

## 2011 Geothermal Technologies Peer Review Summary: State Geothermal Data

### 1. State Geological Survey Contributions to the National Geothermal Data System

- Association of American State Geologists, managed by the Arizona Geological Survey
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- Core Project Team:
  - Co-Principal Investigator: Stephen M. Richard, Ph.D.
  - Chief Financial Officer: Lori Smith
  - Project Coordinator: Kim Patten
- Subcontractors and Participating Organizations:
  - Subcontractors (45)
    - Geological Surveys (State Agency or University Based):
      - AL, AK, AR, AZ (CA), CO, FL, IA, ID, IL, IN, KS, KY, LA, MA (CT), ME, MN, MO, MS, MT, NC, ND, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, TN, TX, UT, VA (DE, GA, MD), VT, WA, WI, WV, WY
    - Universities:
      - HI, MI, ND (for NE), SD (Sinte Gleska University)
  - Western Regional Partnership, State of Arizona, Energistics, Microsoft Research, U.S. Geological Survey
  - In Discussion: Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI), iPlant Collaborative, DataONE, Federation of Earth Science Information Partners (ESIP), Groundwater Protection Council/Interstate Oil and Gas Compact Commission (IOGCC), American Geological Institute (AGI) Online Education

### 2. Project Objectives and Purpose

The project objective is to expand and enhance the National Geothermal Data System (NGDS) by deploying and populating a national, sustainable, distributed, interoperable network of state geological survey-based providers. These providers will develop, collect, serve, and maintain geothermal-relevant data that operates as an integral component of NGDS. As a result the geothermal industry, the public, and policy makers will have access to consistent and reliable data, which in turn, reduces the amount of staff time devoted to finding, retrieving, integrating, and verifying information. With easier access to information, the high cost and risk of exploration drilling is reduced.

The NGDS State Geothermal Data Project provides the data support, acquisition, and access to cyber infrastructure necessary to reduce cost and risk of Geothermal Technologies Program goals focused on the production and utilization of geothermal energy. The project is developing the knowledge and data foundation necessary for discovery and development of large-scale energy production and other practical applications such as direct use and residential/commercial ground source heat pumps. The project provides expanded reference and resource data for research and development activities (a subset of the GTP goals) and includes data from across all fifty states. Thus, the project incorporates not only high-temperature potential but also moderate and low-temperature locations incorporating the GTP's goal of producing 3 GWe of installed low-temperature geothermal capacity by 2020. The project, through its cyberinfrastructure, will help lead to innovative exploration technologies through increased data availability on geothermal energy capacity. Finally, the project will contribute new data from previously unexplored locations.

### 3. Technical Barriers and Targets

The project faces a variety of significant technical challenges related to developing, implementing, and populating interchange formats that will usefully account for the extremely wide variety of information being compiled by the states. The metadata content schema must be constructed to apply to all resources of interest, and this schema must be implemented and its use documented sufficiently to allow the data providers to accurately populate metadata records. We are utilizing off-the-shelf, preferably free, open-source software as much as possible. This requires evaluating available products and familiarizing the team with configuration and operation of several systems. This learning and evaluation process has been time-consuming. Design of interchange formats for the actual geoscientific data requires consideration of potential use cases as well as the actual data that are available to balance current capabilities, design complexity, and desired future capabilities. Locating and hiring staff with the necessary mix of training and experience with geoscientific data, information management, and web architecture has also been a major challenge. Significant effort has been devoted to hiring and training staff at AZGS and training partners at the regional server hubs and data-providing institutions.

Target metrics for this year include:

- June 1, 2011: Receive and review data from at least 40 first-year subcontracts in preparation for review of Statements of Work for next cycle
- October 1, 2011: Have content models reviewed and posted on [stategeothermaldata.org](http://stategeothermaldata.org) for all Year 1 delivery data
- December 1, 2011: Have at least 50 service instances conforming to AASG geothermal data content models running across the 4 system hubs and state partners hosting their own services
- April 1, 2012: All Year 1 data online and operational, some data from all 50 states live online.

