon area and central Idaho offered intriguing prospects. The metals industry may rebound a bit due to improved precious metal prices. Production has increased in 1993 for construction-related commodities due to much greater demand.

- The Survey has been reviewing the mining industry since 1975 and has witnessed definite changes in the principal minerals mined. The mainstay in Idaho’s minerals has shifted dramatically in recent years. The seemingly inexhaustible deep underground silver/lead/zinc mines in the Coeur d’Alene district proved otherwise by the early 1980s after so many decades of national prominence. The new excitement for the 1980s lay in statewide exploration for gold. Today,
phosphate and the other industrial minerals including sand and gravel are the hottest commodities.

In 1993, the Survey added the word "environment" to its industry report title, because well over half of the year's mining news was related to environmental matters. In fact, the report is now a relatively complete annual chronicle of environmental matters related to mineral resources in the state. Plans call for expanding this section even more. Issues such as the Superfund, the future of salmon and other endangered species, the extent of wilderness, mining law reform, and a host of water and aquifer concerns are now daily front page news.

Tillie Creek Landslide

At the request of the advisory committee for the Idaho Department of Transportation (IDOT), the Survey mapped the Tillie Creek landslide located east of Grangeville. The abnormally wet spring and early summer of 1993 activated the slide, which blocked State Highway 14 to Elk City and raised concerns about the contamination of fish habitat along the South Fork of the Clearwater River. State officials feared that the Mt. Idaho grade slump might also become active and block all access to Elk City.

The Mt. Idaho grade slump and the Tillie Creek debris flow are two different slides, each with different characteristics. The chance of both becoming active at the same time is slight. Nevertheless, the Tillie Creek flow is problem enough. It will be difficult to contain, and about the only cure for solving the access problem is to relocate the highway to the east side of the South Fork of the Clearwater, a very expensive proposition.

Written and oral reports on the geology of the slides were presented to the IDOT advisory board in November. The Tillie Creek debris flow is similar to several other landslides and slumps along the South Fork including ones on Camp Creek, Grouse Creek, and Mill Creek and across from Schwartz Creek. All are related to regional faults.
The much-heralded coming of the "Information Superhighway" has already crept inroads here at the Idaho Geological Survey. The agency is expanding its publication formats to include data on computer disks. The first product was released last year in the form of geologic maps digitized on 7.5-minute quadrangles covering the Boise Valley and adjoining area. This year the earthquake history of the state as far back as reliable modern records go has been published on disk. For the last few years, the agency has been developing statewide databases for mines and prospects and a geologic bibliography. Future releases will include other applications such as chemical analyses. The appeal of this digitized data is that it is readily usable for computer manipulation and can be quickly related to other information with ease.

This year the Survey also introduces a new document series called Staff Reports. The series is designed to disseminate information considered too transitory, parochial, or esoteric to publish. Because of the limited interest and distribution expected, titles in the series are available only on a print-on-demand basis. Types of documents include data files, preliminary studies and progress reports connected to longer projects, technical assessments in response to local, state, or federal agencies, special summaries or analyses prepared for a limited purpose, and final reports for grants or contracts. The Staff Report series provides a proper and credible outlet for information that is not being prepared or recommended for publication. The series category creates an official, citable source for research that would otherwise be neglected in office files. The information may be released in written form or on computer disk. Staff Reports will be catalogued for public reference yearly in the List of Publications and the Annual Report.

In FY-94 the Survey released the following publications and reports:


GeoNote 29. Gigantic Rhyolite Lava Flows in Owyhee County's Bruneau and Jarbidge Canyons, by Bill Bonnichsen, 2 p.


Technical Report 94-1. Preliminary Neotectonic Map of Idaho, by Andrew P. Hilt, Roy
M. Breckenridge, and Kenneth F. Sprenke, 1 sheet.

Rocks & Potholes: Two 12\texttimes{} 18" posters of black and white photographs from Idaho Geological Survey Information Circular 54, Rocks and Potholes of the Big Wood River, South Central Idaho.

PERSONNEL

Robert W. Bartlett  
DIRECTOR

Roy M. Breckenridge  
RESEARCH GEOLOGIST

Ann G. Killen  
PUBLICATIONS ASSISTANT

Earl H. Bennett  
ASSOCIATE DIRECTOR  
STATE GEOLOGIST

Charlotte D. Fullerton  
ACCOUNT TECHNICIAN

Charles R. Knowles  
RESEARCH GEOLOGIST

Bill Bonnichsen  
RESEARCH GEOLOGIST

Virginia S. Gillerman  
RESEARCH GEOLOGIST

Kurt L. Orthberg  
RESEARCH GEOLOGIST
Project Research Staff

Publications

Rocks & Potholes: Two 12” x 18” posters of black and white photographs from Rocks and Potholes of the Big Wood River, South Central Idaho Idaho Geological Survey Information Circular 54.

