Report of the Arizona Geological Survey Review Committee

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American Institute of Professional Geologists, Arizona Section

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Prepared for

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Report of the Arizona Geological Survey Review Comittee

EXECUTIVE SUMMARY

"Civilization exists through geological consent, subject to change without notice"

- Will Durant

A committee of the Arizona section of the American Institute of Professional Geologists (AIPG) has completed a review of the activities of the Arizona Geological Survey (AZGS) relative to the agency's mission.

The AZGS and its predecessor agencies have been recording and interpreting Arizona geology for over 108 years. During this period, the Survey has produced hundreds of reports and maps documenting the geological framework of the state for use by geologists, ecologists, other scientists, engineers, developers, recreationists, environmentalists, regulators and legislators, and members of the general public.

The accumulated geological database represents a valuable investment on the part of the people of Arizona. This value is becoming more apparent through the wider appreciation that this geological database is fundamentally important not only to the economic development of the state but also to the management of ecosystems and a better understanding of our social environment.

The Review Committee has formulated 29 conclusions and 26 recommendations relating to AZGS competencies, products and services, productivity, office equipment, public visibility and marketing strategies.

The fundamental relationship between geology and Arizona's economic and social development and the corresponding diverse responsibilities of the AZGS warrants that it remain

a separate, scientific agency within the state government.

AZGS customers in industry, private consulting, education and public agencies rate the Survey's products to be reliable and of high quality. The AZGS office in downtown Tucson is well and popularly located for the greater majority of statewide customers and the staff form a very professional research and service oriented group with an excellent reputation for prompt attention to customer requests.

Although the Survey's contributions have received wide commendation among geology professionals, AZGS has not gained an appreciation and a visibility among the general public worthy of its importance and achievements. This can be overcome through the promotion of non-technical publications and more aggressive marketing of the basic fundamentals of geology and how they impact on the human environment.

The rapid development of electronic communications is signaling unavoidable changes in the way the AZGS will distribute its products and services. There is an escalating demand for digital map information among industrial and private consulting clients and this same constituency is seeking access to several of the Survey's comprehensive electronic databases through the Internet. Electronic transfer of all types of information will be conventional practice among all customer groups by the turn of the century necessitating significant updates in computer equipment and software and a corresponding expansion of AZGS electronic communication skills.

In order to serve as a primary source of geological information in Arizona - a principal goal of the AZGS under state statutes - the Survey should keep appropriate records of other geologic and geologically-related databases that are maintained, also under statute, by other state agencies. It would be mutually beneficial to all parties if the AZGS developed information sharing programs with other state and federal agencies who have a frequent and essential need for unbiased and reliable geological information.

Geologic mapping, in its broadest sense, is a primary activity of the AZGS. Through the production of Open-File Reports, the Survey geologists have generated a timely flow of new map information for customer use. An examination of the demand for AZGS publications confirms the popularity of the map product, but the Survey should monitor the customer demand for all of its publications to determine the presentation preferences and needs with respect to the delivery of

its geologic output.

Geologic mapping is invariably enhanced when integrated with geophysical and applied geochemical surveys. The identification of geophysical and geochemical features and trends aids interpretation and understanding, improves the map product, enhances economic and environmental assessments, and increases overall productivity. Whenever budgets, special appropriations, or future hiring opportunities allow, the AZGS should acquire applied geophysical and geochemical skills to further improve the widely-used, primary mapping product.

While endorsing the recommendations of previous advisory committees, it is apparent to the present Review Committee that the state of Arizona, in these times of budget constraints, is unlikely to invest significant dollars in drill core and cutting storage to improve the present, inadequate, user-unfriendly facilities. In spite of this, the AZGS should continue to preserve the important information contained in these expensive-to-obtain, sub-surface samples through a program of digitally imaging (or photographing) all submitted drill core and cutting materials and digitally recording all logs and other relevant information.

A productive AZGS is essential to the on-going economic and social development of the state of Arizona. The implementation of the Review Committee's recommendations will require short-term expenditures for appropriate new computer hardware and software (estimated at $30,000) and the addition of a competent and experienced geotechnical staff member to meet the predictable growing customer demand for electronic information and services. Geochemical and geophysical expertise for integrated mapping and interpretation should initially be covered by contract funding and gradually phased into the strategic plan as needs and benefits become apparent. Hydrogeological and engineering geology skills can be similarly incorporated to cover the projected need for groundwater-related expertise. In the longer term, these additions will lead to operating efficiencies commensurate with customer needs and in keeping with standards of efficiency that the AZGS has established.

CONCLUSIONS OF THE REVIEW COMMITTEE

C1 The Arizona Geological Survey (AZGS) and its predecessor agencies have been recording and interpreting Arizona geology for over 108 years. During this period, the Survey has produced hundreds of reports and maps which document the geological framework of the state for use by geologists, other scientists and ecologists, engineers, environmentalists, regulators, developers, recreationists, legislators, and other members of the general public.

C2 The quality of the AZGS product is reliable and highly regarded. The accumulated database represents a valuable investment on the part of the people of Arizona.

C3 As our appreciation of earth systems expands, it is clear that the geologic database is fundamentally important not only to economic development in the state but also to the management of ecosystems and the better understanding of our social environment.

C4 Under state statutes, a principal objective of the AZGS is to serve as a primary source of geologic information in the state of Arizona. However, other state agencies have statutory responsibility to generate and maintain certain types of geological data and this information is not always available through the AZGS.

C5 Merger of the AZGS with other agencies to form a larger natural resources department would be restrictive on the AZGS in its responsibility to address all geological concerns within the state in an unbiased manner.

C6 The state of Arizona and the AZGS derive numerous benefits through AZGS's active involvement and interaction with representatives from other states through the Association of American State Geologists (AASG).

C7 The AZGS office in downtown Tucson is well and popularly located for the greater majority of its statewide customers and the location provides communication and networking benefits for the Survey's research geologists. The presence of the AZGS is an important asset to the Tucson community.

C8 Long-term planning (five years and beyond) within the AZGS is in its infancy. Currently, long-term objectives are developed by the Director and the Administrative Services Officer.

C9 AZGS staff does not focus on goals beyond a one-year period. Although output performances are satisfactory, the Review Committee detected some passive attitudes.

C10 The Arizona State Oil and Gas Conservation Commission (OGCC) is administratively attached to the AZGS. This relationship is working satisfactorily and the OGCC is currently operating effectively in its jurisdictional role over the oil, gas, and geothermal resources of the state.

C11 The AZGS has on-going arrangements with the US Geological Survey and the Arizona Department of Water Resources and cooperative projects with other federal and state agencies. With the exception of the on-going programs, the interaction with other agencies is generally intermittent. It is clear, however, that both federal and state agency customers have an important need for geological information.

C12 The participation of AZGS Director and staff members in professional organizations is mutually beneficial. AZGS staff are severely restricted in national participation by lack of funding for out-of-state travel.

C13 The AZGS has benefitted significantly from the reports of previous advisory committees and a high percentage of recommendations have been implemented. Well-managed advisory committee activity is a mutually productive exercise benefitting the AZGS, its customers, the state authorities, and the legislators.

C14 Although the Survey's products have received wide commendation among geology professionals over the years, the AZGS has not gained an appreciation and visibility among the general public worthy of its importance and achievements. It is acknowledged that the AZGS has not overlooked its role as a provider of geological information to the public, but more aggressive marketing is necessary to achieve the deserved recognition.

C15 The lay public is mostly, but not totally, unaware of the AZGS. Those who are aware are commonly involved in a geology-related activity. However, there has been a progressive

increase in demand for the "Down to Earth" series of non-technical publications prepared for the general public audience.

C16 Tucson is a major center in the southwest for exploration personnel investigating the mineral potential of Arizona, New Mexico and large sections of southern California, western Texas and Sonora. Much of the information on Arizona geology needed by this constituency is provided primarily by the AZGS. Industry geologists rate AZGS publication quality to be good to very good and are well satisfied with the Survey's services.

C17 The Tucson location of the AZGS presents no problems for environmental/engineering geologists based in outside of Tucson in obtaining Survey information. This constituency is complimentary of AZGS products and services. Hydrologic data are obtained from other state agencies.

C18 Earth science educators indicate that they have a need for more "layman-friendly" publications with information presented in a format that will assist teaching activity. Generally, the format of most AZGS publications is not useful to them, although the "Down to Earth" series may meet some of their needs.

C19 School teachers frequently encourage students to use the Internet to find additional information beyond that found in textbooks. Many educators would welcome access to educational material either at the AZGS website or through linkages.

C20 Teacher workshops are more effective than presentations to school classes in conveying a better appreciation and understanding of geology into the educational system. The AZGS is aware of this approach.

C21 It is clear from a survey of both federal and state agency customers that the AZGS is a reliable and cooperative supplier of essential geological information needed by many government departments.

C22 The AZGS staff constitute a very professional research and service oriented group. Interviews with AZGS customers clearly reveal that Survey personnel have developed excellent skills in responding to outside enquiries and in providing customer satisfaction.

AZGS research geologists are proficient in all aspects of geological mapping, geochronology, Quaternary and environmental geology, mineral deposit investigations and digital mapping techniques. The Review Committee observed, however, that there is very limited in-house expertise in applied geochemistry, hydrogeology, engineering geology and geophysics.

C23 Part of the AZGS mission is to maintain a repository of drill cores, well cuttings, and related sub-surface information from oil and gas wells, mineral exploration and development drilling and from water wells. It is apparent to the Review Committee that the state of Arizona is unlikely, in these times of budget constraints, to invest significant dollars in drill core and cuttings storage based on lack of customer enthusiasm for and usage of the existing facilities.

C24 Geologic mapping, in its broadest sense, is a primary activity of the AZGS. This conforms with the agency's stated mission and enabling legislation. Consensus of the State Geologic Mapping Committee has generally favored the quantity of Open-File Reports (OFR's) over the more complete and finished quality of formal Bulletins. The timely release of information is the objective here and explains the Survey's relative emphasis on OFR production in recent years.

C25 All maps published in the future will be digital maps. The AZGS recognizes the universal trend towards improved and more comprehensive digital mapping capability and is striving to keep abreast of this trend.

C26 Comments received by the Committee clearly indicate that many customers of geoscience data, especially the major users, favor electronic media to acquire information. In recent years, the AZGS has developed several electronic databases. Generally, the customer appetite for digital information exceeds the rate of production by the AZGS.

C27 Databases take a large amount of time to develop and maintain. They are, therefore, significant investments on the part of the Survey and constitute important state assets.

C28 Although the AZGS currently has a sufficient number of computers, many of these are now several years old and are not equipped with the necessary hardware and software for the

professional staff to efficiently manipulate and present geologic data. Additionally, in the year 2000 many computers will be rendered inoperable because the hardware and/or software will not recognize dates beyond the year 1999. The potential loss of important data makes this a critical issue.

C29 The products of field mapping, research, map preparation, and data compilation activities of the AZGS are distributed to customers primarily through publications. A comparison of sales and releases of AZGS publications indicates several imbalances. The calculation of "demand multiples" for individual publication categories confirms disparities between the current publication output of the Survey and the sales to its customers. The demand for Bulletins exceeded the number published.

RECOMMENDATIONS OF THE REVIEW COMMITTEE

R1 To become the premier source of geological information in the state of Arizona, the AZGS should maintain basic information about other geological databases generated and maintained under statute by other state agencies.

R2 The Review Committee strongly recommends that the AZGS remain a separate, scientific agency within the state government.

R3 The Director of the AZGS should continue active participation in the Association of American State Geologists (AASG). Adequate funding should be available in support of this important interaction with other state geologists.

R4 In addition to the necessary high standards of qualification and experience demanded by the position of the Director of the AZGS, incumbents should have the ability and skills to continue and further develop cooperative and interactive relationships with other public agencies and further promote good communication with the Governor's office and with members of legislature.

R5 The professional geological community in Arizona should be asked to submit nominations of qualified candidates during future recruiting campaigns for the position of AZGS Director and State Geologist.

R6 It is recommended that the AZGS senior geological staff be involved in a formal planning process for the Survey in order to facilitate the formulation and achievement of long-term goals.

R7 The Committee recommends that a more aggressive attitude be cultivated within the AZGS staff to achieve larger goals in service to its customers. Staff members should be expected to promote the AZGS beyond their designated tasks.

R8 The Committee commends the AZGS for its speakers program whereby the staff deliver talks on geological topics to school teachers and other groups. The Survey's intention to continue this program and to include presentations to service groups is endorsed.

R9 It is recommended that the AZGS establish a more frequent schedule of advisory committee reporting - two year intervals are suggested - to maintain its relevance and technological and scientific excellence in pursuit of its mission. This schedule will also serve to establish constructive communication channels between the agency, its broad customer base, and the state authorities.

An on-going advisory committee should be established composed of five or six geologists with expertise in several relevant disciplines.