### 4. Technical Approach

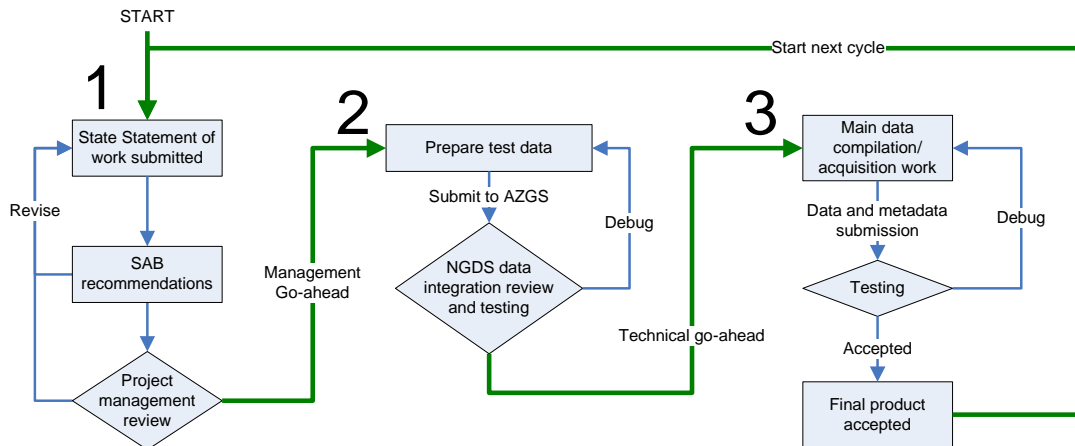


Figure 1: Cyclical workflow for developing statement of work, review, data compilation and approval and acceptance.

Our technical approach is to conduct data acquisition throughout the project in roughly annual cycles. In each cycle, state subcontractors develop a Statement of Work (SOW) identifying specific deliverable data for that cycle, prioritizing the types of data most in demand or most critical to identifying and characterizing its geothermal resources. The Science Advisory Board (SAB) reviews and approves each SOW before data acquisition begins and evaluates results before recommending approval to AZGS for the next cycle.

Data item types are identified by the AZGS team based on submitted SOWs; delivery schema content models for these items typed (features or observations) are developed, reviewed by the community, documented and tested to bring data online. These content models are then posted to the [stategeothermaldata.org](http://stategeothermaldata.org) web site, and used for subsequent contributions of similar data.

On delivery of sample data products from subcontractors, AZGS works with the subcontractors to assure that datasets conform to the adopted content models. Final delivered products are reviewed by AZGS to determine if the SOW has been met to complete the cycle. NGDS resources are published and become part of the system when metadata records describing them are published by a node in the NGDS catalog system, and the described resource is available online and accessible using information in the metadata record.

## 5. Technical Accomplishments

To date we have:

- Evaluated software for catalog implementation (GICat, Geonetwork OpenSource, Deegree, ESRI Geoportal) and selected ESRI Geoportal for implementing the catalog.
- Documented the basic metadata content required to meet system use requirements.
- Tested various metadata creation approaches; implemented web applications for creating metadata with or without uploading described files; implemented light-weight software for creating xml metadata from flat files for bulk uploads; configured the ESRI Geoportal to utilize the USGIN ISO metadata profile.
- Developed rule-based process for better metadata validation to improve quality checking on metadata.
- Developed system for redirecting http identifiers (URI) using a pattern-based rewrite, to facilitate linking data using standard web architecture.
- Loaded 4500 metadata records for Arizona and California Geological Survey documents and other geothermally-relevant documents, as well as sample metadata from several other states. (<http://catalog.usgin.org/geoportal>)
- Implemented a project web site (<http://stategeothermaldata.org>) and utilized it for distributing project information. Based on experience with the site, we are now migrating to a new implementation and content model for the site to simplify maintenance and improve functionality.
- Identified and documented 29 data items for delivery by system services, with draft content models.
- 8 content models developed, reviewed and version 1 posted on StateGeothermalData.org site.
- 13 web feature services on line, with three of the four hubs hosting active services (AZ, IL, KY). Services include borehole temperature, thermal springs, and well headers
- Designed, acquired and deployed new server hardware system for AZGS hub with upgraded network bandwidth capacity, additional scalable storage, and more processor capacity.
- Participated in national and international standardization efforts to keep AASG geothermal data schema and protocols harmonized with evolving technology.

