



# **Review and Guidance to the United States Geological Survey National Cooperative Geologic Mapping Program**

**November 2006**



**American Association for the Advancement of Science  
Research Competitiveness Service**

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**American Association for the Advancement of Science**  
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## **I. Introduction**

This report presents the findings and recommendations of a review panel convened by the Research Competitiveness Service (RCS) of the American Association for the Advancement of Science (AAAS) to provide programmatic review and guidance to the US Geological Survey National Cooperative Geologic Mapping Program (NCGMP). The review panel was requested by Randall Orndorff, acting program coordinator, and the site visit occurred October 10-13, 2006 at the USGS headquarters in Reston, VA. The USGS National Cooperative Geologic Mapping Program was founded by an act of Congress in 1992 to be a coordinated program between the US and state geological surveys to prioritize the geologic mapping requirements of the Nation and to increase production of geologic maps. This program has three components –

FedMap (federal partners), StateMap (47 state partners), and EdMap (a training and educational component). The program also produces and maintains a National Geologic Map Database accessible on the web at <http://ngmdb.usgs.gov/>. The specific charge to the AAAS review panel was to 1) Assess integration of geologic information to facilitate analysis and decision-making as set forth in the Office of Management and Budget, Program Assessment Rating Tool (PART),

2) Recommend policy changes (if necessary) to support and promote improved science and evaluation within the program, and 3) Evaluate the role the Program should take in producing derivative products to meet the needs of society.

The panel found an impressive and well-run program that coordinates partnerships across the United States. The NCGMP has been very effective in leveraging limited funds with state and other agencies for cooperative projects, and the program has been quite effective at balancing its political and societal needs. The products that have been developed are generally of the highest quality, true examples of good science being done by good researchers. Overall, the products have a high societal value as well, even as those needs change and evolve.

This report is structured as follows: this introduction is followed by a section, Part II, addressing common themes that arose during the review, including strengths and opportunities for improvement of the program. During the review, the panel was asked to consider several questions posed in the statement of work. The answers to those questions appear in Part III, and are followed by the conclusion in Part IV. The site visit agenda is included in Appendix A, and the CVs of the panelists are included in Appendix B.

## **II. Common Themes**

### **A. Strengths**

#### *1. Effectiveness in leveraging funds with state and other agencies for cooperative projects*

The National Cooperative Geologic Mapping Program's \$25 million annual budget represents 2.5% of the USGS appropriation and 11% of the Geology Division budget. Despite the limited budget it has been extraordinarily effective in responding to the pressing national need for comprehensive geologic mapping. The program balances effectively the needs and priorities of multiple stakeholders and constituencies and leverages federal and state funds through diverse cooperative projects and program initiatives.

The NCGMP program by its very structure is tasked with addressing sometimes conflicting needs and priorities. The StateMap element operates within a state context and disburses funds for state-directed geologic mapping. It is responsive to the differing stages of the states, ranging from states like Kentucky that have complete geologic map coverage and are focused on developing digital information systems and derived products for diverse users, to states that still lack substantial geologic map coverage and are therefore focused on basic map production. There is consequently a healthy discussion and differing priorities between basic mapping and GIS-enabled derivative products. All agree however on the high value and time-critical need for more extensive geologic information. While manpower issues limit the ultimate capacity and production rate, anecdotal evidence suggests the system could handle up to three times the funding and map production rate, which consequently increases the tension between focusing funds on mapping versus derived products and analysis systems.

The FedMap element operates within the federal USGS culture of mission-focused projects with outcomes that include a map product, new geologic knowledge, and allied research, and are responsive to changing societal and congressional priorities, e.g. wilderness/minerals in the 1970s and 1980s, human hazards and impacts from the 1990's to present time, and resource/environmental issues surrounding water, as exemplified by an ongoing karst initiative. It is also responsive to the specific needs of sister federal agencies, such as the National Park Service response to the National Resource Challenge which calls for digital geologic map coverage of all the national parks. This project is an example of partnership and leveraging by the NCGMP to increase the program effort. So, the StateMap and FedMap projects respond to differing needs and cultures, yet draw from the same funding base.

The EdMap element seeks to increase the number of geoscientists interested and trained in field geologic mapping, despite the general trend in earth science education and student interest away from mapping exercises and towards process-based science. The EdMap program seeks to unite these two complementary aspects of field geology.

Given the great diversity in priorities and the limited funding, the review panel found that the NCGMP program has been highly effective in balancing these issues. Overall the program is addressing local and national needs in a cost-effective manner. This conclusion is reflected in the PART reviews, the Federal Advisory Committee reports, and the comments from the state, federal, and industry stakeholders.

## *2. The quality of the science in the NCGMP program is excellent*

The consensus opinion of the review panel is that the overall quality of the science and technology sponsored by the geologic mapping program is first-rate. During the review, the panel was given an opportunity to listen to a diverse set of presentations that highlighted expertise ranging from the specialized skills and knowledge required to produce new quadrangle maps, to the scientific expertise that enables basic scientific research. Obviously, these projects are only a small fraction of the many funded by the mapping program, but the panel believes they are emblematic of a portfolio of high quality technical projects conducted by talented geoscientists. To a significant degree, this outcome was expected due to the good reputation earned by the



USGS among peer groups.

Presentations during the review were of generally high quality. All were informative and well delivered, but future reviews would benefit from a better explanation of how each presentation fits into the program's strategic goals and perhaps a more detailed description of the decision-making process and strategy that arrives at the portfolio of projects funded by the program. Testimonials by several end-users of products provided by the mapping program were a highlight of the agenda. Significantly, most of these "customers" lauded the technical quality of the work, while consistently expressing a still unfulfilled need for these products. We also appreciate the fact that many busy people, some of whom are not funded by the program, took the time to participate in conference calls or fly in for their sessions.

### *3. The USGS products have societal value, even as societal needs change and evolve*

The products of the NCGMP - geologic maps in print and digital formats - are fundamental to US science and society. As concluded in a 2001 report by the National Research Council, "the most important of all geologic records are geologic maps. Geologic maps are the primary foundation for a broad range of science investigations to land use planning." As such, the mission of the NCGMP –"the production of a geologic map data base for the Nation" – is cardinal within the USGS.

The scientific and societal impacts of the NCGMP have greatly expanded beyond their primary importance previously in mapping the location and extent of the nation's energy and mineral resources, although these functions still remain important to the nation's economy and well-being and are part of the NCGMP portfolio of activities. Today, the primary importance of the maps produced by NCGMP is to inform decisions based on the best science regarding hazards and the nation's water resources. Specifically, the maps are critical to evaluation and policy regarding the state of the nation's groundwater aquifers, the impacts of such hazards as climate change, earthquakes, volcanic eruptions, coastal erosion, landslides, flooding, and subsidence, and the geologic context for sustaining ecosystem structure and function and our natural resources. Being able to predict the timing and consequences of such hazards and natural catastrophes is vital to the nation's economy, infrastructure and way of life. For example, landslides and mudflows from volcanoes are risks to local communities, transportation networks and powergrids. Earthquakes cause liquefaction of soils, collapse dams and generate massive floods and fires. Secondary products, such as vulnerability maps, are critical for

land use planning. Among other services, they can identify areas of artificial fill and water-laden sediments that are hazardous for construction and earthquakes; or playas and dunes that are source material for dangerous dust sand storms; or poorly cemented soils and sediments that would be prone to erosion during storms and floods. In this regard, the NCGMP's FedMap and StateMap programs are working with the USGS hazards programs, other federal agencies, such as the U.S. Forest Service, and various state agencies. Examples here include Oregon and California StateMap projects involving hazard zonation for landslides and earthquakes; the karst mapping program to identify sinkhole areas in the Shenandoah Valley; the mapping of potential landslide areas in southern California national forests; and the mapping of the urban corridor in the Pacific Northwest to hazards such as landslides in the Puget Lowlands. Another example comes from the recent high profile USGS-led commemoration of the centennial anniversary of the great San Francisco earthquake, which derived its baseline 3-D geologic map of the SF Bay area from a FedMap effort. This 3-D map was the basis for the entire seismology community's landmark simulations of this 1906 event.

In addition, the mapping program serves the National Park Service in resource management, and the EdMap component is essential to training the next generation of geologic mappers, thereby maintaining the nation's expertise in a vital skill that has been in danger of disappearing at US universities. The StateMap component leverages 1:1 funding for mapping quadrangles that are the highest priorities of individual states for mitigating potential hazards, managing ground-water supplies, and planning land use.

In sum, the review panel finds that the NCGMP has adapted well to the nation's current and future needs by prioritizing areas to be mapped that are significant for provision of hydrological resources, assessment and management of a variety of geologic hazards, and managing the lands of the National Park Service.

Finally, the increasing production and availability of the geologic maps and their associated data in interoperable digital formats is revolutionizing their accessibility and enhancing their impacts on science and society in geological and other disciplinary domains. Digital information most easily enables investigators to turn description into powerful prediction through application of a variety of computer-mediated analyses and modeling algorithms. Examples include detailed measurement and modeling of land use, land cover, soils and biotas, mapping coastlines, detecting and analyzing chemical compounds in soils and groundwater, and forecasting and visualization of environmental phenomena under different scenarios of change.

