Bureau of Economic Geology

Strategic Plan

2006

Scott W. Tinker, Director

Executive Summary

Since its creation in 1909 in the dual role of the first Organized Research Unit at the University of Texas and the State Geological Survey of Texas, the Bureau of Economic Geology has grown into a major research institution for addressing global earth science problems to benefit society.

What the Bureau Offers

The Bureau benefits the School in several ways. The Bureau's annual bookings have grown from $10 million in 2000 to nearly $20 million today. In terms of the research mission, the Bureau attracts significant external research funds each year—$13.6 million in FY2006 from a diverse portfolio of Federal, State, private and foundational sources. External investment in research and education could grow from just under $20 million Schoolwide to over $40 million by expanding programs to collaborate with the Department and Institute and by creating new programs. The Bureau has research strengths that complement those of the other units (so growth would not be duplicated), and it has a tremendous capacity, if supported, to contribute to graduate education. Diversity at the Bureau is good—approximately 21% of our research staff is female and international employees are broadly represented, and with growth the ratio can improve and be leveraged across the School. As the State Geological Survey, the Bureau is politically engaged and can open doors for the School to help bring science to policy. Finally, the Bureau has a professional support staff that can benefit the entire School.

What the Bureau Needs

The Bureau has three pressing tactical needs: talent, stabilization, and facilities. In the area of talent, seven programs requiring annual support of $2.8 million are requested. These include Talent Growth, Research Chairs, and Jackson Fellows, Postdoc Matching, Moving and Startup, Integration/Collaboration Incentive, Excellence Support Fund, and Joint Appointment Insurance. In addition, Research Frontiers and Graduate Student and Equipment Support are important, but operational structures need to be reconsidered and funding amounts have yet to be determined. For stabilization, five programs requiring annual support of $1.9 million are requested and include Base Level Researcher Support, Researcher Backstopping, Support-Staff Capacity Building, Service and Outreach, and a Development Fund. Finally, in terms of facilities, support of $2.7 million is requested in four areas, $2.5 million of which represents one-time expenses, including Satellite Operations, Database Modernization, and a Houston Research Center Renovation match.

In addition to financial investments, organizational requirements in the form of incentives, removal of barriers, portfolio balancing and policies will strengthen the Bureau's role in the School. These include managing the external investor portfolio, GSC membership, membership in the School for all researchers and directors, facilitating hybrid research/faculty positions, and improving ways for all staff to meet and interact. The impact of these changes would include increased donor giving; investment in research and education programs; leveraging of private sector investment for Federal grants; faculty, researcher, and student interaction; capacity for student support and distributed advising load; research opportunities for students; teaching capacity; collaboration, interaction, and participation; quality of science; and sense of community—all leading to a major improvement in School reputation.

The Forefront of Research

Many of the projects and programs represented by the 175 active Bureau accounts address common research or societal themes and can be "rolled up" into *focus areas*. There are two broad classes of Focus Areas, one in which projects are coordinated around a common *Research* theme and the other, which is represented by *Major Programs* with an overarching purpose driven by the Bureau mission. Research focus areas comprise Advanced Energy Consortium, Coastal Change in Texas, Fracture Processes, Salt and Shale Tectonics, Sedimentary Rock Systems, Seismic Imaging in Complex Environments, Unconventional Fossil Energy, and Groundwater Hydrogeology. The major program focus areas are represented by significant, funded research or service programs in which the Bureau is heavily invested. These include the Center for Energy Economics, Gulf Coast Carbon Center, International Research and Education Partnerships, Professional and Societal Service, State Geological Survey, and State of Texas Advanced Resource Recovery program.

The Bureau aims to solve refractory challenges by using innovative, integrated geoscience and engineering approaches to benefit society. Addressing research opportunities often requires multidisciplinary, collaborative research teams that cross focus areas and engage in efforts sustained over many years. We call these long-term, integrated efforts *scientific movements*. *Carbon Management*, for example, seeks to advance technology and identify scientific, engineering, regulatory, economic, and public policy issues in collaboration with JSG climate-change science. *Coastal Dynamics* addresses the need to protect coastal environments under pressure from population increase, sea-level rise, and hurricanes. *4-D Quantitative Stratigraphy* integrates sedimentology, stratigraphy, geophysics, geostatistics, numerical modeling, and fluid-rock interaction to improve recovery and storage of subsurface fluids, monitor contamination, and explain Earth and climate history. Developing technology for mobile micro- and nanosensors injected into fractures and pores is the goal of 4-D Heterogeneity Characterization. *Mobile*

Substrate Tectonics, which creates three-dimensionally complex structures on an impressive scale, is investigated at a fundamental level to improve exploration for petroleum and other resources, elucidate geohazards, and add to basic knowledge of continental margins and orogens. *Structural Diagenesis* combines structural geology and geochemistry to help us understand chemical and mechanical processes in chemically reactive, fractured rocks in order to target resources and sequester reactive materials. Finally, *Sustainable Water Resources* is exploring biosphere and hydrosphere linkage between land-use change, climate variability, and groundwater.

The Forefront of Education

The Bureau educates at many levels: undergraduates and graduates, K-12 students and teachers, private citizens, government employees and decision makers, and private industry. Students at the Bureau have access to research teams working on important issues, excellent data sets generally unavailable in academe, leading technology, and industry contacts and careers. There are several key areas in which the Bureau, with the proper School support, can help the School attain the forefront of education: advising and mentoring, teaching, internships, and recruitment. The team-based research program promotes student interaction with scientists and faculty and fosters a strong sense of community. The Bureau's outstanding research and core facilities, flexible staff, and administrative structure can facilitate education at all levels. Facilities could include a student/researcher area, computer workrooms with skilled IT support, and a visualization lab with TACC, a library, and classrooms. In addition to graduate education, the Bureau engages each year in extensive outreach and professional education. Activities include symposia, professional courses and training, field trips, leadership of professional societies, presentations at conferences, State and Federal testimony, and publishing in local, regional, national, and international journals, as well as our own publication series. Prominent ongoing Bureau outreach includes the Petroleum Technology Transfer Council, Earth Science Week, Teach the Teachers, the Decision Makers Seminar and Field Trip, museum displays, Earth View Texas, extensive involvement with GeoForce Texas, the Down-to-Earth program, K-12 science fairs, and museum educational projects.

The Fabric of the School

The fabric of a great School is perhaps best measured by community and collegiality, represented by threads such as interaction and collaboration within and between the units and outside the School; service to our School, profession, and society as a whole; partnerships in research, education, and outreach and with industry, governments and foreign nations; active friendships and associations with alumni; and mentoring of colleagues, students, and staff. At the

Bureau, these attributes compose what we call “The Bureau Family,” and we look forward to our family becoming an integral part of the greater Jackson School fabric.

The process of planning has brought a welcome internal examination of the Bureau and assessment of our role in the School and our impact on science and society. The Bureau today is a healthy, growing, globally recognized science and engineering organization with broad-ranging research and education strengths. Bureau researchers are engaged in programs that have the potential to influence the way others think or act in their daily lives—to contribute substantially to real issues that impact global society. For example:

- How can we transition globally from carbon-based energy to decarbonized energy?
- What, if anything, can we do about climate change?
- What new discovery is possible if we put smart, mobile, microsensors into the Earth?
- How should societies adapt to coastal dynamics?
- Where will the world’s freshwater come from this century?
- How can societies build sustainable economic, business, institutional, and human-resource capacity to address these issues?

This potential for transformational impact is rare in any field of endeavor. In the end, it is exactly this kind of impact that drives us—that wakes us up early and keeps us up late.

CONTENTS

1 Introduction to the Bureau

The Bureau of Economic Geology (Bureau) was created in 1909 as the first Organized Research Unit at the University of Texas *and* the Texas State Geological Survey. The Bureau evolved from a small minerals and mapping unit to a major research institution that addresses global earth science problems having a significant impact on society. Bureau programs result in fundamental science being brought to fruition in practical applications.

Bureau success requires flexibility, adaptability, alacrity, diversity, and a sense of community. We develop and depend on enduring internal and external relationships. The Bureau has a reputation for developing new ways to solve problems. Our reputation depends on delivering quality; our results include new concepts documented in the scientific literature, new practices attested to by changes in industrial procedures and government policies, and service to the State and Nation via our mission as the State Geological Survey.

The Bureau receives financial support externally via competitive grants and contracts. Our reputation and *brand* are essential for financial health and continued success. The Bureau model of grant and contract funding has challenges and requires tremendous discipline, commitment, and hard work. For those who fit the culture, it offers an exciting and rewarding career. There is a perception that soft money implies financial instability. The Bureau, however, has an excellent record of stability that has allowed high achievers to enjoy an enduring and rewarding tenure. To reduce financial volatility, the Bureau maintains a diverse portfolio of funding across Federal, State, private, and foundational sources. However, budget cuts are outside Bureau control (Federal and State reductions, industry volatility) and must be anticipated and mitigated. Lack of significant institutional funding and the associated perception of volatility make attracting and retaining talent an ongoing challenge.

The Bureau has grown steadily the past 7 years, from a $10-million organization in 2000 to a $20--million organization today. As a result, the Bureau has positioned itself to lead several programs with high impact on society, including carbon management, unconventional energy, subsurface nanotechnology, advanced resource recovery in Texas, and geoscience data preservation. The Bureau was able to build these programs because of existing strength in the disciplines of structural geology, stratigraphy, diagenesis, hydrogeology, reservoir characterization, coastal geology, geophysics, petrophysics, and engineering. The ability to develop and manage large, integrated programs is a particular strength of the Bureau.

The Bureau today is healthy and fully engaged, but we can be more! As part of the JSG, the Bureau has the potential to springboard from being a national leader in several programs to becoming an international leader with a global impact that has never been available to the geosciences.

1.1 The Bureau and the Jackson School

The John A. and Katherine G. Jackson School of Geosciences (School) comprises three unique units: the Department of Geosciences (Department), the Institute for Geophysics (Institute), and the Bureau of Economic Geology (Bureau). Upon his arrival, Dean Eric Barron initiated a welcome strategic planning process and charged us to "engage and excite,…define the path for our investments,…attract the next set of resources,…focus on the scholarship of teaching as well as the scholarship of research,…empower the next generation of students,…promote collaboration and cohesion as a strategic objective,…and play off the existing strengths of this school and this university…." Dean Barron emphasized that he wants not only to maintain the autonomy of, and strengthen, the units, but also to determine and invest in overlaps between the units and in so doing strengthen the School.

The Bureau can help build a stronger School, and the School can help build a stronger Bureau. This relationship must be carefully considered and nurtured so that the organizations become symbiotic, not parasitic or unfavorably competitive, so that the whole becomes greater than the sum of its parts. To accomplish this goal requires balanced attention between tactical and strategic investments.

After setting the financial stage, we discuss how the Bureau can help the School and how the School can help the Bureau—both now and in the future. This discussion is followed by a prioritized list of School investment requests and a second list of organizational needs that will remove barriers and/or create incentives that will contribute to the making of a great School. These priorities summarize and tie directly to subsequent sections on the Forefront of Research, the Forefront of Education, the Fabric of a School, and the Appendices.

1.2 Current Financial Status

There are three broad arms of funding in the School: Appropriations (University/State appropriations for all units), Foundations, and Grants/Contracts (external grants, contracts, and sponsored research). For the three units of the School in FY06, Appropriations totaled $6.5 million, Foundations totaled $5.9 million (on $17.5 million of earnings), and Grants/Contracts totaled $19.3 million (Figure 1). Grants and Contracts offer a major growth area for the School.

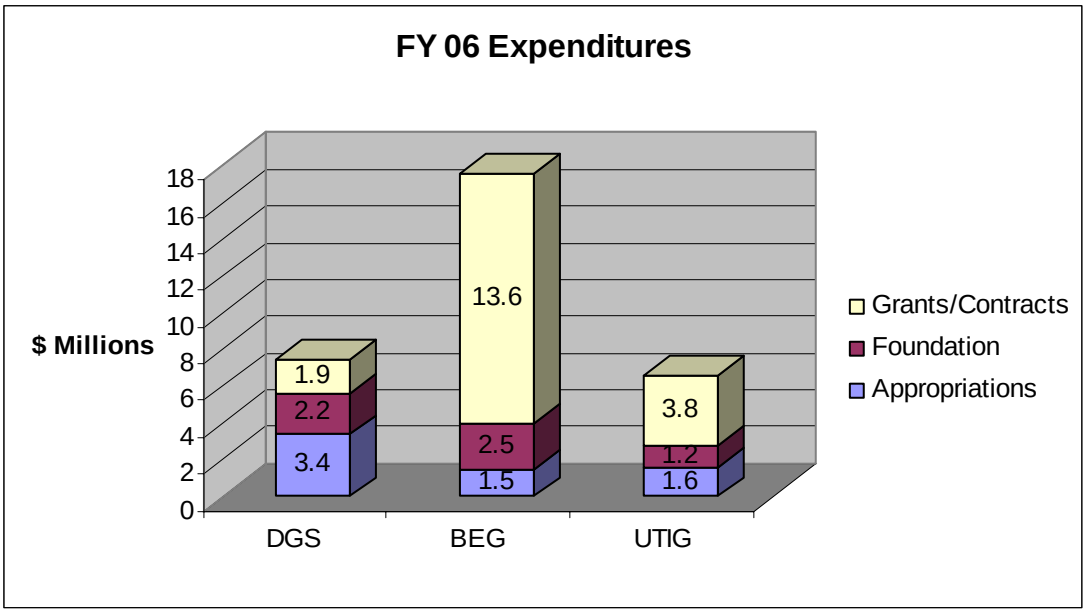

Figure 1: Fiscal Year 2006 expenditures. Data from D. S. Trinque.

1.3 What the Bureau Offers

The School will grow. Each unit will grow, and new departments and units will undoubtedly be formed or added. Growth requires funding, talent, and support. Diversity, facilitated by an international reach, can be improved as we grow. The Bureau can help.

1.3.1 External Funding

The Bureau has a successful strategy for identifying and funding significant long-term research initiatives. How the Bureau has built these programs is described in Appendix 2. Our industrial, Federal, and State networks are extensive and at the highest levels. We have a rich history in conceiving and developing research programs and attracting funding, and we look forward to strong collaborations within the School that will result in, at minimum, a doubling—from approximately $19.3 million Schoolwide in fiscal year 2006 to $40 million or more in 5 years—of external investment in the research and education enterprise. This growth will be accomplished through expansion of existing Bureau programs to include collaborative partnerships with the Department and Institute, as well as via the development of new, major programs Schoolwide, which the Bureau can participate in and help lead. Such an increase will allow the School to pursue the grandest of challenges, increase the reputation of individuals and the School, and attract the best students, faculty, and researchers.