## 6. Challenges to Date

Subcontracting delays account for the most critical challenge to the project. The project kick-off meeting, held May of 2010 in Washington, DC, provided the background for the contracting process that began May 24, 2010. Review of SOWs and budgets by AZGS and SAB occurred immediately following the State Geological Survey's submissions (June of 2010). Contracts then required modifications to the SOW and budget to comply with SAB and AZGS review. Finally, contracts required extensive review by the associated state or university legal offices. Thus, the majority of final contracts were not signed until fall of 2010.

In conjunction to these delays, budget issues across the nation have impacted a number of state agencies. Some geological surveys have, until recently, been uncertain as to the future of their agency. Many states have had hiring freezes resulting in a challenge of recruiting personnel for the project, creating further delays.

Current solutions for resolving these issues include adjusting the deliverables timeline for sub-recipients and redirecting current staff. In addition, many states are choosing to hire individuals as contractors rather than employees. AZGS has agreed to honor a full year from contract signature date for Year 1 deliverables. The same process will apply for Year 2. However, Year 3 will be shortened to honor the initial contracting date of May 24. Therefore, all sub-recipients have agreed to finalize all three years of deliverables by May 24, 2013. To resolve hiring delays, AZGS has worked with sub-recipients to revise budgets and budget justifications to account for current employees or contract employees rather

than new hires. It is the intention of most sub-recipients to continue requesting new positions from their state agencies throughout the process.

The challenges have impacted technical deliverables only in the sense that the deliverables have been delayed respective to the aforementioned delays. AZGS intends to request a no-cost grant extension based on these challenges.

## 7. Conclusion and Plans for the future

All sub-awards to State Geological Surveys or other participants are now contracted totaling 45 sub-awards and covering all 50 states. Fifteen state proposals were selected for acquisition of new data. A working agreement was negotiated with the Western Regional Partnership (WRP) to link the WRP central GIS data repository (currently 3,500 land management data layers in five states, growing to 10,000) to NGDS. Technical standards or protocols were completed and posted on the State Geothermal Data website – [www.stategeothermaldata.org](http://www.stategeothermaldata.org). These include interchange content models for Active Fault, Basic Metadata, Borehole Temperature Observation, Geologic Map Data, Hot Springs Feature, and Well Header; recommendations for geoscience metadata content; USGIN profile for encoding of metadata; definition and use of http URI's to identify resources; URI dereferencing application using Django; and metadata production and entry workflows. The project team has 5 publications, gave 26 talks and 10 briefings, hosted 7 webinars/webcasts, staffed 3 national exhibits, gave 6 news interviews, and runs 3 project-related websites. Webinars are posted to the AASG YouTube channel for public viewing. Sub-recipients are actively digitizing thousands of at-risk data sets. Data sets have been received from 34 states for review in the workflow.

Key activities for Year-2 include approval of each state's Year-2 work plan based on work progress in Year-1. These will be reviewed by the project's Science Advisory Board June 2-3, 2011 in Salt Lake City. The 3 regional server hubs are expected to be fully functional by the end of June 2011. A prototype deployment of the system will roll out incrementally during summer 2011. AZGS will address issues and constraints with operational deployment and the use of the system through scaling, validation, response times, up-time, and user feedback. In addition, the production of training programs continues. These include webinars, videos, guidebooks, online tutorials, and short courses. Most of the new data acquisition will take place over the next year including drilling a minimum of 21 gradient and research holes in 6 states (ID, NV, OR, UT, WA, WI). All new drilling projects require NEPA clearance.