Therefore, the review panel strongly recommends that the conversion from print and PDF to GIS/digital formats occur with increasing speed in the solicitation, receipt and serving of map information. Specifically, in the StateMap component, we strongly recommend that, if possible, the NCGMP begin to require in its guidelines and RFPs that StateMap products be submitted and served in multiple, modern, standard, web-deliverable, GIS geospatial formats, such as Shapefile, AutoCad, ARCview, and others, for multiple applications and secondary products.

## **B. Opportunities for Improvement**

### *1. Managing expectations and communicating with partners*

While the various stakeholder groups (state agencies, federal agencies, private sector, the Federal Advisory Committee) regard the program as being highly effective, there were concerns expressed about the priorities, performance metrics, and balance of the program. The review panel did not interpret this as dissatisfaction with the overall program. Rather, it reflects the stakeholders' recognition that they did not know or participate in setting the overall vision, goals and priorities of the program. For example, at the state level, some respondents believe that the program should prioritize the production of basic geologic maps and that FedMap should also reflect this focus. Other states want a focus on derived products and enhanced usability. From the federal perspective, the FedMap program needs to reflect the typical USGS program combination of research and geologic map production. Some members of the Federal Advisory Committee (FAC) commented that the recommendations they made in their annual report were not translated into program priorities. While the FAC recognizes the different goals of StateMap and FedMap, they would like a discussion of prioritization and resource allocation. Some members also believe the productivity of FedMap, as measured by the number of geologic maps produced, is not consistent with its funding.

The review panel did not see these concerns as indicating poor performance of the program, rather it sees the concerns as expressions of committed stakeholders and participants who relate strongly to the program but who do not have a clear sense of the overall priorities of the program, and don't believe they have had appropriate input to setting these priorities. Paradoxically, while almost everyone believes the actual work accomplished in NCGMP is high quality and cost-effective, they are unclear and uneasy about how the program priorities are set and project decisions made, both strategically and tactically.

The primary recommendation of the review panel is therefore not directed at a concern about the quality of work accomplished, rather at the stakeholders' understanding and input to the program vision and priorities. While everyone understands that the budget limits what can be accomplished, they want more input into the discussion. Actually, the NCGMP program leadership should be commended for actively soliciting and including stakeholder input, but it is perceived to be ad-hoc and episodic. The review panel therefore recommends a more formalized process to solicit input and engage the stakeholders in discussion and decision about the mission, priorities, and resource allocation within NCGMP. This process should be open and inclusive, and should engage an independent facilitator to lead the discussion. This process will ensure all stakeholders are formally and visibly able to provide input, so that while they may not necessarily agree with the final outcome and priorities, they will have buy-in and perceive it as representing the community's views. It will formally articulate and balance the differing goals and priorities of the various constituencies. It will explain and discuss the federal USGS program culture, processes, and multi-year project timelines, the unique matrix management approach resulting from the partnering and leveraging of multiple agency funds (which results in project selection that is opportunistic), and the move towards having a small number of coherent thrusts per region. It will address the tradeoffs at the state level and differences between the states regarding priorities for basic geologic mapping and developing GIS-enabled systems and derived products aimed at a broad range of users, from geologists to planners to the general public. This area is actually already covered in the excellent annual meetings related to the National Geologic Map Database, but would still benefit from a discussion that includes all the stakeholders. The discussion could and should lead to allowing StateMap funds to be used for digitization and derived products, which are presently precluded. It will allow discussion of an issue raised by some stakeholders of the perceived current bias towards urban projects (which is related to the federal priorities to address societal and human impacts).

This mediated discussion should address the vision, priorities, and project selection processes of the overall NCGMP program. The discussion should be repeated at intervals, perhaps in concert with the 5-year planning cycle, with a mid-cycle update.

Allied to this community consensus-building process, the review panel recommends a regular independent external review of the program, in addition to the oversight by the Federal Advisory Committee. The FAC is actually designated by the enabling legislation as the program review body and its composition is legislatively defined to include the stakeholder agencies and groups. It is somewhat ironic therefore that the one major concern expressed in the PART review was the lack of independent review of the program. As the

FAC composition cannot be changed, establishing a separate external review committee will address the PART concerns.

## *2. Budget considerations*

Concerns about the overall budget for the mapping program and how this budget is partitioned among the major components of the program add to tensions described in the following section. Our impression is that the overall funding level for the program is unlikely to increase significantly in the near term, so planning should proceed with the current budget limitations in mind. Clearly, it seems that holding on to an objective of producing 1:24,000 geologic maps for the entire country is unrealistic given the pace at which they can be produced and the budget available.

In a matrix management scheme like the one adopted by the USGS and perforce used by the NCGMP, it is difficult to smoothly balance the assignment of personnel while simultaneously meeting the defined needs and objectives of programs. Compromises that affect both the costs of the program and decisions about which projects to support are nearly always necessary. Additionally, it is essential to look beyond the existing expertise of the staff and their current assignments to prepare for meeting the next set of programmatic assignments, but doing this often involves making difficult decisions about the allocation of resources. The review panel believes that it would be very valuable for the program to develop a clear description about their funding philosophy (for FedMap in particular) and to clearly communicate this strategy to stakeholders both inside and outside the program. Improved communications may be especially beneficial in helping to reduce stress related to the partitioning of efforts within the FedMap program between applied efforts and relatively basic-science applications like the program's participation in the project to investigate the Chesapeake Bay Impact Crater.

## *3. Tensions*

The panel notes that there are a number of sources of tension in the NCGMP. Such tensions are not at all surprising in a program the size of NCGMP, particularly because it includes very disparate elements. Sources of tension noted by the panel include the following issues:

a) Basic geologic maps versus derived products

The Reauthorization Act for both the federal and state components directs that the objective “shall be to establish the geologic framework...” This direction is broad enough to include both basic geologic mapping and also the development of derivative products such as information of distribution of fractures, the hydrologic character of the area mapped, or the vertical distribution of units. However, most states and the American Association of State Geologists (AASG) have interpreted the Act’s primary goal to be to complete basic geologic mapping of the entire United States at the 7-1/2 minute quadrangle level.

b) Geologic mapping versus research that leads to improved geologic maps

The NCGMP supports both basic geologic mapping as well as projects of a more fundamental nature that provide a broader context for understanding the geology of regions. Examples are the investigation of the Chesapeake Bay Impact Crater. The investigation of this event led to improved understanding of the hydrology of the Virginia Coastal Plain.

c) Short (one year) deadlines (StateMap) versus five year project plans with less clearly defined objectives and deadlines (FedMap)

Under StateMap, funding is provided for a one year time period with states required to produce a product at the end of the one year of the award, while under FedMap, projects have a five year lifetime. The deliverables and schedule under FedMap are also more relaxed than those under StateMap.

d) Goals of states versus goals of USGS/Geologic Discipline (GD)

NCGMP supports groups with very different mandates and approaches. The states are very focused on solving specific problems within their jurisdiction. The USGS/GD has a tradition and staff that is focused on carrying out research. USGS/GD is focused on the solution of national problems, but it is a different focus than the direct development of geologic maps that are the focus of the AASG.

In general we think that the Program managers are successful in balancing these tensions in many instances and areas. However, the Program could do more to promote the understanding of the different roles of the various participants in the NCGMP. We recommend several actions to promote this better understanding: 1) Implement a more open process in the selection of FedMap projects. The review panel for FedMap projects includes state geologists, Survey scientists, and academic scientists. This part of the process appears to work very well. However, the process leading up to review is a critical part of the selection process and this

appears to happen “behind closed doors” in discussions between NCGMP managers, the scientists proposing the work, and their team leaders. It appears that input from a broader community at this critical juncture in the process would be beneficial. Likewise, at the other end of the process, it appears that NCGMP would benefit from additional communication to NCGMP participants regarding the decisions and the reasons for the decisions made for FedMap. 2) Implement a truly independent advisory committee, as discussed on pages 7-8. While NCGMP does have a federally mandated advisory panel (the FAC), the membership of this panel is specified in the enabling legislation. Eight of the ten members dictated by the Reauthorization Act are individuals with responsibilities for the program or individuals that receive funding from the program. While NCGMP has to keep the mandated Federal Advisory Committee, we recommend that the NCGMP task a truly independent group to periodically (annually) review the program and provide additional advice.

Regarding other identified tensions, we think they are generally a reflection of the involvement of a healthy diversity of interests and aims in the program, and we do not recommend that the program attempt to resolve them by moving strongly to either side.

#### *4. The process for choosing proposals to fund is unclear*

As discussed above, a number of essential tensions exist within and between the FedMap and StateMap programs with regard to how projects are proposed, reviewed and chosen for funding. Ideally, although FedMap and StateMap are separate programs, economies of scale and more efficient and timely accomplishment of high-priority national and state mapping needs could be achieved through a closer collaboration between the two programs.

