Contracting out geologic map digitization and attribution using the GeMS standard

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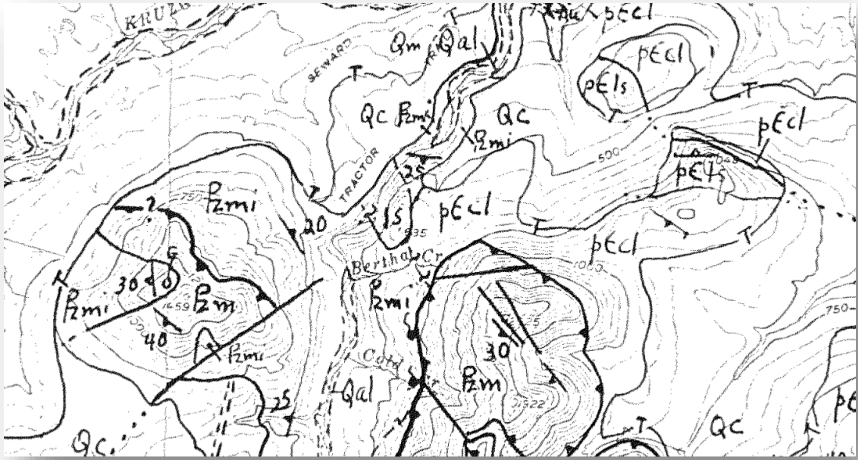
DIGITAL MAPPING TECHNIQUES 2022, ROLLA, MISSOURI, MAY 22-25
PRESENTED BY JENNIFER ATHEY, MAY 23, 2022

Why contract GeMS conversions?

Funding opportunity to complete more conversions, but staff were busy with STATEMAP: Hire or contract?

- FFY21 NGGDPP proposal to convert 4 maps – test of our AK GeMS documentation
- Digitization of 8 paper maps for FFY21 STATEMAP

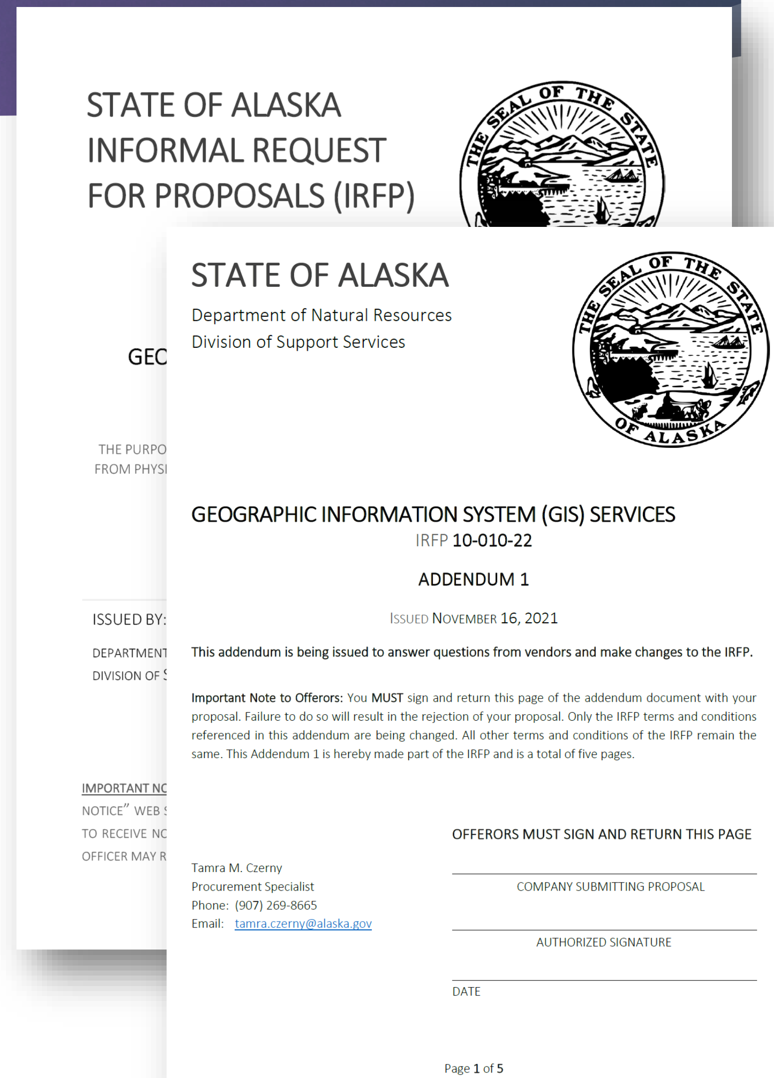


Request for Proposals

- Firm Fixed contract, monthly billing
- Minimum experience: 6 months of geoscience position working with maps and 2 years of GIS
- Documentation: AK GeMS, GeMS, symbology, USGS cartographic standards, DMT GeMS conversion talk

> "Thankfully, USGS has a great online resource for info on GeMS, very detailed, and fairly up to date which helped me a lot"

- Deliverables and data: URLs to maps, sheets to be converted, existing legacy data
- Communication expectations


STATE OF ALASKA
INFORMAL REQUEST
FOR PROPOSALS (IRFP)

STATE OF ALASKA

Department of Natural Resources

Division of Support Services

GEOGRAPHIC INFORMATION SYSTEM (GIS) SERVICES

IRFP 10-010-22

ADDENDUM 1

ISSUED NOVEMBER 16, 2021

This addendum is being issued to answer questions from vendors and make changes to the IRFP.

Important Note to Offerors: You MUST sign and return this page of the addendum document with your proposal. Failure to do so will result in the rejection of your proposal. Only the IRFP terms and conditions referenced in this addendum are being changed. All other terms and conditions of the IRFP remain the same. This Addendum 1 is hereby made part of the IRFP and is a total of five pages.