Upon conclusion the project will have digitized, cataloged, and produced metadata records for most of the existing and legacy geothermal related data. All of this data will be made accessible online, hosted by individual providers or in the cloud via the regional hubs. Network operations will provide distributed backup and facilitate data transfers. In addition, third-party data or service providers will have access to become full system participants. Finally, a sustainable business model will be produced.

## 8. Publications and Presentations

### Publications

- Allison, M. Lee, Stephen Richard, Linda Gundersen, & Ian Jackson, 2010, U.S. Geoscience Information Network (GIN) and Convergence towards Global Data Integration in the Geosciences, Microsoft Environmental Research Workshop 2010, Redmond, Washington July 14, 2010, p4, Proceedings, 48p, <http://research.microsoft.com/en-us/events/environmentalresearch2010/erw2010.pdf>
- Allison, M. Lee and Stephen M. Richard, 2011, State Geothermal Contributions to the National Geothermal Data System: Annual Report 2010, AZGS Open-file Report 11-01, 46p.
- Walker, J. D., Linda C. Gundersen, and M. Lee Allison (convenors), submitted, Workshop on Working towards a National Geoinformatics Community (NGC), USGS Denver Federal Center, Denver, Colorado, September 23-24, 2010, 39p.
- Allison, M. Lee, Linda C. Gundersen, Stephen M. Richard, in press, Geoinformatics in the Public Service: Building a Cyberinfrastructure Across the Geological Surveys, Geoinformatics, R. Keller & C. Baru, eds, Cambridge University Press.
- Richard, Stephen M., Ryan Clark, and Wolfgang Grunberg, in review, Application of the U.S. Geoscience Information Network to deploying a National Geothermal Data System, in "Geoinformatics," R. Keller & C. Baru, eds, Cambridge University Press.

### Talks

- Allison, M. Lee, Soc. of Mining, Metallurgy, and Exploration (SME), Environmental Division annual luncheon, "Towards a Global Data Network for the Geosciences," SME Annual Meeting, Phoenix, AZ, March 2, 2010
- Allison, M. Lee, Project Management Institute, Tucson Chapter, "Building a Global Data Network for the Geosciences," Tucson, AZ, March 9, 2010
- Allison, M. Lee, Arizona Hydrologic Society, "Building a Data Network for the Geosciences," Tucson, AZ, April 13, 2010