1.3.2 Education

The Bureau educates at many levels: private citizens, elected officials, government employees, scientists and engineers in industry, undergraduate and graduate students, and K-12 students and teachers. The Bureau has been actively involved in supervising, advising, and mentoring graduate students for many years, but these activities are all volunteer—above and beyond a full-time job. With strategic support from the School, the capacity for the Bureau to contribute to the graduate education mission is tremendous and includes advising and mentoring, internships, and undergraduate and graduate recruitment. The Bureau's team-based research program naturally promotes student interaction with scientists and faculty associated with Bureau programs and a strong sense of community. The Bureau's flexible staff and administrative structure can facilitate internships and innovative recruitment at all levels.

1.3.3 Talent Leveraging

The Bureau has research strengths that largely complement, not compete with, the strengths of the other units. Rather than duplicating strengths that exist in the units via new faculty hiring, with the right organizational design, the School can leverage the strengths of the Bureau (and the Institute) such that research and education missions are achieved and the overall reputations of both the Bureau and the School are enhanced. We look forward to participating in this leveraging endeavor.

1.3.4 Diversity and International Reach

Bureau diversity is greater than that of most academic geoscience organizations. Our research staff is about 21% female and 22% of the researchers are from countries other than the United States. With growth, we see continued diversification, which can increase the international, diversified flavor of School.

1.3.5 Government Impact

As the State Geological Survey, we are engaged extensively in the State and Federal political process. We are well known in the Texas capital and inside the Beltway in Washington. As a result, we are often called to testify, advise State agencies, educate decision makers regarding issues in which earth science plays a role, and help bring science to policy. This exposure and impact are vital to our reputation as a School.

1.3.6 Support Staff

The Bureau has an outstanding support staff that includes people who excel in purchasing, grants and contracts, employee relations, accounting, editing, graphics and media, IT services (including expertise in networks, visualization, programming and software support), geoscience data storage and curation, internal publishing and publication sales, libraries, facilities and vehicle management, and public outreach. We maintain this staff in order to accomplish the State Survey

mission and thus dedicate our State line-item appropriation to the support staff. We have the space and infrastructure to house the staff. There is no reason to duplicate the functions performed by Bureau staff in the other units or in the Dean's office. With School support, the Bureau staff could grow as needed, maintain a Bureau reporting line, and serve all members of the School to enhance the overall enterprise.

1.4 What the Bureau Needs

There are three areas in which the School can help the Bureau: talent, financial stabilization, and facilities. Although the discussion that follows is focused on the Bureau, many of the programs we propose would be beneficial Schoolwide.

1.4.1 Talent

Finding, attracting, hiring, and retaining talent is a great challenge for any research organization. We use as recruiting tools the reputation of the Bureau and the University, quality facilities, outstanding support staff, strong collaborative research team, the City of Austin, and our ability to self-direct and pursue exciting research. These, however, can only go so far. Attracting new talent and retaining existing talent are a competitive business and require new approaches. The proposals that follow have strong investments from both the Bureau and the School; both have key roles to play.

1.4.1.1 Talent Growth

A new-hire transition from hard to soft support over a 3-year period would provide a tremendous recruiting tool to allow a researcher to get her feet on the ground and establish a successful program. The result would be School growth and higher quality applicants. Our recommendation is for the School and the Bureau to share the transitional costs as follows:

Table 1. Proposed distribution of funding support between the Bureau and the School.

	Proposed Funding Split		
Year	JSG (Hard)	BUREAU	Total
1	75%	25%	100%
2	50%	50%	100%
3	25%	75%	100%
4	0%	100%	100%

Annual School Support for Bureau: The School component of the personnel costs (including postdocs supported by the School at ~ 50%) starts in 2008 at ~ $1.5 million and grows to ~$3.1 million in 2010 (Table 2). We anticipate hiring approximately 20 new researchers per year for the next 3 years across all current programs. This represents a 3-year total of 11 Senior Research Scientists, 16 Research Scientists, 18 Research Associates and 15 Postdocs (see

Table 5 and Appendix 1). With normal attrition accelerated by the competitive industry climate and U.S. baby-boomer demographics, these 60 new hires represent a 3-year net growth of about 40 Bureauwide. This growth will require build-out of the remaining open work areas in PRC 130 and perhaps some further use of PRC 131. This type of growth also requires a major recruiting and human resources effort.

Table 2. School personnel costs associated with Bureau hiring for the next 3 years, in thousands of dollars.

	2008 Hires	2009 Hires	2010 Hires	Annual Total
2008	$1,466	$0	$0	**$1,466**
2009	$1,042	$1,466	$0	**$2,508**
2010	$619	$1,042	$1,466	**$3,127**

The Bureau component of the manpower costs also grows to $3.127 million in 2010 and continues to grow as the Bureau picks up the full cost of new employees beyond 2010.

Table 3. Bureau personnel costs associated with hiring for the next 3 years, in thousands of dollars. The combined School and Bureau cost (salary + benefits) in 2010 for Table 2 and Table 3 is $6,254k, which does not reflect overhead. For later reference, the 2010 personnel total with overhead equates to a rate of $9,380k.

	2008 Hires	2009 Hires	2010 Hires	Annual Total
2008	$619	$0	$0	**$619**
2009	$1,042	$619	$0	**$1,661**
2010	$1,466	$1,042	$619	**$3,127**

1.4.1.2 Research Frontiers

The School will establish frontier research programs on various scales. We recommend that the Executive Committee consider how to apportion the Schoolwide investment to benefit each unit most appropriately (chairs, faculty hires, joint appointments, multiple researchers, facilities, etc.), as a function of existing unit talent and specific research frontier topic. The School should avoid self-funding and require frontier areas to be leveraged by external funding and become largely self sustaining over some period of time. Collaboration is an important component (see Integration/Collaboration Fund below). We think that the Research Frontier program will be valuable in terms of reputation, ability to attract major external investments, and as a vehicle for graduate education. This program should receive a substantial component of School funding, but that number has yet to be determined (TBD).

1.4.1.3 Research Chairs and Jackson Fellows

Many faculty or private-sector researchers are seeking research appointments with reduced or self-directed teaching loads. Research chairs at the Bureau or the Institute could attract such

talent to the School and not require that all new endowed lines be faculty. The Jackson Fellow program has had a strong impact, particularly for retaining younger stars, and it should be continued. Annual School Support for Bureau: $300k (5 Chairs @ $30k; 5 Senior Fellows @ $20k; 5 Fellows @ $10k).

1.4.1.4 Postdoc Matching

We strongly support the existing Postdoc program, which includes a 50% School match, and we encourage its continuation and enhancement. Annual School Support for Bureau: $300k (12 @ $25k per year).

1.4.1.5 Moving and Startup

Access to normal moving and startup support exists currently for all units and has been extremely helpful and should be continued. Major startup costs for faculty or researchers should be considered by the Appointments Committee and recommended to the Executive Committee on a case-by-case basis. Annual School Support for Bureau: $250k (20 new hires @ $12.5k each).

1.4.1.6 Integration/Collaboration Incentive

Great advances will most likely occur at the crossovers between disciplines. However, collaboration is hard, particularly outside of one's field, and especially for Assistant Professors and Research Associates given the limited time (6 years) to produce. It is safer when seeking tenure or up-or-out promotion to stay focused in a specific area and develop a program with selected students and focused funding. To encourage more collaboration, this fund would be administered by a Schoolwide committee and specifically target integrative collaborations. Annual School Support for Bureau component: $250k.

1.4.1.7 Excellence Support Fund

Many faculty members and researchers are selected as distinguished lecturers (AAPG, SPE, etc), named lecturers (Birdsall-Dreiss, etc.), President of national and international societies (GSA, AAPG, AASG, Energy Economics, etc.), and the like. Salary and expenses for these forms of professional recognition and acclaim are critical. Annual School Support for Bureau: $200k (4 @ $50k each for salary and expenses).

1.4.1.8 Joint Appointment Insurance

Co-appointments are difficult at the Bureau because the University does not recognize external funding as "hard" and will not bear the risk. The School could provide salary insurance (25%, 50%, or 75%) to satisfy the University's aversion to risk and can be repaid each year from external contracts. Annual School Support for Bureau: No cost as long as external funds are raised.

1.4.1.9 Graduate Student Support

Student support is a major component of annual School expenditure. Most applicants do not understand the difference between a “guarantee” from another university that is supported only by the faculty member’s ability to raise funds versus a guarantee from the Jackson School that has a $300-million foundation backing it up. This distinction needs to be communicated. Student support should always be leveraged by external grants, contracts or teaching assistantships (TAs) and limited by student quality and Schoolwide graduate advisor capacity, but not by curricular group counts or TA support limits. We support the formation of a Task Force to examine how to create performance incentives for faculty and researchers who are more actively engaged in the graduate education mission, and we are open to varying levels of student support as a function of several student and advisor performance measures. The funding for this program is to be determined (TBD).

1.4.2 Stabilization and Retention

The Bureau’s funding model has been historically volatile (Figure 2). Throughout its history, the Bureau has been able to adapt and, for the most part, preserve the jobs of key staff.

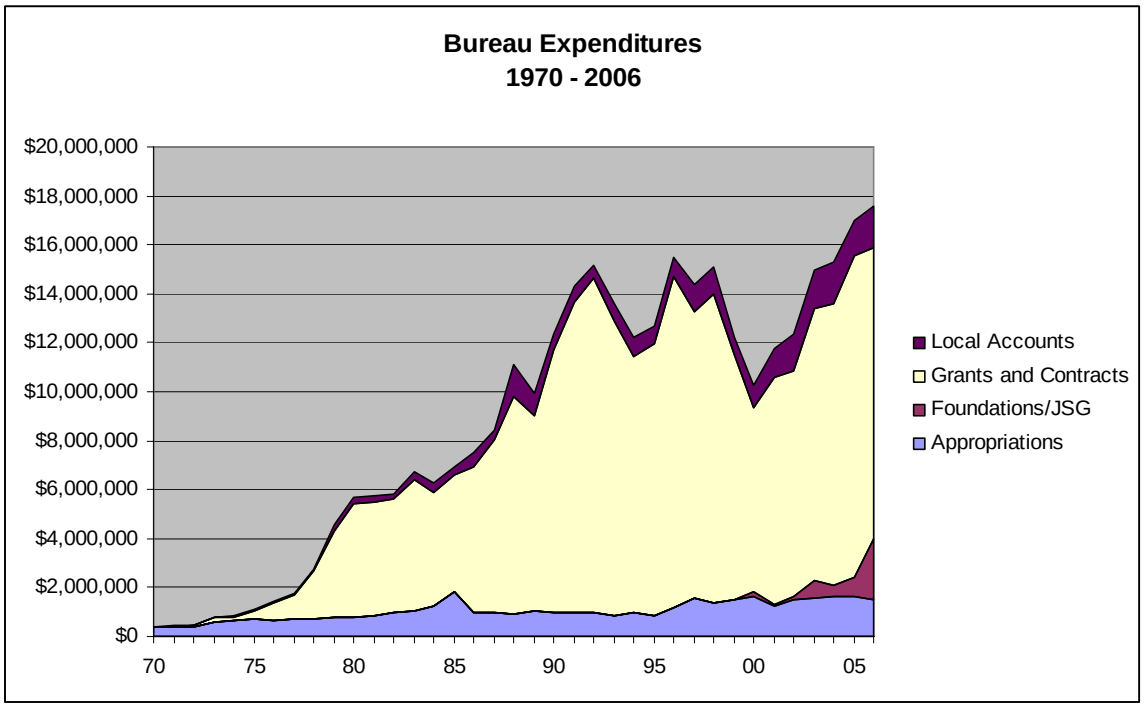

Figure 2. From 1909 through 1974, the Bureau maintained a small, stable staff supported by State-appropriated dollars. Expenditures grew substantially from 1975 through 1992 as the Bureau successfully pursued external funding from Federal and State agencies. Expenditures fell 20% in 1994, grew again to a high in 1997, and had fallen 30% by 1999. Since 2000, expenditures have grown steadily and are at an all-time (nominal) high today.

Part of the historical volatility is a function of the instability of external funding sources, which the Bureau can influence but cannot control. To control volatility, we intentionally attempt to equalize the spread of funding sources across Federal, State and private sources (Figure 3). We also try to balance the contract size and duration portfolio, tracking closely the contracted backlog of accounts, which is today at an all-time high.

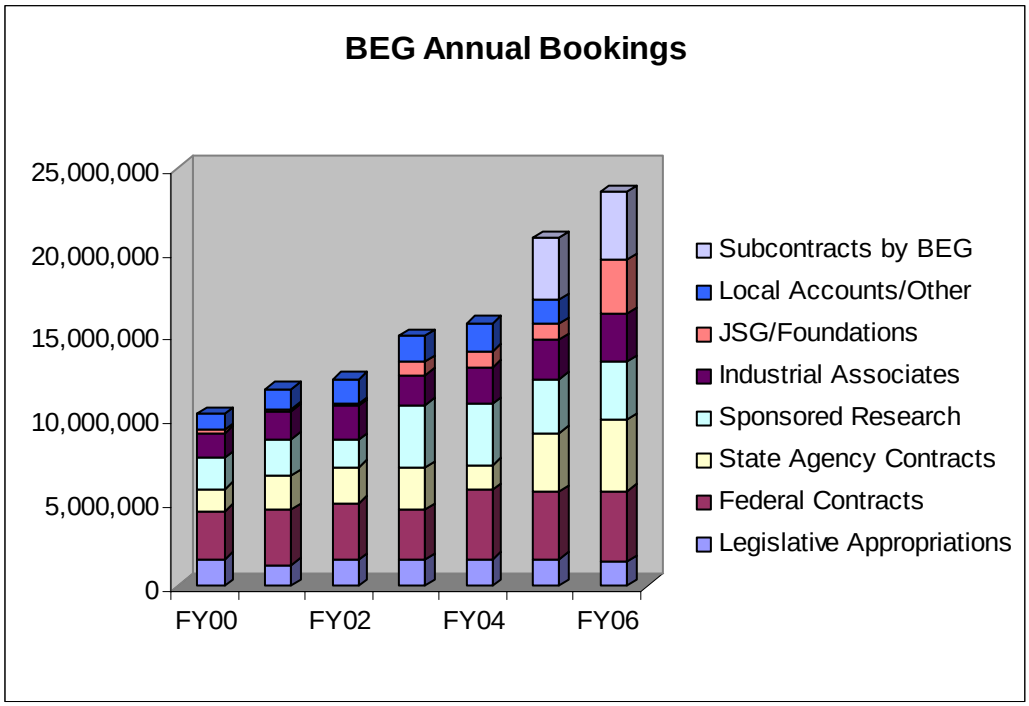

Figure 3: Annual dollar bookings from Fiscal Years 2000 to 2006. Subcontracts were not tracked prior to FY05 and represent Bureau funding that is passed through to non-Bureau researchers and staff.