R10 There are several ways the AZGS can increase its visibility and establish the agency as a prime source of geological information on Arizona. It is recommended that the Survey adopt a more active marketing strategy for its products and services which will build on the current planned programs of public displays, talks and workshops, and provide potent opportunities to further geological understanding. Specific recommendations are as follows:

* The Survey should develop links with science correspondents of Arizona newspapers, magazines, and television stations and establish itself as a ready and complete source of geological information for the communication media.

* The Survey should take full advantage of opportunities offered by the electronic media. The AZGS web page should be broadly accessible to all popular Internet software systems and should include geological vignettes of popular interest in addition to anticipated listing of publications and other services. The web page should also be widely advertised to stimulate the interest of students and teachers in educational institutions, and to attract the attention of lawmakers and their staff members as well as advocates for various causes around the state. The Internet offers great opportunities for creative communication.

* The Survey should take advantage of any reasonable opportunity to expand its program of field trips and workshops for educators in schools and other institutions.

Assistance in the planning and presentation of these activities may be forthcoming from geologists in industry and academia as well as retirees willing to dedicate their time.

* AZGS geologists should continue to expand their participation in Arizona societies fostering a variety of geology-related disciplines. Regular attendance and involvement in these meetings will identify the scientific needs of these groups and provide opportunities for AZGS personnel to establish communication links and disseminate relevant information.

* Initiation of a series of invited open houses, each one designed for a different customer constituency, would serve to bring attention to AZGS services and promote direct dialogue useful in future planning.

R11 Although it is unlikely that the general public will develop a strong interest in the more technical AZGS products, the provision of more geologic information in the form of broader-based, less technical reports in the "Down to Earth" series for school and other general public audiences is recommended as a realistic AZGS objective.

R12 Exploration geologists, when acquiring AZGS data, frequently seek information on mining property which falls within the statutory realm of the Arizona Department of Mines and Mineral Resources (DMMR). It is recommended that the AZGS pursue mutually cooperative information sharing agreements with DMMR whereby the AZGS continues to maintain a complete file of DMMR publications and additionally publishes joint databases combining AZGS and DMMR information of interest to the exploration community.

R13 It is recommended that the AZGS investigate the possible establishment of an aerial photograph reference library in the Tucson office as suggested by environmental/engineering geology customers.

R14 It is recommended that the Survey investigate the earth science teacher needs in the state. It is possible that teachers would welcome an introduction to organizations that can supply earth science teaching materials and retired, local geologists may be willing to assist the AZGS in addressing these issues.

R15 It is recommended that the AZGS evaluate the possibility of obtaining National Science Foundation funding in support of "speakers bureau" activity for addressing school workshops and also evaluate how these educators can obtain useful geological information through the AZGS web site and appropriate linkages.

R16 The Committee recommends that the AZGS continues and possibly expands staff representation in the Arizona Science Teachers Association as a means of conveying to teachers an understanding of the fundamental importance of geology in science, ecosystems, and as a contribution to human well-being.

R17 The potential for information sharing via the Internet is recognized by many federal and state agencies as a means of increasing efficiencies and furthering the objectives and services of these agencies. It is recommended that the AZGS investigate these possibilities for conveying essential geological information needed by many government departments.

R18 The Committee recommends that the Survey's current emphasis on geological mapping be maintained.

R19 Whenever budgets, special appropriations, or future hiring opportunities allow, the AZGS should carefully consider the acquisition of the following types of geologic expertise: 1) applied geochemical and geophysical skills to add critical components to integrated geological mapping programs. This integration will lead to more advanced geological understanding and economic potential evaluations as well as increased professional productivity; 2) hydrogeology background to reflect the increased awareness of the general public and legislature on water issues; 3) geotechnical background on surface geology issues and hazards; and 4) public education experience. Because of the restrictive budget allowances, AZGS should consider an in-house or a subcontractor position which combines some or all of these geologic skills.

R20 In order to establish an on-going record of Arizona's subsurface, the Committee recommends that AZGS develop a program of receiving and digitally imaging (or photographing) all submitted drill core and cutting materials and digitally recording all logs and other relevant information.

R21 The Committee concurs with current placement of emphasis on Open-File Report production to provide a more timely release of information to AZGS customers. However, sales figures indicate that some customer constituencies prefer the more finished product of formal publications. It is recommended that the AZGS monitor and evaluate the publication records on a continuing basis. These analyses should influence AZGS activity planning and marketing strategies for future years.

R22 The Committee notes potential constraints in digital map production in the AZGS and emphasizes that every effort should be made to improve and expand AZGS digital capabilities in almost all activities, but especially in maps and mapping.

R23 It is the opinion of the Committee that customer access via the Internet to databases such as AZGEOBIB and others developed by the AZGS will be conventional practice within the immediate short-term period of 2 to 3 years. The AZGS should make reasonable provision, therefore, for interactive databases to be developed and made available, in accordance with state laws and regulations, to those customers needing frequent and unrestricted access.

R24 In order to avoid a critical and embarrassing situation involving the potential loss of important data from older computers in the year 2000, it is recommended that the AZGS address computer equipment needs promptly and modify equipment replacement practices accordingly.

R25 Many of the products now being distributed as paper copies, including databases, will have to be made available to the electronic world of the Internet. The state (and the AZGS) must establish an acceptable procedure for the distribution of products and receipt of payments over the Internet that will meet state regulations, provide security, and facilitate customer needs.

R26 If the recent interest in natural carbon dioxide gas potential results in significant production, additional personnel will be required to handle the increased workload. Should the workload increase, personnel should be hired at that time rather than waiting until the next budget is prepared.

RESPONSE FROM THE ARIZONA GEOLOGICAL SURVEY

The American Institute of Professional Geologists' Committee conducted a thorough, objective review of the Arizona Geological Survey's (AZGS) performance, made accurate, relevant conclusions, and presented constructive, attainable recommendations. I commend the Committee members for their commitment and perseverance in undertaking this review and I thank the Arizona Section for recognizing this as a worthy project.

The purpose of the AZGS is to provide object geologic information. The Review Committee has identified information and related activities they believe will be needed by the professional community and the public as we begin the 21st Century. I will distribute copies of this report to AZGS staff and discuss with them how to implement the Committee's recommendations.

Larry D. Fellows
Director and State Geologist
26 November 1997

INTRODUCTION

Purpose of the Review Committee

In 1985, Dr. Larry D. Fellows, Assistant Director of the Arizona Bureau of Geology and Mineral Technology, invited the Arizona Section of the American Institute of Professional Geologists (AIPG) to appoint a special committee to review the performance of the Geological Survey Branch relative to its statutory mandate. The report of this committee (see **Appendix 1**) was particularly constructive and the majority of the recommendations were adopted.

Following the establishment of the stand-alone Arizona Geological Survey (AZGS) in 1988, other advisory committees focusing on Mineral Resources, Environmental and Engineering Geology and Earth Science Education, reported in late 1990 and early 1991, and a State Geological Mapping Committee was established in 1992.

In 1996, the Arizona Section of AIPG developed a new strategic plan for the years 1997-1999. Included in this plan was the establishment of a (sub)committee to perform a peer review of the AZGS during this period and make recommendations to the State Geologist, as appropriate. In 1996, Dawn H. Garcia, the 1996 President of the Arizona Section, was asked by Dr. Fellows to convene this committee to review the overall performance of the AZGS with respect to its mission and prepare recommendations on how the Survey should proceed to meet the needs of its customers into the 21st century. A Review Committee of four AIPG members was subsequently established and began this review of the AZGS in January 1997.

Background of the Review Committee

Summary résumés of the members of the Review Committee are as follows:

Dawn H. Garcia, Committee Chair (CPG-8313). Bachelor's and Masters degrees in Geology. Registered Geologist in Arizona and California. Has 12 years of experience in hydrogeology primarily in California and Arizona and currently employed by Groundwater Resources Consultants, Inc. (Tucson).

J. Alan Coope (CPG-8736). Retired. B.Sc. in Geology; Ph.D. in Applied Geochemistry. Over 40 years of world-wide exploration experience including 33 years with Newmont Mining Corporation and its subsidiaries. Founding President of the Association of Exploration Geochemists; Past-President of the Geological Association of Canada. Participated in three advisory committee reviews of the Geological Survey of Canada and one advisory committee review of the Chemistry and Geochemistry Department of the Colorado School of Mines.

Walter E. Heinrichs, Jr. (CPG-0688). Professional degree in Geological Engineering (Geophysics major). Semi-retired from Heinrichs GEOEXploration Company (Tucson). 57 years of experience in the U.S., Australia and elsewhere. Co-discoverer of Pima copper mine south of Tucson. Recipient of Peele Award (AIME), Van Diest Award (Colorado School of Mines) and Medal of Merit (Mining Foundation of the Southwest) for significant professional contributions. Registered geological engineer and geophysicist.

Erick F. Weiland (CPG-6892). Bachelor's degree in Geological Engineering and Master's degree in Geochemistry. Twenty-five years of experience in North America, South America and South Pacific Regions. Currently employed by AGRA Earth and Environmental (Phoenix). Registered geologist in Arizona.

Activities Conducted during the Review Process

Committee review of the Arizona Geological Survey (AZGS) commenced in early March 1997 in a meeting with the Director and a walk-through of the Survey offices. AZGS staff members, including the Director, were interviewed during three subsequent meetings and, in early June, all members of the Committee traveled to Phoenix to meet with three state employees - an appointed assistant to the Governor and two budget liaisons - with whom the Director communicates regularly. Between these meetings, Committee members individually interviewed, face-to-face or over the telephone, selected persons from different parts of the state representing various customer constituencies of the AZGS. Report compilation commenced in late June and after a series of meetings and exchanges in August and September, a preliminary draft was prepared for review with the Director. Final copy of the Advisory Committee's report was delivered on November 11, 1997 and the AZGS response to the Committee's conclusions and

recommendations was added to complete the report on November 26,1997.

The Importance of Geology

Geology is a fundamental and important natural science. The Earth's sedimentary, metamorphic, and igneous formations provide the essential resources for our increasingly technological society; geological processes such as plate tectonics and mountain building affect climatic conditions, and the nature and composition of rocks directly influence the physical and chemical composition of the weathered materials that support the world's ecosystems. In short, an understanding of geology is fundamentally important not only to our economic well-being but also to our appreciation of the vital relationships between the Earth's biological kingdoms and its non-living framework.

The Arizona Geological Survey, and its predecessor agencies, has been interpreting and recording Arizona geology for over 108 years. During this period, officers and staff have produced several hundred reports and maps which document the geological framework of the state for use by geologists, other scientists and ecologists, engineers, regulators, developers, recreationists, environmentalists, legislators and the general public. In addition to meeting the demand for geological information from the industry and academic sectors, increasing amounts of data generated by the AZGS are being used by other state regulation and management agencies. An average of almost 4,700 publications per year have been purchased by AZGS customers in the present decade.

The quality of the AZGS product is reliable and highly regarded. It represents a valuable investment on the part of the people of Arizona and as appreciation of earth systems expands, it is clear that the geologic database is fundamentally important, not only to economic development in the state, but also to the management of ecosystems and the better understanding of our social environment.

THE ARIZONA GEOLOGICAL SURVEY

History of the Arizona Geological Survey

The **Office of the Territorial Geologist** was approved in 1881 and received its initial funding in 1889. First established in Prescott, the Territorial Capital, the office was moved to Tucson when the University of Arizona opened in 1891. The Territorial Geologist was given a joint appointment as a university faculty member.

In 1915, the **Arizona Bureau of Mines** was created by the State Legislature as a state agency under the administration of the University of Arizona. The Bureau included the College of Mines mineral-testing laboratory and continued the functions of the Office of the Territorial Geologist. There was no formal appointment of a "State Geologist" but these duties were performed by the Director of the Bureau.

In 1939, following internal disagreements regarding Bureau management and function, the State Legislature created a separate **Department of Mineral Resources**, headquartered in Phoenix. This department has been renamed the **Department of Mines and Mineral Resources (DMMR)** and is presently overseen by a five-person Board of Governors, appointed by the Governor.

In 1977 the Arizona Legislature changed the Arizona Bureau of Mines' name to the **Arizona Bureau of Geology and Mineral Technology**. At this time the Geological Survey Branch was given specific responsibility to identify geologic hazards and material resources. Because of space restrictions, the Geological Survey Branch was moved to privately-owned rental space adjacent to the University of Arizona campus.

In 1988 the Legislature dissolved the Arizona Bureau of Geology and Mineral Technology and renamed the former Geological Survey Branch the **Arizona Geological Survey**. The Survey became a stand-alone State agency. It assumed administrative responsibility for the **Oil and Gas Conservation Commission** in 1991. The Mineral Technology Branch remained within the University of Arizona. In 1995 the Survey offices were relocated to the State of Arizona Regional

Complex in downtown Tucson.

Mission of the Arizona Geological Survey

The Arizona Geological Survey was established to provide unbiased scientific information to the public, to enhance understanding of geological materials, resources, and processes, and to support prudent management and use of Arizona's land, mineral and energy resources.