OFFERORS MUST SIGN AND RETURN THIS PAGE

Tamra M. Czerny
Procurement Specialist
Phone: (907) 269-8665
Email: tamra.czerny@alaska.gov

COMPANY SUBMITTING PROPOSAL

AUTHORIZED SIGNATURE

DATE

Page 1 of 5

DGGS and contractor staff

Jen Athey, DGGS PM

Charlie Barnwell, Kinney Engineering PM

Mike Hendricks, DGGS technical lead and final QC
Amy Macpherson, DGGS GIS support

Chris Wyatt, DGGS QC and conversions
Alec Wildland, DGGS conversions

Lars Arneson, Kinney Engineering digitizing and conversions

Project implementation

- Digitization into nominal AK GeMS and then full AK GeMS conversions
- Tracking hours, funds, and deliverables
- Communication
  - Kick-off meeting
  - Weekly meetings
  - Quick responses to questions (<8 hours)
  - MS Teams
- Documentation and training

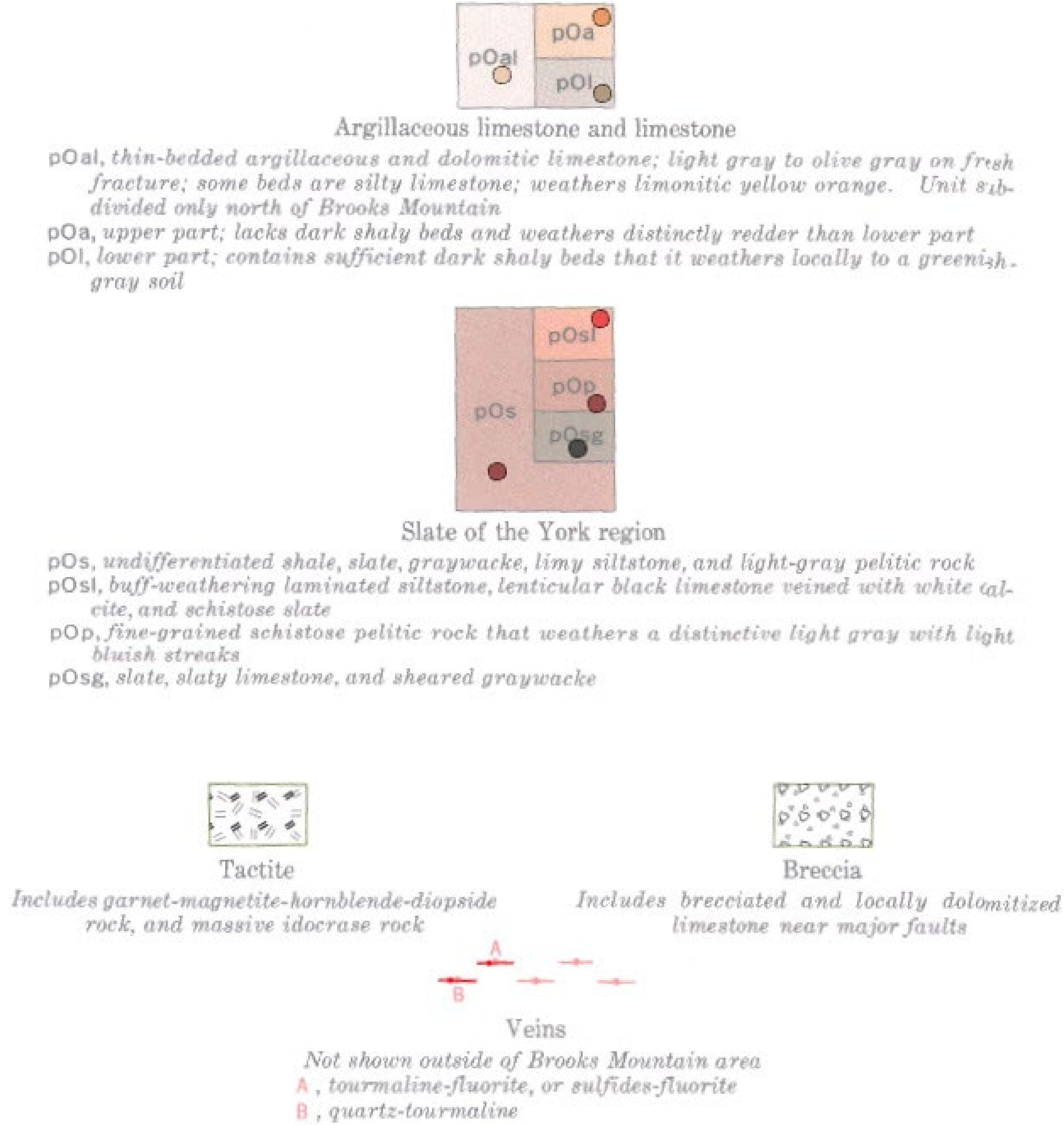
Nominal AK GeMS

Heads-up digitized linework to AK GeMS feature classes:

- map unit points
- contacts and faults
- structure lines
- orientation points
- cartographic points
- cartographic lines
- cartographic polys