Regardless of these healthy financial numbers there remains a perception today, particularly with newer staff, that because the Bureau runs largely on soft-money, it is volatile. And we would be naïve to think that we might not face similar volatility in the future. Volatility, both real and perceived, reduces our ability to hire and retain.

There are many measures of success besides external funding; some success measures are hindered by the full-time pursuit of external funding. These include time and support to work with students, to publish research results in high-quality journals, to pursue research that is higher risk or not yet mainstream, and to develop and pursue larger, more collaborative programs. The School can help the Bureau in four ways, in order of priority.

1.4.2.1 Base Level Researcher Support

A base level of annual support is needed for Bureau researchers, to be administered annually by the Director to provide time to develop grants, participate in education and outreach, and publish

research results. Annual School Support for Bureau: $600k (10% of the annual researcher budget for FY07).

1.4.2.2 Researcher Backstopping

A Schoolwide pool of earned support that researchers with funding success can access as a bridge between periods of support. Annual School Support for Bureau: $500k to start the fund, but thereafter the School component of overhead related to Bureau grants and contracts could be directed at sustaining the program.

1.4.2.3 Support Staff Capacity Building

As described in the earlier section *What the Bureau Offers,* the Bureau can provide outstanding Schoolwide support in the areas of purchasing, grants and contracts, employee relations, accounting, editing, graphics and media, IT services (including expertise in networks, visualization, programming and advanced software support), geoscience data storage and curation, internal publishing and publication sales, libraries, and vehicles. We currently spend most of our State appropriation on the support staff, which covers only part of annual costs; the rest is covered by contracts. Some of our support functions have been used by the other units on an ad hoc or consulting basis. With School support, these services, managed by the Bureau, could be strengthened and offered Schoolwide. The total current annual cost for the Bureau support staff is ~ $1.9 million. Annual School Support for Bureau: $400k (20% of total annual cost) for capacity building.

1.4.2.4 Service and Outreach

The Bureau engages each year in a wide variety of outreach and service activities, including the Bureau's Decision Makers Trip, Austin Earth Science Week, the School's Down-to-Earth program, support of graduate education, K-12 science fairs, museum educational projects, leadership of professional societies, presentation of outreach activities at conferences, and publishing in local, regional, national, and international journals. Annual School Support for Bureau: $200k.

1.4.2.5 Development Fund

This support can be provided at the discretion of the Dean to the unit leaders in order to support development of major research or graduate education programs. The Advanced Energy Consortium (AEC) and FutureGen efforts were supported early by the Vice President for Research (VPR). AEC will yield a return of $21 million 3-year booking on the $100,000 VPR investment. FutureGen attracted $5 million in direct State funding in 2006–2007 and has the potential to bring a $1-billion facility to Texas, plus huge reputation and recognition benefits. Examples of possible graduate education programs include geophysics and coastal dynamics.

Annual School Support for Bureau: $200k (success could pay for itself in overhead return to the School).

1.4.3 Facilities

The Bureau maintains three full-time facilities in Austin, Midland, and Houston. We use overhead-return funds to renovate and build out our Austin facility. We are building endowments to operate our Midland and Houston facilities in perpetuity. The School can help in three ways.

1.4.3.1 Satellite Operations

The Midland and Houston Facilities are on target per the business plans and nearing endowment completion. The purpose of the endowment is to generate funds to cover operating costs. We plan to meet the endowment goal and become self sustaining in these two facilities. Section 3.4 describes the educational benefit of these collections. To date, the Department of Energy (DOE) has funded the annual operating costs of the HRC to allow us to grow the endowment. The DOE funding was zeroed out of the Federal budget in FY07. We need either (1) 2 years of operational support from the School to complete the endowment growth plan or (2) a final investment to complete our endowment accounts. One-Time School Support for Bureau: *Option I:* $1 million operational support for 2 years; we raise $3 million for the endowment. *Option II:* $3 million to complete the endowment at $11 million.

1.4.3.2 Database Modernization

The Bureau is the largest curator of core, cuttings, and wireline logs in the United States and probably the world. Our databases are digital, but the data are inaccurate, and the ability to perform modern GIS searches is nonexistent. To increase use and create *the* flagship geoscience data preservation facility that we envision requires modernization of the databases. We have begun the project for 900,000 well logs and 2,000,000 boxes of rock. One-Time School Support for Bureau: $1 million over 2 years.

1.4.3.3 Major Renovations

Major renovations to our physical plant will require support from the School. For example, we can renovate the main level in the Bureau to complement the new Institute facility and to create a JSG student center at the PRC. Annual School Support for Bureau: $200k.

1.4.3.4 Equipment

Modern labs are important for a science and research reputation. But labs are expensive to build and to maintain. Start-up costs, maintenance, and operations (including staffing) should require an external match from some combination of grants and laboratory use paid for by grants and contracts. A Schoolwide Task Force should make recommendations on appropriate use of the Foundation for equipment. Annual School Support for Bureau: TBD

1.4.3.5 HRC Renovation Match (AEC)

Renovations of the Houston Research Center are required as part of the Bureau's leadership of the Advanced Energy Consortium. One-time School Support for Bureau: $500k.

1.5 Prioritized Bureau Summary

Bureau requests for financial support from the School are prioritized under each of the major headings and in the order presented in the text (Table 4 left side). A composite ranking of all Bureau financial requests is shown on the right side of Table 4.

Table 4. Ranking of Bureau requests for School support for the next 3 years.

Categories from Text	$ 1000s Annual	$ 1000s One-Time
New Talent		
Talent Growth[1]	$1,500	
Research Frontiers	TBD	
Research Chairs & Jackson Fellows	$300	
Postdoc Matching	$300	
Moving and Startup	$250	
Integration/Collaboration Incentive	$250	
Excellence Support Fund	$200	
Joint Appointment Insurance[2]	$0	
Graduate Student Support	TBD	
Stabilization and Retention		
Base-Level Researcher Support	$600	
Researcher Backstopping[3]	$500	
Support-Staff Capacity Building	$400	
Service and Outreach	$200	
Development Fund[3]	$200	
Facilities		
Satellite Operations		$1,000
Database Modernization		$1,000
Major Renovations	$200	
HRC Renovation Match (AEC)		$500
Equipment Fund	TBD	
Total	**$4,900**	**$2,500**

[1]Grows to $3.1 million by 2010

[2]Supported by external grants

[3]Supported by School overhead return after startup

	Ranking of Requests	$ 1000s Annual	$ 1000s One-Time
	Ongoing		
1	Base-Level Researcher Support	$600	
2	Talent Growth	$1,500	
3	Researcher Backstopping	$500	
5	Research Frontiers	TBD	
6	Research Chairs & Jackson Fellows	$300	
7	Postdoc Matching	$300	
8	Support-Staff Capacity Building	$400	
9	Moving and Startup	$250	
10	Service and Outreach	$200	
11	Development Fund	$200	
12	Integration/Collaboration Incentive	$250	
13	Excellence Support Fund	$200	
14	Joint Appointment Insurance	$0	
15	Major Renovations	$200	
16	Graduate Student Support	TBD	
4	Equipment Fund	TBD	
	One Time		
1	Database Modernization		$1,000
2	Satellite Operations[1]		$1,000
3	HRC Renovation Match (AEC)		$500
	Total	**$4,900**	**$2,500**

[1]Option 1 is shown. Option 2 is $3 million.

In addition to specific financial requests, there are several organizational requirements in the form of incentives, removal of barriers, portfolio balancing, and policies that will serve to strengthen the School. They are prioritized below.

1. Consider the external investor portfolio—sponsored research, government agencies, and corporate and private donors—in a well-coordinated and strategic fashion so as not to unknowingly undermine existing efforts and successes of the units. Impact:
    a. Increased investment in research and education programs
    b. Increased donations
    c. Increased leveraging of private sector investment for Federal grants
2. Provide GSC membership, where appropriate, for researchers to supervise graduate students. Impact:
    a. Broadening of research opportunities for students
    b. Increased faculty, researcher, and student interaction
    c. Increased capacity for student support and distributed advising load
3. Enable voting membership in the School for all researchers and directors (Figure 4). Impact:
    a. Allowing each unit to assign titles appropriate to its mission and avoiding the need for title normalization across units. Currently, titles are inconsistently applied between the three units, and this inconsistency has an impact on voting membership in the School.
    b. Increased sense of community and broader participation
    c. Reputation of the School

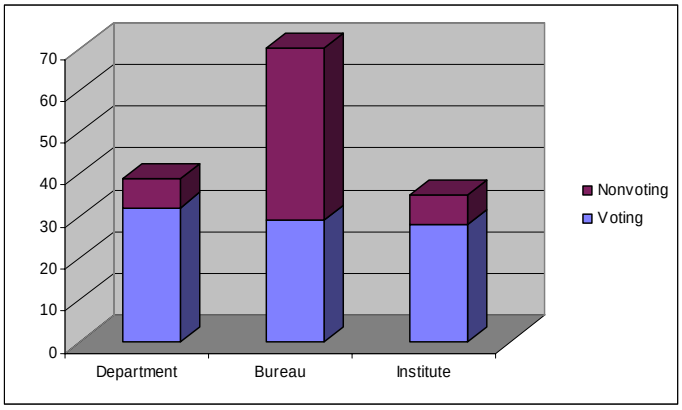

Figure 4. Current status of School membership for all full-time faculty and researchers in the School.

4. Increase the capacity for hybrid research/faculty positions. Impact:
    a. Increased faculty, researcher, and student interaction
    b. Attraction of talent that would otherwise not be interested
    c. Increased teaching and research capacity

5. Facilitate ways for researchers, faculty, postdocs, students, visiting scientists, and staff to meet and interact. Impact:
    a. Collaboration and interaction leading to new research
    b. Increased quality of science
    c. Sense of community

1.6 Strategic Planning

The dual role of Organized Research Unit and State Geological Survey results in Bureau programs that run the gamut of research—from basic to applied, short term to long term, single researcher to highly integrated team, schedule driven to open ended, product based to knowledge driven, and research to service. How these components can interact positively is outlined in Appendix 2. Bureau planning therefore requires a balance among the *strategic* aspects of determining and conducting research and service relevant to society in the broad areas of energy and environment, the *tactical* components of maintaining a diversified portfolio of external funding in order to minimize volatility, the *practical* challenges of attracting funding while retaining premier talent, and the *desired* results of actual societal impact and service. The Bureau must also balance the strategy for necessary growth with the need to strengthen what exists and is healthy today. This balance is described in the context of the Jackson School Planning Outline, which establishes three themes: the Forefront of Research, the Forefront of Education, and the Fabric of a Great College.

2 The Forefront of Research

Many of the projects and programs represented by the 175 active Bureau accounts address common research or societal themes and, with extensive input from Bureau staff, have been "rolled up" into a loose classification that we call *focus areas*, which serve to map the current state of the Bureau. A systematic summary (Appendix 1) for each focus area includes, where pertinent, a short overview, specific goals, intersections with other units and schools, a talent plan (to fill gaps), measures of success, budget and growth, existing and potential funding sources, challenges and specific School investments that could result in a measurable payout, and the broad School frontier areas to which a focus area might contribute. Many of these programs have the potential for substantial intersections across the School.

Following the discussion of focus areas, we look at longer term Research Frontiers that serve, in Dean Barron's words, to "engage and excite, define the path for future investments, attract the next set of resources, promote collaboration and cohesion as a strategic objective, and play off the existing strengths of the school and this university." We call these longer term, integrated scientific endeavors *scientific movements*. As we describe in Appendix 2, we think that

movements cross unit, School, and University boundaries with the potential of having a major impact on science and/or society.

Although not addressed in specific order, woven into the discussion and appendices are many other components suggested by the Strategic Planning Outline, including filling the gaps at the core of our discipline, resources and facilities that support excellence, graduate and undergraduate participation and education, and support-staff needs.

2.1 The Bureau Today: Focus Areas

Focus area classification is imperfect because some projects impact more than one focus area and some projects defy easy classification. Focus areas are not intended to incorporate every project at the Bureau. There are two broad classes of Focus Areas, one in which projects are coordinated around a common *research* theme, and the other, which is represented by *major programs* with an overarching purpose driven by the Bureau mission.

Each research focus area commonly includes a variety of funding sources and several areas of scientific and technical expertise. Research focus areas comprise Advanced Energy Consortium, Coastal Change in Texas, Fracture Processes, Salt and Shale Tectonics, Sedimentary Rock Systems, Seismic Imaging in Complex Environments, Unconventional Fossil Energy, and Groundwater Hydrogeology.

The major program focus areas are represented by significant, ongoing, funded research or service in which the Bureau is heavily invested, and commonly have a large “anchor” funding source. These include the Center for Energy Economics, Gulf Coast Carbon Center, International Research and Education Partnerships, Professional and Societal Service, State Geological Survey, and State of Texas Advanced Resource Recovery (STARR).

All of the Bureau focus areas are healthy and represent annual programs of $1 million or greater or the strong potential to become that size. Most of the focus areas could, and in some cases currently do, engage and support graduate students.

Table 5. Bureau hiring and budgets for focus area growth in the next 3 years.

	2007 Annual	New Hires 3-Year Total				Total	Annual Other	2010 Annual
Research	Budget	SRS	RS	RA/RSA	Post Docs	Cost[1]	Costs	Budget
Advanced Energy Consortium	$100	2	2	1	2	$1,151	$749	$2,000
Coastal Change in Texas	$750	1	1	1	1	$644	$106	$1,500
Fracture Processes	$700	0	1	0	0	$176	$124	$1,000
Salt and Shale Tectonics	$770	0	0	0	1	$117	$113	$1,000
Sedimentary Rock Systems	$2,000	1	1	3	1	$917	$83	$3,000
Seismic Imaging in Complex Environs	$500	1	1	1	2	$761	$39	$1,300
Unconventional Fossil Energy	$750	1	1	1	1	$644	$106	$1,500
Groundwater Hydrology	$750	1	2	3	2	$1,209	$41	$2,000
Major Programs								
Center for Energy Economics	$500	0	1	1	2	$546	$154	$1,200
Gulf Coast Carbon Center	$1,250	1	1	1	1	$644	$106	$2,000
International R&E Partnerships	$250	1	2	3	1	$1,092	$158	$1,500
Professional and Societal Service	$100	0	0	0	0	$0	$200	$300
State Geological Survey	$1,500	1	2	2	1	$956	$544	$3,000
STARR	$1,500	1	1	1	0	$527	$0	$1,500
Totals	**$11,420**	**11**	**16**	**18**	**15**	**$9,380**	**$2,523**	**$22,796**

[1]2010 total of salary, benefits and overhead.