The authorizing document for the Arizona Geological Survey is the Arizona Administrative Code, Title 27, Article 4. Under this authorization, the Survey is established and a State Geologist is appointed by, and serves "at the pleasure of" the Governor. The Survey is funded by an annual appropriation from the State general fund and by a revolving printing fund. The objectives of the Survey as stated in Article 4 are as follows:

1. Serve as a primary source of geologic information in the state.

2. Inform the public in matters concerning the geological environment and the development and use of the mineral resources of the state.

3. Encourage the wise use of the lands and mineral resources of the state toward its development.

4. Provide technical advice and assistance in geology to other state and local governmental agencies engaged in projects in which the geologic setting or the mineral resources of the state are involved.

5. Provide technical advice and assistance in geology to industry and other members of the public toward the wise development and use of the mineral and land resources of the state.

Article 4 also stipulates specific duties of the Survey, such as conducting geologic investigations and publishing the results.

A comparison of the AZGS' designated mission with the current activities of the Survey

are the focus of this section of the AIPG review. All State agencies are required to establish a mission statement with identified programs and specific goals. According to the 1996 Annual Report, the mission of the Survey is "to provide unbiased information to the public, to enhance understanding of geological processes, materials, and resources and support prudent management and use of Arizona's land, water, mineral, and energy resources".

Its goals can be summarized as follows:

- To provide geologic information;
- Conduct geologic investigations; and
- Assist the Oil and Gas Conservation Commission.

AZGS currently has three programs identified within its organization: the Information, Investigations, and the Oil and Gas Programs.

Ideally, the AZGS should be the premier source of geologic information in the State of Arizona. This desire fits in well with the stated AZGS objective in Article 4. However, in reality, the Survey is not the primary source. Many professional geologists contacted as part of the end-user surveys indicated that they were successful in retrieving certain types of data from the Survey. In particular, basic geologic structure, history and mapping data are readily available for some areas in Arizona. Hydrogeologic data, however, is not maintained by AZGS. The AZ Department of Water Resources has statutory responsibility for water-resources data, which may be considered to fall within the realm of hydrogeologic data of interest to geologists. There are several other state agencies which generate and maintain geologic data, including the Arizona Department of Environmental Quality, Department of Mines and Mineral Resources, and Arizona Department of Transportation. AZGS attempts to avoid interagency conflicts over territories and responsibilities. This allows the Survey to operate in an atmosphere of mutual cooperation, however there are projects conducted in other agencies that would benefit from the expertise of the geologic staff in AZGS. Later in this document is a discussion regarding the pro's and con's of a consolidated natural resources agency. It should be noted here that it is not possible for one agency to maintain all geologic databases if the information is being generated by multiple agencies. The Committee recommends that the AZGS maintain basic information about other databases and be ready to provide information to customers, including a referral to the primary database holder.

Organization of the Arizona Geological Survey

AZGS is a stand-alone state agency overseen by the State Governor's office. A State Geologist, also having the title of the Director of the AZGS, is appointed by the Governor. At the time of this review, Mr. Joe Lane, special assistant to Governor Fife Symington, was the Governor-appointed administrator with oversight responsibility for the AZGS. There are three major divisions within the AZGS: Investigations, Information, and Oil and Gas (**Figure 1**).

There are eight functions within the Geological Information and Investigations division: Geologic Mapping - Framework; Geologic Mapping - Mineral Resources; Geologic Mapping - Hazards; Land Subsidence & Earth Fissures; Geology Library; Geology Databases; Drill Core and Cuttings Repository; and Earth Science Education. This division provides the scientific and technical skills for geological mapping and the research for developing publications. The division also provides direct public, industry, and government support through the library, drill core and cuttings repository, geologic databases, and the earth science education programs. Currently, three research geologists (Dr. Jon E. Spencer, Dr. Philip A. Pearthree, and Dr. Steve M. Richard), two level II geologists (Ms. Robin Frisch-Gleason and Mr. Richard A. Trapp) and one level I geologist (Mr. Tom G. McGarvin) are assigned to this division. Additional contracted personnel are assigned geologic mapping tasks on outside-funded projects as needed. Contracted personnel currently total four people.

The Oil and Gas division is headed by a Program Administrator (Mr. Steve Rauzi). Within this division there are four functions: Permits; Inspections; Well Files; and Subsurface Geology. The division provides information and services to the public and other government agencies relevant to the exploration for and production of oil and gas resources within Arizona. There is a separate Oil and Gas Conservation Commission, consisting of five persons appointed by the Governor plus the State Land Commissioner who serves in an ex-officio capacity. The Survey

ARIZONA GEOLOGICAL SURVEY

ORGANIZATION AND FUNCTIONS

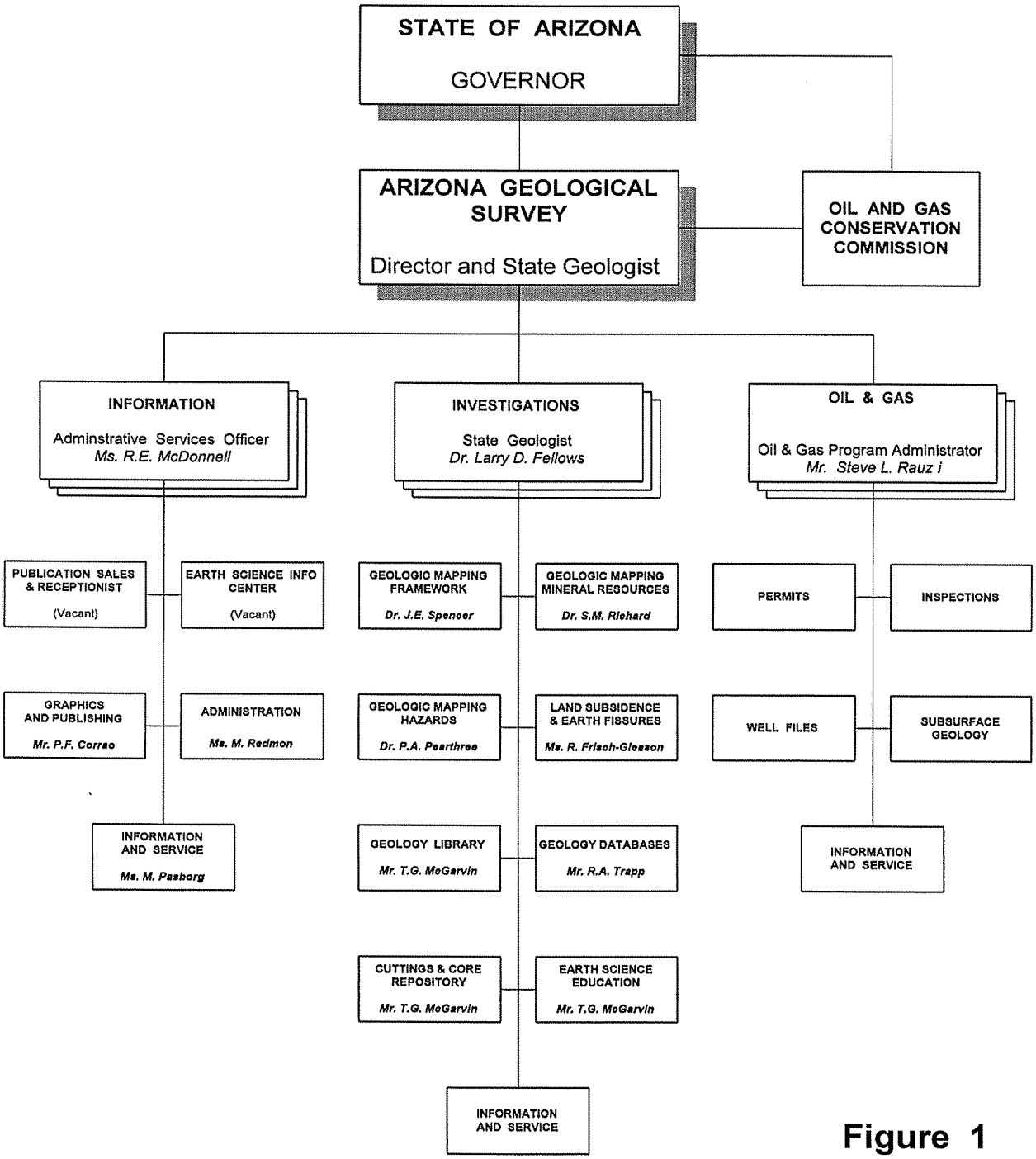

Figure 1

Report of the Arizona Geological Survey Review Committee
Prepared by the American Institute of Professional Geologists, Arizona Section
November 26, 1997

provides administrative support to the Commission. The Oil and Gas Program is administered directly by the AZGS with one employee on full-time assignment. Mr. Richard Trapp provides part-time support to Mr. Rauzi, principally covering the office when Mr. Rauzi is in the field and away from Tucson.

The third division, Publication and Administration, is headed by an Administrative Services Officer (Ms. Rose Ellen McDonnell). Within this division are four functions: Administration; Publication Sales; Earth Science Information Center; and Graphics and Publishing. This division fields all the incoming calls and requests, directing them to the appropriate AZGS personnel. The Publications Sales position is currently open. General administration duties are provided by Ms. Mary Redmon, who also assists with customer service when needed. Graphics and publishing support duties are provided by Mr. Peter Corrao. The Earth Science Information Center is a joint venture between the US Geological Survey and the Arizona Geological Survey, but after September 1997 AZGS will cover all operating costs. The Center is operated by Ms. Redmon and supervised by Ms. McDonnell.

AZGS is charged under the Arizona Administrative Code to provide geologic advice and assistance to other agencies within the state of Arizona. Based upon the liaison reports prepared by Mr. McGarvin, the AZGS responds frequently to requests from other State agencies. These agencies have included the Arizona Departments of Administration, Commerce, Corrections, Education, Environmental Quality, Emergency Management, Game and Fish, Industrial Commission, Mines and Mineral Resources, Public Service, Real Estate, Revenue, State Land, State Parks, Transportation and Water Resources. In addition, government offices outside of designated departments which have used AZGS services have included: the Attorney General's office, the Arizona State Museum and the Arizona Radiation Regulatory Commission. This list of contacts clearly demonstrates that AZGS actively provides services to other state agencies in fulfillment of its charter.

AZGS also enters into cooperative agreements with other agencies and groups. As part of these agreements, AZGS receives payment for services. During the fiscal year July 1, 1995 to June 30, 1996, AZGS worked cooperatively with the Arizona Departments of Emergency and Military Affairs, Environmental Quality, Transportation, and Water Resources; Arizona Radiation Regulatory Agency; Arizona Geological Society; Federal Emergency Management Agency; U.S. Army Corp of Engineers; U.S. Environmental Protection Agency; and the U.S. Geological Survey.

Agencies fulfilling a role comparable to the AZGS within Arizona also exist within most other states. These agencies tend to be organized in one of three ways:

- Within a department of natural resources or related agency;
- Administered by a state university; or
- As a stand-alone agency that reports directly to the governor.

As described, the AZGS was initially organized under the state university and subsequently became established as a stand-alone agency. Over time there have been discussions to form a natural resources agency within Arizona that would incorporate AZGS as well as a number of other agencies. This proposal has received mixed reactions. Many feel that a larger agency will create bureaucracy that impedes productive work. Some of the end-users of AZGS remarked that AZGS is a refreshing anomaly among stereotypical governmental agencies, because it does not suffer from detracting bureaucratic tendencies.

Other discussions have focused on whether AZGS should be combined with the Arizona Department of Mines and Mineral Resources (DMMR). This agency's responsibilities relate strictly to mining-related functions. Its focus is the promotion of mining, compilation of mineral production statistics and the administration of the State Mineral Museum in downtown Phoenix. The difference between the two agencies' missions would be restrictive for the AZGS to address all geologic concerns within the state in an unbiased manner.

Overall, AZGS is cognizant of defined and unspecified roles played by other state agencies and takes care to avoid duplicating or competing on efforts. As indicated in this report earlier, GEOLOGY IS FUNDAMENTAL TO THE ECONOMIC and SOCIAL LIFE OF ARIZONA. The Review Committee therefore strongly recommends that the AZGS remain a separate and scientific agency. The internal structure of the agency is appropriate to its current obligations based on this Committee's review.

Association of American State Geologists (AASG)

AASG is an association of the directors of the state geological surveys. The members work together closely on matters of mutual interest, including federal legislation and federally-funded projects. Dr. Fellows has been an active member, serving on several committees and as AASG

President in 1988-89. The Advisory Committee agrees that AASG involvement should be an integral part of the AZGS director's role. Though not mandated by the Arizona Administrative Code, active participation on the national level benefits Arizona. Observed benefits include access to experience and expertise developed in other states relating to various technological and professional practices, participation in coordinated planning and national thrusts such as the introduction of the National Geological Mapping program, and involvement in the development of standardized methodologies (e.g., digital mapping techniques). Continued participation should be encouraged and supported by funding to allow for travel to appropriate functions.

Arizona Geological Survey Office Location

The AZGS office location in downtown Tucson houses the staff, the library, all data files, the oil and gas records, the publication inventory, and the Earth Science Information Center. The drill core and cuttings repository is located in the adjacent building.