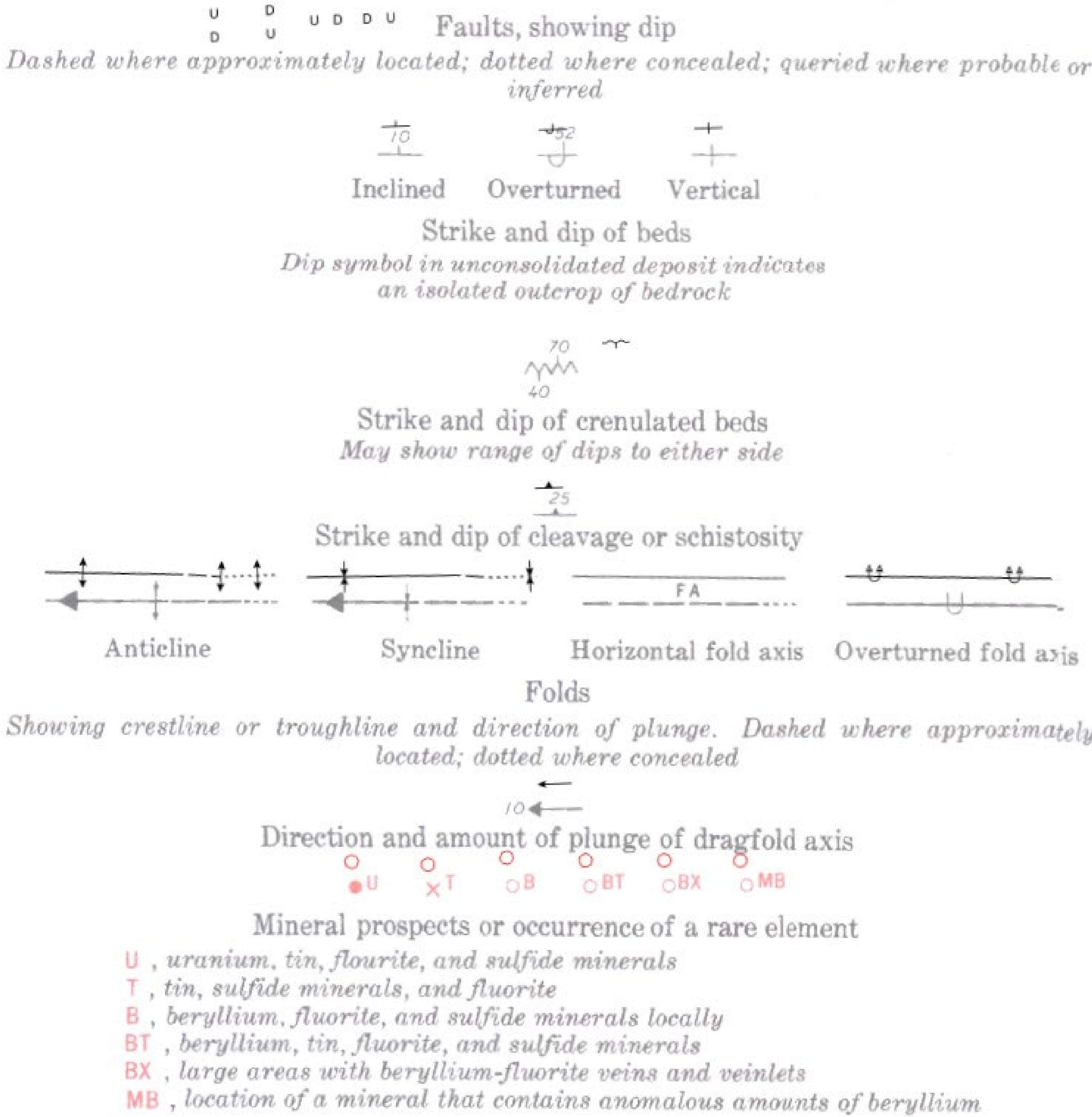
Digitizing process

- Map unit points
- Colors
- Patterns
- Linework
- Build polygons



Digitizing process

- Symbols
- Feature templates



Quality control process

DGGS QC checks

- Every field in every table gets, at least, a glance.
- Sorting by different attributes and spot checks are conducted first. If multiple errors are found, more thorough scans are conducted.
- Visual scan/inspection at 2-3x scale can reveal missing features or symbol errors.
- Topology error inspection at larger scale can reveal other nearby errors.

From: Wyatt, Chris (DNR)
Sent: Thursday, April 28, 2022 2:21 PM
To: Lars Arneson
Subject: council_surficial .gdb review notes

Hi Lars-- Here are some notes for the council_surficial map .gdb"
A few of these are marked on the review_items_point layer, too, attribute issues mostly.

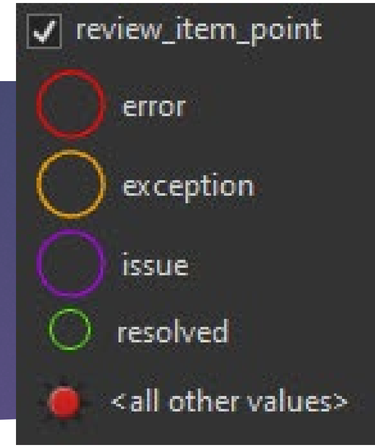
Some of these might apply to big_hurrah_surficial as well? I'll start looking at that .gdb next.