Note about Table 5: These numbers presume full JSG investment and do not include additional hiring that may result from School investment in Research Frontiers. Total growth is 45 researchers and 15 Postdocs and cost with overhead is $9,380k as is reflected in Table 5 discussion. Approximately half of the cost of the growth will be supported by external grants and contracts and the other half will be facilitated by School support for talent as detailed in Table 5.

2.2 The Bureau Tomorrow: Scientific Movements

Bureau scientists seek to solve refractory challenges with practical benefits by looking at relevant science and engineering issues in new ways. To address key research opportunities often requires multidisciplinary, collaborative research teams that cross focus areas and engage in efforts sustained over many years. When this these long-term, integrated efforts lead to a new theory, method, or conceptual framework, we call these scientific movements. The Bureau's approach to generating scientific movements, with a description of the "life cycle" and several examples, is discussed in Appendix 2. Examples of scientific movements in which the Bureau is currently engaged follow.

2.2.1 Carbon Management

The Bureau is at the forefront of testing new methods of carbon management. Climate is a fundamental driver of Earth systems because it sets the tempo of cyclic sedimentary deposition; controls weathering, erosion, and marine sea level; energizes ocean circulation; drives freshwater recharge; and drives glaciation. Potential impacts of anthropogenic perturbation of climate caused by changing atmospheric composition add urgency to the need for rigorous understanding of climate and its interactions. Transfer of carbon from storage in the Earth as fossil fuel to carbon

dioxide in the atmosphere is a key geoscience issue. Research has rapidly expanded to assess both the causes and effects of climate change, thus leading to the practical question: what are the geologic options for stabilizing the change in atmospheric composition? Two types of mitigation are within the expertise of geoscience: deep subsurface storage (sequestration) of carbon captured from concentrated point sources (power plants, refineries, cement plants, etc.) and increased terrestrial storage (increased soil or plant carbon uptake). Large-scale subsurface carbon storage requires developing a new geoscience discipline that draws on expertise from reservoir characterization, sedimentology, fluid-flow simulation, geochemistry, groundwater protection, and vadose-zone gas flux and combines them in new ways. The Bureau's Gulf Coast Carbon Center (GCCC) is an academic–industry research consortium, formed in 2003 in recognition of the unique character of the Gulf Coast as a region of concentrated CO_2 sources and an array of co-located, subsurface sinks. The GCCC is working to advance technical capabilities and to identify intersecting scientific, engineering, regulatory, legal, economic, and public-policy issues that must be overcome to move ahead. The Bureau's Frio I and Frio II pilot injection projects represent the first successful CO_2 brine sequestration experiments in the U.S. and have achieved national and international recognition. The JSG has a strong presence in this explosively growing research area and the potential for international leadership over the next decade. To achieve this leadership requires growth of a large and integrated program, linking understanding of the climate system (provided by UTIG and DGS) with solutions provided by the Bureau, such as geologic storage of carbon.

2.2.2 Coastal Dynamics

The Bureau is a leader in a new synthesis of imaging and process studies in coastal dynamics. Sustaining competing uses and ensuring the viability of coastal environments in light of expected increases in population, sea-level, and hurricane effects is a huge challenge. More than 50% of the U.S. population lives in coastal counties, many of which lie along the low-lying, hurricane-prone passive continental margins of the east and Gulf coasts. Geoscientists will play a central role in learning about, monitoring, and developing policy responses to the effects of climate change in the coastal zone. They will do so by charting the past, coming to an understanding of the dynamics of, and predicting future changes in, coastal geoenvironments. In addition to field mapping of coastal environments, new space and airborne remote-sensing instruments that acquire digital photography, multi- and hyperspectral images, active radar and lidar data, gravity measurements, and electromagnetic characteristics are providing unprecedented observations of change in coastal environments. The School and collaborators at the Center for Space Research (CSR) are at the forefront of developing acquisition and analysis techniques. To address research opportunities in coastal change, the Bureau has invested heavily in airborne topographic lidar, GIS, and data visualization. We have also partnered joint research projects with CSR and UTIG. A key question is how can we optimally fuse these new data sets and combine them with

historical data to develop reliable models of coastal change? The new remote-sensing technologies, combined with targeted ground investigations and shallow 3D geophysical data sets, could greatly lessen the trade-off between small-area detailed studies and broad-area general studies. Earth scientists with extensive experience in coastal depositional systems and the ability to acquire, analyze, and apply the new remote sensing data sets will be at the forefront of addressing coastal environment problems and future effects of climate change.

2.2.3 Four-Dimensional Heterogeneity Characterization

The Bureau pioneered concepts in heterogeneity characterization. We are pursuing revolutionary new ways to extend this characterization to much finer scales. A great challenge in subsurface understanding is advanced imaging and sensing to resolve subsurface geologic heterogeneity over distances of decimeters to kilometers. In addition to continued advances in multicomponent reflection seismic imaging, a step change in subsurface understanding will result from development and deployment of mobile sensors small enough to access fracture and pore networks and make real-time measurements of the spatial position and chemical, thermal, and pressure environment. To address this opportunity, the Bureau has created the Advanced Energy Consortium, to be supported by the world's large energy companies, with a primary goal of developing subsurface micro- and nanosensors. The School is at the forefront of pore-system understanding and will contract with universities and labs around the world for sensor technology development; invention is at the heart of this movement. A key question is whether materials exist that can be assembled at the necessary scale to survive in severe subsurface conditions. Successful subsurface sensors would add a third major class of subsurface measurement to existing wireline logging and seismic technology and revolutionize subsurface understanding. These technologies can also have an impact on near-surface sensing—for example, in hydrogeology or in sub-ice investigations. Main societal drivers are the demand for energy, freshwater, and metals. There is potential of revolutionizing understanding of fluid distribution and pore systems with the greatest economic impact on the fluid extraction industries. Those Earth scientists who are first to receive, analyze, and reduce the data will be at the forefront of this opportunity. The greatest need is attracting talent. This movement is kicking off with an annual budget of $7 million and is expected to grow substantially from State and Federal leveraging potential. Earth science applications of nanotechnology offer a striking opportunity for the Jackson School to lead where others can only follow.

2.2.4 Four-Dimensional Quantitative Stratigraphy

The Bureau continues to lead in developing new themes, conceptual frameworks, and methods for understanding stratigraphy. Stratigraphy records the Earth's evolution, and stratigraphic architecture dramatically controls how natural resources are distributed globally. Concepts such as sequence stratigraphy have revolutionized our understanding of temporal and spatial

distribution of strata and the controls on genesis. Significant questions remain. What controls the three-dimensional distribution of fine-scale stratigraphic elements, including stratal geometry, lithology, and porosity and permeability? How do strata construct and deconstruct over time? What are the implications of these processes for understanding change in the Earth's evolution? Breakthroughs in these areas of geology will be gained by an understanding of sedimentological processes in four dimensions (3D space + time) and by building stratigraphic models that integrate the data and further our understanding of concepts. New technologies being developed by the JSG such as multispectral Earth imaging, 3D multicomponent seismic, airborne and ground-based lidar imaging, high-resolution CT scan, and SEM imaging allow us to quantify and link these processes at multiple spatial and temporal scales in both outcrop and the subsurface. One fundamental challenge in understanding and modeling reservoir and aquifer fluid flow is integration of sedimentology, stratigraphy, geophysics, geostatistics, numerical modeling, and fluid-rock interaction from pore to basin scale, thereby predicting the distribution of petrophysical properties within a coherent framework. The synergies among several research programs within the JSG, such as RCRL, EGL, QCL, DSG, and STARR at the Bureau, along with programs at DGS and UTIG, provide a critical mass for making breakthroughs relative to modeling fluid flow at multiple scales. This research base is supported by graduate students and funds derived from the DOE, JSG, State of Texas, industry, and other grants. Main societal drivers for this research are (1) recovery of additional hydrocarbons, (2) better quantification and management of our water resources in aquifers, (3) more efficient storage or disposal of fluids or gas in subsurface, (4) better identification and monitoring of contamination, and (4) a fundamental understanding of the sedimentary deposits that are the unique record of past Earth history and climate. The JSG is positioned to be the international leader in this multidisciplinary movement.

2.2.5 Mobile Substrate Tectonics

Gravity-driven tectonics dominates all continental margins underlain by mobile substrates, such as salt or overpressured shale. Salt and shale tectonics create three-dimensionally complex structures on an impressive scale and strongly affect the interplay between bathymetry and stratigraphy. The School hosts the world's leading research group on salt tectonics, the Applied Geodynamics Laboratory, which integrates seismic interpretation, physical modeling, numerical modeling, and fieldwork. The program incorporates structural geology, tectonics, mechanics, stratigraphy, and regional geology. Complementary research on overpressured shale substrates by the Quantitative Clastics Laboratory uses seismic interpretation and outcrop study to explore the links between seismic geomorphology and shale tectonics. Shale tectonics is an under-researched topic, in which the Bureau is poised to take a leadership role in the research community. Combining the strengths of these programs in salt tectonics and shale tectonics improves success in exploration for petroleum and other resources—especially in improving techniques of subsalt imaging, trap prediction, and drilling. Applying this research also reduces

the societal impact of destructive geohazards such as submarine landslides and mudflows. The wider implications of this research improve our understanding of larger-scale tectonic settings, such as divergent continental margins, rift basins, inverted basins, and orogens.

2.2.6 Structural Diagenesis

A collaborative research movement at the Bureau and the Department of Geological Sciences is overturning traditional ways of approaching structural geology and geochemistry problems in sedimentary rocks. This effort has the potential to evolve into a new discipline. With support from the DOE Office of Basic Energy Sciences, industry, and the School, the initial focus has been on pursuing a breakthrough in understanding controls on fluid flow and other processes in the deeper parts of sedimentary basins. A fundamental question is what are the feedbacks between chemical and mechanical processes in moderately to deeply buried, chemically reactive, fractured rocks? In breaking down the disciplinary barriers between structural geology and sedimentary petrology, the School is at the forefront of new hypotheses and new analytical approaches to measuring and modeling mechanical and chemical interaction. Using an integrated approach that combines field and core observations, microimaging, and geomechanical and geochemical modeling, our research addresses the interaction of fracture opening and fracture cementation with chemical and physical change in sandstone, shale, and carbonate, creating a bridge between lower temperature diagenesis and higher temperature metamorphism. Poorly understood chemical and physical processes take place in this transition realm. These studies require the collaboration of sedimentary and metamorphic petrologists. Diagenetic and structural modeling integrated with petrographic analysis will provide fundamental breakthroughs. The program has generated many ideas for additional sponsored research, including opportunities to apply insights into seismic processing and interpretation. The program has also set a positive example of interunit collaboration and innovation in cross-unit student mentoring. The main societal drivers for this research are practical ones of extracting resources from unconventional, fractured, and complex reservoirs and of sequestration of reactive materials. New imaging technologies can be developed in collaboration with instrument manufacturers through a JSG-wide center for micro- and nanoscale imaging of geomaterials, with support from the energy sector and Federal sources. This center would have natural links to the Advanced Energy Consortium.

2.2.7 Sustainable Water Resources

The Bureau is fostering a unique integration of hydrologists, climate-change researchers, and modelers to develop an understanding of sustainable water resources. Sustainable water resource management is critical to meeting the demands of drinking water, food production, and other needs that are increasingly important, such as biofuel production. Understanding linkages and feedbacks among land-use change, climate variability/change, and water resources is

essential to developing sustainable water resources. Current programs at the School are making significant advances on quantifying impacts of land-use changes (cultivation, urbanization) and climate variability/change (El Niño Southern Oscillation, Pacific Decadal Oscillation, glacial/interglacial cycles) on the water cycle through environmental tracers and numerical modeling analysis on a range of spatial scales from point-field to regional and global measurements. Texas is a microcosm for global systems with a wide range in climate and water-usage issues (irrigated agriculture, aquifer depletion, environmental flows). The greatest impact for the School will come from expansion of Texas research programs to a global scale. Key questions include (1) What is the relative impact of climate variability/change and land-use change on water resources? (2) How do different driving forces affect water quantity versus water quality? (3) What are the linkages and feedbacks between the biosphere and hydrosphere in controlling system response to different stresses? (4) How can we scale up results from plot scale to global scale and from days to millennia using field studies, modeling, and satellite data? and (5) How can research results be translated into policy to develop sustainable water management programs? Expansion to global scales will require strong collaboration with other national and international programs, and strong visiting-scientist and postdoctoral programs.

2.3 The Bureau's Role in Research Frontiers

Several broad Research Frontiers emerge as candidates for School emphasis, five of which stand out as having significant potential for Bureau impact: energy, climate, subsurface nanotechnology, computational geosciences, and water. In addition, the Bureau will continue to play a strong role in geoscience data preservation, outreach, public service, and bringing science to policy.

2.3.1 Energy

The Bureau's leading role in the scientific movements of 4D Quantitative Stratigraphy, Mobile Substrate Tectonics, and Structural Diagenesis, combined with our considerable strength in the focus areas of Fracture Processes, Salt and Shale Tectonics, Sedimentary Rock Systems, Seismic Imaging in Complex Environments, Unconventional Fossil Energy, the Center for Energy Economics, International Research and Education Partnerships, and the State of Texas Advanced Resource Recovery (STARR), make us a natural global leader in geoscience energy research. These strengths can be leveraged with the Department and Institute to allow the School to play a major role at UT in order to drive this research frontier area.

2.3.2 Climate

The Bureau's Gulf Coast Carbon Center, Center for Energy Economics, and Coastal Change in Texas focus areas and the Coastal Dynamics and Carbon Management scientific movements are tied intimately to the climate research frontier area. With ongoing programs in all three units, the

School has the capacity to capture a significant component of the climate research spotlight that has not yet been claimed—namely "what can be done about it," both scientifically and in terms of policy.

2.3.3 Subsurface Nanotechnology

Nanotechnology is changing the world in ways most of us do not yet understand. Medical, space, and hi-tech industries are leading, but the State of Texas and Federal Governments have committed billions to nanotech research. The Bureau has positioned the School to lead the world in developing mobile micro- and nanosensors for investigation of subsurface rock/fluid systems. The Bureau developed and will be the managing organization for the Advanced Energy Consortium, an initial 3-year, $21-million program comprising the world's leading energy companies poised to leverage State and Federal investments and bring nanotechnology to the subsurface. If successful, this technology will provide data similar to the first images returned from the Hubble telescope. Intersections cut across the School from geophysics, to petrophysics, to rock physics, to geochemistry, to pore-scale stratigraphy, to fluid dynamics, to computational geosciences and visualization, and beyond.