AZGS is conveniently accessible to the public at its current location in an attractive, renovated building with a large lobby where publications are displayed. The internal office space was constructed in consultation with AZGS, resulting in a well-organized, practical arrangement. Both the staff and public are very satisfied with the current office space, and have remarked that it is an improvement over the previous facility. The location of the AZGS office in downtown Tucson attracts more walk-in visitors than its previous locations, primarily because of its accessibility and proximity to other public offices. A billboard outside of the AZGS office is used as a marketing tool for its publications. Walk-in visitors indicate an interest in AZGS publications, especially maps. Free parking in an adjacent lot makes the location easily accessible to frequent visitors such as geologists, environmental scientists and other earth science professionals.

Though Tucson is not the major population center in Arizona, it is the major geographical center in the southwest for mineral exploration. Many mining exploration professionals working in Arizona, New Mexico, southern California, western Texas and Sonora, Mexico are primarily located in Tucson. Information on Arizona geology needed by this constituency is provided largely by the AZGS, but also by the University of Arizona and the local office of the U.S. Geological Survey. Cooperation and the sharing of geological information between the University of Arizona Geosciences Department and the Survey is important to the work of Survey research geologists. Most customers remarked that requests for information are handled via telecommunications (i.e.,

phone, facsimile, e-mail or the Internet) and because of the efficiency of the AZGS staff in handling requests for information there is no public desire or is there a need to relocate the AZGS offices to a more populous area such as Phoenix. The prevailing attitude is that business is no longer location specific, including the services required by the AZGS customers. In addition, the decentralization of government and state resources is viewed as a healthy, statewide, stimulus . The Committee has concluded that the AZGS is well and popularly located for the greater majority of its statewide customers and is, indirectly, an important asset to the Tucson community. It is a good example of the benefits of decentralized government services to smaller state communities.

AZGS Director and State Geologist

The holder of the combined position of AZGS Director and State Geologist is appointed by and serves at the pleasure of the Governor. The incumbent is required to be a registered Arizona geologist, a graduate of an accredited institution and otherwise qualified by education and experience. Dr. Larry D. Fellows has served in this position since 1979.

Activities and responsibilities of the director are primarily administrative, but include the reviewing and monitoring of AZGS technical publications. The director has little direct contact with the Governor, and reports to an appointed assistant (recently Mr. Joe Lane) in the Governor's office. There is also frequent interaction with two budget liaisons: one in the Governor's Office of Strategic Planning and Budgeting (recently Mr. William E. Greeney) and the other in the Joint Legislative Budget Committee (Mr. Chris Earnest). During Committee interviews with these individuals, all indicated that they were well satisfied with the communication practices established by the AZGS director.

Fiscal analysts assigned to monitor the AZGS in both the Governor's office and in the Legislative Budget Committee change frequently. Analysts commonly work briefly at a small agency such as AZGS and are subsequently promoted to oversee larger agencies. This practice works to the disadvantage of the AZGS management, which is required to spend increased time to ensure that the new analysts are sufficiently knowledgeable of the Survey's purpose and role.

When it is necessary to appoint a new director, there is likely to be a transition period as a replacement is sought. A new director will be appointed by the Governor, but, there is no standard procedure for the selection process. The appointment may be made following input from

a separate search committee with confirmation by the Senate Natural Resources Committee. A national advertising campaign preceded Dr. Fellows' appointment. In addition to the necessary high standards of qualification and experience, it is essential that future directors should have the ability and the skills to continue and further develop existing good contacts within the Arizona legislature, and its policy committees as well as other public agencies. The Governor's office should be encouraged to consider nominations of qualified candidates for the State Geologist-AZGS Director position from the professional geological community.

Arizona Geological Survey Long-term Planning

AZGS uses several methods to aid in planning. As for all state agencies, AZGS prepares a 3-year strategic plan that is submitted to the Governor's Office of Strategic Planning and Budget for annual approval. Direct approval by the Governor or his special assistant overseeing AZGS is not required for the Strategic Plan. In 1997, AZGS is operating under the Strategic Plan for Fiscal Years 1996 through 1998, which includes goals, objectives and performance measures, resource assumptions, and financial information. The objectives for Fiscal Year 1997 include the publication of three "Down to Earth" series books and four issues of *Arizona Geology*.

A budget for AZGS is prepared in 2-year increments based upon a proposed biennial budget prepared by the AZGS Director and the Administrative Services Officer. The budget is not usually adjusted within the 2-year period. The next biennial budget will be due September 1, 1998, to be reviewed and approved by the legislature in spring 1999 for Fiscal Year 2000 (July 1999 through June 2000) and Fiscal Year 2001 (July 2000 through June 2001).

Some long-term objectives for the AZGS discussed by the Director include the following items (no hierarchy stated):

- Prepare for the selection of a qualified director for AZGS.
- Market AZGS services and products to the non-geologic public.
- Make AZGS the premier repository for Arizona geologic data.
- Expand professional competencies of staff as budget allows.
- Continue geologic mapping efforts.
- Maintain and expand AZGEOBIB.

AZGS staff do not appear to focus on goals beyond a one-year period. It is not clear whether the appropriate staff members are not encouraged to participate in the long-term planning or whether the initiative does not exist. For whichever reason, the staff is not involved with the long-term planning, which the Committee feels makes the formulation and achievement of long-term goals more difficult. The staff seems to be pleased with the overall work environment, but perhaps somewhat complacent. Their performance is not negative in any aspects and, as indicated by user comments, staffers certainly provide good service to the customers. The atmosphere appears to be somewhat passive.

The Committee recommends that a more aggressive attitude be cultivated by the AZGS staff to achieve bigger goals. The current quality of service must not be sacrificed in order to achieve those goals. It is also recommended that a formal long-term planning process be developed which includes the input of the senior staff. Staff members should be expected to promote the AZGS beyond their designated tasks.

Arizona State Oil and Gas Conservation Commission (OGCC)

In 1991, the OGCC, as a separate state agency, was eliminated and the Commission was attached, administratively, to the AZGS. The Commission has jurisdiction over enhanced recovery, disposal and storage wells, and geothermal resources. The OGCC is the state agency responsible for conservation of oil and gas, the regulation of oil and gas wells and well-drilling specifications related to safe and efficient recovery, groundwater resource protection and prevention of uncontrolled interstrata mingling of fluids and gases.

The Commission itself, consists of five members appointed by the Governor, plus the State Land Commissioner who is an ex-officio member. The AZGS staff provide technical and administrative assistance to the Program Administrator. OGCC's mission is to encourage exploration for and to ensure safe and efficient development of Arizona's oil, hydrocarbon gases, helium and geothermal resources in an environmentally sound manner. This includes the enforcement of sound conservation practices, assuring public health and safety, providing information and assistance to government, the public and industry. The Commission is also responsible for the collecting, compiling and archiving of well files, logs, cuttings and core samples from drilling operations and industry records, including all production data.

Recent interest in natural carbon dioxide gas potential has created a flurry of activity in the St. Johns area. If this activity persists and results in any significant production, additional personnel will be required to handle the increased program workload. Hiring of personnel should be commenced when the workload increases, rather than waiting until the next budget is prepared. If additional personnel are not hired when needed, companies will not be able to proceed smoothly and efficiently through to production. The additional revenues from this resource to the state are likely to be significant and will comfortably offset expanded staff costs.

The Committee is generally satisfied with AZGS performance in its administrative responsibility and assistance to the Commission. However, attention must be continuously paid to moving information to electronic media as rapidly and completely as feasible. Additional database development may be required if current growth continues. This would improve overall efficiency and accuracy of OGCC operations for maximum benefit to the public and industry.

Interaction With State Agencies and Others

AZGS has on-going arrangements with the US Geological Survey to operate an Earth Science Information Center on the AZGS premises. AZGS also has a long-term agreement with Arizona Geological Society to distribute Society publications and to assist in the planning and coordination of certain Society functions.

The Survey's Center for Land Subsidence and Earth Fissure Information was established in cooperation with the Arizona Department of Water Resources and is in its third year of operation. The Center is the single contact point where the public, industry, and government can obtain relevant information. The fundamental tie to geology is crucial to the understanding of the cause and effects of these hazard-related processes.

Beyond the on-going arrangements mentioned above, interaction with other agencies is generally intermittent. Currently there are cooperative projects with the Arizona Departments of Emergency and Military Affairs, Environmental Quality, Transportation, Water Resources (in matters besides earth fissures and subsidence), Arizona Radiation Regulatory Agency, and the Federal Emergency Management Agency, U. S. Army Corps of Engineers, and U.S. Environmental Protection Agency.

In conversations with state employees, the Committee learned that there are possible alternate funding sources outside of the current state source that funds AZGS. Alternate sources suggested were the Heritage Fund, discretionary funds within the Game and Fish Department, and preservation funds within State Parks. The AZGS Director has sought funds from these sources several times during the past 16 years, but no joint projects have been developed. The Committee recommends that these efforts to develop joint programs be continued. The wider appreciation of the critical importance of geology in the understanding of ecosystems may lead to fruitful cooperation with these agencies.

Politics is almost always a factor in the interaction between the various governmental agencies. This Committee believes that more use of AZGS services and know-how by other state agencies would benefit the state and its citizens in the long run. Because of political realities, however, the best way to strive in this direction is to be responsive and to maintain a high quality and professional service within the Survey. It is also important for every geologist to keep demonstrating the fundamental need and use of geological science in modern society.

Arizona Geological Survey Staff Participation in Professional Activities

The AZGS Director is an active participant in the Association of American State Geologists (AASG). This organization, through the cooperative interactions between members, has considerable experience with the pros and cons of how state surveys can, should, and do operate. This Committee reiterates that this participation is important to the role of the AZGS Director and should be encouraged and supported.

Locally, the Survey and its personnel have participated with and assisted the Arizona Geological Society in its publications, meetings and field trips. Benefits are reciprocal to both groups.

Several of the AZGS staff are active members and/or officers of a number of local and national professional organizations. These involvements should be viewed as opportunities to promote AZGS expertise and services through the development of communication links which will identify the scientific needs of its customer groups within the state (see section entitled *Arizona Geological Survey Customers*).

AZGS staff are severely restricted in full national participation by lack of funding for any out of state travel. The Committee feels that a modest increase in out of state travel funding would be most beneficial in helping the Survey professional staff keep abreast of the rapid scientific and technical development in earth science and its fundamental relationship with society.

Within the state, the staff responds to numerous requests for speakers and has given lectures on Arizona geology, earthquake hazards, radon gas and other geologically related matters of public concern. They have also provided information and presentations for the benefit of teachers, earth science educational groups and students. The staff has also helped to organize and lead field trips and serve as technical reviewers of funding proposals for earth science projects and professional geologic articles and papers. This Committee commends these efforts and encourages the staff to continue these activities.

Advisory Committees

The Arizona Geological Survey has convened several committees to advise on its programs and its direction. In 1985, AIPG Arizona Section completed a performance review of the Survey (then part of the Arizona Bureau of Geology and Mineral Technology). Following the establishment of the Survey as a stand-alone agency in 1988, three other advisory committees focusing on Mineral Resources, Environmental and Engineering Geology and Earth Science Education were established in anticipation of the 1992 "Sunset Review" of the AZGS by the Arizona Legislature. Initially, these committees met twice per year and prepared reports with recommendations that were published in Arizona Geology in late 1990 and early 1991. The Survey has not received formal peer-level input from advisory committees during the 7-year period preceding the establishment of the current AIPG committee.

The State Geological Mapping Committee was mandated by the National Geologic Mapping Act of 1992 to advise the Director on geological mapping programs in the state being federally funded under this program. The Committee is multi-disciplinary with 26 members who communicate among themselves by memoranda and questionnaires.

The Survey has benefitted significantly from the recommendations of its advisory committees. A high percentage of advisory committee recommendations have been implemented, and, as a result, the Survey serves its customers and its overall mission more effectively. Survey

management is aware, however, that advisory committee members serve without remuneration for time and expenses and is reluctant to impose too heavily on the private and academic sectors for the valuable input and discussion that well-focused and well-managed advisory committee activity provides. While such considerations are necessary, it is also important to appreciate the value and usefulness of the well-prepared advisory committee report. Not only does the Survey management receive a reliable and pertinent indication of the present and future needs of its customers, the effectiveness of its programs and the quality of its research, but the public report expands the public awareness of the Survey's services and products, and also provides State authorities and legislators with a professional documentation of the effectiveness and the importance of the state agency. Moreover, the employers and associates of the members of the advisory committees are assured of a direct communication link and the opportunity to contribute information and constructive comment which, in the longer term, offsets the cost of periodic employee involvement. Well-managed advisory committee activity is, therefore, mutually productive.

It is recommended that the Survey establish a more frequent schedule of advisory committee reporting - two year intervals are suggested - to maintain its relevance and technological and scientific excellence in the pursuit of its mission. This schedule will also serve to establish constructive communication channels, through the agency, between its broad customer base and the state authorities.