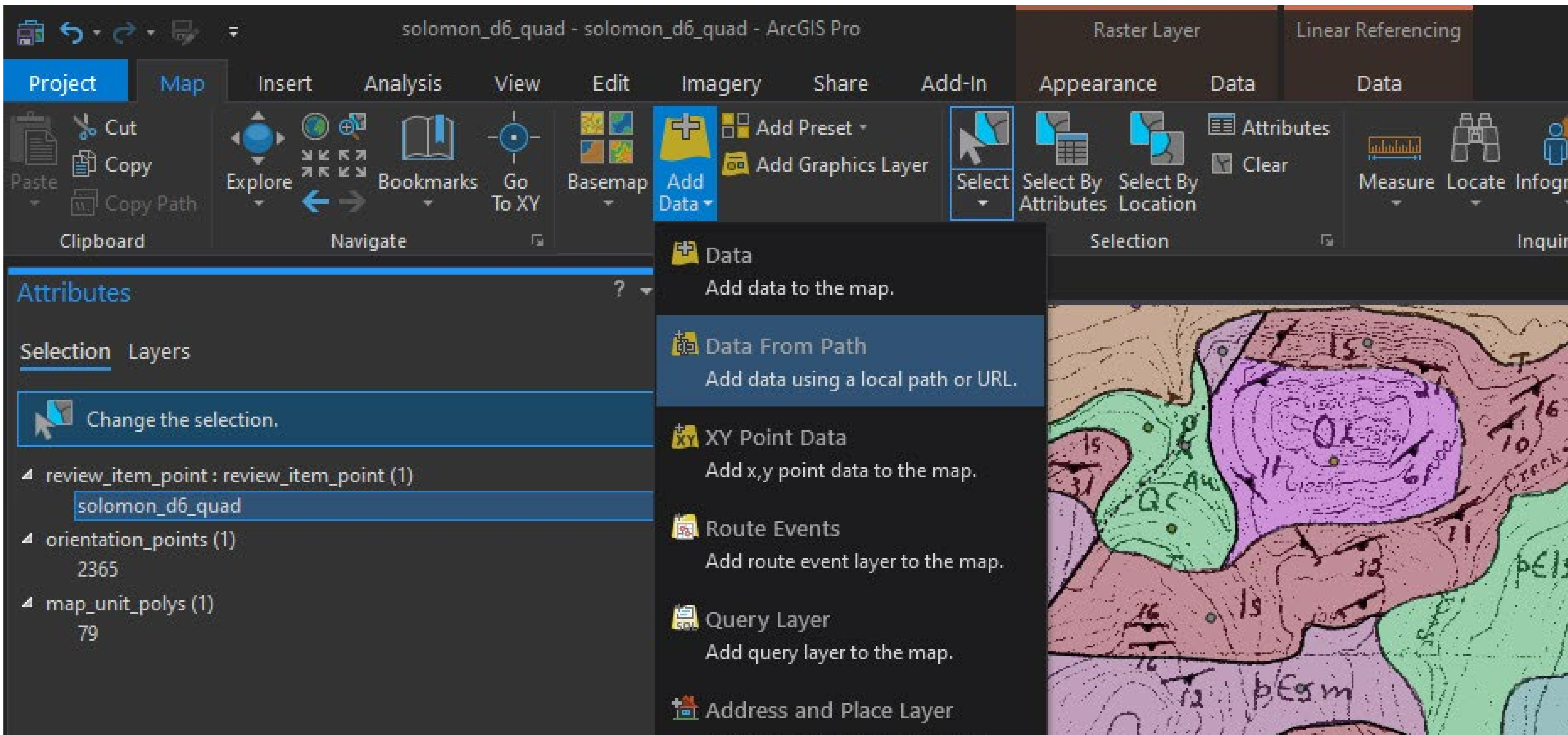
contacts_and_faults
typo in 'notes' field: "approximate"
set the notes field to match the raster PDF "MAP SYMBOL" description for these, since it's not clear from the FGDC symbol or category/type: "Photointerpreted contact – Approximately located"
'layer' field: contacts/faults that touch surficial polygons are layer = 1
contacts/faults that touch only bedrock polygons are layer = -1
faults are almost always a bedrock feature, or layer = -1
boundary = 0
This is a little tricky to assign, with a series of select-by steps to separate the surficial and bedrock features; I can populate 'layer' or show you how I do it.

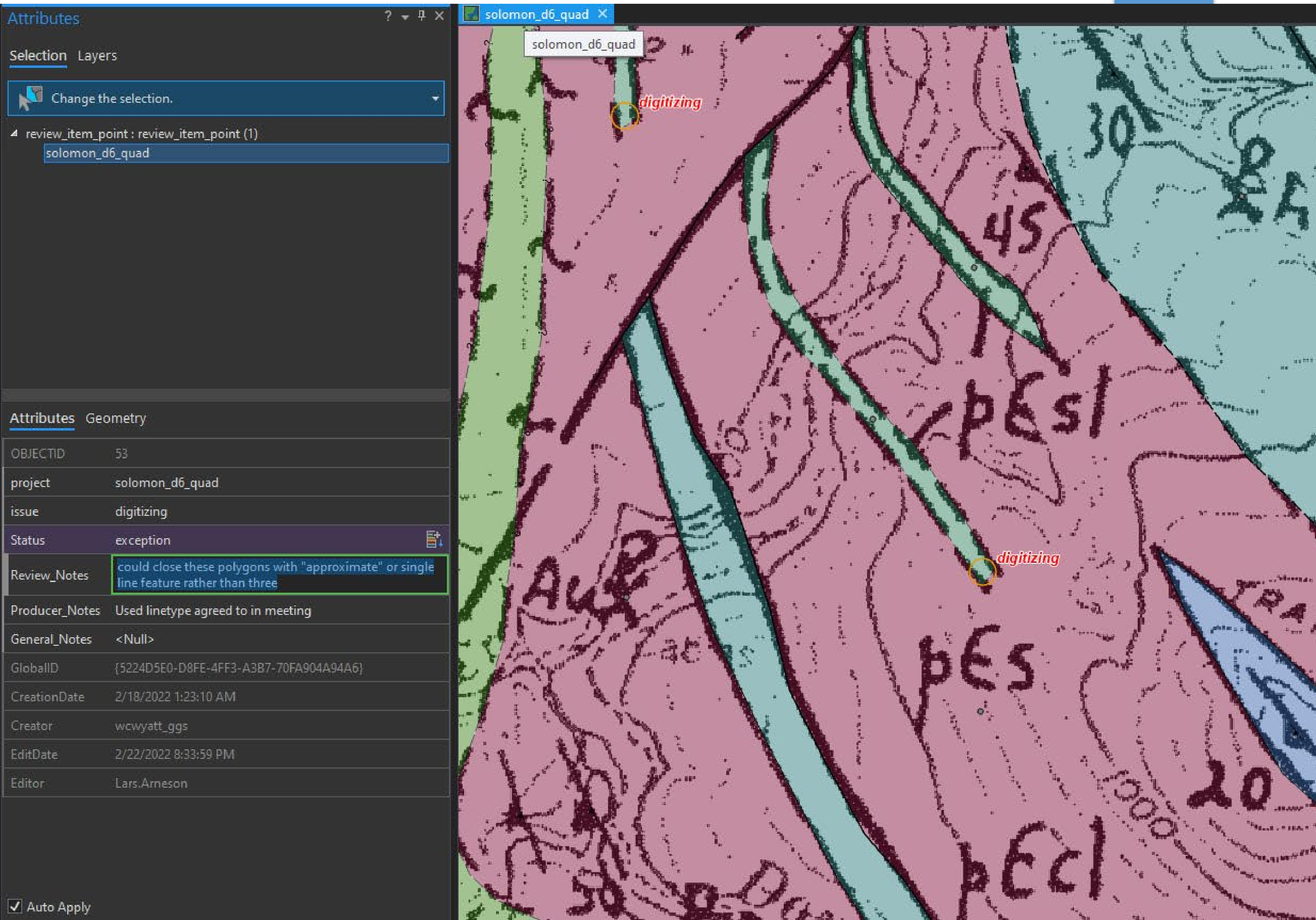
map_unit_polys
'layer' field: surficial polygons are layer = 1
bedrock polygons are layer = -1
water is layer = 1
Where map_unit_polys 'label' is queried with "?", set map_unit_polys 'identity_confidence' to "questionable"