- Allison, M. Lee, Black Canyon City Rockhounding Group, "Geothermal Energy Potential in Arizona," Black Canyon City, AZ, April 15, 2010
- Richard, Stephen, "Web services to assemble pieces of a geoscience information network," U.S. Geological Survey seminar, Menlo Park, CA, April 15, 2010
- Allison, M. Lee, Arizona Geological Society, "Everything Digital, Online, and Integrated," Tucson, May 4, 2010
- Allison, M. Lee, OneGeology Initiative Roundtable, European Geophysical Union Annual Conf., Young Earth Scientists (YES) Network, "Data Integration in the U.S.," Vienna Austria, May 7, 2010 by webcast
- Clark, Ryan, Stephen Richard, and Wolfgang Grunberg, "The National Geothermal Data System: The Geoscience Information Network in Action," Digital Mapping Techniques Workshop, Sacramento, CA, May 17, 2010, <http://lab.usgin.org/sites/default/files/group/file/u6/NGDSPoster.pdf>
- Allison, M. Lee, DOE-NGDS Roundtable, "Data Integration for the National Geothermal Data System," Arlington, VA, May 17, 2010
- Allison, M. Lee, US Dept. of Energy Geothermal Technologies Program Peer Review "State Geological Survey Contributions to the National Geothermal Data System," Arlington, VA, May 18, 2010
- Allison, M. Lee, "A Digital Revolution in the Geosciences," Association of Engineering & Environmental Geologists (AEG), July 8, 2010, Tucson AZ
- Allison, M. Lee, Stephen M. Richard, Ryan Clark, and Wolfgang Grunberg, "The National Geothermal Data System: An Implementation of the Geoscience Information Network," Webservices Blast, 2010 USGS Community for Data Integration Workshop, Denver, CO, August 10-13, 2010
- Allison, Lee, Jon Spencer, Jeri Young, and Stephen Richard, "Digital Data Integration of Uranium Resources of Northern Arizona," Arizona Hydrological Society Symposium, Tucson, AZ, September 1-4, 2010
- Allison, M. Lee, "Perspectives from the U.S. on Data Interoperability," OneGeology-Europe final workshop, Paris, France, October 27, 2010
- Allison, M. Lee, and Stephen M. Richard, invited, "State Geological Survey Deployment of the National Geothermal Data System," Geological Society of America Annual Meeting, Denver, CO, November 2, 2010, [http://gsa.confex.com/gsa/2010AM/finalprogram/abstract\\_178582.htm](http://gsa.confex.com/gsa/2010AM/finalprogram/abstract_178582.htm)
- Allison, M. Lee, Stephen Richard, Linda Gundersen, & Ian Jackson, submitted, "U.S. Geoscience Information Network (GIN) and Convergence towards Global Data Integration in the Geosciences," Geological Society of America Annual Meeting, Denver, CO, October 30 - November 3, 2010, [http://gsa.confex.com/gsa/2010AM/finalprogram/abstract\\_178715.htm](http://gsa.confex.com/gsa/2010AM/finalprogram/abstract_178715.htm)
- Allison, M. Lee, "A Digital Revolution in Resource Exploration," SME Tucson Chapter dinner meeting, Tucson, AZ, November 10, 2010
- Allison, M. Lee, "Global Data Integration in the Geosciences," Council of State Regulatory Officials, Interstate Oil & Gas Compact Commission, Annual Meeting, Tucson, AZ, November 17, 2010
- Allison, M. Lee, Stephen M Richard, Ryan J. Clark, Wolfgang Grunberg, 2010, "Application of the U.S. Geoscience Information Network to deploying a National Geothermal Data System," American Geophysical Union Fall Meeting, San Francisco, CA, December 17, 2011
- Gundersen, L., Whitmeyer, S.J., Walker, D., Allison, L., Babaie, H., Cervato, C., Fils, D., Richard, S.M., Arrowsmith, R., 2010, "New Initiatives in the Development of a National Geoinformatics Community," American Geophysical Union Fall Meeting, San Francisco, CA, December 15, 2010
- Allison, M. Lee, "Meeting the challenges of the 21st century with data integration," Geo-Data Informatics: Exploring the Life Cycle, Citation and Integration of Geo-Data, National Science Foundation Workshop ("GeoData2011"), Broomfield, CO, March 3, 2011
- Allison, M. Lee, "Online Data for Mining and Mineral Resources – Arizona Leads the Way," ARPA Critical Issues Conference, AZ Rock Products Association, Phoenix Airport Marriott, Phoenix, AZ, April 1, 2011
- Allison, M. Lee, "Everything Digital, Online, and Interoperable," keynote address, Utah Geographic Information Council, 20th annual meeting, Riverwoods Conference Center, Logan, Utah, <http://gis.utah.gov/ugic-conference/general-information>, April 6, 2011
- Allison, M. Lee, Stephen M. Richard, Arlene Anderson, and David Cuyler, "National Geothermal Data System and Global Geosciences Data Integration," ESRI Petroleum User Group (PUG) Conference, Data Management & GIS Technology - Data & Standards session, George R. Brown Convention Center, Houston, TX, April 19, 2011
- Allison, M. Lee, "Everything Digital, Online, and Interoperable," Americas Petroleum Survey Group, 25th Annual Conference, Houston, TX, May 6, 2011

