Progress Report on the evaluation and implementation of NCGMP09

Submitted to the U.S. Geological Survey (USGS) and Association of American State Geologists (AASG), by David R. Soller (Chief, National Geologic Map Database) on behalf of colleagues noted in the "Summary of Progress", below.

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The purpose of this report is to provide USGS and AASG management with a summary of progress toward adoption of NCGMP09 as a standard format for the publication of geologic maps. Background information on NCGMP09, and justification for its use and adoption is, therefore, purposely brief. It is recommended that any questions be addressed to the technical experts whose input provided the basis for this Progress Report.

It has been said that "a standard is a product shipped in volume" -- in other words (and this is especially true in the scientific community), a true standard cannot be pre-defined, but instead must represent commonly-held views and methods. As noted in the Appendix, a collaborative approach to standards development has generally been used by AASG and USGS, but because NCGMP09 was initially designed by two projects, we are now engaged in the important work of evaluation and revision by the broader community. The results of this outreach are an encouraging mix of pragmatic, near-term results (e.g., "Let's try out the design by publishing some map databases") and longer-term objectives (e.g., How do we engage more people in this effort? How will it be supported? What kinds of software tools and other resources might be needed? Can NCGMP09 be used as an enterprise-level database?). We hope that USGS and AASG are encouraged by the progress described in this report.

BACKGROUND -- What is NCGMP09?

The following is excerpted from "NCGMP09—Draft Standard Format for Digital Publication of Geologic Maps, Version 1.1" (http://pubs.usgs.gov/of/2010/1335/pdf/usgs_of2010-1335_NCGMP09.pdf):

> *"NCGMP09 is a standard format for geologic map publications funded by the National Cooperative Geologic Mapping Program (NCGMP) of the U.S. Geological Survey. This format, or database design, is named NCGMP09 to reflect the initial audience. We hope that this design will adapt to evolving needs and expectations, and meet the needs of a larger community of users.*

NCGMP09 is designed for encoding content analogous to that contained in a single, traditional geologic map published by the USGS and by State geological surveys. It is intended to provide a stepping stone toward development of multimap databases, in particular the National Geologic Map Database (NGMDB). The NGMDB Project assists with coordination of database design work between the USGS and State geological surveys, and is mandated to build a national archive of standardized geologic map information. The database design proposed herein will significantly promote that goal.

In our years of work prior to defining NCGMP09, we learned that a single database design cannot (yet?) suit all purposes. This lesson has been underscored by our colleagues' evaluations of this design. A database most suited to the needs of a field geologist will likely not address the content and cartographic requirements of a single-map database that is intended to be published and then used by geologists and nongeologists, nor the requirements of a multimap database maintained in perpetuity by a mapping agency. We further recognize that even for one of these purposes a single design may be contentious, in part owing to varying requirements (for example, for field systems, requirements imposed by local geology or particular hardware). We have pragmatically developed a design that should prove generally useful, recognizing that many will not find it their first and best choice. Compromise in design, without sacrificing the flexibility necessary for science-driven information management, is the path we have sought during development of this standard."

SUMMARY OF PROGRESS:

At the Digital Mapping Techniques '13 workshop, a two-hour Discussion Session was held, entitled "Progress on implementing the NCGMP09 database design". This Session focused on the efforts in State geological surveys, USGS, and other agencies to evaluate, implement, and recommend improvements to the NCGMP09 database design. Additional comments were solicited from states that were not able to attend DMT'13. A concise summary of comments by the representatives from each agency is provided below. Where feasible, these comments are verbatim from the respondents. [Ralph Haugerud (USGS), Ryan Clark (Ariz. GS), Charlie Frye (ESRI), and Willy Lynch (ESRI) provided Session minutes that significantly improved the accuracy of these summary paragraphs.]