Abstracts

Reports and Presentations
Bliss Landslide, by Virginia S. Gillerman: American Institute of Mining Engineers, Boise Section, October; Idaho Geological Survey Advisory Board meeting, Boise, December; Idaho Association of Professional Geologists, Boise, February.
Coupled Sulfate and Chloride in the Pocatello Aquifer, by John A. Wellman: Ground water technical forum, Pocatello, January.
Demonstration of Rapid Visual Screening of Buildings for Potential Seismic Hazards: Use of Applied Technology Council Publication No. 21, by Roy M. Breckenridge: Geology 360 class, University of Idaho, November.
Development of an Integrated Geologic Model of the Pocatello Aquifer, by John A. Wellman: Pocatello City Council study session and city council meeting, November.
Geology Near the Environment Toxic Waste Site, Owyhee County, Idaho, by Bill Bonnichsen: Ad hoc Envirosafe evaluation committee, Boise, January.
The Geology of the Tillie Creek Landslide and Mt. Idaho Grade Slump, Idaho County, Idaho, by Earl H. Bennett: Idaho Department of Transportation Advisory Committee, Moscow, November.
The Hydrogeology of the Snake River Plain and Its Implications for Sole Source Aquifer Designation, by John A. Welham. State Health Association: regional meeting. Detroit 6 Health Department, Peoria, Illinois.
Idaho Mining, by Virginia S. Gillerman. Environmental geology class, Centennial High School, Boise, November.
Idaho's Mining Legacy, by Earl H. Bennett. Idaho Mining Association, McCall, August.
Metasedimentary Rocks Between the Buttebox and Alturas Lakes of the Idaho Batholith and Their Relationship to the Belt Supergroup, by Reed S. Lewis, Russell F. Burmester, and Earl H. Bennett. Belt Symposium III, Whitefish, Montana, August.
Metasedimentary Rocks Between the Buttebox and Alturas Lakes of the Idaho Batholith and Their Relationship to the Belt Supergroup, by Reed S. Lewis, Russell F. Burmester and Earl H. Bennett. Postcard session at Belt Symposium III, Whitefish, Montana, August.


Chair, southwest district, Idaho Association of Professional Geologists, Boise chapter (V.S. Gillerman).

Chair, ground water technical forum, Post Falls, January (J.A. Welhan).

Director and co-director, Environmental Geology and Hydrology Workshops (Geology 500 sections 80 and 81, University of Idaho), St. Anthony and McCall, summer (K.L. Othberg).

Chair, Director and co-director, Idaho earthquakes field workshop for teachers sponsored by the Idaho Earth Science Teachers Association, Idaho Geological Survey, and Idaho Bureau of Disaster Services, summer (K.L. Othberg).

Director, Idaho Geological Survey/College of Mines and Earth Resources paleomagnetism laboratory (K.L. Othberg).

Disaster coordinator, Idaho Military Division, Bureau of Disaster Services, Boise (R.M. Breckenridge).

Earth Science Teachers Workshop, McCall, August (K.L. Othberg, J.A. Welhan).

Fellow, Geologists of the Americas (B. Bonnichsen).

Fellows, Society of Economic Geologists (B. Bonnichsen and V.S. Gillerman).

Field trips, water resources and hydrology of the Minidoka basin drainage basin; natural history of the Portneuf Basin; Indian Hills Elementary School 6th grade classes, October and November (J.A. Welhan).

Field trip, Quaternary geology of the Mission Valley area, Montana, Friends of the Pleistocene Rocky Mountain Field, September (R.M. Breckenridge).

Friends of the Rhyolite field trip, Juniper Mountain area of southwest Owyhee County, July (B. Bonnichsen).


Idaho State University Seminar Series, February.

Idaho Earth Science Teachers Field Conference, Challis, July (J.A. Welhan).

Idaho Geographic Information System advisory committee meeting, Boise, November (L.R. Sanford).


Instructor, Geology 408, field methods for earth science educators, fall semester (K.L. Othberg).

Instructor, Geology 405, earth science education issues and activities, University of Idaho, spring semester (K.L. Othberg).
Instructor, Geology 421 and 421L, ore depos-
its, Boise State University, spring semester
(V.S. Gillerman).

Instructor, mine taught, Geology 360, geologic
hazards, University of Idaho, fall semester
(R.M. Breckenridge, K.L. Odhberg).