2.3.4 Computational Geosciences

Several of the Bureau's focus areas involve increasingly intensive computational geoscience needs, including the Advanced Energy Consortium, Coastal Change in Texas, Fracture Processes, Salt and Shale Tectonics, and Seismic Imaging in Complex Environments. All seven scientific movements either do, or soon will, require a considerable computational geosciences component. It is the application of computational geosciences to real-world problems and programs such as these that will set the School apart and at the head of the pack.

2.3.5 Water

The Bureau's Groundwater Hydrology focus area allows us to participate in, and drive a component of, the scientific movement that we call Sustainable Water Resources. Combined with the Department's strengths in water and the Institute's strengths in ice-sheet dynamics, it provides the seeds for a research frontier. It also topped Jack Jackson's list.

3 The Forefront of Education

The Bureau educates at many levels: private citizens, elected officials (decision makers), government employees, scientists and engineers in industry, undergraduate and graduate students, and K-12 students and teachers. Each group is important to the mission, reputation, and advancement of the Bureau and the School. In this section, we outline the role that we see for the Bureau within the School education mission. We address many of the recommended components in the JSG Strategic Planning Outline, namely professional development, excellence

in teaching in and out of the classroom, and access to opportunities, an outstanding undergraduate geoscience education, and support-staff and student services, as well as creation of student-oriented spaces for graduate and undergraduate students.

Education of teachers, citizens, policy makers and industry leaders is woven into most Bureau programs and is thus not emphasized in this section. In the next section, we focus on graduate education, followed by brief comments on facilities and outreach.

3.1 Graduate Education

Participation in Bureau research projects exposes students to research teams working on important issues, excellent data sets, and leading technology. Students enjoy practical opportunities for career advancement through contact with the Bureau's research supporters in industry, thus gaining access to prestigious internships and advantageous entry into industry careers. Students also benefit from support by human resources, information technology (IT), and other support staff, who deal with student issues from visas to software.

Three key areas in which the Bureau can help the School attain the Forefront of Education are advising and mentoring, internships, and undergraduate and graduate recruitment. The Bureau's team-based research program naturally promotes student interaction with scientists and faculty associated with Bureau programs and a strong sense of community. The Bureau's flexible staff and administrative structure can facilitate internships and innovative recruitment at all levels.

3.1.1 Advising, Supervising, Committees, and Mentoring

The Bureau is committed to excellence in JSG graduate student education. Formal graduate student advising will not involve all Bureau researchers, but those who are engaged are serious about their roles. Top students involved in Bureau research benefit both the program and the student. Involvement with students is an effective way to promote cross-unit collaboration. There are Schoolwide organizational challenges, but these can be overcome. Students have always received formal guidance as Bureau employees, and supervisors have served as formal and informal academic mentors. Many Bureau researchers serve on student committees or as work supervisors, and thus influence student education.

History indicates that the Bureau's collaborative projects with other units and departments help students by providing a broad, rich resource of scientists and other students available for research guidance and thesis and dissertation preparation. Much of this contribution is outside formal committee responsibility. For example, Bureau scientists have taken the lead in fostering writing circles to assist students in improving their self-expression. Some groups within the Bureau take a leading role in fostering student-focused events for research teams.

For students, Bureau programs provide opportunities for professional training and exposure. In addition to supporting student presentations at national and regional professional meetings, students working on Bureau projects have opportunities to present their work to industry elite at research sponsor meetings. With School support, student access to these meetings could be broadened. National Oil Company (NOC) programs could be venues for building sustained study-abroad programs, as well as attracting motivated students who often come with financial support.

3.1.1.1 Priorities and Goals

Increasing the quality and to some degree the number of graduate students must be a School priority. Although the Department is a natural leader for undergraduate and graduate education, the Bureau can make a significant contribution, primarily in research projects that are collaborative with faculty. Research projects provide financial support, data sets, and an immersive collaborative environment in which students flourish. Bureau researchers have a long history of supervising and advising the international students who often come with support to work on industry data sets. This area could remain a good niche in which the Bureau could help serve the School.

3.1.1.2 Actions

A mechanism for engaging the Bureau research staff in graduate and undergraduate education is a joint appointment (25:75 or 50:50). We have no desire to convert Bureau staff into faculty, but some joint appointments could increase collaboration and communication. Co-appointments are difficult at the Bureau because the University does not recognize external funding as *hard* and will not bear the risk. The School could solve this problem by providing insurance to Bureau contract salary support in order to satisfy the risk aversion of the University. Such a backstop could be repaid to the School each year from Bureau contract funds.

Provision should be made for shared office space on the main campus for PRC staff holding joint appointments, co-teaching, or advising graduate students.

Membership on the Graduate Studies Committee (GSC) and the opportunity to supervise students are vital to attracting and retaining certain young researchers at the Bureau. Currently, membership is an entirely volunteer activity, above and beyond a full-time Bureau job. GSC membership allows increased student advising by Bureau researchers and benefits the School in many ways. Invitations to Bureau researchers to join the GSC would engage them in helping to attract the best students and would help distribute the responsibility for graduate student mentoring. At the same time the breadth of guidance and research options available to students

would increase. To ensure that curriculum development remains in the hands of the faculty, unit GSC members could have a class of membership that allows sole supervision of students but perhaps no binding vote on curricula.

3.1.2 Teaching

Many Bureau researchers have engaged in departmental teaching and regularly participate in professional teaching. Most of these researchers teach graduate courses, but Bureau staff members have also taught undergraduate courses. Bureau scientists have also participated in courses by teaching a few ad hoc lectures. As undergraduate and graduate enrollments grow, developing approaches for broadening the teaching load and curriculum is important.

Bureau staff can also provide strategic insights to the curriculum and hiring plans, such as recent developments in sedimentary petrology, which is traditionally an area of strength for UT but lately has been without faculty involvement. Bureau collaboration with petroleum industry scientists has provided insight into tremendous new opportunities for students and research in this field. These developments are not yet widely known outside industry because of their economic importance to deep drilling.

3.1.2.1 Priorities and Actions

Certain Bureau researchers are well qualified and interested in participating, on occasion, in full- or part-time teaching. Our priority is to collaborate with colleagues in the Department in areas where course offerings would be enriched by selective involvement of Bureau scientists. The Bureau is open to a dialog with the Department on how we can best help the School in this regard. We recommend that this issue be considered, together with opportunities for temporary Bureau research appointments for the faculty (see section 3.2.1.2).

3.1.3 Student Professional Development: Internships

For student employees, the Bureau offers a unique atmosphere for professional development. With a work environment and pace resembling that of industry, students can experience a professional internship without leaving Austin. Bureau employment provides students with wider experiences than typically afforded by academic training alone. By working on Bureau projects, students can acquire familiarity with concepts, techniques, and technology outside their fields of academic training. In the past, this on-the-job training was advantageous to students seeking entry into the petroleum and environmental industries. Even now, with high demand for students in the petroleum industry, work at the Bureau is an asset in the job market and a great way for students to enhance their skills and learn workplace discipline.

3.1.3.1 Priorities and Goals

Graduate student employment at or above current levels remains important for many Bureau projects. The Bureau will continue to provide internships and job experiences for students, as well as conventional graduate student mentoring and supervision. As described later, if deemed in the best interests of the School, the Bureau could help create a new JSG internship program, strengthened by the industry focus of many large Bureau projects—a well-established work culture mimicking that of the private sector—and flexible staff and administrative structures.

3.1.3.2 Action: New Student Internship Program

The School could build on the foundation of the Bureau work environment in order to provide a novel broadening *internship experience* for students aiming for academic careers, who otherwise might not face this applied aspect of geoscience. Such an experience would undoubtedly extend the mentoring capabilities of JSG graduates attaining academic posts. For our graduates pursuing careers in other fields, this wider awareness would help create more knowledgeable citizens having geoscience backgrounds. Project budgets currently dictate student employment opportunities at the Bureau and generally confine the experience to qualified graduate students in geosciences and petroleum engineering. School support would be needed to create a formal intern program or to expand systematically to undergraduates or prospective JSG students from other departments or other universities. And as we describe later (section 3.1.4.1), Bureau internships need not be restricted to students.

3.1.4 Student Recruitment

For the Bureau and the School, a high priority is recruitment of *elite* graduate students. Innovative student recruitment programs should involve all units. With School support, the Bureau staff and administrative structure have the flexibility to create and follow through on innovative student recruitment programs. The Bureau is in a position to dedicate time and effort to activating recruitment ideas from all units and from the Dean's office. Moreover, in the short history of the Jackson School, the Bureau has a record of proposing novel recruitment programs, including an international field course for non-UT undergraduate students administered by the Bureau having an intraunit staff. This program is documented in the 2005 JSG seed-grant records.

3.1.4.1 Action: Non-UT Faculty Internships

New programs that could take advantage of Bureau strengths and schedule flexibility include focused internships for non-UT academics. The aim of internships for visiting professors would be to enhance the reputation of the School and to increase the effectiveness of student recruitment. With suitable School support, the Bureau could coordinate a Department/UTIG/Bureau program to host professors from targeted elite, small to medium, undergraduate-focused science departments. Such a program in Austin or in the field is not the same as hosting visiting research

collaborators, which the Bureau has done all along. Many faculty members at small colleges will undoubtedly want to broaden their experience and engage in research within established programs. Many would welcome the opportunity to discover opportunities for promoting research to be conducted by their undergraduates. Owing to lack of exposure, many top science and math students in these numerous small colleges may never consider a career in geosciences. Consequently, many of these students may not be influenced by conventional student recruitment.

We expect that this program would lead to more successful recruitment of top undergraduates into the JSG graduate program for the following reasons. Small college faculty members who have spent a stimulating summer, 6 months to 1 year in the Jackson School will feel loyal to us. The same networks being developed to keep in contact with Texas EX's could embrace these new JSG extended-family members. It will be natural for them to send their most promising students our way. Such a program ideally should be coordinated with field courses, internships, and subsidized visits for students. The program could be extended to attract exceptionally talented undergraduates to The University of Texas.

3.2 Student Facilities at Pickle

The combined Bureau and Institute facilities at the Pickle Research Campus (PRC) already offer excellent services for student research. This facility has space for an outstanding satellite facility for students if it becomes a high priority for the School. Renovations could include a common room to facilitate student/researcher interaction, computer workrooms with dedicated IT support, an immersive visualization lab in conjunction with TACC, a full-service library, and dedicated classrooms for instruction.

In our view, however, new facilities will only be transformative if new space is accompanied by creative use of the space, and productive use of new space can be assured by helping to found beneficial traditions .The Bureau is already considering a plan for establishing recurring use of some space for writer circles made up of junior research staff. With access to the Bureau editorial staff, as well as a large number of junior scientists and Postdoctoral Fellows and students at the Bureau and UTIG, a PRC common room could readily provide a venue for groups of scientists and students honing their skills in writing circles. Such a tradition would address one of the central skills of self-expression that the School seeks to build in all its members, and particularly in students and junior staff.

3.3 Core Facilities in Austin, Midland, and Houston

The world-class subsurface sample collections in the core repositories in Austin, Midland, and Houston are enormously useful resources for education and outreach, as well as being an

irreplaceable starting point for research. These facilities are a potent source of data for student projects, as well as essential elements in professional education, outreach, and service. Maintaining and fully exploiting these resources is central to the Bureau's strategy for rock-based sedimentary research. The potential for these facilities to grow into specialized teaching and outreach venues and into museums is high. Creative ideas should be entertained in the context of building the endowments for these collections.

3.4 Outreach, Professional Education, and Service

In addition to graduate student mentoring, advising, and promoting cross-departmental and programmatic interaction, the Bureau engages each year in extensive outreach and professional education. Activities include invited State and Federal testimony, symposia, professional courses and training, field trips, leadership of professional societies, presentations at conferences, and publishing in local, regional, national and international journals, as well as our own publication series. Prominent ongoing Bureau outreach efforts include the Public Information Geologist, the Petroleum Technology Transfer Council (PTTC), Austin Earth Science Week, Teach the Teachers, the Decision Makers Seminar and Field Trip, museum displays, Earth View Texas, extensive involvement with GeoForce Texas, the Down-to-Earth program, K-12 science fairs, museum educational projects, and the Center for Energy Economics' annual 2-week program, "New Era in Oil, Gas and Power Value Creation." The Bureau intends to continue contributing to high-visibility educational initiatives beyond the UT campus.

The School can increase the impact of Bureau outreach by sponsoring international research seminars organized by school faculty and staff aimed at our research focus areas and by supporting the time needed to prepare monographs associated with these research meetings. Support might include fellowships and travel funds for invited participants. We expect that support from the School would be matched with external funds. We think that research symposia and published books or proceedings volumes should be an important part of Research Frontier programs.

Expanded outreach will increase JSG contact with teachers, academics and government, industry, international professionals, and the general public. In time, a JSG professional education program will be perceived by peer institutions as an influential intellectual exchange and a unique service. With flexible schedules Bureau staff will be able to design and lead more workshops, symposia, and field excursions. Bureau researchers will also more readily participate in outreach activities if time for preparation were minimized. An aggressive outreach and professional education program could benefit from a staff member devoted to organization and logistics. Such a staff member can be supported with an initial JSG subsidy, with course-fee

support increasing with time. In addition, a permanent space on the Pickle Research Campus could host repeating events. Professional educational development will strengthen relationships with JSG alumni, providing exposure to current research and ideas within the School.

3.5 Support for Improved PRC–Main Campus Communication

Physical separation between PRC and Main Campus provides a barrier to collaboration among the JSG units. With modest effort, the barrier can be reduced and willingness of staff to engage in collaboration increased; some suggestions are listed next. Success of efforts should be assessed by surveying school members and associated staff until effective methods are identified.

3.5.1 Hospitality via Shared Office for PRC Staff in the Geology Building

This single shared office would allow PRC staff a locked room in which to leave possessions and a comfortable work environment while on campus. The office would allow PRC staff to work part days on campus, host visiting scientists without the trip to PRC, and a rendezvous point for equipment and supplies. Reciprocal support for Main campus faculty and staff visiting Pickle should be provided also.

3.5.2 Parking Support

The number of loaner permits to allow parking in university vehicle slots behind the Geology building should be increased or a specific Pickle parking place should be allowed. Garage parking for Pickle staff members should be paid if permit parking is not available near the Geology building, especially at midday during the semester.

3.5.3 Improvement of Transportation

The frequency of the Pickle bus should be increased and sustained. Current limited ridership causes the bus to run less frequently and irregularly, thus further reducing ridership. Bus arrival and departure to campus on the quarter hour would allow one time to walk across campus to arrive at a lecture or meeting on the hour. Rides could be shared for popular events, such as brown bags and tech sessions.

3.5.4 Video Link

It would be desirable to be able to attend campus meetings and seminars via videoconference. Links should be provided in major conference rooms.