- Alaska Division of Geological & Geophysical Surveys
(represented by Jennifer Athey and Patricia Gallagher)
The need for a standard database design, and consistency in content and format is well understood. The division director and state geologist has now made it mandatory to use NCGMP09 in current mapping projects, and a plan has been

developed to incrementally adopt NCGMP09. Field data are collected with Esri mobile software in an NCGMP09 format and then transferred to an NCGMP09-compliant file geodatabase. For each project, a NCGMP09 geodatabase is created by using the NCGMP09v1.1_Toolbox1_Arc10.1.zip file found on the NCGMP09 website. At the DMT meeting, there was discussion regarding whether the variations between the Ariz. GS design and the NCGMP09 standard were significant enough to cause incompatibilities; this issue is not yet resolved. Geologists are now working in the NCGMP09-formatted geodatabase; some like it, and some don't. The agency's long-term plan is to build an enterprise version of NCGMP09, to manage all AKDGGS geologic map data. They plan to have the enterprise geodatabase completed by the end of 2013. The DGGS has published one map in the NCGMP09 format (http://www.dggs.alaska.gov/pubs/id/25179), and have three or four additional maps under development in this format.

- Arizona Geological Survey
(represented by Janel Day and Ryan Clark)
They have been creating new data in a (slight) variant of the NCGMP09 format for four years. It's working very well, and the geologists are using it. NCGMP09's specification for supplementary tables is useful, but managing such tables (which may be customized to a single or a few maps) introduces what may become a significant long-term data management challenge. The agency is working to migrate ~30 legacy datasets, and are ~75% completed. These migrated datasets will need to be checked by geologists, preferably the map's author, to ensure that certain decisions on content made by the person migrating the data (e.g., locational certainty, standard lithologic terms) are reasonable.

- Delaware Geological Survey
(represented by Sandy Schenck and Lillian Wang)
After last year's DMT meeting, they evaluated the NCGMP09 design and decided to implement it with all the required elements except the glossary. With respect to the glossary, they ask for discussion regarding whether content for the Glossary table can be widely shared (this they would prefer) or whether it will be customized to each map and (or) agency. Because a principal purpose of a data model is to standardize data, they suggest there could be an overall glossary made available online through the NGMDB web site that everyone can add to and then point at for reference. This would minimize duplication and differences in style and content. They have begun to implement NCGMP09 for all new 1:24K geologic maps published by the state geological survey.

- Idaho Geological Survey
(represented by Loudon Stanford)
For many years they have managed all map data in a CAD-based system whose design incorporated concepts that were developed when the data manager participated in the North American Data Model committee (ca. 1998-2004). They now intend to consider migrating their enterprise system, and new map data, to the NCGMP09 design if funding and expertise for the transition can be secured. They

have begun this process by developing tools for converting CAD-based maps, and for creating new maps in NCGMP09.

- Illinois State Geological Survey
(represented by Jennifer Carrell)
They invested in a database design in 2008, and are not able to justify migrating the 100+ legacy maps or separately implementing NCGMP09 for new datasets. As noted by other states, the proverbial big carrot or stick would be needed before a change could be considered. The ISGS does intend to test the NCGMP09 with data from Illinois to understand in detail how it compares with the ISGS model. Should the NCGMP09 become a requirement for Statemap deliverables or for the NGMDB, they would export data to NCGMP09 but would maintain their own model for the near future. Concern was expressed that the GeneralLithology term list would be a signficant obstacle to overcome. [Note from this compiler -- his experience indicates that, compared to other aspects of NCGMP09, using this list does not present a significant challenge. The more general issue of whether this list is adequate for the intended purpose needs to be addressed in the longer term, ideally after a period of evaluation and use.]

- Indiana Geological Survey
(represented by Matt Johnson)
They are not yet invested in a standard database design. Their geologists have their own databases and some do not see NCGMP09 as relevant, and so the GIS cartographer receives the map information in different formats (shapefiles, features, etc) that the geologist provides. In order to become more efficient in map production and data management, they will attempt to implement NCGMP09. An interface to manage data entry and editing of NCGMP09 tables would be helpful. After the DMT'13 meeting, the IGS had a discussion about a pilot study for one of next year's deliverables. They will be looking at adding fields and changing field names of the current databases to allow exports into the NCGMP09 format. Also the IGS will be looking at where the implementation of the database model will be taking place, either during data collection or during production of the map.

- Kansas Geological Survey
(represented by John Dunham)
They are not finding any problems in using NCGMP09 for new projects. But migrating legacy datasets is time consuming and problematic because NCGMP09-required content is not always present (e.g., locational uncertainty, map unit descriptions). [See also Dunham's note in this section, below.]