In addition to providing this advice and these linkages, the Committee can, and should, work closely with the Director and provide vision and guidance with respect to the role of geology in public policy and the future geological needs of the state and its citizens. It is recommended that the advisory committee be established as an on-going committee composed of five or six geologists with expertise in several relevant disciplines.

Visibility/Marketing

For over 108 years, territorial and state geologists have been compiling data and producing maps and reports in their mission to provide unbiased geological information to the public. This work has proven to be of fundamental importance in the understanding, development and prudent management of Arizona's land, water, mineral and energy resources.

Although the Survey's products have received wide commendation among geology professionals over the years, the Survey has not gained an appreciation and a visibility among the general public worthy of its importance and achievements.

While making this observation, it should be noted that the AZGS has not overlooked its role as a provider of geological information to the general public. It has a very effective system of responding to public enquiries of all kinds and, in addition to its scientific output, has launched popular publications such as "Down to Earth" series for distribution of information to non-professionals. Staff members also give presentations on interesting geological topics to school teachers and to other groups and institutions.

It is rapidly becoming appreciated that geological understanding is fundamental to many ecological and environmental conditions and other relationships in the biological sciences as well as the proper management of natural resources and the prediction of natural hazards. Among the general public as a whole, however, there is an incomplete appreciation of how geology impacts so fundamentally on so many aspects of the human experience and economic well-being.

A recent article in the Arizona Daily Star (May 31, 1997) featured the geological history of the Tucson Mountains. Contributions of AZGS geologists to the understanding of this history are noted in the article but the accompanying list of sources for additional information on the geology of the Tucson region and the rest of Arizona does not include the AZGS. This example highlights the lack of visibility of AZGS in the media.

There are several ways the AZGS can increase its visibility and establish the agency as a prime source of geological information on Arizona. It is recommended that the Survey adopt a more active marketing strategy for its products and services which will build on the current planned programs of public displays, talks and workshops, and provide potent opportunities to further geological understanding. Specific recommendations are as follows:

- The Survey should develop links with science correspondents of Arizona newspapers, magazines and television stations and establish itself as a ready and complete source of geological information for the communication media.

- The Survey should take full advantage of opportunities offered by the electronic

media. The AZGS web page should be broadly accessible to all popular Internet software systems and should include geological vignettes of popular interest in addition to anticipated listing of publications and other services. The web page should also be widely advertised to stimulate the interest of students and teachers in educational institutions, and to attract the attention of lawmakers and their staff members as well as advocates for various causes around the state. The Internet offers great opportunities for creative communication.

- The Survey should take advantage of any reasonable opportunity to expand its program of field trips and workshops for educators in schools and other institutions. Assistance in the planning and presentation of these activities may be forthcoming from geologists in industry and academia as well as retirees willing to dedicate their time.

- AZGS geologists should continue to expand their participation in Arizona societies fostering a variety of geology-related disciplines. Regular attendance and involvement in these meetings will identify the scientific needs of these groups and provide opportunities for AZGS personnel to establish communication links and disseminate relevant information.

- Initiation of a series of invited open houses, each one suited to a different customer constituency, which would serve to bring attention to AZGS services and products and promote direct dialogue which would be useful in future planning.

ARIZONA GEOLOGICAL SURVEY CUSTOMERS

Customers were divided into six categories for comparative purposes by the AIPG Review Committee: general public, mineral exploration geologists, environmental/engineering geologists, science educators, federal agencies and state agencies. The Committee conducted user-surveys via phone and personal interviews to assess the opinions of the end-users regarding the AZGS services. The surveys are not statistically valid, but were deemed to be useful in this review. Opinions stated also reflect the personal experiences and views of the Committee.

AZGS maintains records of customers who have contacted the Survey for information. The internal library/public liaison reports classify these customers into several categories. AZGS Annual Reports include this information.

In July 1997, AZGS conducted a survey of customers to rate service quality. AZGS randomly selected one out of every seven customers to receive a postcard questionnaire. Four questions solicited customer comment on (i) overall quality of service received; (ii) staff helpfulness; (iii) staff courtesy; and (iv) quality of items purchased. AZGS received 50 responses out of the 97 mailed requests. AZGS customers were extremely complimentary with virtually all rating AZGS performance and/or quality to be excellent in their response to all questions. This high quality is confirmed not only by members of the Committee but also by other customers contacted as part of this review.

Public Customers

In addition to walk-in visitors who purchase materials at AZGS, there are a number of recreationists who use AZGS for informational purposes. Topographic maps are popular with hikers as well as tourists. Rockhounds request maps and information. Citizen groups request speakers and information. During 1996, for example, AZGS employees gave talks to the Cottonwood Rotary Club, Friends of the San Pedro, Mining Foundation of the Southwest, Verde Independent--Verde River Day, Tohono Chul Park docents, and the Tucson Gem and Mineral Society.

The Committee did not complete an exhaustive survey of the general public regarding usage of AZGS information and services, but the following conclusions were reached after informal observation and conversation. The general public is mostly, but not totally, unaware of the AZGS. Those who are aware are commonly involved in a geology-related activity. Typically, geologic data is not used on an individual basis and there is no interest in the geologic databases maintained by AZGS. Products most frequently purchased are topographic maps. Most members of the general public have only a cursory interest in geologic subjects but, since their introduction in 1991, there has been a progressive increase in demand for the "Down to Earth" series of non-technical publications. Although it is unlikely that the general public will develop a strong interest in the highly technical AZGS products, the provision of more geologic information in the form of broader-based, less technical reports in the "Down to Earth" series for school and other general public audiences would appear to be a realistic AZGS objective. Because AZGS speakers can reach a number of people at school, service, and other club meetings, this activity is a wise allocation of available time to convey an understanding of geological processes that impact on society. The recently established AZGS "Speakers Bureau" program is endorsed by the Committee and the Survey is encouraged to carefully prepare appropriate lectures and presentations to ensure the effectiveness of this initiative.

Mineral Exploration Industry Customers

Tucson is the major center in the southwest for exploration personnel investigating the mineral potential of Arizona, New Mexico and large sections of southern California, western Texas and Sonora. Information on Arizona geology needed by this industry constituency is provided, primarily by the AZGS, but also by the University of Arizona and the local office of the U.S. Geological Survey. Networking opportunities are presented by local branches of the Society for Mining, Metallurgy and Exploration, the Arizona chapter of the American Institute of Professional Geologists and the active, Tucson-based, Arizona Geological Society.

A series of interviews were held with Tucson-based mineral exploration personnel to gather comment and opinion on AZGS products and services. On average, each company contacts the AZGS for information twelve times per year. Usually, these contacts are made through personal visits to the AZGS offices but enquiries by phone are common. AZGS personnel are very responsive to requests for information and, overall, the industry constituency is well satisfied with the Survey's services.

Publications most frequently used by exploration geologists include geological maps, Open File Reports, Bulletins, Circulars, and topographic maps and map indices from the Earth Science Information Center. Only on very rare occasions are industry personnel unable to find needed geological information in Survey records, the Survey library or through consultation with Survey geologists. The scientific quality of AZGS publications is rated good to very good and the format of publication presentations is satisfactory. Major and junior exploration companies strongly support the Survey's move towards digital map production and advise that greater availability of these digital products would significantly facilitate their activities. Although endorsing the timely release of data through open-file reporting, several exploration geologists - from the individual consultant to those employed by major corporations - would welcome the publication of more formal reports covering larger areas and containing expanded interpretations of geological relationships. Information on the latest mineral production figures, staking and permit-filing reports and summaries of exploration activity for the state of Arizona would be welcomed in the quarterly newsletter. The Committee understands the exploration geologist's interest in this statistical and activity information and is aware that collection of these records falls within the statutory realm of the Arizona Department of Mines and Mineral Resources. It is recommended that the AZGS pursue mutually cooperative information sharing agreements with DMMR whereby the AZGS maintains a complete file of DMMR publications in its Tucson library and publishes joint databases combining AZGS and DMMR information of interest to the exploration community.

Exploration geologists are becoming more and more electronically adept - as evidenced by the increasing demand for digital map data. Those familiar with the AZGEOBIB database consider it to be an excellent product and urge that this cross referenced, bibliography source, plus other AZGS databases, be made available through the Internet. The same group would also be frequent visitors to a regularly updated and informative AZGS web page.

Environmental/Engineering Geologist Customers

The AZGS 1996 Annual Report, lists 71 environmental and engineering firms who had contacted AZGS for information. An informal survey conducted by the Committee asked geologists employed by environmental and engineering companies the following questions:

1) How frequently do you use AZGS services?
2) What type of information do you get?

3) How is the information received (e.g., via phone, fax, mail, on-line)?
4) What information do you need but cannot obtain?
5) How is the quality of service received?
6) What works/doesn't work in AZGS system?
7) Are you familiar with the AZGS products available? Are they easily obtained?

There are a number of geologists working in environmental companies who use only a limited amount of AZGS information because it maintains little hydrogeologic data. They indicated that the Arizona Department of Water Resources and the US Geological Survey Water Resources Division were sources of needed hydrogeologic data. Some Arizona-based geologists indicated that their project sites are primarily out of state.

Maps and publications of particular areas were the products most frequently obtained from AZGS. A wide variety of methods are used to obtain information, including personal visits, phone conversations and faxed data. None of the geologists indicated that the location or set-up of the AZGS office were hindrances to obtaining information (The respondents included geologists located in Tucson, Phoenix and Prescott). Geologists were all aware of the existence of AZGS and most had a good idea of the particular products available. Not every geologist received the quarterly newsletter, though all were aware of it as a source of information. Some geologists not receiving a personal copy of *Arizona Geology*, consulted the newsletter in their company library or shared a copy received by a co-worker.

There were a number of complimentary comments made by the customers. The staff and director were complimented on their desire to help customers and the AZGS was touted as a non-typical public agency. Service improvements suggested by respondents included the inclusion of longer technical articles in *Arizona Geology* and the addition of a library of aerial photographs for reference in the Tucson office.

Earth Science Educator Customers

Interviews were conducted with Earth Science Educators from the Tucson and Phoenix areas who had made previous contact with the AZGS. The educators were from middle and high school levels and included district wide education specialists as well as class room teachers. The *Arizona Geology* publication is being received by all of these educators at the current time. Several

have taken the "Earth Science Workshop" arranged by the Arizona Science Teacher's Association with AZGS participation, but none of those interviewed have made contact with the AZGS within the last year, nor have they been to the new building. Earth Science educators identified several very clear needs they would like to obtain through AZGS services.

Several educators indicated that the new format of the AZGS publication *Arizona Geology* is not useful to them. It is too broad brush and technical for their use. Their needs are for publications that are more "layman-friendly" with earth science information presented in a format that will assist in teaching activity. Articles of local interest and discussion of earth science related issues of current interest were often specified. It is clear from expressed feelings of "isolation" that some earth science teachers have difficulty in obtaining appropriate geologically related materials for their needs. AZGS publications in the "Down to Earth" series may meet some of these needs but it is recommended that the Survey investigate the earth-science teacher requirements in the state. It is possible that teachers would welcome an introduction to organizations that can supply earth science teaching materials. Retired local geologists may be willing to assist the AZGS in addressing these issues.

Many of the educators use the "Roadside Geology" series of books to assist in field trip planning for themselves and for students. Self-guided geological field tours (with permanent, descriptive markers and guidebooks) similar to the one established adjacent I-70 on the western outskirts of Denver were cited as excellent facilities for teaching geology to middle and high school students. Self-guided field tours need to be relatively short and the sites readily accessible in order to meet constraints imposed by bus scheduling and other special requirements.

Most schools now have access to the Internet. Teachers frequently ask the students to use this medium to find additional information beyond that found in their text books. This is in addition to encouraging students to ask questions of people doing research in various areas (usually college professors and government agencies). Most of the educators interviewed would like to obtain access to educational information either at the AZGS web site or through linkages. Topics of interest would include virtual field tours, career information, day in the life of a geologist, earth science issues (especially local ones), mineral identification (a step by step approach where the student is led through the process), and contact with mentors who can answer students' questions on different subjects.

The Tucson Unified School District is interested in applying for National Science Foundation grants in partnership with the AZGS. School teachers indicated that local support through mentors and speakers are helpful in obtaining these grants, primarily due to their perceived partnership with local agencies and professionals. Several educators suggested that the National Science Foundation funding might be available in support of the AZGS Speakers Bureau. The Committee recommends that the AZGS evaluate these suggestions put forward by earth science teachers to determine if cooperative programs are feasible.

One very astute teacher indicated that there are two types of teachers:

- "Sponges": who collect information and use it.
- "Takers": who attend workshops but instead of developing their own course materials, seek outside individuals to present subjects to the students.

Presentations to the "sponges" are, therefore, most productive and the interviews confirmed that teacher workshops are more effective than individual presentations to school classes in conveying a better geological appreciation and understanding into the educational system. The AZGS is aware of this approach and it should continue to focus on educators rather than students as its speaking programs develop. Again, the AZGS should explore joint efforts with other agencies and associations to develop long term speaker, workshop or short course programs for middle and high school teachers in Arizona.