This recommendation is driven by examples of excellent collaboration and complementarity in previous and ongoing projects, in turn formulated through a series of needs assessment workshops concerning the Middle Rio Grande, the Bedrock Regional Aquifer Systematics Study, the Great Lakes Coalition, and Death Valley. These examples should serve as a model for the submission, review and funding of future projects in the FedMap and StateMap programs. FedMap also collaborates well with other federal units, such as the National Park Service. In other words, this committee recommends building on success, while still preserving the ability to fund high priority individual projects in each program. Critical here is a well-balanced portfolio, in which each funded project hews to and serves the highest priority goals of the FedMap and individual

StateMap strategic plans.

Implementing a greater degree of collaboration and complementarity between the two programs will require evolutionary changes in the solicitation, review and awarding of FedMap and StateMap project proposals. Under the current solicitation guidelines, StateMap projects are proposed according to the state-level priorities determined by state committees, typically with little reference to FedMap projects.

At the same time, FedMap projects “bubble up” from the interests of individual NCGMP scientists or team leaders with little reference to proposed or ongoing StateMap projects, or, indeed in some cases, the NCGMP strategic plan. A good example is the Chesapeake Bay project, the science of which is not in question - it is a given that the science behind all NCGMP mapping projects is excellent. Although the Chesapeake Bay project also advances 3D geospatial analysis, simulation and visualization, it is “farther afield” in fulfilling the FedMap mission, as admitted by NCGMP staff. The question, therefore, as also asked by the FAC, is whether such a research project properly belongs in the NCGM program or in another USGS unit/budget.

In general, then, one of the most serious concerns of the FAC, echoed here by this review panel, is that the “bottom-up” process by which FedMap projects are proposed, reviewed and awarded is, in some cases, neither transparent nor obviously tailored to fulfilling the strategic mapping priorities of the FedMap program.

The review panel recommends that the NCGMP consider implementing the following changes, perhaps on a phased-in schedule, in the FedMap and StateMap process for solicitation, review and awarding of projects in the interests of greater collaboration and complementarity.

- StateMap RFP guidelines should evolve to give a competitive advantage to those projects that simultaneously serve high priority needs of the state and NCGMP. The StateMap proposal review process should give significant weight to this criterion in deciding among otherwise equally meritorious proposals. Concurrently, the FedMap website should list projects conducive for StateMap collaboration, and FedMap scientists and team leaders should conceive FedMap projects that can engage such partnerships while serving FedMap priorities at the same time. Although this recommendation seemingly threatens StateMap and FedMap independence, it provides a win/win



solution and economies of scale to an otherwise seriously underfunded program. Essentially, through collaboration and complementarity, both FedMap and StateMap can accomplish high priority mapping goals more quickly than either can on its own. Further, through such collaboration, FedMap and StateMap might be able to resolve the either/or tension between the need to produce basic maps as well as derivative maps for societal benefit. A partnership could more easily produce both in tandem. For example, if a StateMap project will produce a basic map that requires a derivative map application, FedMap could produce the latter, particularly if it involves, say, aquifers or hazards that encompass two or more states.

- StateMap RFP and guidelines should begin to request that mapping products be delivered in multiple GIS formats for web serving, for quicker dissemination of the basic map information and development of derivative maps based on that information.
- The NCGMP should continue funding 2-year and 3-year StateMap projects, so that states have the option of developing longer-term strategic projects with both basic and derivative mapping products, or projects that encompass more than mapping a ½ quadrangle at a time
- In place of the current “bubble-up” process, FedMap should design and implement a more formal, transparent RFP process that requires meeting explicit criteria of collaboration and complementarity with StateMap projects as well as strictly serving FedMap’s strategic goals and mission. Proposals that best hew to these two criteria, among others, would be more competitive during the review process. Proposals that represent excellent science but are outside the strict scope of the FedMap program should be shopped to other appropriate USGS units or federal agencies. The FedMap proposals should be reviewed by an impartial panel of experts from academia and industry that have no vested interest in the outcome and cannot be perceived to have any such interest.

Finally, these recommendations for StateMap and FedMap proposal generation and review are given in the larger context of, and recommendation for, a balanced portfolio approach by the two programs in meeting their strategic plans and goals. Essentially, in each budget year, both programs could “fence” resources for (1) collaborative, complementary projects and (2) highest priority stand-alone projects or for projects that partner with other agencies and institutions.

### **III. Answers to Specific Questions Asked by NCGMP in the Statement of Work**

#### **Question 1a: Is the National Geologic Map Database (NGMDB) effectively distributing geologic map information to users and decision-makers?**

This question is addressed on two levels. At a high level, the NCGMP (via the NGMDB) is effectively distributing geologic map information. This is evidenced primarily by the continued increase in the number of federal and state map products being inventoried and made available via the NGMDB, and the corresponding high levels of traffic on the program website. However, the timetable by which map products, particularly from the FedMap component, are being made available is not satisfactory. It was indicated that there is a lag time of up to 3 or 4 years for FedMap map products to be published and released. Feedback from the user community emphasized the immediate, pressing societal need for these products. The users interviewed expressed a desire for gaining access to these map products sooner, even if it meant that such products were released in a preliminary form, with appropriate caveats regarding appropriateness of use. The final published versions could then be released later as documented updates. While the USGS may be constrained in some ways by federal publishing and document release regulations, every effort should be made to investigate viable options for improving the delivery time for individual FedMap products. This is discussed in further detail in the response to Question 2.

More specific to the effectiveness of the NGMDB itself as a map information distribution mechanism, the components of the NGMDB web site are adequately providing users with access to the map products and associated geologic map information such as geologic terms and names.

The Map Catalog, Image Library and Geologic Names Lexicon provide users with a range of interface options for acquiring and viewing geologic map data. However, the overall appeal of the NGMDB site could benefit from a more modern web site design. The beta version of the new map-based interface that was demonstrated looks to be a step in the right direction, as is the Google Earth interface. NGMDB staff are encouraged to continue to evaluate and implement emerging web technologies to improve both the functionality and the overall “look and feel” of the web site. There may be opportunities to leverage specific technologies or components developed by other members of the geologic community (e.g., Kentucky’s KGSGeoPortal).

Where feasible, this sort of leveraging should be strongly encouraged. Refinement of the site might also benefit from an evaluation by an external organization that specializes in professional web design, as those skilled in developing the functionality for web applications are not necessarily as well suited for developing the high-quality graphics and layouts that make a web application look and feel really professional and useful to users.

**Question 1b: Is it (the NGMDB) effectively developing standards and procedures for standards, data collection, preservation, and exchange?**

Yes. The USGS' longstanding leadership role in the standards development process within the geologic community is to be commended. Standards development when done properly is a difficult and time consuming process that requires focused attention to garner broad-based input and resolve differing perspectives. The NCGMP should continue to actively press for developing and implementing standards at all levels – cartographic, data model, data exchange, metadata, and data capture. The existing NGMDB documents that provide guidelines are a good start in lieu of formal standards: “Guidelines for publication of digital geologic map products and inclusion of such products in the National Geologic Map Database”; and “Guidelines for digital StateMap products”. While more definitive standards-based requirements are being developed, the USGS should do all it can to encourage adherence to these existing guidelines, especially within the FedMap component over which it has the most direct control. In particular, the need for providing geologic map products in GIS-compatible data exchange formats (e.g., Shapefile, AutoCad, etc.) should be emphasized.

It is encouraging to see that, after many years of work, the cartographic standards for geologic maps are in the final stages of FGDC approval with official release set for Fall 2006. The standards issues with respect to geologic terminology are more difficult to resolve. They are particularly challenging due to the wide range of common usage by geologic scientists depending upon the region, level of detail, and particular purpose of each map that is produced.

This warrants the focused attention that is being paid in order to yield map products that can be used more readily and appropriately for decision-making.

Although detailed discussions about the status and progress of the North American Geologic

Map Data Model (NADM) were not within the scope of this review, a brief inspection of documents produced by the NADM Steering Committee (on which USGS staff sit), and associated documents authored by USGS staff for the Digital Mapping Techniques Workshops, indicate that significant progress is being made in this area as well. Creation and adoption of a standard geologic data model will greatly help to make geologic maps more useful to a wide range of end users. Standards regarding both the data model content and specific physical encodings (e.g., GeoSciXML, ESRI Geodatabase, GML) are critical. The USGS' role in continuing to advocate and lead in this area will be of high societal value.

With respect to data collection, the NCGMP should continue its efforts to promote the use of new technologies and techniques for improving the efficiency of geologic map production as well as the accuracy of the map products. The downward trend in the number of person-hours required to produce a map shows good progress in this area.

Lastly, although the issue of standards related to data preservation was not a particular focus of the panel review, it was noticed that the USGS has just released (October 10, 2006) the "Implementation Plan for the National Geological and Geophysical Data Preservation Program".

This effort, being conducted in coordination with the NCGMP, is evidence of the integral role the NCGMP is currently and should continue playing in this area as well.

## **Question 2: How can the Program better serve geologic information to customers?**

A clear message that we heard from users of the geological maps and the derivative products, as well as USGS staff, is that timely delivery of the information, even if it is in preliminary form, should be a top priority of the Program. In fact, for many users, timely release of the information in printable form is viewed as more important than delivery of the preferred digital form.