- Kentucky Geological Survey
(represented by Bethany Overfield)
The agency will begin creating NCGMP09 datasets this year. As noted by others, migrating their extensive set of legacy datasets will pose a signficant challenge.

- Maine Geological Survey
(represented by Chris Halsted)
Chris was recently hired to translate legacy map data and tools from ArcInfo, coverages and AMLs to ArcGIS, geodatabases and Python. MGS will likely keep its own data formats and symbology for map production. However, they will be working on a 'crosswalk' process for exporting to NCGMP09. This will allow creation of maps in both formats from one dataset.

- Massachusetts Geological Survey
(represented by Joe Kopera)
They recognize the very pressing need for a standard and are grateful for the hard work of all involved in NCGMP09. The MGS has no immediate plans to fully implement NCGMP09 as detailed in their response to Don McKay's 2012 solicitation, which can be summarized, in order of importance, as:
1) Zero resources to accomplish this work.
2) The standard, as-is, requires a lot of modification to provide for the complex metadata that their geology necessitates (regional correlations, multiple ages for structural features, rock fracture datasets, etc.). Supplementary tables aren't found to be an ideal solution due to resulting complexity and fragmentation of data linkages.
3) They are transitioning to FOSS (Free and open-source software) deliverables as mandated (NSF, OGI, NRC 2009, industry trends, etc.), and gradually moving away from ESRI products in their workflows for a variety of data management and accessibility issues.
With that said, they recognize the benefits of the core concepts of NCGMP09, and hope to adopt certain aspects of it into their STATEMAP FY14 deliverables, as the MGS's limited resources allow. They echo other surveys' desires for increased communication and sharing of expertise.

- Minnesota Geological Survey
(represented by Jacque Hamilton)
Jackie was recently hired, and is tasked with test-implementing NCGMP09 for a legacy map. Migration of all legacy maps, and creation of new maps in NCGMP09 format is anticipated, and is acknowledged to be a significant challenge.

- Missouri Division of Geology and Land Survey
(represented by Edie Starbuck and Cheryl Seeger)
Shortly after the NCGMP09 design was published, they test-implemented it for a typical quadrangle geologic map. They may be restricted from a broader implementation because: (1) their ArcGIS license is at the basic (ArcView) level, and so they cannot build topology (which hampers the development of a NCGMP09 geodatabase), and (2) their geologists are creating maps in ArcView, with very limited support from GIS staff (most of whom were relocated to other departments in state government). However, they recently compiled a statewide database, and were able to use some of the NCGMP09 field names and non-spatial tables. [Note from this compiler -- Because NCGMP09 includes a specification for output to a

shapefile, Missouri's software limitation does not preclude it from releasing their map data in a NCGMP09-compatible format. Their use of NCGMP09 field names in the published shapefile underscores a principal goal -- i.e., widespread adoption of common terminologies and the names of fields, tables, and files.]

- Montana Bureau of Mines and Geology
(represented by Paul Thale)
They have committed to using the NCGMP09 data format for geologic maps prepared in the future. Maps currently in production will be released in the existing database structure. They note that migration of legacy data into a new format (in this case, to NCGMP09) will be a significant challenge, and various factors must be carefully considered (e.g., whether to re-release maps as separate quadrangles, or merge them into a single database).

- National Park Service and Colorado State University
(represented by Stephanie O'Meara)
They have a mature design that is widely used in their agency. They will create a NCGMP09-compliant map database in order to evaluate it as an output format (or future database design) for the agency. They are tentatively planning to provide NPS GRI digital geologic-GIS maps in a NCGMP09 data model format as a derivative product from their file geodatabase and GRI data model product.

- Nevada Geological Survey
(represented by Irene Seelye)
Budget and staff are very limited, and so they must retain their existing design.

- New Mexico Bureau of Geology and Mineral Resources
(represented by Mark Mansell)
They evaluated NCGMP09 several years ago, and decided to adopt a more complex and detailed design for the agency. Owing to the relative complexities in data entry and management for their in-house design, they are considering migrating both legacy and new mapping to NCGMP09. Challenges include the migration of complex legacy datasets to a simpler design (i.e., NCGMP09) and identifying a common standard that satisfies geologist's different opinions on the level of complexity to include in a published map. The use of extended tables in NCGMP09 may allay some of these concerns, although difficulties in implementing such tables are noted.