Leader, field trip on Boise area geology,
Grangeville students, March; Boss Element-
ary 6th graders students, May (V.S. Giller-
man).

Leader, field trip to Hells Canyon, Walla
Walla Community College Continuing Edu-
cation, April and May (E.H. Bennett).

Leader, field trip to Idaho and Utah mines,
ore deposits class, Boise State University,
April (V.S. Gillerman).

Leader, field trip to the Bunker Hill Superfund
site, Kellogg and vicinity, April (E.H. Ben-
nett).

Liaison and resource person, Water Education
for Teachers (Project WET) ground-water
flow model, southeast Idaho (J.A. Welhan).

Meeting on SPOT remote sensing, U.S. For-
est Service, Boise, July (V.S. Gillerman).

Member, board of directors for national re-
sources, National Association of State Uni-
versities and Land Grant Colleges (R.W.
Barlett).

Member, advisory board, Geology Depart-
ment, University of Delaware (E.H. Ben-
nett).

Member, American Geophysical Union (J.A.
Welhan).

Member, American Institute of Mining, Met-
allurgical and Petroleum Engineers (V.S.
Gillerman).

Member, American Quaternary Association
(K.L. Odhberg).

Member and representative, Idaho Associa-
tion of Professional Geologists, southeast
Idaho area (J.A. Welhan).

Member, Association of American Geo-
logists (E.H. Bennett).

Member, Association of Earth Science Editors
(R.C. Stewart).

Member, College of Mines and Earth Re-
sources Advisory Board, University of Idaho
(E.H. Bennett).

Member, executive committee, Western States
Seismic Policy Council (R.M. Brecken-
ridge).

Member (ex-officio), hazardous waste manage-
ment council, Idaho State University (J.A.
Welhan).

Member, field trip for teachers’ committee,
U.S. Geological Survey/Idaho Geological
Survey/Eastern Washington Univer-
sity/Coeur d’Alene School District, sum-
mer (K.L. Odhberg).

Member, Geological Society of America (E.H.
Bennett, V.S. Gillerman, K.L. Odhberg).

Member, Geological Society of Nevada (V.S.
Gillerman).

Member, Idaho Association of Professional
Geologists, Boise chapter (V.S. Gillerman).

Member, Idaho State Teachers Association
(K.L. Odhberg).

Member, liaison committee, Association of
American Geologists (E.H. Bennett).

Member, National Association of Geology
Teachers (K.L. Odhberg).

Member, National Earth Science Teachers
Association (K.L. Odhberg).

Member, Northwest Ice Age Task Force (R.M.
Breckenridge).

Member, panel on reinveting U.S. Bureau of
Mines’ research, National Academy of
Science (E.H. Bennett).

Member, peer review committee, Association
of American State Geologists for the Na-
tional Geologic Mapping Act (E.H. Ben-
nett).

Members, American Institute of Mining, Met-
allurgical and Petroleum Engineers (R.W.
Barlett, V.S. Gillerman).

Members, Idaho Earth Science Teachers As-
sociation (R.M. Breckenridge, K.L. Oth-
berg, J.A. Welhan).

Members, Northwest Mining Association
(E.H. Bennett, V.S. Gillerman).

Member, technical advisory committee, Boise
geo thermal injection well design project
(J.A. Welhan).

Member, working group on technology, American Mining Congress (R.W. Bart-
lett).

Member, Moscow High School extended learn-
ing internship program, spring semester
(K.L. Odhberg).

Northern Section Mining Association Conven-
tion, 99th Annual Meeting, Spokane, Wash-
ington, December (E.H. Bennett, V.S.
Gillerman).

Participant, Earth Science Teachers Work-
shop, McCall, August (J.A. Welhan).

Participant, Perspectives on Rural Earth-
quakes Workshop, Boise, October (R.M.
Breckenridge).

Representative, Department of Geology, Uni-
versity of Idaho (K.L. Odhberg).

Representative, Boise State University Depart-
ment of Geosciences (V.S. Gillerman).

Representative, Earthquake Engineering Re-
search Institute, Oakland, California (R.M.
Breckenridge).

Representative, Idaho Natural Resources
Roundtable (V.S. Gillerman).

Representative, mining advisory committee,
Idaho Department of Lands (V.S. Giller-
man).

Representative, water planning coordination
committee, Idaho Department of Water
Resources (V.S. Gillerman).

Secretary/Treasurer-elect, Association of
American State Geologists (E.H. Bennett).