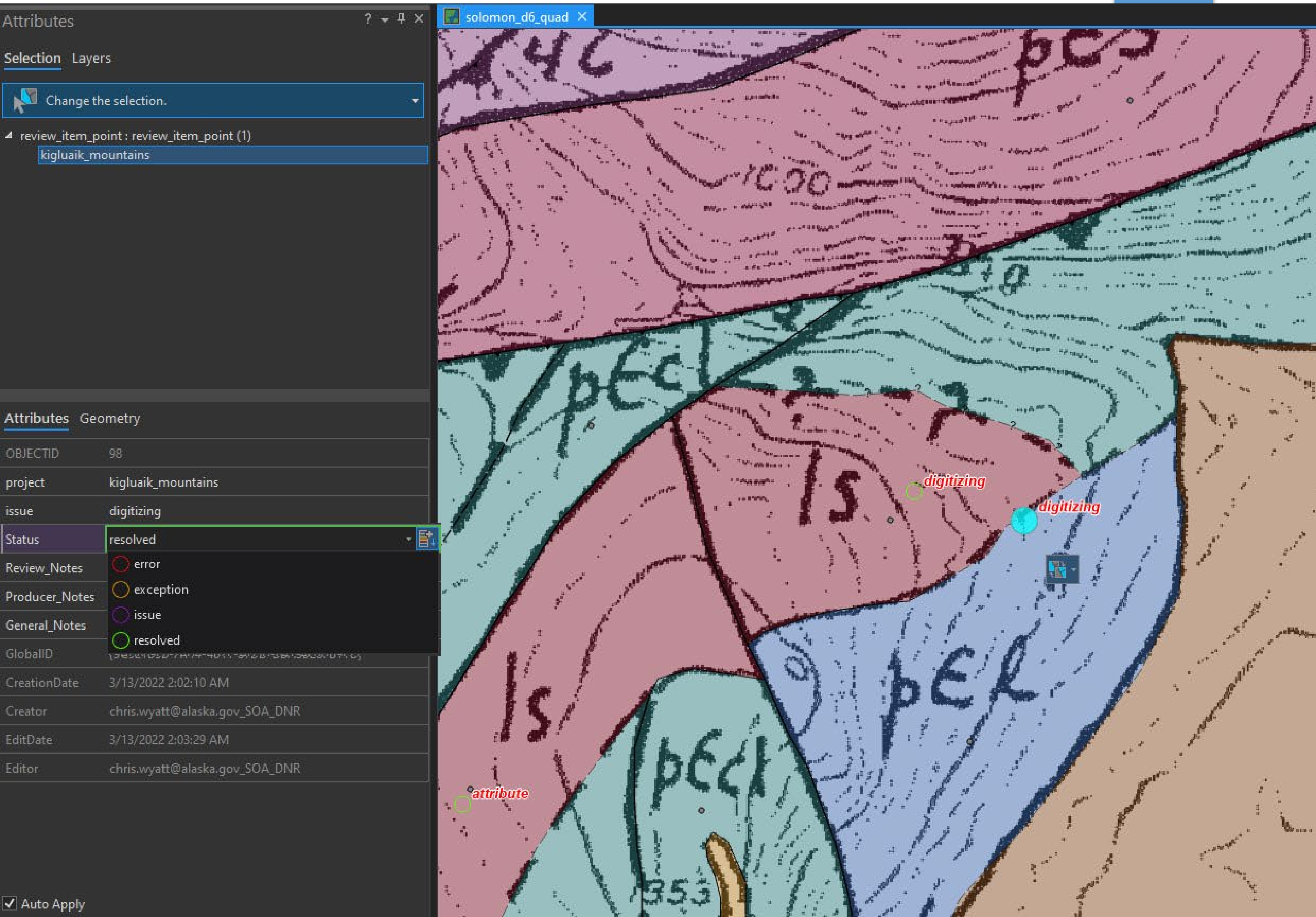
geologic_lines
flow direction indicators are missing attributes

Quality control web service






Attributes
Selection
Layers
Change the selection.
review_item_point : review_item_point (1)
solomon_d6_quad
Attributes
Geometry
OBJECTID 53
project solomon_d6_quad
issue digitizing
Status exception
Review_Notes could close these polygons with "approximate" or single line feature rather than three
Producer_Notes Used linetype agreed to in meeting
General_Notes <Null>
GlobalID {5224D5E0-D8FE-4FF3-A3B7-70FA904A94A6}
CreationDate 2/18/2022 1:23:10 AM
Creator wcwyatt_ggs
EditDate 2/22/2022 8:33:59 PM
Editor Lars.Arneson
Auto Apply
solomon_d6_quad
solomon_d6_quad
digitizing
digitizing


Attributes
Selection
Layers
Change the selection.
review_item_point : review_item_point (1)
kigluaik_mountains
Attributes
Geometry
OBJECTID 98
project kigluaik_mountains
issue digitizing
Status resolved
error
exception
issue
resolved
Review_Notes
Producer_Notes
General_Notes
GlobalID
CreationDate 3/13/2022 2:02:10 AM
Creator chris.wyatt@alaska.gov_SOA_DNR
EditDate 3/13/2022 2:03:29 AM
Editor chris.wyatt@alaska.gov_SOA_DNR
Auto Apply
solomon_d6_quad
digitizing
digitizing
attribute

Time and effort

Time estimates per map	Digitized maps	GeMS conversions
Contractor digitization	16 hours (digitizing only)	30 hours (digitizing + GeMS)
Contractor QC	2 hours	15 hours
DGGS QC and fixes	4 hours	4 hours+
DGGS finish conversion	40 hours	7 hours
Total Time	**62 hours**	**56+ hours**

Less than two weeks for each map!