- Oregon Oregon Department of Geology and Mineral Industries
(represented by Warren Roe)
For several years they have focused on completion of the statewide Oregon Geologic Data Compilation (OGDC), and the design of a new enterprise database and the workflows to support it. As their enterprise system continues to evolve, it may or may not incorporate elements of NCGMP09. Regardless, they envision a relatively straightforward export of map data from their design to NCGMP09 format.

- South Carolina Geological Survey
(represented by Erin Koch)
At present, the simple nature of their data structue does not seem to warrant conversion to NCGMP09 format. However, this could change if re-evaluation of NCGMP09 indicates advantages and if more complex data becomes available and can readily be incorporated.

- Wyoming Geological Survey
(represented by Suzanne Luhr and Phyllis Ranz)
They have just begun to evaluate it, and will implement it for two STATEMAP deliverables this year. They would benefit by increased communication among agencies that are using NCGMP09, in order to decrease time spent learning the concepts and increasing productivity.

- U.S. Geological Survey - Denver office
(represented by Paco Van Sistine)
Current database design is simple and has been in use for about ten years. They have tested NCGMP09 by converting an almost-completed map from the current design. It was found to be difficult, but feasible. They will now build a new map database directly in NCGMP09 format, and anticipate this will be easier.

- U.S. Geological Survey - Menlo Park office
(represented by Ralph Haugerud)
Has published a map in NCGMP09 format (Suquamish quadrangle, http://pubs.usgs.gov/sim/3181/), and developed tools to create, edit, and validate a NCGMP09 database. Has developed guidance for content of LocationConfidence field, which may address concerns expressed by agencies now evaluating NCGMP09.

- U.S. Geological Survey - Reston office
(represented by David Soller and Nancy Stamm)
They focused on NCGMP09's DescriptionOfMapUnits (DMU) table, in order to evalulate issues inherent in converting the large number of older, paper maps to this format, especially in those cases where the map's authors cannot be consulted. This work also contributes to building the foundation for a nationwide database of these descriptions, in NCGMP09 format. Parsed information from the DMUs (e.g., unit descriptions, age and hierarchy of units, geologic names, and standardized lithologic descriptors) for ~3361 map units on 65 regional (250K and 100K) maps. Owing in large part to variations in DMUs and important subtleties expressed in both the DMUs and Correlation of Map Units, significant challenges in parsing this information into a database table were clearly evident. This finding argues for the work to be performed by geologists with knowledge of the mapped region.

- Virginia Division of Mines and Geology
(represented by Matt Heller)
They have accepted the general design of NCGMP09, and use it for their new maps. They began using NCGMP09 several years ago, and found that as they applied it to

their maps and data in the previous database structure, certain changes to the organization of data in NCGMP09 were needed. For example, in the feature classes of the "geologic map" part of NCGMP09 -- at the start of each project, they add a new line feature class called "surface contacts" where they put all contacts for surficial deposits. They do this to make it easier to create maps that show the surficial or bedrock geology separately. They also have considered adding new feature classes for fold axes and karst as well; currently these data are stored under the grab bag of "other lines," and in order to turn off these layers in ArcMap, you also have to turn off the map border. They also believe that combining the "contacts and faults" and "concealed contacts and faults" feature classes is appropriate. They have a strong interest in participating in discussions related to updates or improvements to the NCGMP09 standard.

- Washington Geological Survey (Division of Geology and Earth Resources) (represented by Meredith C. Payne)
They have continued with their NSDI CAP grant pilot project for implementing the NCGMP09 schema for a recent legacy quad (published in 2010). [They will be working on that project until February 2014.] This project incorporates testing of the NCGMP09 schema and generation of documentation recording the Division of Geology and Earth Resources data-conversion experiences, as well as the creation of a cookbook detailing how the NCGMP09 geodatabase was created. Importantly, they are noting the circumstances under which the conversion can be automated, and which aspects of the transition still rely upon manual generation. They also share the frustration of others when it comes to applying the full NCGMP09 standard to legacy data, and find themselves unable to complete certain required fields (e.g. LocationConfidenceMeters) even in cases where the original authors can be consulted. They have decided to implement the "NoData" value of -9 in cases where a numerical field is required but the value had not been recorded and cannot be reconstructed. For the 2013 mapping season they are still using their simpler in-house data schema, but the agency's schema is evolving and changes to it are made with the NCGMP09 structure in mind, either adopting some of the NCGMP09 fields and definitions, or ensuring that changes will be such that a transition to NCGMP09 will not be made more difficult by the alterations. A constant dialog is going on between the Division of Geology and Earth Resources cartographers, data managers, and mapping geologists on aspects of NCGMP09 that work, or don't work, or are confusing. They note a strong value in holding the monthly National NCGMP09 Working Group telecons. Finally, the Division of Geology and Earth Resources is adopting the mindset that NCGMP09 geodatabases may be a required component of STATEMAP deliverables in the near future.