The Arizona Science Teacher's Association (ASTA) and the National Science Teacher's Association (NSTA) are active and influential organizations among educators. The AZGS has made oral presentations at annual ASTA meetings for the past ten years and has also participated in regional NSTA meetings. The Survey should continue, and possibly expand, these contacts as a means of conveying to teachers an understanding of the fundamental importance of geology in science, ecosystems, and as a contributor to human well-being.

Federal Agency Customers

The Committee contacted a number of federal agencies who have used the AZGS services, including U.S. Geological Survey divisions of Water Resources, Mineral Resources, and

Geology, Bureau of Land Management, Bureau of Reclamation, and EPA. Among these agencies, only the EPA did not appear to use AZGS services.

The U.S. Geological Survey has strong ties with AZGS, both on personal and professional levels. AZGS is currently under cooperative agreement with U.S. Geological Survey for geologic mapping. The Mineral Resources division in Tucson actively uses the AZGS library and publications and finds the AZGS staff to be extremely helpful and efficient. The attitude of the federal agency employees reflected appreciation for the technical expertise of the research geologists.

The seven Bureau of Land Management offices in the state are very frequent users of AZGS information and services with up to 30 contacts per month. Information on mineral deposits, surficial geology, geomorphology, soils, and hydrology is frequently requested in support of BLM's regulatory functions. The various offices are frequent users of AZGEOBIB. AZGS quality and service is rated highly and there is very good understanding and cooperation between the two agencies. A senior BLM officer expressed a need for information sharing through the Internet and indicated dollar cost savings could result. Also, it was suggested that the concept of "Geological Heritage Sites" should be considered to promote an understanding of geology. Because of down-sizing, the Bureau of Reclamation anticipates increased use of AZGS data in the future. It finds AZGS quality and service to be very satisfactory.

State Agency Customers

State agencies contacted by the Committee included Parks and Recreation, Department of Mines and Mineral Resources, Department of Environmental Quality, Department of Water Resources, Department of Transportation, State Land Department, and the Radiation Regulatory Agency. The agencies using AZGS services most often were the Department of Water Resources and the Department of Transportation. Both of these departments have funded cooperative agreements with AZGS and each is in contact with the Survey for services and information at least once per week.

Between the various agencies, all AZGS services and products are used. The overall quality rating given by agencies regarding AZGS was very high. The technical work done by AZGS and staff service were rated as excellent. Productive professional relationships exist and all

customers find the downtown Tucson office to be conveniently located and the service facilities to be very satisfactory. Improvements that would be welcomed include the availability of the AZGEOBIB database on the Internet, an expansion of the quarterly newsletter to include more features, and the use of better quality paper for map publishing (comparable with the paper stock used by the U.S. Geological Survey). State Parks and Recreation would welcome more publications with broader and more general geological descriptions for distribution to the general public. Geological booklets for the information of visitors to the Kartchner Caverns and other spectacular, local geological locations would be very popular.

The Department of Mines and Mineral Resources has intermittent contacts with the AZGS and exchanges are friendly and productive. The quality of the AZGS product and the services provided are rated as good. Excellent on-going relationships exist between the AZGS and the State Land Department. This Department would welcome geological information that would complement their "Mineral Management Plan" program and will seek the cooperation of the AZGS as well as some federal native Indian agencies.

It is clear from responses from both Federal and State agency customers that the AZGS is a reliable and cooperative supplier of essential geological information needed by many government departments. The potential of information sharing via the Internet is recognized as a means of increasing efficiencies and furthering the objectives and services of these agencies and it is recommended that the AZGS investigate these possibilities.

ARIZONA GEOLOGICAL SURVEY CAPABILITIES

Professional Competencies

The AZGS staff constitute a very professional, research and service oriented group. Interviews with AZGS customers clearly reveal that Survey personnel have developed excellent skills in responding to outside enquiries and providing customer satisfaction. The administrative staff are efficient and thoroughly understand their jobs and responsibilities. Accounting procedures are hierarchical and time consuming primarily due to the need to meet exacting paper-trail standards demanded by the state auditors. The Oil and Gas Administrator is very familiar with all state regulations and, at the present levels of activity, is able to provide information to the public and effectively oversee oil and gas drilling and other exploration activities in the state with only limited assistance from the geological staff.

AZGS research geologists are skilled in all aspects of geological mapping with expertise in structural geology, geochronology, Quaternary and environmental geology, mineral deposit investigations, and digital mapping techniques. All personnel time is fully utilized. The production of digital maps to meet customers' increasing needs is limiting the time being devoted to mineral deposit studies within the state and digital map production itself will be constrained in the near future by the absence of geotechnical help. Surficial mapping programs would benefit from additional expertise in soil science.

During its review of the professional competencies of AZGS geologists, the Committee observed that there is very limited in-house expertise in applied geochemistry, hydrogeology, engineering geology, science education and geophysics. These particular geologic skills would be very useful for the AZGS to both broaden its base of public service and to add to the geologic maps already being produced by AZGS. Public awareness of geologic hazards such as earthquakes, land subsidence and landslides is high. Water quality and quantity issues are extremely important to the citizens in the State of Arizona. Additional in-house expertise in hydrogeology and engineering geology will allow AZGS to better address these issues, including some aspects which may not be overseen by other Arizona state agencies.

Expertise in magnetic, gravimetric, and other geophysical data can be integral in the

interpretation of stratigraphic and structural geological relationships, the extent and nature of overburden cover and the detailed evaluation of groundwater conditions, geothermal areas, natural hazards, and mineral deposit environments. Geochemical data of various kinds are characteristically used to facilitate the interpretation of geological relationships and a knowledge of the geochemical nature and behavior of chemical elements is fundamental to many environmental problems and to resource evaluation. In the present day context, appropriate geochemical and geophysical surveys contribute critical components to integrated geological mapping studies leading to a deeper geological understanding, a more advanced evaluation of economic potential, as well as increased professional productivity.

The acquisition of these skills should be considered whenever budgets, special appropriations, or other future hiring opportunities present themselves.

Drill Core and Cuttings Repository

Part of the AZGS mission is to maintain a repository of drill cores, well cuttings, and related sub-surface information from oil and gas wells, mineral exploration and development drilling, and from water wells. All previous review committees have reported that the AZGS repository facilities are inadequate and encouraged the Survey to acquire more storage space and develop a usable system for cataloging and retrieving information on the repository materials.

Currently cores, cuttings, and other materials are in basement storage in the building adjacent to the AZGS office. A catalog of stored materials is included in Open File 93-2 (Duncan and Spencer, 1993) and the digital database (AZWELL) of the well-cutting repository has been published on an IBM-formatted floppy disk as DI-2 (McGarvin and Trapp, 1994).

The concept of a state repository for drill hole samples is well founded. These materials, which are donated primarily by industry, are costly to obtain and contain invaluable sources of information on the geology and resource potential of the subsurface. Storage and proper documentation of drill samples provides opportunities for future explorers and future researchers to examine, analyze or thin section the archived materials. This adds to the Arizona geological information bank and, more practically, provides critical information for the better evaluation of proposals to conduct additional exploration on state and federal lands. In all situations, information is obtained without customer's waste of time and money to duplicate previous drilling.

In some states and in several Canadian provinces, local governments have made substantial investments in land and buildings (totaling hundreds of thousands of dollars) to provide for secure and adequate storage of drill cores and cuttings. These facilities have work benches and other aids for sample examination and are well used by both researchers and exploration companies.

Mining and exploration companies working in Arizona have indicated considerable willingness to submit cores and drill cutting materials to the AZGS for repository storage. In some instances, because of the lack of space, the AZGS has elected to keep only type-materials from specific intervals along the holes rather than preserving the continuous sequence of materials. Some holes have been rejected entirely, again, primarily because of lack of storage space.

Despite the awareness of mining and exploration companies of the AZGS repository, the facility is little used for sampling and inspection. The reason for this may be, in part, the inadequate and unfriendly facilities as well as the skeletal records. A request for contributions from industry in 1991 to improve the facilities met with a disappointing response with only one company (Homestake Mining) being willing to donate. As a consequence of this experience, there is little enthusiasm among AZGS staff to propose any expenditures to upgrade the current facilities.

It is apparent to the Committee that the state is unlikely in these times of budget constraints to invest significant dollars in drill core and cuttings storage based on these recent experiences. In the medium to longer-term context this is unfortunate. In order to establish some on-going record of Arizona's subsurface, the Committee recommends that AZGS develops a program of receiving and digitally imaging (or photographing) all submitted drill core and cutting materials, and digitally recording all logs and other relevant information. Skeletal cores and drill cutting samples (preserved on sample boards) should be selected and maintained for hands-on reference.

This practice will severely limit the amount of additional information that might be obtained through chemical analysis, thin section or other means, when entire cores and percussion sampling sequences are placed in storage. It will, however, preserve some record meeting the standards of observation and recording at the time of acquisition.

Geologic Mapping

Geologic mapping, in its broadest sense, is the primary activity of AZGS. This conforms with the agency's stated mission and enabling legislation.

Geologic mapping contributes information fundamental toward the identification and evaluation of mineral potential, geologic hazards and certain hydrogeologic and ecological matters of extreme importance to modern society. Availability of good geologic maps and associated geologic investigative reports are essential to proper understanding and use of geologic knowledge. More than one-quarter of the Survey's budget is expended on geologic mapping and other activities related to geologic mapping.

As used here, the term "geologic mapping" refers to the field work mainly done by research geologists and is often described as "field investigations". However, in order to make the acquired information useful to the general public, it must first be put into the form of narrative reports and/or geologic maps. The reports and maps are largely prepared by the research geologists themselves with the help of office support staff including a graphic artist.

The Survey has had an organized State Geologic Mapping Committee for the last 4 years. Consensus of that committee has generally favored the quantity of Open File Reports (OFR's) over the more complete and finished quality of formal Bulletins. The timely release of information is the objective here and explains the Survey's relative emphasis on OFR production in more recent years (**Table 1**). The Committee concurs in this placement of emphasis, at least under present circumstances. However, contrary to industry preferences, other customer constituencies sometimes prefer the more finished product (**Table 2**).

Geologic maps and related publications comprise the largest product demand among the Survey's clientele (**Table 1**). In addition to portraying the geological framework of the state and providing the essential basis for all types of mineral resource estimation, mapping leads to the identification and understanding of geologic hazards and many hydrogeologic and ecological relationships of extreme importance to modern civilization. The Committee recommends that the proportional emphasis of this part of the Survey's activities at least be maintained, if not actually augmented by more aggressive marketing.

Digital Mapping

All maps published in the future will be digital maps. This media allows for the rapid modification of maps, easy transfer of the information to other entities and applications, and is quickly becoming the delivery format of choice for many government agencies and industry clients. The Survey recognizes the universal trend toward improved and more comprehensive digital mapping capability and is striving to stay abreast of this trend. The Committee has already noted potential constraints in digital map production and emphasizes that every effort should be made to improve and expand AZGS digital capabilities in almost all activities, but especially in maps and mapping.

Unfortunately, no clear leadership has emerged in the format of digital geological map publication. A great deal of work has been done by the Nevada Bureau of Mines and Geology in this medium. The U.S. Geological Survey is using the medium but does not have a consistent format, even within the agency. The AZGS has an opportunity to be among the leaders in developing a consistent and viable format for this medium. The question is whether or not this is the best use of the agency's resources.

New AZGS geological maps are being compiled and produced using ARC-INFO digital mapping techniques. Field sheets are completed by hand and the drafted version used for the open-file reports. Once an open-file map is approved for production in a large scale map, it is given to a technician for digitizing. Only large scale maps (1:100,000 scale) are planned for digitization and publication in digital format. Digital geological maps that have been completed include four Phoenix 30'x60' (1:100,000 scale) Quadrangles (Reynolds and Grubensky, 1997) and the Digital Geological Map of Arizona (Reynolds and Richard, 1993). Four Mesa 30'x60' Quadrangles are scheduled for digital format publication, but there is no set publication schedule.

Computer Equipment and Usage

Databases

Comment received by the Committee clearly indicates that many customers of geoscience data, especially the major users, favor electronic media to acquire information. The availability of

information in a digital form provides the greatest flexibility for the utilization of this data.

In recent years, the AZGS has developed several electronic databases. Generally, the customer appetite for digital information exceeds the rate of production by the AZGS (and other state and federal surveys). This situation requires the focused attention of the AZGS management.

Databases developed by the AZGS include AZGEOBIB (Arizona Geological Bibliographic Information), AZMIN (Arizona Mineral Districts), AZWELL (Well Cuttings and Core), Oil and Gas Production Data, Arizona Age Dates, Arizona Stratigraphic Names, library holdings, several mailing lists and various small databases used by the professional staff. Some of these databases have been published and are available to the public (AZGEOBIB, Arizona Stratigraphic Names, Arizona Age Dates, and AZMIN). The remaining databases are used by Survey staff for reference and report generation.