How well did our documentation and training prepare the contractor?

- GeMS and AK GeMS docs
- FGDC cartographic standard
- Feature templates and styles
- Tools and scripts
- Two 1-hr training sessions
- Digitizing tips and tricks
- Weekly meetings

- Step-by-step digitizing instructions were incredibly helpful. Would like instructions to be formalized.
- Timing of GeMS training sessions was too early in project

"Once I had a better handle on how important building out the DMU was, everything else started to make more sense."

- Should have had a training session on topology
- Rotating mouse wheel to get correct structure orientation saved time
- Work prompted adding to FAQs and feature templates

Successes

I feel the digitizing was a big success. I don't think there will would be short-term success with having contractors do the entire full GeMS map process, but there would be long-term success if the same contractor had time to learn the whole process effectively.

Lars has built up enough experience that he can make full GeMS maps, e.g., I can tell he had to make a decision here, and he made the good one.

The learning curve for understanding the schema was steep. It took me a couple maps before I had a great sense of how to determine which line or points belonged in each part of the schema. Many of my questions for Mike and Chris revolved around how a specific data point should be categorized or symbolized.

The weekly check-ins and the ability to QC in stages enabled us to discover any misconceptions/mistakes early on and reduce their reoccurrence in future maps.

What could we have done better?

When starting out on the digitizing and then the conversions I think it would have helped me to send my work for review more often. This allows for the feedback to be addressed in the rest of the work going forward. The challenge was sending uncomplete work that likely had errors that I may have caught if I spent more time with the data.

With feature template and style file, the most efficient way is to leave the line work to the contractor and GeMS attribution to DGGS. It takes almost as much time to review the attributes as it does to populate them.

I think the “GIS tech” requirement should have been stronger, as the requirements as stated in the IRFP could have resulted in someone who would require lots more training.

It may be easier to digitize a map than convert legacy data, unless there is a lot of orientation data.

"Overall, I think this has been a great project. It's rare to get a good combination of client, contractor, technical teams together like this, and things working on schedule, and (somewhat!) on budget."

Join the CDEFG discussion

- Monthly teleconferences, next July 11 @ 2pm EST
- Project wiki
- Questions?

Contact Jen Athey at 907.451.5028 or jennifer.athey@alaska.gov

https://dggs.alaska.gov/gemswiki/

Contracting out geologic map digitization and attribution using the GeMS standard

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[1]Alaska Division of Geological & Geophysical Surveys
[2]Kinney Engineering, LLC
(accompanies slide deck presented at Digital Mapping Techniques 2022 workshop, May 22-25, 2022, Rolla, Missouri)

Abstract

The Alaska Division of Geological & Geophysical Surveys (DGGS) hired a contractor to (1) digitize legacy geologic maps in raster format into an abbreviated database structure based on the published geologic database standard GeMS (Geologic Mapping Schema) and (2) convert several non-GeMS digital geologic maps to Alaska's version of the full GeMS standard. This project was designed as a test of the utility and completeness of our AK GeMS documentation to determine whether someone not familiar with GeMS could interpret the information correctly and produce compliant GeMS deliverables in a reasonable amount of time. This presentation reviews the initial specifications, documentation, and helpful files given to the contractor for the work; methodology during the project such as routine communication and quality control procedures using web services; and analysis of the final results of the project such as contractor time per map and description of the successes and challenges of the work as performed. The project team, including DGGS and contractor staff, was interviewed as the project was closing, and pertinent quotes from team members are included throughout the document.

What is GeMS and why did we contract this work?

GeMS is the published database standard for digital geologic map data developed by the U.S. Geological Survey (USGS) in collaboration with state geological surveys. The standard provides a framework for encoding traditional geologic maps into organized sets of spatial objects with feature-level metadata and symbolization information. GeMS provides a standardized distribution and archiving format that is being harnessed by U.S. federal and state geological surveys to create regional geologic compilation maps and ultimately, seamless bedrock and surficial geologic maps covering the U.S. To meet this national goal, several USGS grant programs currently require geologic map deliverables in GeMS.

DGGS was awarded funding through the FY2021 National Geological and Geophysical Data Preservation Program to convert four maps, some with multiple map sheets, to GeMS (slide 2). One map with multiple sheets required digitization, while the other three maps were available as legacy, non-GeMS digital files. Through the USGS STATEMAP grant program, DGGS received funding to convert an additional eight maps with multiple sheets to GeMS. These maps were only available in paper format. Due to staffing and project-schedule constraints making the completion of the tasks challenging, we decided to test whether outsourcing the work would be a viable way to complete the deliverables. If successful, contracting GIS work would become a future option to complete similar grant-funded work.

What did we learn about the best way to set up a contract to do this work?

DGGS used an Alaska Department of Natural Resources (ADNR) procurement vehicle called Informal Request for Proposals (IRFP) to solicit bids from prospective contractors. The IRFP process may be used for ADNR contracts less than $50,000. The IRFP was released online, standard periods of time (weeks) elapsed as bidders prepared proposals, and then proposals were reviewed by DGGS. Two amendments were issued to the IRFP: one to extend the bidder response period by one week, and another to answer specific bidder questions about the IRFP and project. DGGS was pleased by the number of bidders and quality of proposals. This section includes team member thoughts on the important parts of the IRFP and contract set-up process (slide 3).

Type of contract: A firm-fixed contract with monthly billing worked well. A firm-fixed-price contract provides for a price that is not subject to any adjustment based on the contractor's actual time-cost performance. This contract type places maximum risk and full responsibility for all costs and resulting profit or loss upon the contractor. Caution: If the contractor is not familiar with GeMS, they may underbid from underestimating its complexity and time needed. Billing by task, map, or sheet completed is another option to consider.

Contractor location: Use of a remote but local contractor worked well because of the use of open, easy communication via video conferencing, email, phone, etc. Caution should be taken before using remote, offshore contractors where challenging communication may be a factor.