These state summaries are purposely brief, in order to emphasize the major points. The following letter, submitted by John Dunham (Kansas Geological Survey) after the DMT'13 meeting provides a more direct, first-hand account of some issues referred to above:

"The legacy dataset issue is important to us. I want to use the standard as much as possible now that I've had time better educate mself about it (still an ongoing process!). But I wrestle with how to handle GIS data that predate me and have skimpy attribution and little or no metadata. There is also the issue of handling data such as our historical geology datasets, digitized from scans of pre-GIS county geology maps. Should they be "NCGMP09'ed" with attributes left blank, should impossible-to-fill (or)non-applicable fields be omitted, or what? Some sort of "NCGMP lite", an official simplified/reduced version of the standard might be beneficial for these situations.

I am using the standard for new projects and am also converting our recently-produced geology GIS data to the standard. Even this can be time-consuming, though, such as assembling glossary tables with appropriate definitions and other information not originally provided by the geologists. We are revising our geologic mapping workflow so that the mapping geologists provide the necessary information (for both the geology and the process steps involved in data collection) at the time they deliver their mapping products to me. We are also working toward having all our mappers use GIS for their mapping rather than turning in hand-delineated quadrangles. (This seems easy, but it is not necessarily so when mappers have been using the same technique for many years, and geologic mapping is only a percentage of their total workloads.)

To summarize, I like the standard and am working on its application, and our geologists are recognizing the need for it (such as confidence levels for contacts, which earlier seemed like a daunting task to them) now that I've better explained it. It's still tough to apply retroactively, and a stripped-down version might be nice for that. I also think it's important to get the standard to a point where it's stable, so that we don't all put hours of time and effort into implementation, only to have a "newer and better" standard arrive."

POTENTIAL OBSTACLES TO WIDESPREAD ADOPTION OF NCGMP09, AND SOME RECOMMENDATIONS

From the comments voiced by agency representatives, issues that might hamper widespread adoption of NCGMP09 were readily identified during the subsequent discussion at the DMT'13 meeting. Each issue is summarized below.

1. Complexity of design

Depending on an agency's tradition, perspective, and current data holdings, the design of NCGMP09 is considered to range from too complex to too simple. For example, if an agency or author's focus is on publication of a printed map or graphic file, supported by a rudimentary GIS file containing points, lines, and polygons with minimal descriptors (e.g., type of line, or name of map unit), then the required elements of NCGMP09 far exceed what currently is provided. But if an agency

maintains an enterprise-level database of geologic map information, then NCGMP09 may be inadequate because it focuses only on the content of a single, published map. Possibilities for extending NCGMP09 in order for it to serve as an enterprise-level design will be explored.

For cases where NCGMP09 is considered too complex and time-consuming to use, it could be recommended that the most relevant parts of it be adopted. For example, NCGMP09 field and table names, standards term lists, and concepts (e.g., location confidence), when used within the agency's current database design (or mapped to the existing design), could enhance the efficiency and ease-of-use of the data when combined with data obtained from other agencies. This approach begins the process of standardizing the data products provided by the many geological agencies of the Nation. For cases where NCGMP09 is found to exclude pertinent information managed in an agency's current database, additional tables ("extensions") or files could be provided with the NCGMP09 database, in order to accommodate that information.

2. Legacy versus new mapping

NCGMP09 was designed specifically for new publications. If any but the simplest map database design is applied to previously-published ("legacy") maps, significant challenges may be encountered. A person assigned to convert information from a legacy map to a database may be faced with questions about the map's content that are not provided on, or not interpretable from, the published map. As the result, these may be unanswerable if the map's author is not available to assist with the process. For example, if the map unit descriptions are sparse (or non-existent) or found to be in error, this essential component of the NCGMP09 design then would have little value for that data set, and may actually be detrimental. In some cases, text found in an accompanying report or pamphlet can provide the map unit descriptions, but this is not the norm.