3.6 Prioritized Education Summary

The Bureau can significantly benefit the educational mission of the School. Costs for most of these programs are listed in the Prioritized Summaries section (Table 4) and include

1. Support for interested researchers to contribute through School investment in Research Chairs and Jackson Fellows, supporting the role of Bureau scientists as mentors and GSC members.
2. Attraction and development of top talent (Table 5).
3. Graduate student recruitment.
4. Support for service and outreach.
5. Support for improved PRC–Main Campus communication.
6. Renovations on the Pickle Campus tied to specific educational endeavors.
7. Support for the Bureau core facilities, which offer an enormous education and outreach opportunities for the school.

4 The Fabric of a Great School

A saying goes “I can’t define excellence, but I’ll know it when I see it.”

Perhaps so it is with the School—there may not be a rigorous, fully quantifiable set of measures or definitions for a great college, but most will recognize it when we see it. One thing we can be sure of: creating a great college from a school made up of three strong units will take time—weaving good fabric always does.

Of all of the components of fabric, perhaps community and collegiality stand out from the others. Strong communities share certain attributes. For our School, these include activities such as interaction and collaboration within and between the units and outside of the School; service to our School, profession, and society as a whole; partnerships in research, education, and outreach and with industry, governments, and foreign nations; active friendships and associations with alumni; and mentoring of colleagues, students, and staff.

At the Bureau, these attributes compose what we call *the Bureau family*, and we look forward to our family becoming an integral part of the greater Jackson School fabric.

Creating a family is not without challenges. An early step is to assess the current state of affairs and then establish a set of strategic attributes and desired behaviors such as collaboration, service, partnership, and mentoring that are worth striving for and will result in excellence. To

date, planning has brought us to the point where we recognize and have defined several such strategic opportunities, particularly in the areas of Research and Education. We make specific, prioritized requests and recommendations that will help us take advantage of these opportunities, and we have tried to weave the threads of the Bureau into the School fabric throughout, including programs and ideas that will:

- Promote student and researcher interaction across units;
- Develop the next generation of faculty and scientists;
- Create international research and education opportunities, specifically in Latin America, Asia, and the Middle East;
- Promote industry and government relations and interactions and recognize future needs in human-capacity building;
- Promote and reward service to the profession;
- Promote research, education, and outreach partnerships;
- Eliminate or break down barriers; and
- Involve alumni throughout the School.

4.1 Impact

This strategic plan takes a substantive look at where the Bureau is today, what we offer the School, and what we need from the School to make us better both today and in the long term. We describe in detail our research focus areas, discuss how we participate in and drive scientific movements, and provide a forecast for growth in talent and funding and expansion of the Bureau's education, outreach, and service mission, which would result from School investments. We also anticipate increased publication when these School investments are made in the Bureau. These are things that can and should be measured.

Beyond these more tangible aspects, the process of planning has brought a welcome internal examination of the Bureau and assessment of our role in the School, as well as our impact on science and society. The Bureau today is a healthy, growing, globally recognized science and engineering organization having broad-reaching research and education strengths.

Bureau researchers are engaged in programs that have the potential to influence how others think or act in their daily lives—to contribute substantially to real issues that impact global society. For example:

- How can we transition globally from carbon-based energy to decarbonized energy?
- What, if anything, can we do about climate change?
- What new discovery is possible if we put smart, mobile, microsensors into the Earth?

- How should societies adapt to coastal dynamics?
- Where will the world's freshwater come from this century?
- How can societies build sustainable economic, business, institutional, and human-resource capacity in order to address these geoscience issues?

The potential for this kind of transformational impact is rare in any field of endeavor. In the end, it is exactly this kind of impact that drives us—that wakes us up early and keeps us up late.

Appendix 1: Bureau Focus Areas

Research

Each research focus area commonly includes a variety of funding sources and several areas of scientific and technical expertise. Research focus areas comprise Advanced Energy Consortium, Coastal Change in Texas, Fracture Processes, Salt and Shale Tectonics, Sedimentary Rock Systems, Seismic Imaging in Complex Environments, Unconventional Fossil Energy, and Groundwater Hydrogeology.

Advanced Energy Consortium

Scientific Movements. 4D Heterogeneity Characterization, 4D Quantitative Stratigraphy

Overview. New research in the geologic nanotechnology arena focused on materials science and subsurface sensors.

Goals. Research, develop, and demonstrate the technical feasibility of a new class of measurement tools (*sensors*) that could collect information in the Earth's subsurface.
Survey work being done in the nanomaterials industry and develop leveraging strategies to stimulate development and testing of materials that might be applicable to the oil and gas industry.

Intersections. UT Center for Nano- and Molecular Science and Technology (Paul Barbara); Remote sensing (Paine—Bureau); Micro electronics (Bannerjee); Materials Science; Advanced computation (Ghattas—ICES).

Talent Plan. Hire nationally recognized technical leader and nationally recognized operations manager and three additional scientific staff.

Budget and Growth. Seven companies form initial membership. Each will pay $1 million annually with a 3-year commitment, for a $21-million 3-year budget. Bureau portion of this funding will be $2 million per year for the first 3 years (~$6 million).

Funding Sources. Initially Shell, BP, Oxy, Schlumberger, Halliburton, Marathon, ConocoPhillips**.** Future leveraging from State and Federal programs

Measures of Success. Hiring of an AE Consortium leader. Successful execution of a DARPA-type RFP solicitation, including seed-grant contracting. Acknowledged progress in the sensor arena within the initial 3 years**.** Add three new Industrial Associate companies in the first 3 years.

Challenges/Requests to JSG.

Challenge. Obtain formal approval from Department of Justice.

Challenge. Execute a formal contract with the seven initial member companies.

Challenge. Attract and hire nationally recognized leadership, operations manager, and staff.

Challenge. Manage appropriate growth of the Consortium.

Challenge. Leverage outside funding to continue growing the budget.

Request. Facilities start-up match of $500k.

JSG Frontiers. Energy, Computational Geosciences

Coastal Change in Texas

Scientific Movements. Coastal Dynamics

Overview. The coastal zone of Texas is a highly populated, fragile, transitional zone of environments that are sensitive to climate change, relative sea-level change, and various human activities. Integration of remote-sensing-based environmental-change detection, geodetic analysis, hydrogeology, and ecological mapping can decipher the effects of sea-level change, climate change, and urbanization.

Intersections. Marine Science Institute (MSI) at UT; Remote sensing-group at CSR; Coastal environmental policy CIEEP (Groat); Clastic Systems Research (DGS, Bureau, UTIG), Climate Change (UTIG, DGS)

Talent Plan. Hire three Ph.D. researchers—coastal geomorphology, coastal wetlands, and lidar. Create two ongoing postdoc positions, one-half funded by UT MSI.

Measures of Success. Continue the Coastal Group's reputation as the foremost source of information on shoreline and wetland change and expand our reputation to include the effects of global climate change in the Texas Gulf Coast. Continue to be the primary source of information on coastal research for Texas Government agencies and officials. Become a research program that graduates one to two Ph.D. students a year in a joint program with UT-MSI. Show a twofold increase in Coastal Research budgets within 5 years.

Budget and Growth. Current coastal funding is approximately $750K per year. Over the next 5 years we plan to grow to $1.5 million per year.

Funding Sources. State/Federal Government's Coastal Impact Assistance Program (CIAP)—potential projects for funding next year include**—**Beach/Dune and Shoreline Change Morphodynamics Project; Characterization of Bay Shoreline Changes Project.

Challenges/Requests to JSG.

Challenge. Maintain and grow GSC membership for likely supervisors of graduate students.

Challenge. Attract and supervise top students in coastal studies.

Request. Develop a GSC membership policy that is inclusive of Bureau researchers.

Request. Provide administrative support in development of a graduate program in coastal geoscience, possibly joint with UT-MSI or Engineering.

Request. Create hybrid research/faculty positions for more senior researchers.

Fracture Processes

Scientific Movements. Structural Diagenesis; 4D Quantitative Stratigraphy

Overview. The deep basinal environment—broadly, rocks that have experienced burial to >3 km or temperatures >80°C—is an important frontier. Understanding postdepositional processes

affecting rocks in these settings requires new models of mechanical and chemical interaction and new methods of microstructural analysis. With support from a grant from the Office of Basic Energy Sciences, industry, and the Jackson School, a research effort is under way across disciplinary boundaries in quantitative and experimental structural geology, mechanics, diagenesis, geochemistry, and petrophysics. New modeling capabilities, seismic approaches, and deep drilling are creating opportunities for radical improvements in understanding of complex upper crustal structures having impacts on fluid flow and sequestration.

Goals. Understanding processes that govern chemical and mechanical interactions in basins.

Intersections. Structural geology (Marrett, Cloos, Mosher—DSG; Olson—PGE). Structural diagenesis (Marrett, Milliken—DSG; Sen—UTIG, Laubach, Dutton, Loucks, Eichhubl, Reed, Gale, Day-Stirrat—Bureau), Basin modeling (New RS—Bureau), Seismic imaging/rock physics (Fomel, Hardage, Sava—Bureau; Sen—UTIG); Mudrocks research program (Ruppel, Loucks, Wright, Gale—Bureau; Milliken—DSG)

Talent Plan. Utilize a faculty co-appointment for a new diagenetic modeler. Hire basin modeler. Attract graduate students to program.

Measures of Success. Obtain new DOE or RPSEA funding. To produce 1 NAS Candidate in structural-diagenesis-related research in 10 years. Produce two textbooks in fracture-related research in 5 years. Host an international symposium every third year.

Budget and Growth: Anticipating an annual budget of more than $1 million by 2010

Funding Sources. Industry Sponsors, JSG, RPSEA, IOCs, NOCs

Challenges/JSG Support.

Challenges: Grow interaction between Bureau and DGS faculty

Request. Support faculty involvement.

Challenge. Increase faculty teaching Diagenesis.

Request. Hire one new faculty position teaching Diagenesis.

Challenge. Maintain and grow GSC membership for likely supervisors of graduate students.

Request. Develop a GSC membership policy that is inclusive of Bureau researchers.

JSG Research Frontiers. Energy, water.

Salt and Shale Tectonics

Movements. Mobile Substrate Tectonics; 4D Quantitative Stratigraphy

Overview. New modeling capabilities, ever-improving seismic data, and deep drilling are creating opportunities for radical improvements in understanding the enormous three-dimensional complexities in sedimentary basins having mobile salt or shale substrates

Goals. Improve understanding of the kinematics and dynamics of salt and shale tectonics and their interaction with other processes in sedimentary basins.

Intersections. Continental margins (Mann, Austin, Bangs, Fulthorpe—UTIG; Cartwright—Cardiff; Steel—DGS). Deep shelf (Dutton, Loucks—Bureau). Tectonostratigraphy (Horton—UTIG/DGS);

Planetary geology (Blankenship—UTIG); Structural geology (Marrett, Cloos, Mosher—DSG); Basin modeling (New RS—Bureau, Lavier—UTIG); Seismic imaging/rock physics (Fomel, Hardage, Sava—Bureau; Sen—UTIG); Quantitative Seismic Geomorphology (Bureau-QCLIA); US Mudrocks Systems program (Ruppel, Loucks—Bureau)

Talent Plan. Continue to attract graduate students to program. Collaborate with existing faculty and coordinate with existing colleagues. Host visiting scientists. Add a postdoc in mobile shale studies.

Measures of Success. Provide steady stream of new breakthrough concepts, continued publications in top journals, and strong funding from industry and other sources

Budget and Growth. 2010 budget: $1 million annually

Funding Sources. Industry, RPSEA, JSG, NS, USAID

Challenges/Requests to JSG: Invite involvement in salt-tectonics program from individuals at UTIG and DGS to broaden talent; support for postdoc and transitional (new talent) funding.

JSG Frontiers. Energy, Climate, Service to society.

Sedimentary Rock Systems

Scientific Movements. 4D Quantitative Stratigraphy, 4D Heterogeneity Characterization; Coastal Dynamics

Overview. The 1960's and 1970's Bureau-led research movement in depositional systems, followed by the seismic stratigraphy and sequence stratigraphy revolution in the 1980's and 1990's created a renaissance in stratigraphic and sedimentologic understanding. Sequence stratigraphy is now largely in an application phase. Investigations are now focusing on how sedimentology, diagenesis, and pore systems can be fit into a sequence stratigraphic context and whether the evolution of matrix-pore-fluid systems can be predicted on the basis of a sequence stratigraphic context. Current Bureau programs include RCRL (carbonate reservoirs), QCL (Quantitative Clastics Laboratory), PBGS (Permian Basin Geological Synthesis), LASR (Laser-assisted Analogs of Siliciclastic Reservoirs), Sandstone Reservoir Quality in Deep Shelf Gas Play, FRAC (Fracture Research and Applications), and several others.

Research Goals. Integration of quantified outcrop and subsurface data—including sequence stratigraphy, petrophysics, diagenesis, geostatistics, and flow modeling—resulting in advanced sedimentary system understanding. Quantitative seismic geomorphologic analysis of shallow and deep-marine clastic and carbonate systems. Clastic sequence stratigraphy and reservoir characterization of Tertiary margins around the world.

Intersections. Modern depositional systems and processes (Mohrig, Kerans—DGS); Fracture and diagenetic processes and products (Laubach—Bureau, Milliken—DGS, Lander, Bonnell, consultants); Seismic imaging (Fomel, Zeng, Hardage—Bureau, Ferguson—DGS); Basinal synthesis (Mann, Galloway, Austin—UTIG, Weimer—CU, Cartwright—Cardiff); Outcrop sequence stratigraphy (Kerans—DGS, Steele—DGS, Pyles and Bouroullec—CSM); Fluid flow

simulation and computational geosciences (Ghattas, Wheeler—ICES; Bryant, Srinivasan—PGSE).

Talent Plan. Hire two researchers (RA or RS) in 2007 in the broader area of multiscale quantitative stratigraphy. Hire two more junior researchers by 2010 to maintain program growth. Add additional Research Associate or Research Scientist Associate with strong computer mapping and ArcGIS Skills. Add one postdoc. Maintain strong representation on GSC and develop mentorship program to add members to the GSC. Host a visiting scientist per year in the area of clastic or carbonate research.

Measures of Success. Maintenance of international connections and collaborations. Continued involvement by international companies. Diversification of funding sources through collaboration and proposal writing. 10% increase in granting of degrees to graduate students supervised by Bureau GSC members**.** Addition of two new members to the GSC in Stratigraphy and Sedimentology within 5 years.

Stable or increasing number of companies sponsoring IA programs (RCRL, QCL, US Mudrocks)

Budget and Growth. Combined budgets will be $2 million/year in 2007 and grow to $3 million/year by 2010.