> "In my experience with many Alaska GIS projects, I would say that [an Alaskan bidder] preference is a good thing, for these reasons: 1) understanding Alaska's unique geography and environment is important, I think, [especially] in GIS, and 2) non-[Alaska] firms tend not to have an interest in the project, which does count for something." — *Contractor*

Contractor experience: Person doing the work should have a minimum of six months experience in a geoscience position working with maps and two years of professional GIS. If a skilled contractor pool is anticipated, it would be beneficial to bump up minimum requirements. List and emphasize specific experience and skill areas needed: topology, digitizing, geologic mapping, etc. This will help contractors develop a better bid.

> "Specified in qualifications that wanted a "GIS tech", which basically was ok, with minimal experience, and education. I think the requirement should have been stronger, as the requirements as stated in the IRFP could have resulted in someone who would require lots more training." — *Contractor*

> "I think the experience levels required were a bit light, e.g., +2 for geologic and +2 GIS. I would have required more on the GIS experience, at least +4. I think having a requirement for both geology and GIS was smart. GIS was the primary skillset needed for the project, but having a geology understanding helped, I think. Requiring GeMS experience would have made it difficult to find contractors." — *Contractor*

> "This project needed a GIS tech with a fairly robust set of skills, in terms of proficiency with ArcGIS Pro, wide range of GIS experience, e.g., digitization, georeferencing, working with Portal, and general ability to work independently." — *Contractor*

Contract deliverables: Include a bulleted, detailed list of maps with individual sheets to be processed. This can be later modified into a checklist for deliverable management and communication.

Background information and documentation: Links were provided in the IRFP to the AK GeMS data dictionary publication (Hendricks and others, 2021), AK GeMS symbology publication (Ekberg and others, 2021), USGS/FGDC cartographic standards (Federal Geographic Data Committee, 2006), and Digital Mapping Techniques 2020 GeMS conversion talk (Wyatt and others, 2020).

Data: Provide links to online data and/or include data files for contractor to review.

Communication expectations: Set the basic ground rules for communication in the IRFP. These can be modified later depending on how the project progresses.

Bid length: Consider limiting proposal length to 15-20 pages, which helps proposal reviewers and contractors alike. Forces more succinct language too.

<u>Reviewing bids:</u> Look for a comprehensive methodology section that specifically addresses the project and weight this section highly in the evaluation criteria. Look for proposed delivery schedule, understanding of requirements, and research into GeMS. The more points assigned to a section in the evaluation criteria, the more time the contractor will spend writing or proposing that section.

> "A qualified and dependable contractor is crucial for a project like this, and therefore the evaluation criteria should be carefully written and thought out." — *Contractor*

> "Writing RFPs is a tough thing for contractors, as they have to invest time, energy, and thought into a proposal. This can make proposal evaluation difficult. In particular, sections "Understanding of the Project", "Methodology Used for the Project", and "Management Plan for the Project" should be critically reviewed by the review team to see if indeed the proposer does actually understand the project, has a good methodology, and management plan." — *Contractor*

> "I think the Methodology section for a project like this is critical. I spent a lot of time on this while writing our proposal. It's actually important for any project, but for this project in particular I wanted a section that was true, and consistent with methodologies developed to date for GeMS projects by USGS and others. And that made sense in terms of practical GIS workflow. Thankfully, USGS has a great online resource for info on GeMS, very detailed, and fairly up to date, which helped me a lot." — *Contractor*

> "It was faster to award the contract than to hire new staff through the state system." — *DGGS*

What did we learn about the best way to implement a contract to do this work?

The project was implemented through a combination of DGGS and Kinney Engineering, LLC (hereafter referred to as 'Kinney' or 'contractor') staff (slide 4). Both organizations assigned project managers responsible for administrative, resource, and deliverable management. Technical implementation was conducted by two DGGS staff, who directly provided standards, GIS methodology and expectations, general process oversight, and final quality control. An additional DGGS staff member conducted quality control of deliverables submitted by the contractor and determined when deliverables were accepted. DGGS staff then completed any work needed on accepted deliverables in preparation for final quality control. One Kinney employee conducted all the contracted GIS work. Both initial project setup and processes developed during the project highlighted important considerations for future, similar contract work and GIS projects (slide 5).

<u>Digitization into nominal GeMS:</u> For the digitization portion of the contract, an abbreviated portion of the GeMS standard was utilized (table: few fields in Description of Map Units; feature classes: map unit points, contacts and faults, structure lines, and orientations points). All other spatial objects were digitized into feature classes cartographic points, lines, and polygons with limited attribution, such as USGS symbology code information (GeMS "symbol" field) and map legend text (GeMS "notes" field) so that features could be redistributed to more specific feature classes later by DGGS.

<u>Deliverable priority:</u> Determining the order in which the deliverables would be completed turned out to be a critical decision. Although the full GeMS map conversions were due as a grant deliverable sooner than the digitized maps, the digitization portion of the contract was selected to be performed first. This gave the contractor more time to learn about GeMS using the abbreviated schema before needing to know the full intricacies of GeMS.

<u>Project tracking:</u> The contractor tracked project hours for billing purposes and to get a better understanding of how long each type of deliverable took to complete. This information is also useful for both organizations to design future contracts and proposals. Deliverable tracking could have been

improved by perhaps utilizing an agreed-upon, definitive checklist of deliverable items (maps and map sheets) with tags to be updated during the project: not started, in progress, in QC, complete, etc. An additional nicety could be to make this list available in real-time to both organizations using file sharing software.