Because locational uncertainty of geologic features is generally not specified on a map prepared solely as a cartographic product, how can these values be derived for a database? If the lithologic terms in NCGMP09's standard list do not seem to readily apply to a map unit description, the problem may be with the list, or with the unit description; without the map author's guidance, the chosen lithologic term may therefore be of limited use.

These issues may be partially addressed, if regional geologic experts can be engaged. As noted in the USGS-Reston summary above:

> *"Owing in large part to variations in the Descriptions of Map Units and important subtleties expressed in both the DMUs and Correlation of Map Units, significant challenges in parsing this information into a database table were clearly evident. This finding argues for the work to be performed by geologists with knowledge of the mapped region."*

Given the difficulties noted here, agencies might be inclined to not adopt NCGMP09, or any but the simplest database design, for the conversion of legacy maps to digital format. However, the very large number of legacy geologic maps

argues for adding them to the relatively small collection of geologic maps in GIS format. This would greatly increase the availability of our geologic maps to the GIS community -- records of the NGMDB Map Catalog indicate more than 21,000 geologic maps are not in GIS format, versus less than 2,000 maps available in a wide variety of GIS formats.

How can we reconcile the NCGMP09 data requirements with the content of legacy maps? A simplified version of NCGMP09 (i.e., "NCGMP09=-lite" ?) may be warranted, and will be discussed among the state and Federal stakeholders.

3. Must we use NCGMP09 for a new map, from start to finish?

NCGMP09 is a publication format only, and so there is no need to use this design from the beginning stages of a mapping projects (e.g., in the field). Some agencies or projects may be inclined to do so because it suits their needs and their staffing. Others agencies could decide that, when a map is published with their current database design, to offer NCGMP09 as a secondary format that simply is output from ther database. This second strategy argues for a standardized database design within an agency, and software tools to output the NCGMP09 formatted file.

4. Software requirements

The NCGMP09 design currently is specified as an ESRI Geodatabase. However, it also includes an optional ESRI Shapefile version. Although the Geodatabase version allows for the most efficient use of the database information within modern ESRI software, the Shapefile format is highly recommended because many users prefer Shapefiles. Also, some agencies cannot output in Geodatabase format. Regarding long-term maintenance of these data, and migration to data formats devised in the future, the Shapefile (being a de facto standard format) has certain advantages.

5. Standard terms and definitions

During development of NCGMP09 and its predecessors (e.g., the North American Data Model), there were extensive and oftentimes spirited discussions on the advisability of specifiying standard terms, definitions of terms, and detailed metadata for geologic features in a map database. Consensus that resolves differences in how terms and metadata are used in NCGMP09 may be difficult to reach. It is possible that frequent discussions on these topics will lead to more understanding of other's perspectives, and insight on how best to implement these concepts in NCGMP09.

6. Software tools

The tasks of creating database tables, entering and editing information in these tables, performing data queries, and exporting to various file formats are common to the process of building any database. Certain tasks (e.g., data entry) can

be aided by software tools, which greatly increases efficiencies as well as minimizing errors and inconsistencies in the data. For certain tasks, tools can automate the process -- a "validation" tool can check for format and content errors, topology errors, and other inconsistencies prior to peer review and publication, thereby essentialy performing certain parts of a "technical edit" of the GIS files.

These tools cannot be fully developed prior to rigorous evaluation and testing of a database design. Nor can a design be fully tested without them. And so, concurrent with the "brute force" study and testing of NCGMP09, certain tools have been prototyped. These tools not only encourage more staff and agencies to evaluate NCGMP09, but they also stimulate discussion regarding the types of tools that should be developed or refined. Given the salary costs associated with software development, this prototyping is a critically important activity.