The AZGEOBIB database - an exhaustive, cross-referenced bibliography from multiple sources on the geology of Arizona - has been developed by the AZGS and has proven to be very useful and versatile for research and information purposes. A hard copy of the database (326 pages) plus 2 disks has been published as Open File Report 95-4 (Trapp et al., 1995), but the interactive version, allowing searches based on key words, is only available in the AZGS offices. As a consequence, the public currently does not have full, unrestricted access to all the benefits and features of the database.

The Arizona Stratigraphic Names database lists all the various names that have been used by researchers and authors within Arizona. This database is a valuable resource to anyone studying and reporting on Arizona geology. The information is currently published and distributed as a report, in hard copy only, as Open File Report 88-3 (Childs et al., 1988).

The Arizona Age Dates database compiles all of the age date information that has been published for Arizona rock units. This information is not currently up to date (last published as Bulletin 197 in 1986) and needs to be revised (Reynolds et al, 1986). Once revised, a new report will be published. Survey staff are not currently planning to make this database available electronically.

The Arizona Mineral Districts database AZMIN has been used to publish 2 open-file reports

(OFR-85-12 [Welty, et al., 1985] and OFR-89-8 [Welty, et al., 1989]). Open File Report 89-3 (now out of print) contained a disk with the digital database. The database was last updated in 1989 in DBASE and has not been upgraded to the newer operating systems (Windows 95, NT, or OS2). AZMIN contains geographic location, bibliography, and other reference information.

A series of databases are currently being built by the research geologists which are similar to the US MRDS/MILS database. The compiled data in these databases is for the definition and description of structural information. The information is placed into a series of database files based on area and type of geologic setting. This has been designed as an in-house database and is generally not available to the public.

Two databases have been constructed for the Oil & Gas Commission. The Oil and Gas database contains production data in a spreadsheet program (EXCEL) which allows the Oil and Gas Program Administrator to prepare reports and tables needed by other government agencies and the public. If production were to increase in the state, a more appropriate system for storage of this information will be required.

The Well Cuttings database is a compilation of data submitted in compliance with state legislation by the oil and gas exploration industry. This data has been assembled into a DBASE database referred to as AZWELL. From the database, reports and tables are generated for use by interested parties.

The library database was specifically written for the AZGS and provides an inventory of the AZGS library by volume, not by article or subject. This database is used to print index file cards.

Several databases are maintained to generate mailing lists for the Survey's publications. The information originates from various sources and these databases are maintained by the front office staff.

Databases take a large amount of time to develop and maintain. They are, therefore, significant investments on the part of the Survey and constitute important state assets. Their value is enhanced when they become publicly accessible and are utilized by increasing numbers of Survey customers. Users of the hard-disk version of the AZGEOBIB database are very complimentary and several larger users have expressed interest in a direct Internet access to the

interactive version. Other databases (e.g., AZMIN and Arizona Stratigraphic Names) predictably would be more frequently utilized if they were also electronically available.

Placement of the interactive AZGEOBIB program on the Internet would certainly lead to expanded public use, but would entail significant additional development costs (provisionally estimated at $25,000) on the part of the AZGS. Software and hardware costs for the required server and state security requirements are estimated at an additional $5,000. Further, the time required for the development and establishment of this service is estimated at not less than 2 years, and AZGS resources would have to be diverted from other services to meet these estimates. Similar costs and time delays would be experienced in the development of a "run time version" of AZGEOBIB using Superbase (the database manager for AZGEOBIB) which could be sold directly to customers willing to certify the database was for private use and not for resale.

Another method of allowing full public access would be to post the database on a bulletin board. This would entail a lower development/hardware/software cost on the part of the AZGS than would the Internet version. A potential disadvantage would be long distance telephone costs for out-of-Tucson customers to access the bulletin board. This disadvantage could be offset by making available for purchase a combined package of the AZGEOBIB database with Superbase at a cost of approximately $500.00. Such a cost could be readily justified by major users of the database especially if linked to a subscriber agreement whereby customers could buy updated versions of the database at intervals into the future. To meet Arizona state laws, subscribers would have to certify that the product would be for private (or internal-office) use only and would not be resold.

The cost to the customer is an important consideration although this can be readily justified and offset by the customer if the additional cost guarantees availability and greater convenience. It is recommended that the AZGS continues its present in-house AZGEOBIB service while introducing the AZGEOBIB/Superbase package combined with the subscriber service described above. This would allow the AZGS to obtain, at the lowest cost, a measure of customer demand for a more convenient AZGEOBIB arrangement. The availability of the package should be prominently advertised on the AZGS web page and elsewhere. Customer response should be utilized in future planning. If justifiable, an Internet version of AZGEOBIB would provide the most convenient (and, in future years, the most conventional) access to customers nation- and world-wide who are interested in any aspect of Arizona geology. Accessibility and convenience are

critical elements in attracting a broad, receptive and satisfied customer base.

This experience could then be used for the more efficient marketing of other databases. An oil and gas database (of digitized well data) for the state is currently in the early planning stages and it can be anticipated that there will be important opportunities for digitizing geochemical, geophysical, mineralogical, mineral deposit, and mineral production. Joint production between state agencies of, for example, a combined database of the geology and mineralogy of mineral deposits (AZGS) and mineral production data (DMMR) would be well received by industry customers.

It is the opinion of the Committee that customer access to databases such as AZGEOBIB (and others described in this section) via the Internet will be conventional practice within the immediate short-term period of 2 to 3 years. The AZGS should make reasonable provision, therefore, for interactive databases to be developed and made available, in accordance with state laws and regulations, to those customers needing frequent and unrestricted access.

Computer Infrastructure

Computers at AZGS are essential tools. All AZGS computers are currently networked and a few are linked to the state computer Internet network. The system seems to be fairly stable with a minimum of downtime. One employee maintains the network, computer hardware, computer software, and backup for the entire group. The computer is a tool that must not only be learned, but used regularly to be most effective.

Although AZGS currently has a sufficient number of computers, many of these are now several years old and are not equipped with the necessary hardware and software for the professional staff to efficiently manipulate and present geologic data. Computers generally have a 3 to 5 year life due to the advancement of the technology. Newer versions of the software cannot be run on older computers. Additionally, in the year 2000 many computers will be rendered inoperable because the hardware and/or software will not recognize dates beyond the year 1999. The potential loss of important data and the unpredictability of older software make this a critical issue. Consequently, AZGS **must** replace any computer that is not designed to handle the new dates prior to January 1, 2000. If the current practice of replacing 1 or 2 computers annually continues, AZGS will not have the equipment needed to maintain its services and productivity at

the end of the century.

In order to avoid a critical and embarrassing situation, it is recommended that the computer equipment needs be addressed promptly and equipment replacement practices be modified accordingly.

Web Site/Internet

The AZGS has a web site located at www.azgs.state.az.us.

Internet access is currently being provided through the state computer network. At this time only two AZGS employees have direct access to this service. This is primarily due to the cost charged by the state for this service. The link with the state computer Internet network is expensive compared to the average local commercial access charges.

As the Committee has emphasized previously, the Internet will become a major communication link between AZGS and its clients. Many of the products that are now being distributed as paper copies, including databases such as AZGEOBIB, will have to be made available to the electronic world of Internet.

State regulations require the AZGS to charge a "reasonable" fee for its services but no charging procedure has been established by the state. This is limiting the availability of agency-developed databases over the Internet. Payment methods for products and services over the Internet have been developed in the commercial world and the state (and the AZGS) must establish an acceptable procedure which will meet state regulations, provide security and facilitate customer needs. The AZGS may be able to join forces with other state agencies to develop a common Internet database site.

Review of Publication Output

The products of field mapping, research, map preparation and data compilation activities of AZGS are distributed to its customers primarily through its publications. A variety of publications are produced as follows:

- Bulletins - represent original contributions to Arizona geology by AZGS staff and include comprehensive descriptions, presentations of geologic data and detailed interpretations.

- Circulars - a series of publications containing pertinent data and information but with limited interpretation. The designated series for data-tables, indices and bibliographies compiled by AZGS staff.

- Maps - includes all printed maps that are produced exclusive of accompanying text. Includes maps from external sources and separate maps originally published in Bulletins, Circulars, Special Papers and other series.

- Oil and Gas Publications - known occurrences, production records, well location maps, and geological and geophysical reports relating to hydrocarbon, geothermal, helium and other gas resources in Arizona.

- Special Papers - a publication series that includes contributions largely or entirely from outside the AZGS. Presentation standards may be equivalent to those of the Bulletin and Circular series.

- Contributed Maps (formerly Miscellaneous Maps) - geologic maps, produced by geologists not associated with the AZGS, that represent significant contributions to the scientific literature on the geology of Arizona. Many of these maps are from theses and dissertations which normally are not readily available to the public. (Note: the Miscellaneous Map series was renamed the Contributed Map series in January 1989).

- Contributed Reports - created in January 1989 for reports that are significant additions to the geologic literature of Arizona written by non-AZGS geologists. Many of these reports would not be readily available to the public if not included in this publication series.

- Open-File Reports - This AZGS series was established as a means for more rapid dissemination of information to the public. The series includes: (a) preliminary releases of new AZGS research results; (b) preliminary versions of reports and maps being prepared for formal publication; (c) final reports of externally funded projects; and (d) geologic maps and reports that would not otherwise be published. Many open-file reports

have not been edited or reviewed for conformity with AZGS publication standards and are photocopied on demand. (Prior to 1989, the Open-File report series included significant geologic maps and reports not authored by AZGS personnel).

- Down-to-Earth Series - non-technical booklets on popular geological topics for high school and college earth science students and for layman adults interested in the geological history, resources and the geological processes of the Earth.

- Digital Information - AZGS releases of digital data files commenced in 1993. Digital maps, database and other technical files can be readily updated and greatly facilitates expanding customer demand for compatible electronic information.

Other publication categories include Geologic Information Folios and a postcard with an illustration of the geological map of Arizona. No folios have been published since 1986 and the single postcard was introduced that same year. In addition to the above publication series, the AZGS also sells geological publications produced by the Arizona Geological Society, reports on Arizona geology by other non-AZGS institutions and geological reports and topographic maps published by the U.S. Geological Survey.

AZGS publishes a quarterly newsletter *Arizona Geology* which contains brief news articles plus other information including a listing of recent AZGS publications. This newsletter is currently mailed to 4,500 customers, primarily practicing geologists. Customers find this newsletter to be an important communication tool, principally for information about new publications. Budget constraints have limited the size of the newsletter in recent years. Many customers would like to see the newsletter returned to its earlier expanded format.

Since publication output and publication sales are indicative of AZGS productivity and customer needs, the Committee has made a compilation from available records and these are presented in **Table 1**. The time-lines and reference periods for these categories of data vary. Consequently, comparisons are not always based on coincident databases although general conclusions based on comparisons over longer periods are reasonably valid.

The five highest categories for sales and releases are highlighted in **Table 1**. These constitute 90% of Sales (1991-1996); 95% of Releases (1990-1996) and 91% of Releases (1985-

1996).

Table 1 Summary of Publication Sales and Releases (1985 -1996) Arizona Geological Survey						
Publication Category	**Number Sold (1991-1996)**	**% of Total Sales (1991-1996)**	**Number of New Releases**		**% of Total New Releases**	
			(1991-96)	**(1985-96)**	**(1990-1996)**	**(1985 - 1996)**
Maps	13,786	49.18%	3	9	1.55%	3.13%
OFR's	4,754	16.96%	110	180	56.99%	62.50%
Bulletins	4,366	15.58%	1	4	0.52%	1.39%
MM's/CM's	1,433	5.11%	31	31	16.06%	10.76%
Special Papers	856	3.05%	1	11	0.52%	3.82%
Oil and Gas	622	2.22%	14	14	7.25%	4.86%
Circulars	588	2.10%	0	5	0.00%	1.74%
Postcards	572	2.04%	0	1	0.00%	0.35%
"Down to Earth"	476	1.70%	4	4	2.07%	1.39%
Folios	316	1.13%	0	0	0.00%	0.00%
CR's	199	0.71%	27	27	13.99%	9.38%
Digital Info	62	0.22%	2	2	1.04%	0.69%
TOTAL	28,030	100.00%	193	288	100.00%	100.00%

Note: The top five categories for Sales and New Releases are highlighted.

The relatively large number of publication categories requires a careful analysis of the overall output. The present AZGS thrust to meet the known demand for the map product is the

delivery of Open-file Reports (OFR's). This has been supplemented since 1991 by the publication of Contributed Maps (CM's) which replaced the earlier Miscellaneous Maps (MM's) series. There is a balance between the volume total of Sales and Releases of Maps, OFR's and MM's/CM's in the tabulation although it is apparent that the sales and releases of the individual categories are disproportionate and traditional printed maps produced in earlier years continue to be widely used.

The imbalance between the sales volume of Bulletins compared with Bulletin production since 1985 is striking. These more comprehensive and more formal publications are a favored product of the AZGS and it is clear that several Bulletins published years ago are still relevant and in demand. Reasons for this may be a public preference for the more formal publication with colored maps covering larger areas than other products (such as the OFR's) and containing more in-depth interpretation and a wider-ranging text of interest to a larger audience. These same preferences may also account for the lower, but still relatively important, demand for Circulars and Special Papers. Another outstanding question is why the Contributed Reports (CR's) introduced in 1989 and considered to be significant additions to the geologic literature of Arizona have not gained public favor. These disparities and apparent discrepancies should be evaluated by AZGS.