Team leader, straddle packer research pro-
gram, Idaho Department of Health and
Welfare’s Idaho National Engineering Labora-
tory Oversight Program (J.A. Wel-
han).

Technical advisor to U.S. Geological Survey
in the design and interpretation of labora-
tory column experiments to quantify the
termination of strontium in INEL sedi-
ments (J.A. Welhan).

Technical expert interview on Bliss landslide,
KTVB television, Channel 7, Boise, Au-
gust (V.S. Gillerman).

Technical liaison and resource person to Ban-
nock County commissioners for advising
on geotechnical work at Fort Hall Cann-
ery (J.A. Welhan).

Technical liaison and resource person to Po-
coello for planning and directing Well
Head Ignition Program (J.A. Welhan).

Television interview, Boobs Peak earthquake
10 year anniversary, Channel 7, Boise.

Chair, Channel 10, Twin Falls (R.M. Brecken-
ridge).

Vice-Chair, reauthorization of federal legisla-
tion, National Mineral Institute Directors
(R.W. Bartlett).

Volunteer, gold panning demonstration,
Western Idaho Fair, Boise, August (V.S.
Gillerman).

Western States Seismic Policy Council’s an-
nual meeting, Jackson, Wyoming, Septem-
ber (R.M. Breckenridge).

Western States Seismic Policy Council’s ex-
cutive committee, meeting, Park City,
Utah, July; Jackson, Wyoming, September,
November, and March (R.M. Brecken-
ridge).

Graduate Thesis Committees

Jon Bair, M.S., Geology, University of Idaho
(K.L. Odhberg).

Thomas Dechert, Ph.D., Soils, University of
Idaho (R.M. Breckenridge).

Mason Entes, M.S., Geology, Idaho State Uni-
versity (J.A. Welhan).

Marvin Everland, M.S., Geology, University of
Idaho (J.L. Odhberg).

Jeanne Frumon, M.S., Geology, Idaho State
University (J.A. Welhan).

Andrew Hill, M.S., Geophysics, 1994, Uni-
versity of Idaho (R.M. Breckenridge).

James Keel, M.S., Geology, Idaho State Uni-
versity (J.A. Welhan).

Girty Kindel, M.S., Geology, Idaho State Uni-
versity (J.A. Welhan).

Chris Meenan, M.S., Geology, Idaho State
University (J.A. Welhan).

Timothy Millic, Ph.D., Biology, Idaho State
University (J.A. Welhan).

Victoria Mitchell, Ph.D., Geology, University of
Idaho (E.H. Bennett).

Moshe Muller, M.S., Geology, Boise State
University (V.S. Gillerman).

JASON Nelson, M.S., Biology, Idaho State
University (J.A. Welhan).

Brian Peterson, Ph.D., Geophysics, Univer-
sity of Idaho (R.M. Breckenridge, K.L. Oth-
berg).

Wayne Poulsen, M.S., Geology, Idaho State
University (J.A. Welhan).

Ted Reid, M.S., Geology, Idaho State Univer-
sity (J.A. Welhan).

Robert Reynolds, Ph.D., Geology, Depart-
ment of Geology, University of Idaho (B.
Bonnichsen).

Terry Rowley, M.S., Geosciences, Boise State
University (J.A. Welhan).

Nick Sargent, M.S., Earth Sciences, Memorial
University (J.A. Welhan).

Charles Unsworth, M.S., Geology, Boise State
University (V.S. Gillerman).
Grants and Contracts


Abandoned mines: E.H. Bennett and V.E. Mitchell (U.S. Forest Service, Region IV, $84,951).


Development of a surface and subsurface geologic model of the Pocatello aquifer: J.A. Welhan (Pocatello, $19,902).


Hydrogeologic studies of the Pocatello municipal water supply aquifer: J.A. Welhan (Idaho Water Resources Research Institute, $10,700).

Idaho earthquake research: R.M. Breckenridge (Idaho Bureau of Disaster Services, $9,010, September-December).

Idaho earthquake research FY-94: R.M. Breckenridge (Idaho Bureau of Disaster Services, National Earthquake Hazards Reduction Program, $23,738).


Student support for development of an integrated geologic model of the Pocatello aquifer: J.A. Welhan (Idaho Water Resources Research Institute, $5,000).

Surficial geologic mapping and unsaturated zone geology, western Jerome County: V.S. Gillerman (Idaho Division of Environmental Quality, $22,500).

Transport and dispersion of pollutants in the subsurface environment: J.A. Welhan (National Science Foundation, EPSCoR, $54,250).
Although the state continues to enjoy a growing economy, the Survey has  
unfortunately participated in this good fortune.