Currently there is wide variability in the timeliness of product release. We understand that states like Nevada

can release preliminary maps on their web site very rapidly whereas the USGS can release maps only after the publications group has done thorough cartographic editing, which can take from one to three years after final scientific review. We recommend that the USGS rethink current policies and procedures relative to the dissemination of products, with the goal of achieving as rapid a release of geological maps as possible. We live in an information age and users expect to have as close to instantaneous access to data and information as possible. We base our recommendation not only on the stated desire of users of geological maps but on broad experience with other programs that deal with information and that have grappled with the issue of timeliness in release of data.

It is widely accepted that scientific results from work funded by the US Federal Government should be publicly available in a timely fashion. The NIH<sup>1</sup> states: “Recognizing that the value of data often depends on their timeliness, data sharing should occur in a timely fashion.” In the environmental science arena, the NSF long-term ecological research program has the following stated policy<sup>2</sup>: “Data and information derived from publicly funded research in the U.S. LTER

Network, totally or partially from LTER funds from NSF, Institutional Cost-Share, or Partner Agency or Institution where a formal memorandum of understanding with LTER has been established, are made available online with as few restrictions as possible, on a nondiscriminatory basis. LTER Network scientists should make every effort to release data in a timely fashion and with attention to accurate and complete metadata.”

At least some programs within the USGS have recognized that timely release of information is important and have gotten exceptions to requirements of “final” checking and approval before any release is possible. One example with clear analogies to geological mapping is the exception from early release of information applied to topographic maps<sup>3</sup>: “*National Mapping Division*.

<sup>1</sup>[http://grants.nih.gov/grants/policy/data\\_sharing/data\\_sharing\\_guidance.htm#time](http://grants.nih.gov/grants/policy/data_sharing/data_sharing_guidance.htm#time)

<sup>2</sup> <http://www.lternet.edu/data/netpolicy.html>

<sup>3</sup> <http://www.usgs.gov/usgs-manual/500/500-14.html>

Copies of unpublished or partially completed topographic maps, image products, and associated cartographic data in graphic and digital form including geodetic control survey data, elevation data, reproductions of space and aerial photographs, and copies of color feature separates.” When the rapidity of information release is improved in a program, data use typically grows extensively. For example, when the USGS began making real-time stream-gauge data available on the web, the user base for the information increased substantially.

An objection that may arise is that geological maps include much interpretation – they are, by their nature, much more than “data”. We do not find this to be a compelling argument for withholding information until all scientific and editorial checks have been completed. The policy statement of the global change research program adopted in 1991 remains in effect today and provides clear guidance to the approach that we advocate<sup>4</sup>.

“Deciding when data become widely useful is the responsibility of the funding agency, which should explicitly define the periods of restricted access, if any. In the past, some Principal Investigators have retained data for indefinite periods and this has inhibited their widespread use. This practice should be eliminated through active consideration of the tradeoffs between widespread distribution of data sets and the need to assure data quality and validity. The guiding principle is that as soon as data might be useful to other researchers they should be released, along with documentation which can be used by the other researchers to judge data quality and potential usefulness. In this way, users can determine for themselves if they want to proceed with data of questionable quality or wait for additional developments.”

Note that the key element relating to the geological mapping issue is that early release should be accompanied by documentation that allows users to judge the confidence they may place in the information so they can determine for themselves if they want to proceed with data of questionable quality or wait for additional developments.

<sup>4</sup><http://globalchange.gov/policies/diwg/dmwg-gcp.html>

We also recognize that USGS scientists have a vested interest in retaining proprietary rights to data until they have had a chance to publish key results. The tension between the rights of scientists and early release of information should be recognized, but it should not prevent enactment of a policy for timely release of information. Again, note that the policy for the global change program anticipates the dilemma and specifically states that federal agencies should *explicitly define the periods of restricted access, if any* so that investigators can not and do not sequester information indefinitely.

We recommend that:

- the Geological Mapping Program of the USGS publicly acknowledge that timely release of information is a primary goal;
- the Program leaders actively seek to gain an exception to the USGS restraints on pre-publication release of information<sup>5</sup>;
- the Program work with stakeholders (including USGS scientists as well as State geologists and private-sector users) to develop a formal policy on timely release of geological maps, including periods of restricted access; and
- the NCGMP begin implementing in its StateMap RFP a requirement that map products be delivered in the four or five most useful GIS digital formats for serving on the web and production of derivative map products.

**Question 3: What role should the Program take in producing derivative products to meet the needs of society?**

The NCGMP was created to produce, and still has a role in producing, core geologic maps for the country. The prioritization of areas to be mapped is based on societal needs. Many of the customers of the NCGMP products who were interviewed during the review clearly valued derivative products and expressed their increasing need for them. Future programmatic

<sup>5</sup>This seems to us to be an obvious action given the following USGS statement ([http://www.usgs.gov/usgsmanual/](http://www.usgs.gov/usgsmanual/500/500-14.html)

[500/500-14.html](http://www.usgs.gov/usgsmanual/500/500-14.html)). “To satisfy the public need for timely information, formal publication or other approved methods of release should be accomplished as promptly as possible. When there is an immediate demand for USGS data and prompt publication is impossible or unlikely, the material should be released in open-file format, including appropriate announcements, and where applicable, the reports thus released should contain an adequate statement of their preliminary nature and that the information may be subject to change.”

prioritization should reflect that need. The program has an uneven approach to the development of derivative products with some states doing so, and other states sticking to the production of basic maps. To some extent this reflects the variation in the state of geologic mapping in the country. States with extensive coverage by geologic maps are interested in taking advantage of

StateMap resources to develop other needed products, while states with less complete geologic map coverage want to restrict the program to basic mapping. There is clear value in continuing to carry out the core geologic mapping that is the basis for derivative products and the development of more complete understanding of the structures. The mission of the NCGMP as laid out in the Authorization Act clearly requires a broad, not narrow, approach to meeting the nation’s need for geologic maps. This is most clearly laid out in the guidelines for the Federal Component. However, there is nothing in the Act to prevent states from using StateMap funds to develop derivative products if required to meet societal needs. These concerns spring from differing views of the goals of the Program as discussed above (see Tensions section). As discussed there, greater involvement of all concerned in the planning and decision-making process will help address these concerns.

There is no one answer that will satisfy all states or all participants in the NCGMP. Given the great diversity of needs, NCGMP has to incorporate all. StateMap proposals can be a guide for the most pressing derivative product needs. We recommend, as we have above, relaxing the AASG StateMap rules to allow states to do derivative work. Geologic maps have evolved beyond a single geologist mapping a single quadrangle in isolation. State needs and societal problems are increasingly requiring multidisciplinary approaches to problem solving, and collaborations between all parties with expertise will be the key to rapid solution of national and state problems. These collaborations should include resources and people from both the StateMap and FedMap sides of the program and we encourage increased coordination between FedMap and StateMap products. This collaboration and cooperation will result in more opportunities for everyone and more effective utilization of all NCGMP resources.

**Question 4: What are the barriers, if any, that inhibit integration of geologic and derivative maps to applied scientific studies useful to land-use managers?**



Overall, the geologic and derivative maps being produced through the NCGMP serve a critical function as basic scientific inputs for studies that address a wide variety of societal concerns, including hazard mitigation, water resource protection, mineral exploration, and other land-use management issues. However, a number of barriers were identified that limit the efficient and effective integration of geologic maps into the problem-analysis and decision-making processes.

The most important barrier is that many of the older geologic maps are not available in a GIS-compatible digital format. Although some users interviewed indicated that a digital GIS format was not essential for the maps to be useful at a base level, all agreed that it would be of high additional value. Whereas the true value of having geologic maps in a GIS format is difficult to quantify, land-use decisions are now commonly made using some form of digital mapping and geospatial analysis.

Geologic maps are only one of a number of inputs typically evaluated in digital form that are relevant to a particular land-use, resource, or hazard issue. An analysis of the spatial coincidence and relationships among the various inputs is almost always required to obtain a clear understanding of the area of study. Most users have access to even simple GIS programs that provide basic spatial overlay and attribute identification features, and many other thematic layers (e.g., land ownership, streets, surface hydrology, political boundaries, etc.) are typically already available in GIS format. If the geologic map is not in a GIS format, such spatial analysis becomes more difficult, error-prone, and/or costly. Either the end user must undertake the digitization process himself/herself, or the analysis is performed in a more manual and likely less precise fashion.

Because of the additional value that digital products provide, the NCGMP is encouraged to carefully assess proposals in all of the components, and provide an appropriate level of support for some number of projects that involve the digital conversion of areas mapped prior to the availability of GIS technology. In many of these cases, the updating process will yield the additional benefit of improving the original map product in terms of both spatial and thematic accuracy. The prioritization of such digitization efforts relative to new mapping should be determined based on overall societal need, and opportunities to leverage resources at the state and federal levels.