Funding Sources. Private: IOCs and NOCs; Federal: DOE Basic Energy Sciences, RPSEA, NSF; State: STARR

Challenges/Request from JSG.

Challenge. Funding in low-growth periods in the petroleum industry.

Challenge. Obtain quality new hires in high-growth periods.

Request Create and maintain appropriate IT support for high-end computing needs involving huge data sets.

Challenge. Grow interaction between Bureau and DGS faculty

Request. Support faculty involvement

Challenge. Maintain and grow GSC membership for likely supervisors of graduate students.

Request. Develop a GSC membership policy that formally includes Bureau researchers.

JSG Frontiers. Energy, Water, Computational Geosciences, Advanced Earth Imaging.

Seismic Imaging in Complex Environments

Scientific Movements. 4D Heterogeneity Characterization; 4D Quantitative Stratigraphy

Overview. Ultra-deep-water environments are a major frontier in meeting the US and the world's energy needs. Nearly half of the prospective area in deep-water environments is covered by shallow salt. Highly complex seismic reflection wavefields generated by salt make seismic imaging of the deep subsalt reservoirs extremely difficult. Effective imaging of subsalt ultra-deep-water targets remains a fundamental scientific challenge and requires multidisciplinary efforts and new breakthrough technologies in both processing and interpretation.

Goals. To achieve breakthrough improvements in accuracy, resolution, and efficiency of seismic depth imaging in complex geological environments. To develop new approaches to the most challenging problems in seismic subsalt imaging: velocity model building, illumination compensation, utilization of multiples and multicomponent waves, full wave inversion.
To create reusable 3-D models of deep-water environments and reproducible seismic modeling and imaging experiments
Intersections. Salt tectonics (Jackson, Hudec, Dooley—Bureau-AGL); Multicomponent seismic (Hardage, Murray—Bureau-EGL); Reservoir modeling (RCRL, QCL, PGE); Fractures (Laubach—Bureau; Marrett—DGS); High-performance computing (TACC); Inverse theory (Ghattas—JSG/ICES, Kallivokas—ME, Stoffa, Sen—JSG/UTIG); Numerical algorithms (Engquist, Tsai, Ying—UT ICES/Math), Civil Engineering.
Talent Plan. Unify efforts of salt tectonicists and imaging researchers at JSG, ICES, and TACC. Hire two seismic imaging researchers by end of 2007. Hire one rock physicist (laboratory study of core and in situ rock properties). Incorporate two postdoc and graduate students into program.
Measures of Success. Secure matching State and Federal grants (TETF, RPSEA, NSF) Breakthrough publications (SEG awards). Utilization of TACC supercomputing resources.
Budget and Growth. $500,000 annually at start. $1.3 million annually by 2010
Funding Sources. Industry Sponsors, RPSEA, DOE BES, NSF. Companion projects in subsalt seismic imaging: ExxonMobil ($300K, 2005–2006), Shell+JSG ($500K, 2006–2007), Chevron ($600K, 2007–2010), Hess+Total ($600K, 2007–2010)
JSG Frontiers. Energy, Computational geosciences.

Unconventional Fossil Energy Resources

Scientific Movements. Structural Diagenesis; 4D Quantitative Stratigraphy; 4D Heterogeneity Characterization

Overview. Deep in sedimentary basins where elevated temperatures exist, rates of thermally driven chemical reactions may increase exponentially, resulting in significant changes to mechanical properties of rocks. Little is known about these chemical and mechanical interactions; however, they most likely govern porosity/permeability/capillary pressure, mechanical, and fracture attributes and may also interact with engineering interventions in these rocks. Long-term, integrated research efforts are needed to understand the fundamental physical processes in sandstone, siltstone, shale, and coal inasmuch as they control producibility of unconventional fossil energy resources that are projected to play a large role in the global energy future. Examples include gas from shale, coal, and low-permeability sandstone. In addition, factors controlling distribution, behavior, and safe recoverability from extremely shallow unconventional resources, such as methane hydrates are poorly understood. Such research has implications for seafloor safety in engineering facilities, energy-resource extraction, climate change, and geohazard studies.

Goals. Unified model that predicts porosity, permeability, and mechanical-property evolution in chemically reactive, low-porosity fractured shale, coal, and sandstone in sedimentary basins (stage 1 might be shale). Imaging technology that can map and quantify frozen methane distributions, improve resource estimates, and mitigate hazards associated with deposits. Quantified engineering and economics models cognizant of geosciences research findings that minimize or eliminate inefficient or wasteful development of resources.

Intersections. Permian Basin Geological Synthesis program (PBGSP; Ruppel—Bureau); Petrography/diagenesis (Milliken—DSG; Dutton, Loucks, Eichhubl, Reed, Laubach, Gale, Day-Stirrat—Bureau); Fractures (Laubach—Bureau, Marrett—DSG, Olson—PGE, Marder—Physics); Petrophysics/Reservoir Engineering (Kane—Bureau; Bryant—PGE); State of Texas Advanced Resource Recovery (STARR—Loucks, BEG); Seismic imaging/rock physics (Fomel, Hardage, Sava—BEG; Torres-Verdin—PGE); Microimaging, Geomicrobiology

Talent Plan. Hire three researchers in intersection areas (e.g., petrophysics/rock physics/reservoir engineering; basin analysis/absorbed gas systems; organic geochemistry); add one postdoc; add a faculty member to lead an educational and research component of the unconventional resources program. Attract graduate students into program.

Measures of Success. One major corporate sponsor by end 1Q07; securing matching State and Federal grant money (STARR, RPSEA); enrollment of graduate students in JSG program for unconventional resources within 3 years; add faculty member in unconventional resource studies by fall 08. Addition of graduate courses in study of unconventional resources by fall 08.

Budget and Growth. 2007–2008: $1.25 million annually (JSG plus sponsor); 2010: 1.5 million annually

Funding Sources. JSG, Industry Sponsors, RPSEA, STARR, IOCs, NOCs

Challenges/ Requests to JSG.

Challenge. Need a faculty member to lead unconventional resources academic and research program. Lack of any faculty in diagenesis research and teaching (a gap in core curriculum).

Request. Work with Bureau to hire a faculty member to lead these efforts.

Challenge. Secure single corporate sponsor at $500,000 per year, as partial match to JSG's $750,000 per year for first 2 years.

Challenge. Add courses or focused course elements in issues germane to unconventional resources study.

Request. Support collaborative curriculum efforts between Bureau and DGS.

Challenge. Add high-quality graduate researchers to research program. Maintain and grow GSC membership for likely supervisors of graduate students.

Request. Develop a GSC membership policy that is inclusive of Bureau researchers.

JSG Frontiers. Energy, water.

Groundwater Hydrogeology

Scientific Movements. Sustainable Water Resources

Overview. The Earth's biogeochemical cycles have been significantly perturbed by human activities during the last century. The most widespread changes have occurred as a result of agriculture. Saving the world's water supply from nitrification, pesticides, etc., as well as overuse is a grand challenge.

Goals. Create a group in Sustainable Water Resources research that is a national/international leader in the field. Develop a multidisciplinary team to do research assessing long-term water availability issues in the context of climate variability. Extend current expertise in recharge by adding capabilities in remote sensing of water budget; biogeochemical recycling; modeling including saline/freshwater interactions and desalination

Intersections. Remote-sensing climate change research activities within JSG (Liang); Water Policy research in CIEEP (Groat) and LBJ School (Eaton); CEE international capacity development in Africa, Central and South America (Foss—BEG); research on role of water usage for energy production in CIEEP (Groat) and LBJ School (Eaton)

Talent Plan. Hire at least one senior scientist/faculty position in each of water-cycle remote sensing, biogeochemical cycling, and desalinization, as well as three midlevel Ph.D. scientists in these or related fields.

Measures of Success. At least two PhD students a year in water or water-policy research within 5 years. Sustain a group of at least two postdocs, plus visiting scientists working in water sustainability and related policy fields. Establish new field programs on at least two continents

Budget and Growth. Water program currently has a budget of approximately $750,000 per year, to achieve goals; this should increase to $2.0 million in 2010.

Funding Sources. EPA and EPA pass-through to TCEQ currently is over $500k per year, significant increases unlikely. NSF is a source we currently are not tapping. It should become a major source of funds in the future ($750k+ per year). No current foundation support; target at least $250k per year over 5 years. USAID is a potential source of global support (target $500k per year over the next 5 years)

Challenges/Requests to JSG:

Challenge. Attract top people; may require creating hybrid research/faculty positions for senior staff.

Challenge. Maintain and grow GSC membership for likely supervisors of graduate students.

Request. Develop a GSC membership policy that is inclusive of Bureau researchers.

JSG Frontiers. Water.

Major Programs

Major program focus areas are represented by significant, ongoing, funded research or service, in which the Bureau is heavily invested, and they commonly have a large anchor funding source. These include the Center for Energy Economics, Gulf Coast Carbon Center, International Research and Education Partnerships, Professional and Societal Service, the State Geological Survey, and State of Texas Advanced Resource Recovery (STARR).

Center for Energy Economics

Overview. Conduct research on economics of energy value chains and educate stakeholders to improve public policy and investment for economic development.

Goals. Become an international leader in understanding economic, technology, business, policy/regulatory dimensions of energy resources and infrastructure development, including impact of environmental policies. Human-capacity building, fully integrated with BEG, JSG, other UT initiatives. Public education and outreach on energy.

Intersections. Within BEG: STARR low-pressure gas and other initiatives; unconventional fossil energy resources; Gulf Coast Carbon Center; water resources; coastal processes; stakeholder and decision maker education. Within JSG: Center for Energy and Environmental Policy; EER degree program; international initiatives. Within UT: McCombs School of Business—Houston EMBA and Energy Certificate, Center for Energy Finance Education and Research; PGE—unconventional energy resources, Center for Petroleum Asset Risk Management; UT international partnerships.

Talent Plan. Hire two additional researchers and two postdocs. Develop strategies for utilizing part-time experts with specific skills, backgrounds, talents. Expand visiting-scholar pool, student internships (including international collaborations). Expand strategic collaborations with other programs and research groups.

Budget and Growth. Achieve overall sustained annual budget for CEE combined programs of $1.2 million by 2010.

Funding Sources. Private industry; consultancies and law firms with specific specializations; private foundations. USAID; Higher Education for Development; EPA; national governments and oil companies; DOE—RPSEA. BEG—STARR; State agencies (Texas and elsewhere).

Measures of Success. Increased number of references to CEE research reports. New training and human-capacity-building programs. Successful completion of collaborative agreement with McCombs and implementation of Energy Certificate program in Houston. New international partnerships and expansion of CEE/USAID funded West Africa partnership.

Challenges/Requests to JSG.

Challenge. Continue CEE Development initiatives for West Africa and other key regions

Request. JSG matching funds of $150,000 annually ($450,000 3-year total) for CEE USAID and other initiatives in human-capacity building.

Challenge. Maintain and grow GSC membership for likely supervisors of West African and other international students.

Request. Develop a GSC membership policy that is inclusive of BEG/CEE researchers.

JSG Frontiers. Energy; service to society; water; computational economics and risk modeling.

Gulf Coast Carbon Center

Overview. The GCCC has a global leadership role in carbon sequestration research and must grow to keep pace with this expanding topic area and participate in the production of students ready to lead diverse components of the carbon management industry as it evolves. Bureau research will focus on testing the viability of large- volume, long-term geologic storage of CO_2 in brine reservoirs, assessing security of CO_2 used for EOR, and increasing effectiveness of monitoring techniques. Alliances with other expertise within JSG, elsewhere in UT, and at other research institutions will be required to maintain a leadership role in this multidisciplinary topic.

Goals. To establish global leadership that enables implementation of large-scale greenhouse gas reduction using geoscience techniques through research and public, technical, and student education

Intersections. Energy policy studies at BEG-CEE (Foss), CIEEP (Groat), and LBJ School; Reservoir characterization and reservoir engineering at the Bureau and PGE; Carbon separation technology research in UT Chemical Engineering (Rochelle, Friedman), Soil and Ecosystem monitoring at ESI (Banner), Groundwater and vadose zone monitoring at the Bureau (Scanlon), Global climate models at DGS and UTIG (Yang—DGS; Jackson—UTIG)

Talent Plan. Attract and retain one PhD Research Engineer with experience in CO_2 sequestration and/or CO_2 EOR and/or numerical modeling; one Ph.D. research geologist with experience in geomechanical or geochemical aspects of CO_2 sequestration; and a CO_2 policy expert with a background in economics or environmental engineering in the next 3 years. One of these individuals should serve as a team leader, and several should be members of GSC. Add one postdoc. Develop and maintain alliances to other required expertise.

Measures of Success. Maintain research leadership in long-term CO_2 storage assessment and transmit results to policy forums. Participate in key elements of major field experiments over next 10 years. Establish a carbon sequestration policy research group. Establish a vibrant graduate program in carbon management.

Budget and Growth. GCCC budget should grow from $1.25 million in 2006 to $2.0 million a year in 2010.

Funding Sources. DOE, GCCC industry partners, foundations, specific industry-sponsored projects.

Challenges/Requests to JSG.

Challenge. Static funding level at DOE. Annual dangers to the DOE budget.

Challenge. Increase GCCC Industry Partners from $350K per year to $700K per year.

Challenge. Increase funding for specific industry sponsored projects from $100K per year to $250K per year

Challenge. Difficulty in attracting top people in this field

Request. Support establishing hybrid research/faculty positions for more senior people.

Challenge. DOE carbon sequestration funding requires a 20% match. Finding matching funds is also a great challenge.

JSG Frontiers. Energy, Science Impacting Policy, Service to Society

State of Texas Advanced Resource Recovery (STARR)

Scientific Movements. Structural Diagenesis; 4D Quantitative Stratigraphy;

Overview. Independent operators produce most of Texas' oil and gas. In many cases they lack geoscience expertise and advance interpretation tools. STARR conducts geoscience and engineering research at a variety of scales with selected industry partners who lease mineral rights from the State Lands program. The State benefits from enhanced royalty income and severance tax revenue from the success of the program.

Goals. Be revenue-positive by creating value significantly greater than the budgeted amount received from the State. Create value by improving understanding of and increasing production from existing reservoirs, regional plays, unconventional plays, and enhanced recovery operations.

Intersections. Carbon capture: Bureau-GCCC, FutureGen Texas team; BEG-JSG Unconventional fossil fuels program; Enhanced oil recovery: BEG, PGE, GCCC partners; CEE—economics and commercialization.

Talent Plan. Hire a seismic interpreter.

Hire one geophysicist and one senior stratigrapher/reservoir engineering crossover specialist, 2007.

Measures of Success. Revenue neutrality and continued funding by Legislature.

Budget and Growth. Currently $1.5 million annually. No plans to grow in near term owing to staffing challenge.