Once again, the agency was unsuccessful in  
converting the publications assistant's position  
from half-time to full-time. Bringing the position  
to full-time has been the priority item in  
the budgets of the past three years. Among  
state surveys in FY-93, the agency ranked sixth  
from the bottom in state support.

State appropriations have not kept up  
with inflation, and salaries continue to lag  
behind those for equivalent University of  
Idaho positions. For two years, the money  
allocated by the State Legislature for operating  
expense (OE) has remained at  
$53,100, an amount that reflects the Legislature-imposed  
$7,000 shortfall for FY-93;  
nothing has been appropriated for capital  
outlay (CO). The flat funding for operating  
expenses raises problems for the Survey that  
go beyond a little belt tightening. Already  
trimmed to the leanest in years, the agency  
cannot keep from reducing its effort on criti-
cal programs to balance an accumulating  
and significant inflationary deficit.

Nationally, the Survey continues to com-
pete successfully for grants and contracts  
from mostly federal agencies to undertake re-
search in the state's interest. In FY-94, the  
staff signed agreements for $357,978 in out-
side funds, a slight increase over last year  
($361,283) when the agency was among the  
top twenty states in obtaining federal grants  
and contracts. The money comes from vari-
ous sources including federal agencies (U.S.  
Bureau of Land Management, and U.S. Bu-
reau of Mines) and other Idaho agencies  
(Division ofEnvironmental Quality in the  
Department of Health and Welfare and the  
Department of Water Resources). Contracts  
awarded to the Survey's hydrology program  
continue to grow, as expected.

**RECENT BUDGET HISTORY — Fiscal Years 1990-1994**

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>FY-90</th>
<th>FY-91</th>
<th>FY-92</th>
<th>FY-93</th>
<th>FY-94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating</td>
<td>$389,000</td>
<td>$414,000</td>
<td>$473,000</td>
<td>$486,000</td>
<td>$515,000</td>
</tr>
<tr>
<td>Expense</td>
<td>$56,600</td>
<td>$58,600</td>
<td>$60,100</td>
<td>$53,100</td>
<td>$53,100</td>
</tr>
<tr>
<td>Outlay</td>
<td></td>
<td></td>
<td>$5,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>$445,600</td>
<td>$472,500</td>
<td>$538,300</td>
<td>$559,100</td>
<td>$558,100</td>
</tr>
</tbody>
</table>

* ($10,000 in Capital Outlay authorized from salary savings.

**OVERVIEW OF GRANTS AND CONTRACTS — Fiscal Year 1994**

<table>
<thead>
<tr>
<th>Funding Agency</th>
<th>Project/Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection Agency</td>
<td>Wellhead protection demonstration (3 years) — Pacemill</td>
<td>$8,300</td>
</tr>
<tr>
<td>Idaho Bureau of Geologist Services</td>
<td>Science standards for Idaho</td>
<td>$9,090</td>
</tr>
<tr>
<td>Idaho Bureau of Geologist Services</td>
<td>Seismic research</td>
<td>$23,730</td>
</tr>
<tr>
<td>Idaho Bureau of Geologist Services</td>
<td>Geologic workshops for teachers</td>
<td>$2,300</td>
</tr>
<tr>
<td>Idaho Bureau of Geologist Services</td>
<td>Idaho Department of Education, Dodge D. Tapehouse Act grant</td>
<td>$30,000</td>
</tr>
<tr>
<td>Idaho Department of Health and Welfare</td>
<td>Geologic workshops for teachers</td>
<td>$7,216</td>
</tr>
<tr>
<td>Idaho Water Resources Research Institute</td>
<td>INEL oversight monitoring program</td>
<td>$37,351</td>
</tr>
<tr>
<td>Idaho Water Resources Research Institute</td>
<td>Support for geologic workshops for teachers</td>
<td>$2,200</td>
</tr>
<tr>
<td>National Science Foundation</td>
<td>EPSCoR</td>
<td>$54,530</td>
</tr>
<tr>
<td>Pacemill</td>
<td>Aquifer study</td>
<td>$19,902</td>
</tr>
<tr>
<td>U.S. Bureau of Land Management</td>
<td>Abandoned mine lands</td>
<td>$22,000</td>
</tr>
<tr>
<td>U.S. Forest Service, Region I</td>
<td>Abandoned mine lands</td>
<td>$23,800</td>
</tr>
<tr>
<td>U.S. Forest Service, Region IV</td>
<td>Abandoned mine lands</td>
<td>$86,950</td>
</tr>
</tbody>
</table>

**TOTAL** | $255,028 |
75
Years of Service

Pecten