#### Briefings

- Allison, M. Lee, Project Partners Meeting, "State Geological Survey Contributions to the National Geothermal Data System," Arlington, VA, May 17, 2010
- Allison, M. Lee, Geothermal Breakout Session, moderator, AASG Annual Meeting, New Brunswick, NJ, June 30, 2010
- Allison, M. Lee, "State Geological Survey Contributions to the National Geothermal Data System," AASG Annual Meeting, New Brunswick, NJ, June 30, 2010
- Allison, M. Lee, "Overview of the NGDS," Arizona Geographic Information Council, Data Committee, [briefing and demo], Phoenix, AZ, July 9, 2010 [by web conference]
- Allison, M. Lee, Stephen Richard, "Geoscience Information Network Contributions to the National Geothermal Data System," NGDS Annual Meeting, Boise, ID, August 16, 2010
- Lovasz, Gabe, Mike Hamilton, M. Lee Allison, "GIS Committee Report," Western Regional Partnership, Principals Meeting, Albuquerque, NM, August 17, 2010
- Allison, M. Lee, "GIN as a data integration framework for the Southern Arizona Template," Western Regional Partnership, Southern Arizona Template Working Group, Phoenix, AZ, November 8, 2010

- Richard, Stephen M., U. S. Geological Survey Community for Data Integration, ScienceBase planning meeting, "US Geoscience Information Network", web meeting, January 24, 2011
- Allison, M. Lee, American Institute of Professional Geologists, Mid-year Board Meeting, "AASG Strategic Directions," Tucson, AZ, February 11, 2011
- Allison, M. Lee, American Institute of Professional Geologists, Arizona Section, "Arizona Geological Survey," Tucson, AZ, February 12, 2011
- Richard, Stephen M., System for Earth Science Sample Registration Workgroup Meeting, "Metadata for Geoscience Resources", San Diego, CA, February 22, 2011
- Allison, M. Lee, U.S. Geoscience Information Network (GIN) and Convergence Towards Global Data Integration in the Geosciences, iPlant GIS Advisory Committee, Univ. of Arizona, Tucson AZ, February 25, 2011
- Clark, Ryan, Western Regional Partnership GIS Committee Meeting, "Brief overview of US Geoscience Information Network", Reno, NV, March 8, 2011

#### Web Presentations

- AZGS Webcast: "Thermal Profiling of wells for thermal conductivities and heat fluxes in active sedimentary aquifers," Dr. Franklin Horowitz, Research Professor, at University of Western Australia, School of Earth & Environment, and the Western Australia Geothermal Center of Excellence
- AZGS Webcast: "Geothermal air conditioning opportunities in hot sedimentary Aquifers," Dr. Franklin Horowitz, Research Professor, at University of Western Australia, School of Earth & Environment, and the Western Australia Geothermal Center of Excellence
- AZGS Webinar: "Metadata tools and workflows for AASG Geothermal Data", February 15, 2011 [32 attendees]
- AZGS Webinar: "Metadata tools and workflows for AASG Geothermal Data", February 16, 2011 [35 attendees]
- AZGS Webinar: "Web Services for Bottom-Hole Data," March 16, 2011 [36 attendees]
- AZGS Webinar: "AZGS HUBS – Data and Serving Data," April 12, 2011 [6 attendees]
- AZGS Webinar: "AZGS HUBS – Data and Serving Data," April 26, 2011 [4 attendees]

#### Exhibits

- Geothermal Resources Council annual meeting and expo in Sacramento, CA. A new high-definition (HD) multi-monitor display system was unveiled at the GRC annual meeting and expo to run demonstrations of live Web services and data integration from the project. October 24-27, 2010.
- Geological Society of America Annual Meeting in Denver, CO. The new HD multi-monitor display system was subsequently set up in the AASG booth in the exhibit hall for the Geological Society of America Annual Meeting with live demos run continuously. October 30-November 3, 2010.
- Geothermal Energy Association, Geothermal Energy Technology and International Development Forum, May 4, 2011, Washington, DC [AZGS State Geothermal Data exhibit booth]

#### Workshops

- Allison, M. Lee, Member, Organizing Committee, Workshops on Interoperability/Technology and Education/Outreach aspects of Geoinformatics – working towards a National Geoinformatics Community Organization, September 23-24, 2010, USGS-Denver Federal Center, Denver, CO

#### Testimony/Written Responses

- Allison, M. Lee, Response to "Spatial Data Enabling USGS Strategic Science in the 21st Century," National Research Council, February 16, 2010, 5p