In addition to the traditional hardcopy and plot-file deliverables, the NCGMP, as recommended above, also is strongly encouraged to require GIS deliverables in one or more of the common GIS-compatible formats for all of the program components. For practical reasons such a requirement may need to be phased in over a period of time to accommodate some map producers that are late adopters of GIS technology. But the technology is sufficiently mature that it is certainly reasonable to demand this at the present time. Some of the state representatives interviewed indicated that part of the reason that some state geological surveys have not adopted GIS technology is that there has not been a sufficient force compelling them to do so. It was indicated that a requirement by the NCGMP would likely have a positive impact in this regard.

During the panel discussions an issue was raised regarding the capacity of USGS staff to adequately review the GIS deliverables. Specifically, the concern was that USGS does not have the full range of GIS software applications packages necessary to properly review digital GIS submissions in all of the various GIS file formats. One option is to require that digital GIS deliverables be in one (or more) of only a couple of the most common formats. USGS would then need only to acquire the necessary software and expertise to accommodate these few. In practice, this may not really require much additional expense, as most GIS software packages (such as ESRI products) will support conversion into their format from most of the other major formats. Furthermore, robust GIS file translation software exists (e.g., FME from SAFE Software) that can easily convert among nearly all of the various GIS file formats if there is a concern about not wanting to limit the format of required GIS deliverables in any way. The requirement for hardcopy and plot-file deliverables would still remain as well, providing additional resources for USGS to validate the GIS deliverables.

In any event, existing USGS GIS capacity should not be the limiting factor in moving forward with the adoption of digital GIS file requirements for geologic map products. Indeed, although not required by the NCGMP to do so, many producers are already using GIS to create their hardcopy and plot-file deliverables. And it is likely that these GIS files themselves are the products that are regularly being relied upon by end users and decision-makers. So, at a minimum, when the hardcopy and plot-file deliverables are produced with a GIS program, the NCGMP should be requiring (and reviewing) submission of the GIS files they were derived from as well.

For map data that are currently available in GIS format, there is an additional barrier due to the fact that a standard geologic data model and associated nomenclature and symbology for geologic maps have not yet

been adopted by the U.S. geologic community. Without such standards in place, users will end up spending more time and effort manipulating and properly interpreting each individual map file. USGS' role in advancing geologic map standards has been noted above and is acknowledged again here. The NCGMP should continue to actively promote the creation and adoption of relevant content standards for geologic maps.

Another barrier relates to the inherent complexity of geologic maps. Derivative map products that are focused on specific issues like hazard probability are often more directly useful to decision-makers than the geologic maps themselves. Scientific background and experience is necessary for proper interpretation of the geologic maps in order to create such derivative products. The NCGMP should balance program effort between derivative products, and basic mapping, taking into account that as derivatives can be created by the end users in the private and public sectors. However, for particular regional initiatives, especially where there is potential for collaboration among the FedMap, StateMap, and EdMap components of the program, derivative products are a very useful addition to the basic mapping that is accomplished via the NCGMP. They directly benefit society by providing insight into fundamental issues that might not be feasible to address by any individual state or local entity. The current balance in the NCGMP between basic mapping and scientifically-driven analyses of particular problems (e.g., Chesapeake Bay Impact Crater, Edwards-Trinity Aquifer, etc.) seems reasonable. But this balance should be re-evaluated on an ongoing basis given evolving societal priorities and changes in program funding levels.

Lastly, a single geologic map at a particular point in time is not suitable for supporting all current and future land-use decisions nor does a single geologic map always provide sufficient information to pursue basic scientific studies. Maps of surficial deposits inform one set of issues, while complementary bedrock maps are useful for others, and the scale of older maps may not be suitable for current decision-making purposes. In addition, older maps produced when scientific knowledge about plate tectonics and other geologic processes was not as advanced, and when older, less precise mapping techniques were used, are not as useful today as they could be. Also, in some regions, including along state boundaries, older geologic maps may not be edge-matched to one another, limiting their usefulness for regional analyses. So a balance must be struck between conducting new mapping in areas not previously mapped at all, versus updating previously mapped areas. Addressing these factors enhances the value of converting older non-digital maps into digital form as discussed above.

**Question 5: Are the scales of geologic maps and the detail on the maps meeting the demands of the users? Do 1:100,000-scale maps have a purpose?**

We heard from a variety of users of geological maps during the panel review and there appears to be a broad consensus that an adequate level of detail is being provided through the geological mapping Program, with the preferred level at the 1:24,000 scale. We also believe, however, that 1:100,000-scale maps have their uses (as do maps at finer scales) and they may sometimes be the only practical scale for mapping.

Given that geological maps are now (almost) universally produced in vectorized digital form, the question to address is not what appropriate map scale is, but rather what amount of resolution is adequate for different purposes. For geological maps, the number of traverses done across a given area traditionally has defined the map scale. That is, more field data are collected when mapping a quadrangle than when directly mapping an area comprising, say, some 16 quadrangles. In the former case, smaller features are resolved than in the latter case. With the use of remotely sensed data, the degree of resolution is not absolutely tied to the field observations, but it is still restricted to a large extent by the number of field observations (the “density” of traverses).

Most of the new maps being produced by the Program are at the 1:24,000-scale. The level of resolution implicit with these products is generally what the users need and want. Several

1:100,000-scale maps have been produced by “stitching together” underlying 1:24,000-scale maps. These products are not really different from the original maps in the sense that the supporting data and resolution are essentially the same for both. The “stitched-together” 1:100,000 maps do have intrinsic value, however, giving a more regional picture of the geology, which is exactly what some users need.

There are some cases where support of the base mapping exercise is appropriately at a scale different from 1:24,000. For example, mapping Alaska at the 1:63,360 scale is likely to be adequate and it may be the best resolution feasible given the land extent involved. Other sparsely populated parts of the U.S. may similarly be served well by mapping at the 1:100,000 (1:250,000 for sparsely populated areas of Alaska) scale. At the other end of the spectrum, there are specialized cases where an even finer resolution is desired. An argument can be made that in densely populated areas with critical hazard and water-resources issues, geological

mapping is needed at higher resolution than the usual 1:24,000 effort<sup>6</sup>.

In a slightly more expansive view of the question posed, we offer a few other observations. New tools that can have a significant impact on the creation of geological maps, and on the level of resolution, are constantly being developed. The NCGMP needs to adapt them as appropriate.

We understand that remotely sensed data are used routinely, but we do not know exactly how the products are used. Automatic feature extraction from images is widely used and, we believe, might be quite useful for generating geological maps<sup>7</sup>. In the future synthetic aperture radar data

<sup>6</sup>For example, see <http://www.isgs.uiuc.edu/3DWorkshop/2005workshop/troost2005.pdf>

<sup>7</sup>A question about mapping of the Moon at our review meeting was answered humorously by stating that field work was minimal. But in a serious vein, planetary exploration has led to development of tools that might prove to be valuable in Earth-based applications, for geological mapping in particular. It is interesting to note that USGS scientists have contributed to expert systems used to automatically “map” a spectral image of a planetary surface (Clark R.N., et al. 2003. Imaging spectroscopy: Earth and planetary remote sensing with the USGS Tetracorder and expert systems. *Journal of Geophysical Research-Planets* 108: Art. No. 5131). The Program should periodically assess whether such new tools could be used for helping to create geological maps.

from space-based platforms may provide very high-resolution information of use in preparing geological maps, at least in areas that are volcanically or seismically active<sup>8</sup>. Even seemingly arcane work in nonlinear geophysics may prove to have applicability to mapping in the future<sup>9</sup>.

#### **IV. Conclusion**

As we already have noted, we believe that the USGS National Cooperative Geologic Mapping Program is highly successful, providing critically needed information to a range of users. Given a positive review, it is almost expected that committees like ours will “recommend” that funding for the program be increased

substantially. We have refrained from such a recommendation because we do not have enough of a “big-picture” view to determine what trade-offs are involved in assigning increased resources to the NCGMP under alternate budget scenarios. We certainly do support the pending reauthorization of the Program and are heartened that the proposed funding authorization is well above the current appropriation.

The recent history of funding for the USGS and the near-term budget outlook given costly ongoing commitments by the Federal government suggests that agency budgets may not increase dramatically in the near future. We believe that it would be prudent for the program leadership to prepare a contingency plan for how to operate under a scenario of only modest budget increases over the next five years or so. We think that managers should not shy away from tough questions. Can the Program be sustained under current operating conditions? Is there an alternate business model that would enhance the operation? What is the minimum core cadre of permanent employees needed to be effective? We do not have answers to such questions, but we think that USGS leaders should consider them carefully. We encourage the leaders of the Program to work actively with others in their USGS matrix management sphere and with their state partners to create an implementation plan that (1) is faithful to the Geologic Division strategic plan and list of goals; (2) moves beyond the broad goals and establishes priorities for meeting a set of more specific goals (e.g., mapping in critical urban areas?); and (3)

<sup>8</sup>For example, see Burgmann R. 2000. Synthetic aperture radar interferometry to measure Earth's surface topography and its deformation. *Annual Review of Earth and Planetary Sciences* 28: 169-209.