The contrast between the release and sales volumes for Oil and Gas publications may reflect the economic plight of the domestic industry, Arizona's perceived lower potential for these commodities, and a correspondingly smaller audience of interested customers. As with all commodities, this relationship between publication output and sales could change dramatically with news of an important discovery or a positive, significant research advance.

Sales volume may be influenced by the number of available publications within a publication category. For example, in 1996 788 Bulletins and 986 OFR's were sold. However only 28 Bulletins compared with 270 OFR's were available for purchase suggesting a greater demand for individual Bulletins than individual OFR's. This generalization could be modified by the following:

- factors such as individually popular publications which may be present in any category,
- factors relating to current geologic, public or economic interest, and
- other factors relating to presentation and the effectiveness of marketing in

various customer constituencies.

Consequently, the following analysis relating to demand is tentative but is considered significant in the sense that more detailed investigation of trends, imbalances and conflicting scores will be of value in future planning of AZGS activities.

Table 2 lists a series of "demand multiples" for each publication category calculated by dividing the total number of available publications in each category (in 1996) into the total number of sales of these categories of publications for the 1996 year. For ease of comparison, the publication categories are listed in the same order as the Sales volume (1991-1996) listing in **Table 1**.

Table 2
Publication Demand, 1996
Arizona Geological Survey

Publication Category	Available Publications 1996	1996	
		Demand Multiple	Percentage
Maps	35	97.0	28.40%
OFR's	270	3.7	1.08%
Bulletins	28	28.0	8.19%
MM's/CM's	57	3.6	1.05%
Special Papers	8	12.0	3.51%
Oil and Gas	35	3.0	0.88%
Circulars	12	3.5	1.02%
Postcards	1	138.0	40.35%
"Down to Earth"	4	43.0	12.57%
Folios	15	1.4	0.41%
CR's	39	1.1	0.32%
Digital Info	3	7.0	2.05%

Note: The top five categories are highlighted.

Demand Multiple = Number of publications sold divided by the total number of publications available for sale

It is apparent that several factors are influencing these demand multiples. The highest demand for the postcard is created by low-cost, convenience, usefulness and uniqueness in addition to the fact that only one postcard is available so creating the most "elevating" denominator.

While cautiously bearing in mind previous comments regarding individually popular publications, the data in **Table 2** suggests a broader or greater demand for Maps than for OFR's and a noticeable broader and greater demand for Bulletins and Special Papers. This tends to confirm conclusions on the popularity of these categories of publications based on the analysis of the data in **Table 1**.

Although not tabulated, calculation of demand multiples for the period of 1991 through 1996 reveals that the most popular publication categories for the year 1996 (i.e., Postcards, Maps, "Down to Earth", Bulletins and Special Papers) are also the most popular publication categories over the longer time period. The most popular publication categories are highlighted in **Table 2**.

Careful evaluation of publication sales in comparison with the AZGS output provides useful information on customer preferences and needs. It is recommended that the AZGS monitor and evaluate these records on a continuing basis. These analyses should influence AZGS activity planning and marketing strategies for future years.

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APPENDIX 1

Letter report on the Geological Survey Branch by the AIPG Review Committee

Committee members: R.E. Weeks (Chair), F.S. Turek, J.D. Nations, K.M. Euge, and W.E. Heinrichs, Jr.

1985

Report of the Arizona Geological Survey Review Committee
Prepared by the American Institute of Professional Geologists, Arizona Section
November 26, 1997

AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS

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November 4, 1985

Arizona Bureau of Geology and Mineral Technology
Geological Survey Branch
845 North Park Avenue
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Attention: Dr. Larry D. Fellows
State Geologist & Assistant Director

Gentlemen:

In response to the written request of Dr. Larry D. Fellows dated March 20, 1985, the Arizona Section of the AIPG has completed a performance review of the Geological Survey Branch of the Arizona Bureau of Geology and Mineral Technology. As discussed prior to the commencement of our review process, the purpose of this evaluation was to assess how effectively the Geological Survey Branch has fulfilled its duties as specified in the 1977 enabling act (Title 27, Chapter 1, Article 4, Arizona Revised Statutes). The content of this submittal summarizes the methods by which the Arizona Section performed the review, and compares the past accomplishments and future goals of the survey with the intent of the enabling legislation. Recommendations which we believe would improve the performance of the Survey are stated.

During April of 1985, a review committee of AIPG members was formed. The committee was comprised of Messrs. Walter E. Heinrichs, Frank S. Turek, Kenneth M. Euge, J. Dale Nations and Ralph E. Weeks. The selection of these members was designed to acquire input to the review process from a broad spectrum of geologic backgrounds. The specialties of mineral exploration, hydrogeology, engineering geology and education were represented.

The AIPG review committee met on May 25, 1985 in Phoenix. Prior to this meeting, Messrs. Heinrichs and Weeks visited the offices of the Geological Survey Branch, toured the facilities, and discussed the accomplishments and goals of the Survey with Dr. Fellows and several members of his staff. During the committee meeting on May 25th, Dr. Fellows presented the group with a discussion of the activities of the Survey and provided copies of the Enabling Act and Activity Summaries for 1980-82 and 1983-84.

We view the power and duties discussed in Section 27-152.01 of the 1977 Enabling Act as a guide to our review process. As quoted from the statute, these discussions outline the mission of the Geological Survey Branch as follows:

- Investigate, describe, and interpret the geological setting of this state, including its natural hazards and limitations, its natural attributes, and its mineral resources.

- Publish in the form of bulletins, circulars, maps, and other related series or otherwise make available to state agencies, government officials, industry, and the public the results of all geological, mineral technology, and related research and investigation undertaken by the Bureau.

- Provide lectures, talks, displays, and exhibits for the general education of the public toward a better understanding of this state and the wise use of this state's land and its mineral resources.

- Operate and maintain a central repository for reports, books, maps, and other publications regarding the geology, mineral resources, and associated technologies present or practiced in this state. Such repository shall be available for the use of the public.

- Operate and maintain a central repository for rock cores, well cuttings and related subsurface samples, and all associated supplemental data consistent with laws of this state requiring the deposit of such material and information. Such repository shall be available for the use of the public.

As interpreted from the first statement of the Enabling Act, a primary responsibility of the Survey is to perform geologic research. This research is intended to provide information on Arizona's geologic framework, earth materials, mineral resources, and geologic hazards that could affect the activities of man.

The primary research activities of the Survey are performed by one full-time principle geologist and two research geologists. These professionals are supported by one full-time research assistant and several part-time student employees. In addition, several temporary professionals have periodically performed geologic research supported by contracts awarded by the U.S. Geological Survey, the U.S. Bureau of Mines, and the U.S. Bureau of Reclamation.

With the exception of the neotectonic and mineral resource studies performed

under contract by temporary professionals, the major research activities of the Survey have recently been in the fields of bedrock and structural geology and the characterization of nonmetallic resources. In relationship to the statutory mission of the Survey, there appears to be a lack of emphasis on Arizona's natural hazards and limitations. With the accelerated growth of Arizona's cities and the present and future diversity of land use, the identification of natural hazards and limitations should be considered a primary research objective.

We believe that in order to accomplish the goal of providing information on Arizona's natural hazards, the Survey must first retain a lead professional who is a specialist in Quaternary geology, geomorphology, and environmental geology. Under the direction of this specialist, the Survey could directly fund research programs designed to establish a body of regional information on the nature and distribution of geologic hazards and limitations. Without this full-time effort, a disparity will continue to exist between the Survey's effort to characterize the general geologic setting and resources, and its goal of providing information on environmental geology.

The various geologic hazards or limitations in Arizona which need to be addressed are seismicity, ground subsidence and earth fissuring due to groundwater withdrawal, landslide and other slope processes, fluvial geomorphic hazards, natural collapse and problem soils (expansive and collapsing). Since the Survey has recently performed several studies on Arizona's neotectonic framework and earthquake history, the other hazards should receive more emphasis. Several elements of the studies should be as follows:

- Initial statewide characterization of the location and nature of the various hazards. Use of overview maps (1:1,000,000 scale) which depict these hazards. Use of technical questionnaires and other communications with land planners and private consultants to identify previously unrecognized problem areas.

- Establish bibliographies and index maps which identify all previous research performed.

- Generalized characterization of Arizona's surficial materials.

- Select specific regions which merit detailed field studies. The selection of these areas should consider Arizona's future urban development so these studies can assist planners in avoiding or mitigating geologic problems.

In addition to the geologic hazard characterization efforts discussed above, the Arizona Section of AIPG suggests that a major portion of all research programs be regional in nature. 1:500,000 and 1:1,000,000 scale studies should receive priority over more specific field efforts, although we recognize that specific field studies are sometimes necessary to solve regional problems. In this manner, the public as well as the professional community will profit from the efforts of the Survey.

Although other state agencies have been delegated the responsibility of protecting Arizona's groundwater resources, the geologic characterization efforts of the Survey should be considered as a basis for this protection. Without a proper understanding of a geologic setting, the groundwater resources of that setting cannot be adequately preserved. In part, the delegated mission of the Survey is to investigate and interpret natural limitations. Relative to the issue of groundwater protection, one of these limitations can be interpreted as the ability of underlying geologic formations to prevent contaminant migration from waste disposal sites. Aquifer characteristics such as transmissivity are geologically controlled. Without proper characterization, the design and monitoring of waste disposal systems cannot be accomplished. We would fully support an increased level of activity by the Survey to support the hydrogeologic characterization of the State.

The second major function of the Survey is the publishing of the results of geologic research and investigations undertaken by the agency. In the past, this responsibility has been accomplished by the printing of a bulletin series, several special papers, maps, circulars, and individual papers within an open-file series. Another significant method of distributing information has been FIELDNOTES, a quarterly publication which is distributed free of charge.

We encourage the continued use of the various approaches the Survey has adopted to disseminate the findings of their research. As members of the professional community, however, there are two points we would like to stress. First, the use of an open-file system does allow for recent research efforts to be filed and available to the public soon after completing an investigation. However, the existence of these papers is not widely known, and not readily available as published information. We suggest that a bibliography of these publications be periodically distributed and that every effort be made to formalize this information as soon as possible. The second item is the updating of bibliographies of Arizona Geology. We believe that a formal bibliography of all geologic literature, mapping, and graduate theses on Arizona geology should be published every two years. This effort should take precedence over other publishing activities of the Survey. We discourage the use of FIELDNOTES as the sole source of bibliographic information.

The third goal of the Survey is the dissemination of geologic information to the general nonprofessional public. The Enabling Act specifies that this effort should take the form of either lectures, talks, displays and exhibits. Over the past two years, members of the Survey staff have led field trips, conducted workshops and addressed several nonprofessional groups.

We believe that public education on Arizona's geologic framework and its associated hazards and limitations will increase in importance as our population increases and our urban areas expand. One of the most effective avenues for educating the public is through the primary and secondary school systems. A continuing workshop program for earth sciences teachers should be considered. This program would provide our educators insight into Arizona's geologic framework. Students, our future adult citizens, would thereby learn how Arizona's geologic processes affect public welfare and safety. The Survey should consider the assistance of the three state universities in developing a workshop program.

The fourth responsibility of the Survey is the operation and maintenance of a central repository for geologic reports, books and maps. This library is to be available for public use.

The existing library at the Survey's Tucson headquarters is excellent and well maintained. We have one suggestion which deals with public availability of this information. We recommend that the Survey investigate the possibility of establishing a comprehensive computerized data base for all the retained information. This data base could be linked to terminals in Phoenix and Flagstaff for easy access. Northern Arizona University and Arizona State University would be ideal locations for these computer terminals. The general public and the students of those universities would both benefit from this method of accessing information.

The remaining goal of the Survey is to maintain a central repository for drill cores, well cuttings, and related subsurface information. We believe that the existing sample repository is inadequate. Samples are not presently stored in one location and access to the material is difficult. We understand that samples which have been offered to the Survey have been recently rejected due to the lack of space and resources to catalog the material. We encourage the Survey to secure adequate storage space and provide a usable system of sample cataloging and retrieval.

As a whole, the previous discussions have emphasized approaches to improving the activities of the Survey or eliminating what we perceive to be

deficiencies. In discussing these matters, we do not intend to provide a perception that the Survey has not performed in a commendable manner. In contrast, we believe that the Survey has provided a valuable service to Arizona's public over the past years. Within the context of the resources available for geologic research, this service has been performed in a professional and efficient manner. In the future, we encourage an elevated level of effort which will be required to properly tackle the environmental problems which can compromise the welfare of our state.

We trust that our comments and suggestions relative to the performance of the Survey have been constructive. The Arizona Section has welcomed the opportunity to perform this review.

Should any questions arise during your review of this letter, please feel free to contact us.

Respectfully submitted,

Ralph E. Weeks, P.G.
President - Arizona Section

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