Funding Sources. Texas Legislature via line item in UT appropriation.

Challenges/Requests to JSG.

Challenge. Staff project with more full-time researchers; current organization requires full-time dedicated manager.

JSG Frontiers. Service to society, energy.

Professional and Societal Service

Overview. To engage the talented research and support staff in service without sacrificing the research and education mission. Includes professional societies, community outreach, and education at all levels.

Goals. At least two Bureau professionals serving as officers in local, regional, national, and international organizations—including professional societies, national associations and academies, and trade organizations—each year. Extensive engagement in committee work, conferences, distinguished lectureships, and presenting at conferences. Establish the Bureau as a recognized partner for scientific program development at museums. Launch at least one new museum collaboration (program) per year. Provide educational opportunities to K-12 children and educators of Texas. Establish a permanent funding mechanism for this program. Engage JSG students.

Intersections. Complete suite of geoscience and energy and environmental engineering and economics societies, academies, associations and organizations plus DGS and UTIG.

Talent Plan. Use Bureau and JSG resources to provide salary support for staff to serve as officers of professional organizations, organizers of conferences, and distinguished lecturers. Identify an individual (existing staff) to coordinate our outreach efforts. Identify and secure funding to enable a team of four to six individuals (existing staff) to do planned and ad hoc K-12 programs throughout the year. JSG student involvement

Budget and Growth. This is not a revenue-generating activity. The cost of supporting this kind of service is ~$300k per year, most of which is travel and some salary support. The program has no annual funding for program development and no agreement from outside groups to match the funds that we are able to raise. Our desire is to secure $100,000 of annual funding to run this program and the potential for $100,000 of program matching funds.

Funding Sources. Private museums, individual donors, private industry, foundations (Meadows, JSG and others)

Measures of Success. The Bureau should produce two national officers per year, two national distinguished lecturers per year, two major award winners, and five lesser award winners per year and have extensive service at all levels. Establishment of a funding model that will allow one full-time person to coordinate and part-time staff to contribute to outreach. A new museum project each year. Organize two major K-12 events and five ad hoc K-12 smaller projects throughout the year. Engage JSG students as a key component of the program

Challenges/Requests to JSG.

Challenge. The Bureau funding model does not allow our staff to “buy time” or support the costs of service.

Request. Work with the Bureau to establish a funding model that will allow more flexibility in support of community service.

Challenge. Staff to coordinate and expand current successful efforts.

Request. $100,000 salary and $100,000 matching funds.

JSG Frontiers. Outreach, Energy.

State Geological Survey

Overview. As the State Geological Survey, the Bureau serves the State of Texas and Nation via application of research, public education, and outreach. This role can broadly be described as bringing science to decision makers. Geologic mapping and near-surface geophysics are two of the key science aspects of this function, but we advise State leaders on a wide variety of geoscience issues. Another major role is preservation and curation of geoscience data.

Goals. Bring knowledge gained from global research to the State of Texas to impact resources, environment, and policy. Active partnerships with geoscience-related State agency including the GLO (e.g., coastal erosion), TCEQ (e.g., water quality and sustainability), TWDB (e.g., water availability), RRC (e.g., carbon and FutureGen), and the legislature (e.g., geological hazards such as Wink Sink). Improve mechanisms that continue to strengthen the Bureau brand among State and Federal legislators and decision makers and become the go-to organization for applied geoscience research. Maintain strength of Bureau support staff to support research, facilities, and School outreach programs (e.g., Decision Makers trip, Earth Science week) to serve the State and Nation.

Maintain and strengthen our position as the national leader in geoscience data preservation and curation (three core research centers, several libraries, Statewide digital log library). Continue in our current leadership role among the 50 State Surveys and bring Texas issues to Washington, D.C., via key Federal appointments and invited testimony.

Intersections. Policy and Economics (CEE—Foss, CIEEP—Groat, LBJ School—Eaton, Rice Baker—Jaffe); Water (Sharp—DGS, EPA, State Surveys); Environment (Banner—DGS, Jackson—UTIG, EPA); Coastal (Coastal State Surveys); Hazards (Buckley—CSR/Aerospace)

Talent Plan. Hire four researchers and one postdoc in key applied areas. Hire one resource scientist to develop, track and provide to the public state and federal resource information. Grow the already strong Bureau support staff to serve the broader JSG.

Budget and Growth. Double Bureau State line item in FY 2008 from ~$1.5mm to ~$3.0mm/year.

Funding Sources. State: GLO, TCEQ (EPA), TWDB, RRC, Legislature, State appropriations, TxDOT. Federal: EPA, USFS, NASA. Private: Oil and gas industry.

Measures of Success. Consistent State funding resulting from high-impact, timely products delivered on time, on budget, with high quality results. Service on State and Federal boards, committees, commissions, and task forces to bring science to policy. Bureau publications and activities that deliver usable results to agencies and decision makers.

Challenges/Requests to JSG.

Challenge. Maintain viable core research centers as we grow endowments.

Challenge. Maintain and grow graphics, editing, IT, and grants and contracts support staff to serve the broader JSG (significant economies of scale).

Challenge. Continue major impact programs such as Down to Earth series and Decision Makers trip.

Request. Request support elsewhere as part of Professional and Societal Service focus area.

JSG Frontiers. Service to Society, Science Impacting Policy.

International Research and Education Partnerships

Overview. JSG is viewed by many national oil companies as an important resource for integrated education and research. The Bureau plays a key role in such programs because of its full-time research capability and its involvement in the type of teaching and academic supervision requested by these companies. The challenge is to be selective in partnering so that we can deliver a high-quality, comprehensive program.

Goals. Establish one or two major research and education partnerships by 2008, with Petrobras or similar company or country. Continue the existing Aramco Ghawar Field reservoir characterization project, seeking to grow our impact within the project.

Intersections. Carbonate reservoirs—BEG/RCRL, PGE, Aramco, Petrobras, Pemex; Clastic research—IMP/Pemex, Trinidad Ministry of Energy and Energy Industries, Barbados Ministry of Resources; Carbon management—Saudi Aramco, GCCC; Basin research—UTIG, BEG, NOC's, USGS; Policy, Investment/policy frameworks—BEG/CEE, JSG/EER

Talent Plan. Hire six new researchers and one PostDoc. Draw on existing resources as needed. Be careful not to overburden existing programs with this obligation.

Measures of Success. Enrollment and graduation by NOC/IOC partner employees in JSG degree programs. Funding of significant research areas by partner. Continued level of involvement in Bureau research programs by international companies.

Budget and Growth. Plan for $1.5 million per year in 2010. Currently have $250,000 per year (for multiple years) from Aramco for Ghawar.

Funding Sources. Aramco, plus one additional NOC/foreign IOC.

Challenges/Requests to JSG.

Challenge. Maintain and grow GSC membership for likely supervisors of Brazilian and other international graduate students.

Request. Develop a GSC membership policy that is inclusive of Bureau researchers.

Challenge. Maintain staffing in current competitive climate.

Challenge. Maintain admission and graduation of partner employees in UT degree programs.

Request. Provide an International Coordinator to handle issues such as scheduling of testing, timing of admission, student and employee visitor logistics, etc

JSG Frontiers. Energy, service to society, Latin American Forum.

Appendix 2: Scientific Movements

Successful scientific movements result in broad acceptance and application of *new approaches* to scientific and technical issues. Movements grow from an appreciation of some inadequacy in accepted views and from insights into potential solutions. If successful, movements may establish a new standard. That the Bureau succeeds by deliberately seeking and fostering scientific movements may sound bold, but it is perhaps best seen as a *formula* for how the Bureau sustains grant- and contract-supported research and application efforts over many years. New approaches allow the Bureau to win competitive government grants and contracts or gain membership in industry-supported programs. Only broad issues having marked societal impact can support the funding level that the Bureau requires. Not all Bureau research is transformative. But as a matter of growth and continued health, the Bureau seeks and fosters transformative ideas.

Bureau history illustrates the point. In the 1960's and 1970's the insights of Brown, Fisher, Scott, and others helped create the concept of depositional systems, which led to the sequence-stratigraphic movement—now a central discipline in petroleum exploration and development. In the 1980's, Jackson and others anticipated subsalt oil and gas exploration and led the way in creating the now well-established movement of salt tectonics, and they continue to lead global research in this area. Several such research movements are under way today at the Bureau, each in different stages of a life cycle of testing and acceptance.

To describe how the Bureau participates in scientific movements, we need to show how Bureau projects and programs occupy positions in a life cycle of discovery and application. Although tempting, it would be inaccurate to see the life cycle as one of basic to applied research; no matter how fundamental the scientific questions, Bureau projects start with the aim of asking questions and solving problems that have a societal (and therefore applied) motivation. Instead, the life cycle primarily reflects increasing scope and acceptance of a particular approach. As the scope of research increases, additional research is warranted to investigate further applications. In the end, broadly accepted, well-funded movements spawn new questions and ideas that are the seeds of new discovery, and the cycle begins anew. Thus, the three stages of a scientific movement are initiation, growth, and maturity.

Initiation

Although new research programs have arisen from across the spectrum of Bureau projects, many start and are nurtured in large, established programs. Many of the largest Bureau contracts constitute service to the State and Nation through application of results arising from earlier successful Bureau research. An example is the State of Texas Advanced Resource Recovery

(STARR) effort. This project applies the insights from Bureau breakthroughs in depositional systems analysis in the 1970's and testing and consolidation of those insights in Bureau projects funded by the Department of Energy (DOE) and Gas Research Institute (GRI) in the 1980's. Although such programs conduct research and publish results, the funding is based on the premise of application and service.

Bureau research movements commonly arise within these large service projects. In addition to meeting project deliverables, the humbling process of testing ideas through application often creates a challenge to established patterns of inquiry, resulting in new ideas, preliminary results, and proposals for funding that form the seeds of new research. The starting point is often a simple, practical question. For example, how can we anticipate the effects of disseminated mudstone layers on fluid flow in a particular locality?

Because motivation for the Bureau's basic science is ultimately to solve a practical problem, Bureau scientists may take on scientific issues that much of the geosciences community view as intractable. For example, "what underlying principles explain porosity evolution in carbonate rocks?" A solution would have great value in the development of many hydrocarbon reservoirs, but it is a topic that has fallen out of favor in the relevant scientific community because satisfactory conclusions were not forthcoming and leading academic funding organizations (e.g., National Science Foundation) cannot afford to invest in high-risk research. This is what is meant by a refractory scientific question. When promising solutions to such problems are found, there are scientific and practical repercussions and benefits. An example is a recent breakthrough in the theory of cementation in sandstones. In addition to opening new lines of inquiry in related fields, the consequences of this breakthrough have been profound, leading to more accurate predictions of porosity in deep wells, an important factor for extractive and sequestration industries.

Growth

The second stage is one in which new research movements struggle to find independent support in sponsored projects. This is a period of severe testing for Bureau research initiatives because to prosper and grow, funding must cover researchers' salaries, as well as research and overhead costs. Although some new research efforts succeed in attracting funding and becoming self-sufficient, many do not. If they do become self-sufficient, many develop support from multiple sources, whereas others build a single reliable source of funds. An example is the Bureau's Applied Geodynamics Laboratory (AGL) salt tectonics program, sponsored largely by industry. This program had its inception in the Bureau's large Federal high-level nuclear-waste characterization projects of the mid 1980's. The AGL is now widely considered the world's

premier program for research on salt tectonics. Concepts and terminology pioneered by AGL have had a profound influence and are widely disseminated throughout the petroleum industry, as well as the academic literature.

Most of the Bureau's industrial associates (IA) programs have a history similar to AGL's. The Bureau's IA programs typically focus on issues that most scientists would consider basic research. They comprise groups of scientists committed to a creating new theory, method, or conceptual framework. These are the programs that generate publications, research grants, and exciting research projects for students. These are natural settings for collaboration with scientists from other units. For example, the Bureau's Reservoir Characterization Research Laboratory (RCRL) and Fracture Research & Application Consortium (FRAC) both have co-principal investigators in the Department of Geological Sciences.

These programs span degrees of maturity as scientific movements, with AGL and RCRL having established the dominant viewpoint in their respective fields of salt tectonics and carbonate depositional systems, respectively. FRAC, in contrast, is younger in the cycle and more controversial but gathering adherents to a view of the importance of mechanical and chemical interaction for understanding fractures and diagenesis—the movement is called structural diagenesis. Programs such as the Deep Shelf project possess unique data sets and are in the earliest stages of formulating a distinct viewpoint on deep-basin processes.

The IA programs prosper when they are making progress on fundamental issues of interest to practitioners. Funding for industry IA programs is extremely competitive, and programs survive only if they are perceived as unique, useful, and, in most cases, as being the best program in the field of inquiry. Maintaining a stable funding base is time consuming and may tend to draw programs toward applications studies, sometimes prematurely, to the detriment of basic research. Most successful IA programs leverage industry support to attract Federal grant support. These are potentially among the most exciting Bureau programs for student and young professional involvement, and most of them have included training and supervision for graduate students. However, the priority and commitment of securing funding makes participation in these programs challenging for any but senior scientists.

Maturity

The Bureau builds programs that attempt to take scientific insights from research initiatives, develop and test them, and turn them into applications and then to practical use. Although focused on practical applications, typically much basic research is conducted in the maturity phase of the scientific movement. Often in this phase spin-out programs shift focus to public

service. In addition, development and success of these types of programs at the Bureau is essential to nurturing the development of new research directions.

An example is the Bureau's Unconventional Resources focus area. Aspects of unconventional resource research, including coalbed methane, tight gas, shale gas, heavy oil, and resource estimates, have been conducted in various projects at the Bureau for well over a decade. This combined expertise will be "rolled up" under a single umbrella and strategically coordinated in order to link basic science and societal application and to attract the full range of Federal and industry funding. Unlike in the past, where a coordinated roll-up of projects into a focus area would require 100% external funding, in the case of unconventionals, the Jackson School made the initial investment to allow the Bureau to coordinate talent within the School, better define the strategic focus, and seek strong partnerships for significant external leveraging of funds. If successful, this program will span a decade or more, spawn several new research ideas, and create or significantly impact at least one scientific movement, perhaps more.

Success in developing unconventional resources is important to society. Although commodity prices do not necessarily form a barrier to making profit, profound scientific challenges can impede industry from effectively and efficiently tapping the resource. Bureau basic research on geophysical imaging, structural diagenesis, sandstone, carbonate and shale sedimentary architecture, and fluid generation and flow is applicable to several key challenges in unconventional resources, but the efficacy of the Bureau methods is as yet untested. The program aims to test and prove these concepts, and to use—and show others how to use—the results to improve engineering and economic efficiency and effectiveness. Such programs require integrated research teams that include scientists, engineers, and economists.