<sup>9</sup>For example, see Stewart S.A. and T.J. Wynn 2000. Mapping spatial variation in rock properties in relationship to scale-dependent structure using spectral curvature. *Geology* 28: 691-694.

identifies criteria for making decisions about projects to fund and about possible reductions in the scope of the Program in the face of potentially flat budgets with escalating salary costs.

Even if the flat-budget scenario proves to be incorrect and increased funding is awarded to the

Program, we think that an explicit plan for setting priorities for the Program that has been discussed broadly amongst USGS scientists and State partners would prove to be useful to Program managers.

## **Appendix A: Visit agenda**

# **AAAS REVIEW OF THE USGS NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM**

**October 10 – 13, 2006**

**U.S. Geological Survey, Room 3B457**

**Reston, Virginia**

### **Tuesday, October 10 – Meet and Greet Dinner**

7:00-9:00 pm *Meet and greet dinner at M&S Grill, Reston Town Center* (Review Panel Members)

(Please meet in the lobby of the Homestead Suites Hotel at 6:30 pm)

### **Wednesday, October 11 - Program Projects and Partners**

9:00-9:30 *Welcome and introduction to NCGMP* (Peter Lyttle and Randall Orndorff, USGS)

9:30-10:00 *Presentation of National Geologic Map Database* (Dave Soller, USGS)

10:00-10:30 *Discussion of National Geologic Map Database* (Dave Soller, USGS)

10:30-10:45 Break

10:45-11:15 *Presentation and discussion of State activities on serving geologic data* (Jerry Weisenfluh, Kentucky Geological Survey)

11:15-11:45 *Discussion of USGS-State partnership of delivery of digital data* (Dave Soller, USGS and Jerry Weisenfluh, Kentucky Geological Survey)

11:45-12:45 Lunch

12:45-2:45 *Discussion with NCGMP Federal Advisory Committee* (Linda Gundersen, USGS; Jonathan Price, Nevada Bureau of Geology; James Robertson, Wisconsin Geological Survey; Robert Silva, U.S. Department of Energy; Carla Kertis, U.S. Department of Agriculture; William Siok, American Institute of Professional Geologists; Robert Hatcher, University of Tennessee; Roger Anzzolin, U.S. Environmental Protection Agency; Gene Whitney, Office of Science and Technology Policy, Executive Office of the President)

2:45-3:00 Break

3:00-4:00 *Presentations of NCGMP projects:*

Chesapeake Bay Impact Crater (Greg Gohn, USGS)

Edwards-Trinity Aquifer Study (Chuck Blome, USGS)

4:00-5:00 *Discussion of NCGMP projects*



## **Thursday, October 12 - Program Customers and Geologic Map Users**

9:00-10:30 *Presentations of NCGMP projects:*

3D Geologic Mapping, San Francisco Bay Area (Robert Jachens and Russell

Graymer (USGS)

STATEMAP, FEDMAP, EDMAP partnership, Massachusetts

(Steve Mabee, Massachusetts Geological Survey)

Karst Applied Research Studies (David Weary, USGS)

10:30-10:45 Break

10:45-12:00 *Discussion of NCGMP projects*

12:00-1:00 Lunch

1:00-3:00 *Discussion with Federal government customers and users* (Bruce Heise, NPS; Mary Lou Zoback, USGS emeritus; Ward Staubitz, USGS)

3:00-3:15 Break

3:15-5:00 *Discussion with geologic map users community* (Wendy Jones, Frederick County, Virginia Sanitation Authority; Jim Schmitt, County Materials Corporation, Wisconsin; John Shomaker, Shomaker and Associates, New Mexico)

## **Friday, October 13 -Follow-up Discussions and Wrap Up**

9:00-11:00 *Discussion EDMAP component and follow-up discussions* (Peter Lyttle, Randall Orndorff, and Laurel Bybell, USGS)

11:00-11:15 Break

11:15-12:15 *Closed-door discussions* (Review Panel)

12:15-1:00 Lunch

1:00-2:00 *Closed-door discussions and wrap up* (Review Panel)

2:00-3:00 *Debrief Program* (Review Panel with NCGMP)

## **Appendix B. Panelist CVs**

### 1. CURRICULUM VITAE - George M. Hornberger

Department of Environmental Sciences 308 Farm Lane

University of Virginia Charlottesville, VA

Clark Hall Tel. (434) 295-7459

Charlottesville, VA 22903

#### **Education:**

Ph.D. Hydrology Stanford University 1970

M.S.C.E. Hydrology Drexel University 1967

B.S.C.E. Drexel University 1965

#### **Employment:**

1991-present Ernest H. Ern Professor of Environmental Sciences, University of Virginia

2006-2007 Visiting Professor, University of California at Berkeley

2002-2006 Associate Dean for the Sciences, University of Virginia

1997-1998 Visiting Scientist, Institute for Alpine and Arctic Research, University of Colorado

1990-1991 Visiting Scientist, U.S. Geological Survey and, concurrently, Visiting Professor,  
Stanford University

1984-1990 Professor of Environmental Sciences, University of Virginia

1984-1985 Honorary Visiting Professor of Environmental Sciences, University of Lancaster,  
Lancaster, U.K.

1975-1984 Associate Professor (Department Chairman 1979 - 1984) University of Virginia

1977-1978 Visiting Fellow, Centre for Resource and Environmental Studies, The Australian  
National University

1970-1975 Assistant Professor University of Virginia

### **Current Research Interests:**

Catchment hydrology and hydrochemistry. My work has centered on the coupling of field observations with mathematical modeling. The focus has been to understand how water is routed physically through soils and rocks to streams and how hydrological processes and geochemical processes combine to produce observed stream dynamics. The modeling work allows the extension of work on individual catchments to regional scales. Some of my catchment work now addresses the issue of transport of colloids and associated contaminants through surface and subsurface pathways.

### **Society Memberships:**

American Geophysical Union

Geological Society of America

American Women in Science

### **Editorships:**

Associate Editor, Water Resources Research, 1982 - 1984

North American Editor, J. Hydrological Processes, 1985-1992

Editor, Water Resources Research, January 1993 - January 1997

### **Awards and Honors:**

Virginia Chapter of Sigma Xi, President's and Visitors' Prize, 1986.

Robert E. Horton Award, Hydrology Section, American Geophysical Union, 1993.

Elected Fellow, American Geophysical Union, 1994.

Appointed to five-year Visiting Professorship at University of Reading, UK, 1995

1995 Biennial Medal for Natural Systems, Modeling and Simulation Soc. of Australia

1995 John Wesley Powell Award for Citizen's Achievement (US Geological Survey)

Elected Fellow, Association for Women in Science, 1996

Elected to membership in the National Academy of Engineering, February 1996

1999 Excellence in Geophysical Education Award, American Geophysical Union

Bownocker Lecturer, Ohio State University, May 1999

ISI Highly Cited Researcher, 2000 (<http://authors.isihighlycited.com/>)

National Associate of the National Academies in recognition of extraordinary service, 2001

Langbein Lecturer, American geophysical Union, 2002

Elected Fellow, Geological Society of America, 2005

### **Selected Service on National Committees**

President, Hydrology Section, American Geophysical Union, 2006-2008

Chair, National Research Council, Board on Earth Sciences and Resources, 2002-present.

Member, Nuclear Waste Technical Review Board (Presidential Appointment) 2004-present

Member, National Research Council, Committee on Hydrologic Sciences, Aug 2000 –present

Member, Hydrology Section Executive Committee, American Geophysical Union, 1994-present.

Chair, Publications Committee, American Geophysical Union, 2000-2004 (member, 1998-).

Chair, Advisory Committee on Nuclear Waste, Nuclear Regulatory Commission, 2001-

2003 (Vice-chairman, 1997-2000; member 1996-2004)

Member, Board of Trustees, Virginia Museum of Natural History, 2000-2005

Chair, National Research Council, Committee on the Review of EarthScope Science

Objectives and Implementation Planning, 2001.

Member, Sandia National Laboratories Geoscience and Environment Center Advisory

Board, 1998-2004

Member, Idaho National Engineering and Environmental Laboratory, Geosciences

Advisory Board, 1998-2000

## 2. CURRICULUM VITAE - Kenneth J. Jackson

Laboratory Science and Technology Office, L-003

Lawrence Livermore National Laboratory

Livermore, CA 94550

### **Education:**

B.S., Geology, University of New Mexico, Albuquerque (1976)

B.A., Chemistry, University of New Mexico, Albuquerque (1976)

M.A., Geology, University of California, Berkeley (1979)

Ph.D., Geology, University of California, Berkeley (1983)

### **Positions Held:**

Research Assistant, University of New Mexico (1974-1975)

Research Assistant, University of California, Berkeley (1977-1983)

Teaching Assistant, University of California, Berkeley (1978, 1980)

Postdoctoral Fellow, Lawrence Livermore National Laboratory (1983-1984)

Chemist, Lawrence Livermore National Laboratory (1984-present)

Geochemistry Leader, LLNL WIPP/Salt Repository Activities (1986-1988)

Task Leader, LLNL Geochemical Modeling, Yucca Mountain Project (1987-1988)

Deputy Project Leader, LLNL In Situ Microbial Filters Project (1991-1995)

Project Leader, LLNL In Situ Microbial Filters Project (1996-1998)

Group Leader, Subsurface Flow & Transport Group, LLNL (1993-1997)

Division Leader, Geosciences & Environmental Technologies, LLNL (1997-2002)

Deputy Director for S&T Assessment, Laboratory Science and Technology Office, LLNL (2002-present)

### **Awards and Distinctions:**

W.A. Tarr Award, Graduation with Distinction, and Departmental Honors (Dept. of Geology, Univ. of New

Mexico); James M. MacDonald Fellow, Domestic Mines and Minerals Fellow (Univ. of California, Berkeley); US DOE Certificate of Appreciation from the Office of Geologic Repositories (1986); LLNL Performance Award for ES&H (2000); Society for Technical Communications Award for Excellence in Technical Communication (2004), Society for Technical Communications Southwest Region Competition Merit Award (2005).