7. Communication and collaboration

A "standard" isn't really a standard unless it's widely used. Since the late 19th century, agencies that produce geologic maps have demonstrated the interest and ability to discuss and agree on certain standard methods and techniques for geologic map content and format. Since the advent of digital maps, we have witnessed a convergence of approaches, for example through the Digital Mapping Techniques workshops. Can NCGMP09 become a standard? Our community's past successes in collaboration suggest this is possible, given adequate time and opportunities for discussion of the technical details of this database design. Toward this end, as an outcome of the DMT'13 discussion session, we have established monthly telecons to discuss technical details of NCGMP09. Representatives from each agency are encouraged to participate.

Additional actions are being planned, including establishing a steering committee to oversee the direction of work, improved documentation of the NCGMP09 design and software tools, and improvements to the NCGMP09 Web site.

8. Agency commitment

During the DMT'13 discussion session, concern about lack of resources was widely expressed. These resources include staff time and expertise, and the software tools, GIS software, and hardware needed to execute an agency's publication and data-management plan. All agency management and scientific and technical staff share this concern. It is recommended that discussion of these concerns, and planning for these resources, be done concurrent with evaluation and test-implementation of NCGMP09.

APPENDIX. A brief summary of AASG-USGS collaboration on geologic map database standards, ca. 1996 – present.

In August, 1996, in St. Louis, Missouri, a meeting was held to identify standards and guidelines needed to develop the National Geologic Map Database (NGMDB). The meeting was hosted by the AASG and the NGMDB project. There, the USGS/AASG Geologic Data Model Working Group was formed to develop a standard data model for digital geologic maps. In October, 1997, the Working Group released a draft data model for public comment. In June, 1998, a workshop to evaluate the data model was held. Twenty-eight attendees from the USGS, state geological surveys, and the Canadian federal and provincial surveys attended. Following the workshop, revisions were made to the data model, the objectives of the working group were considered to be met, and the group was dissolved. Documentation is provided at the NGMDB website (specifically, at http://ngmdb.usgs.gov/Info/standards/), and in Digital Mapping Techniques Proceedings volumes (http://ngmdb.usgs.gov/Info/dmt/).

In late 1998, the Federal, State, and Provincial geological surveys of the United States and Canada formed the North American Data Model Steering Committee (NADMSC), to continue development of this data model. The NADMSC completed most of its work by 2004. General information on the Committee process, and progress on the data model and standard science language can be found at http://ngmdb.usgs.gov/www-nadm/. This work gradually evolved in the early 2000's, and was incorporated in the IUGS-supported GeoSciML project (https://www.seegrid.csiro.au/wiki/CGIModel/GeoSciML).

For several years after the NADMSC had completed its work, the issue of whether to develop a standard database design for use by all agencies was not widely debated at the DMT meetings. This subject was reintroduced at the DMT'08 meeting, in the Discussion Session "Can we develop national standards and guidelines for geologic map databases?". Owing in part to experience and understanding gained by the agencies, there was a renewed interest in this subject, and the NGMDB project was asked to resume efforts to coordinate this work.

As an outgrowth of this collaborative work, in 2008, the National Cooperative Geologic Mapping Program (NCGMP) requested a prototype for a simpler, single-map database design, initially to assist the work of a single USGS mapping project. At that time, two members of the USGS Pacific Northwest Geologic Mapping Project (Ralph Haugerud and Evans Thoms, USGS) and of the National Geologic Map Database (Steve Richard, Ariz. GS, and Dave Soller, USGS) were tasked with this work. The result became the NCGMP09 design.

A draft of NCGMP09 was presented at the DMT'09 meeting, and revised later that year. During the next three years, the developers gave presentations at the DMT meetings and solicited comment and suggestions, but did not marshal the resources to actively engage the larger group of colleagues that would be needed to fully evaluate and implement NCGMP09 as a standard. In 2012, the AASG released

the results of a questionnaire to state geological surveys, which provided an assessment of the State's interest and concerns regarding potential use of NCGMP09. The questionnaire indicated that some states had begun to use it to publish their maps, or were evaluating it. However, some states registered significant concerns, which indicated real or perceived obstacles to their implementation of NCGMP09. The timing of the questionnaire was fortunate, for two reasons: (1) it further legitimized the NCGMP09 as a possible standard or recommended format; and (2) it renewed the NCGMP09 developer's motivation to identify the resources needed to coordinate NCGMP09 testing and further development by the broader community. We thank the AASG, and USGS, for focusing attention on NCGMP09 and encouraging its evaluation.