**Patents:**

“Methods for Microbial Filtration of Fluids,” U.S. Patent #5,487,834

“In Situ Thermally Enhanced Biodegradation of Petroleum Fuel Hydrocarbons and Halogenated Organic Solvents,” U.S. Patent #5,753,122

**Professional Affiliations:**

Geochemical Society

Society of Economic Geologists

American Geophysical Union

American Association for the Advancement of Science

**Research Interests:**

Aqueous solution chemistry (thermodynamic properties of aqueous species, activity coefficients for aqueous species to high concentrations, effects of microbial growth on the inorganic chemistry of aqueous solutions, geochemical processes during the formation of hydrothermal ore deposits, solution chemistry of uranium), geochemical modeling (computer modeling and code development for calculating the geochemical consequences of irreversible water/rock interactions in a variety of geochemical environments), organic geochemistry (high temperature decarboxylation/oxidation rates for aqueous carboxylic acid species, experimental investigation of hydrous and anhydrous pyrolysis rates of hydrocarbons, chemical interactions between the organic and inorganic portions of naturally occurring aqueous solutions, measurement of the high temperature hydrous breakdown products of diesel fuel components), environmental geochemistry (in situ use of enhanced microbiological activity to remediate groundwater contaminated with fuel hydrocarbons and chlorinated solvents, thermally enhanced bioremediation of fuel hydrocarbon contaminants, development of environmental treatment options for the disposal of waste water from coal mining and coalbed methane production, assessment of nuclear waste disposal options in mined geologic repositories), science and technology management (management of the strategic investment of resources to further the development of institutional capabilities and core competencies).

## **External Review Panels & Committees, Workshops & Conference Sessions:**

Organizer (with W.L. Bourcier) of international workshop on geochemical modeling, 1986; member of National Science Foundation (NSF) panel for establishing a multidisciplinary program on biogeochemistry, 1994; member of DOE panel for writing a program plan for Natural and Accelerated Bioremediation Research (NABIR), 1995; member of organizing committee for Yucca Mountain Project (YMP) workshop on microbiological effects on nuclear waste disposal, 1995; invited participant in British Petroleum workshop to evaluate solutions to produced water problems, 1996; LLNL representative on DOE Site Technology Coordinating Group, 1995-2002; member of the Department of Energy's Environmental Management Strategic Laboratory Council, 1997-2002; co-organized (with P. Lichtner and C. Carrigan) AGU special session on vadose zone transport; chaired session on "Data Selection and Evaluation" Migration '99 Conference, 1999; Guest lecturer at UC Berkeley "Management of Nuclear Materials and Wastes" class (July, 1999); member of International Atomic Energy Agency (IAEA) sponsored Nuclear Energy Agency (NEA) committee for a critical review of thermodynamic properties of Zr (1999- 2002, chair 1999-2000); served as an external reviewer for Los Alamos National Laboratory's "Laboratory Directed R &D Program;" Cochaired (with Boris Fabishenko, LBNL) a special session at 2002 DOE-sponsored Technical Information Exchange Conference entitled "Remediation of vadose zone contaminants" Oakland, CA November, 2002; Review panel for DOE Environmental Management Science Program, 2005.



### 3. CURRICULUM VITAE - LEONARD KRISHTALKA

The University of Kansas

Dyche Hall, Lawrence, KS 66045

Phone: 785/864-4540; Fax: 785/864-5335

e-mail: [krishtalka@ku.edu](mailto:krishtalka@ku.edu)

#### **Biographical:**

Born: Montreal, Canada. Married (Beth), two children (Molly, Zack); US resident

#### **Education:**

*Texas Tech University* (1972-75): **Ph. D.**, 1975, Biology, Vertebrate Paleontology

*University of Kansas* (1971-72): Ph.D. Program, Systematics and Ecology [transferred to Texas Tech after 1 year to continue working with major advisor, Dr. Craig Black]

*University of Alberta*, Edmonton, Canada (1967-71): **B. Sc.**, 1969; **M. Sc.**, 1971, Zoology,  
Vertebrate Paleontology

*McGill University*, Montreal, Canada (1962-66)

#### **Professional Positions:**

*The University of Kansas* (1995 - present )

Director, Biodiversity Institute

Professor, Department of Ecology and Evolutionary Biology

*National Science Foundation, Washington, DC* (1992-1993)

Program Director, Division of Environmental Biology, for two research programs:

- *Research Collections in Systematics and Ecology*
- *Biotic Surveys & Inventories*

*Carnegie Museum of Natural History* (1975-1995)

Assistant Director for Science, 1989-1995 (leave of absence to NSF, 1992-1993)

Curator, Vertebrate Paleontology, 1989-1995

Editor, Scientific Publications, 1986-1995 (*Annals, Bulletin, and Special Publications*)

Associate Curator, Vertebrate Paleontology, 1980-88

Assistant Curator, Vertebrate Paleontology, 1977-80

Post-Doctoral & Research Fellow, 1975-77

***University of Pittsburgh (1976-1995)***

(Departments of Biology; Geology & Planetary Sciences; and Anthropology)

Adjunct (Asst., Assoc., Full) Professor

### **Awards:**

***CASE*** (Council for the Advancement and Support of Education) Special Merit Award for Excellence in Writing, 1984

***AAAS Fellow***: Fellow of the American Association for the Advancement of Science, 2002.

### **Professional Experience:**

#### ***US Government-Interagency Science Policy and Planning***

Chair, NSF-U.S. AID Biodiversity Steering Committee

U. S. Interagency Committee, National Biodiversity Center

U. S. Interagency Committee, National Biological Survey

UN *Diversitas* conference: *Worldwide Inventory and Monitoring of Biodiversity*

U. S. *International Workshop on Biodiversity Inventory, Survey and Data Management*

U. S. Interagency Committee, International Cooperative Biodiversity Groups

U. S. AID Planning Group for U.S.-Japan biodiversity centers

**National Science Foundation - *Science Policy, Research Planning/Assessment***

***Program Review:*** *Twenty-Year LTER Program Review* (Co-Chair, 2001-2002); *ITR Program* (2002); *LTER Program* (2001); *Division of Environmental Biology* (Chair, 1999); *Ecological Studies Cluster* (Chair, 1998); *Systematic Biology Program* (1991);

***Science Advisory Committee:*** *Directorate for Biological Sciences* (1999- 2004)

***Workshops:*** *Biodiversity Observatory Network* (1998; 1999 chair); *Tree of Life Initiative* (2000); *National Ecological Observatory Network* (2000); *Evo-Devo and Phylogeny* (2000);

*National Cyberinfrastructure for the Environment* (2003); *NEON Biodiversity* (2004); *Environmental Cyberinfrastructure* (2004).

***Research Review Panels***

*Biological Research Collections* (1998, 2000, 2002)

*BIO/POWRE* (1997);

*Biotic Survey and Inventory* (1994, 1995, 1997, 1999, 2000, 2003)

*Informal Science Education* (1994, 1995)

*Information Technology Research* (2002)

*NSF Learning Center* (1994)

*Research Collections in Systematics and Ecology* (1995, 1997)

*Research Training Groups* (1991, 1996)

*Ecology* (1994); *Systematic Biology* (1991)

**Institute of Museum and Library Services—*Review Panel***

General Operating Support program (1997, 1998)

**NAFTA - Commission on Environmental Cooperation**, North American Biodiversity Information Network, *Steering Committee* (1997-2003),

**NEON—National Ecological Observatory Network**, Senior Management Team (2003-2005);

Member of the Board, NEON Inc., (2006-present)

**Long-Term Ecological Research Network**, National Board (1997-2001)

Society of Vertebrate Paleontology (1973-2003)

**Research Interests:**

Science research policy and strategic planning

Museum/biodiversity center leadership and management

Global biodiversity informatics

Evolutionary biology of mammals; Evolutionary patterns, processes and theory

History of science

4. CURRICULUM VITAE –Frederick Pieper

**Frederick V. Pieper** – Director, Application Development and Data Management,

Institute for the Application of Geospatial Technology at Cayuga Community College,

Inc. (IAGT)

**Education:**

- **1993** Boston University, Boston, Massachusetts: M.A., Geography with concentrations in GIS, Remote Sensing, and Dynamic Systems Modeling. Awarded teaching fellowship providing full tuition plus a stipend.
- **1985** Wharton School of the University of Pennsylvania, Philadelphia, Pennsylvania: B.S., Economics: Cum Laude, Finance/International Business major, German minor

**Experience:**

- **2003-Present** Multiple technical management positions for IAGT, Auburn, NY. Currently serving as Director, Application Development and Data Management, coordinating the application development and data management activities across all IAGT program areas. Also serving as senior program manager: for \$2.5 million project to provide geospatial application development and support for the NSF EarthScope program; and, for a project to provide mapping, geospatial analysis, application development, and data management support for a NYS-funded initiative to utilize GPS data from commercial trucking fleets for traffic and transportation planning.
- **2000-2003** Senior Technical / Program Manager for Global Science and Technology, Inc, Spatial Technology Group, Auburn, NY. Provided technical leadership and program management for major contract with the NASA-sponsored Institute for the Application of Geospatial Technology to design, develop and implement innovative applications of geospatial technology for state and local government, education, and the private

sector. Focused on Webbased solutions for watershed management, emergency management, environmental assessment, economic development, geospatial data management and distribution, and general geospatial analysis and visualization.

- **1996-2000** Managing Consultant for CT Male Associates, P.C., Latham, NY & Roy F. Weston, Inc., West Chester, PA. Responsible for design and development of geospatial applications based on client needs. Performed needs assessments and requirements analysis. Conducted joint application development sessions to develop application specifications. Developed logical and physical system designs utilizing standard systems analysis documentation techniques (e.g., data flow, entity-relationship, UML diagrams). Managed and participated in the development of application deliverables. Managed projects, supervised technical staff and ensured quality of GIS/IS deliverables. Conducted strategic business planning, development and marketing activities. Developed and presented proposals and secured new contracts.
- **1998** Program Manager for Bureau of Land Records, Chester County Assessment Office, Chester County, PA. Served as interim GIS Manager providing short-term leadership for GIS-based Land Records System. Stabilized a program suffering from the departure of key staff.
- **1995-1996** System Developer for MassGIS, Boston, MA. Developed custom geospatial data viewer application for the State of Massachusetts. Designed back-end database, user interface, and programmed all application code.
- **1993-1995** GIS Specialist / Assistant Program Manager for NYS Office of Real Property Services, Albany, NY. Served as lead technical analyst and managed both technical and administrative aspects of the \$350,000 start-up School District Income Verification program.
- **1991-1993** Geography Instructor / Teaching Fellow at Boston University, Boston, MA. Taught and administered a full credit course in Environmental Science.
- **1991** Marketing and Planning Analyst for Albany Medical Center, Albany, NY. Conducted regional market analyses of medical services by provider and patient demographics.
- **1990-1999** Self Employed Information Systems Consultant. Developed and maintained a custom property tax abatement case management system.
- **1988-1989** Information Management Specialist/Entrepreneur for Ridgefield Associates, Arlington, MA. Helped start a property tax abatement business. Developed various supporting information management systems.
- **1985-1988** Market / Financial Analyst for D.C. Health & Co., Division of Raytheon Co., Lexington, MA. Completed two year corporate Financial Development Program with comprehensive training in accounting, budgets & planning, and marketing administration. Developed spreadsheet and relational database applications.

### **Accomplishments:**

- 20+ years of experience in successful information technology application development, program management, and general business development and management in business, government, and not-for-profit organizations with a focus on geospatial applications.
- Strong ability to function in both a technical and management capacity. Held both project and departmental management positions, often simultaneously serving as technical lead, staff supervisor, and project manager.
- Broad-based education and experience in information technologies with a more recent focus on geospatial information technologies. Designed, developed, tested, and deployed numerous information technology applications for both internal customers and external clients. Well versed in software engineering practices for

gathering requirements, writing specifications, and documenting system designs.

- Significant use of database and GIS software, and design and development of IT applications in various programming environments across a broad range of market segments. Recent experience focused on developing and managing web-based geospatial applications

## 5. CURRICULUM VITAE – William Prescott

E-mail: wprescott unavco.org

UNAVCO, Inc.

6350 Nautilus Drive

Boulder, CO 80301-5553

### **EDUCATION:**

- Ph.D in Geophysics, Stanford University, 1980.
- M.A. in Mathematics, University of California, Berkeley, 1971.
- B.A., Middlebury College, 1967.

### **POSITIONS HELD:**

- President, UNAVCO, Inc. (2002-Present)
- Research Geophysicist, U.S. Geological Survey (1971-2002)
- President, Geodesy Section, American Geophysical Union (1998-2000)
- President-Elect, Geodesy Section, American Geophysical Union (1996-1998)
- Chairman, Southern California Integrated GPS Network, SCIGN (1995-1997)
- Chief, Branches of Tectonophysics and of Earthquake Geology and Geophysics, USGS (1989-1994).
- National Earthquake Hazard Program Manager (1989-1994)
- U.S. Army, 25th Division, Artillery, Vietnam (1968-1970).

### **SELECTED GEOPHYSICAL CONTRIBUTIONS and HONORS:**

- Honorary Fellow of the American Geophysical Union.
- Meritorious Service Award, U.S. Department of Interior
- Chair of SCIGN network during initiation of construction phase.
- Contributions to understanding deformation in US particularly in San Francisco Bay area
- Developed a variety of methods for analyzing crustal deformation data.

- Developed techniques for processing and displaying geodetic data.



## 6. CURRICULUM VITAE – T.H. Lee Williams

### **A. Current Appointment**

Vice-President for Research

Dean of the Graduate College

Regents Professor of Geography

University of Oklahoma

Norman, OK 73019

Phone: (405) 325-3806

Fax: (405) 325-5346

Email: [lwilliams@ou.edu](mailto:lwilliams@ou.edu)

### **B. Education**

1977 Ph.D., Geography, University of Bristol, England

1972 B.Sc., Joint Honors in Math and Physics, University of Bristol, England

### **C. Professional/Academic Positions**

1999 - current Vice-President for Research, Graduate Dean, Regents Professor of Geography,  
University of Oklahoma

1994 - 1999 Director, Science and Technology Research, and Director, Oklahoma EPSCoR,  
Oklahoma State Regents for Higher Education

1992 - 1993 Interim Dean of Geosciences, University of Oklahoma

1988 - 1999 Associate Dean of Geosciences, University of Oklahoma

1993 - 1999 Coordinator, Oklahoma Alliance for Geographic Education

1992 - 1999 Professor of Geography, University of Oklahoma

1986 - 1992 Associate Professor of Geography, University of Oklahoma

1987 - 1993 Director, OU-NOAA Cooperative Institute for Applied Remote Sensing

1983 - 1986 Research Investigator, Electrical and Computer Engineering Research Lab,  
University of Kansas

1978 - 1983 Research Investigator, Kansas Applied Remote Sensing Program, University of  
Kansas

1977 - 1986 Assistant and Associate Professor (1982 -) of Geography, University of Kansas

1976 – 1977 Visiting Research Associate, University of Oklahoma

1973 – 1976 NERC Graduate Fellowship, University of Bristol

1972 – 1973 High School Science Teacher, Voluntary Service Overseas, Antigua, WI

## **D. Research and Teaching**

My career teaching and research interests have focused on the theory and usage of aerial and satellite images for renewable and non-renewable resources. Specific research activities have included monitoring noxious weeds, exploration geology, urban spatial structure, and groundwater studies in Kansas and India. My work has been supported by over \$3million in grant funding from federal, state, and private sources.

My courses in remote sensing and geographic information systems have drawn students from a wide range of disciplines, which helped stimulate my interest in working across disciplinary boundaries. I have chaired 12 doctoral theses and 19 Master's programs. I have also served on numerous graduate committees in the physical sciences, life social sciences, social sciences, engineering, and humanities.

## **C. Research Administration Experience**

My interest in university administration, and specifically research administration, developed during my time at the University of Oklahoma. As Associate Dean (and Interim Dean from 1992-93) I had broad responsibility for various programs, but concentrated on supporting the research and computing/network programs in the College. My experience as science team leader on an EPSCoR project from 1992-95 led to my position as EPSCoR Director for Oklahoma, and Director of Science and Technology Research for the Oklahoma State Regents for Higher Education.

EPSCoR (Experimental Program to Stimulate Competitive Research) is a research program operating in seven federal agencies (NSF, NASA, DoD, EPA, Department of Energy, NIH, USDA). EPSCoR builds and supports competitive university research in participating states. Oklahoma participates in all the agency programs except USDA. As EPSCoR Director (and Director of Science and Technology Research) I worked for the State Regents and the Oklahoma EPSCoR Committee, and was responsible for all EPSCoR programs and projects in Oklahoma. I developed and implemented strategies for each agency program, and initiated and oversaw proposal development.

In my current position as Dean of the Graduate College and Vice-President for Research at the

University of Oklahoma, I am an executive officer of the university, and have primary responsibility for all graduate degree programs and sponsored research and scholarly activities on the Norman campus. My offices administer all pre- and post- award responsibilities for externally-sponsored programs, and administer the various internal faculty and student research support programs.