> "I think in monthly billings the contractor should be required to provide hours and description of hours [to] work done—a spreadsheet of tasks with percent complete. I think this is good for the client as well as contractor to stay on schedule and budget. It worked well for us. We got into trouble a bit on the conversion tasks in not being able to estimate precisely (down to the 1% level) percent complete, thus we ran short of funds at the end of the project." — *Contractor*

> "I think on the whole [deliverable tracking] worked well—having email notification of acceptance of deliverables. However, sometimes I didn't get an email or notification. So, maybe a different system or more structured way for this notification would be helpful." — *Contractor*

> "I think the system used by us for tracking costs and progress—a master spreadsheet for tasks, hours, and percent complete—was a very good one on the whole. It mirrored to some extent the spreadsheet used by the DGGS technical team. We could accurately track project costs through the life of the project, and tracking hours by tasks (e.g., map) was useful and needed to manage the project properly. We use a timesheet program for the company which allows a manager to track exactly how many hours per task are expended for a given time period, e.g., a week. This is very helpful in tracking costs. This also speaks to the need to estimate very carefully at the beginning of the project hours per task. On the whole we got this right, but the conversion tasks were more than expected. I maybe should have budgeted more hours for me to participate in the final weekly team meetings, which might have helped in estimating hour and cost over runs." — *Contractor*

<u>Communication:</u> The project employed an initial kick-off meeting to discuss deliverables, process, project communication, etc. Weekly meetings run by the project's technical lead were crucial in developing the contractor's understanding of GeMS. Outside of scheduled meetings, only about eight hours of communication occurred between team members, which consisted mostly of discussion around quality control issues and edits. Most communication was conducted via Microsoft Teams, with minimal emails and phone calls. Being able to screenshare data issues and questions in GIS software was extremely important for successful communication between remote team members.

> "A good kick off meeting is crucial to a project. I think having all of the key personnel in the respective teams present at the meeting is important. Contractor should go into this meeting prepared with a schedule, milestones, and speak to challenges of the project, possible pitfalls." — *Contractor*

> "Weekly meetings are a good practice, I think, for managing technical work. I've used weekly meetings in other projects, and it was always helpful to keep the project on track, ensure good communication, and workflow proceeding smoothly." — *Contractor*

> "[Communication is] VERY IMPORTANT. Every company we use should have the employee carve out time in their work week to join our meetings. And I know there is a lot of MS Teams weirdness, but ensuring they are part of our [project team] and can interact through chat and view our documentation would be good." — *DGGS*

> "The weekly check-ins and the ability to QC in stages enabled us to discover any misconceptions/mistakes early on and reduce their reoccurrence in future maps." — *DGGS*

"Chris, Alec, and Mike were always quick to respond to questions sent via email. Later in the project, Chris and I called a few times to go over specific parts of attribution and topology rules that had not been covered by documentation. Overall, I would say these communications were less than 8 hours throughout the life of the project." — *Contractor*

"The virtual team meeting approach, I thought (from afar), was great. Using Teams worked very well, [especially] as our technician was in Anchorage, but overall, this method was very efficient and allowed for clear communications." — *DGGS*

"It was really handy having MS Teams meetings to demo things." — *DGGS*

"The meetings were the most useful time for me to ask questions and get the feedback from the whole team." — *Contractor*

<u>Documentation and training:</u> GeMS and related GIS documentation were provided to the contractor in the IRPF. GIS tools and scripts and two specific GeMS training sessions were provided at the beginning of the project. See Section "How well did our documentation and training prepare the contractor?" and slide 13 for additional information.

<u>Digitizing process:</u> To ensure correct topological relationships between contacts, faults, and polygons, DGGS instructed the contractor to use the overall process of building polygons from linework and map unit points (slide 6). The full process included the following steps:

1. Identification of maps units, picking colors, and filling out a few key fields in the Description of Map Units (DMU) table: map unit abbreviation and cyan-magenta-yellow-black (CMYK) color. The entire DMU was filled out for full GeMS conversions. Map unit points were first digitized onto the DMU area of the georeferenced map sheet to make sure each unit was represented and clearly showing the color the map unit would be assigned. Color was determined using a color picker tool and then matched to the nearest symbol (CMYK color) in the AK GeMS symbology standard. Map unit points were then created and distributed across the map area (one point for each polygon) where digital polygons would need to be built later.
2. Contact-and-fault linework was digitized. Digitization training included a ten-minute demonstration in snapping and DGGS' preferred line-creation process. DGGS suggested that not zooming in more than two times the maps scale would create an optimal number of vertices for a line.
3. Once contact-and-fault linework and map unit points were created, the contractor used a DGGS geoprocessing script to build map unit polygons, with the map unit attribute derived from the previously digitized map unit point. This method helped ensure compliance with topology rules involving ContactsAndFaults and MapUnitPolys.
4. Other map elements and geologic features were digitized onto the symbol key area of the scanned map to ensure all feature types were represented. Map features were then digitized into the feature classes in either the nominal or full GeMS schema (slide 7). The contractor took advantage of pre-made feature templates that auto-populated attributes when a specific symbol was selected.

"The step-by-step process for the digitization that Mike provided in the beginning was incredibly helpful for getting started. As I worked through the maps, things moved faster. Rotating the orientation points to the correct orientation is a time-consuming process, but once I realized you can scroll with the mouse wheel to change the angle this greatly increased the rate of producing the points." — *Contractor*

Quality control process: A DGGS staff member was assigned to quality control contractor deliverables before acceptance (slide 8). Having the same DGGS staff member review all the materials provided consistency in expectations and communication with the contractor. Quality control consisted of random spot checks of all feature classes and attributes, visual scans of the digitized features versus the original georeferenced map, and a thorough check for topological consistency (table 1). Generally, if multiple errors were discovered in one category, the whole category needed to be thoroughly examined for additional errors. Feedback regarding systematic errors and errors in non-spatial tables was emailed to the contractor for correction.

A shared, editable feature service was employed to enhance communication regarding specific spatial and attribute errors, such as misidentified map units and linework dangles (slides 9-11). The web service allowed DGGS to drop points at the error location and comment on an error; errors were subsequently addressed by the contractor. Errors could also be tracked with a status field through the quality control process.

Table 1. Topology rules checked during quality control of contractor deliverables.

Feature Layer 1	**Rule**	**Feature Layer 2**
map_unit_polys	Must Not Overlap (Area)	
map_unit_polys	Must Not Have Gaps (Area)	
map_unit_polys	Boundary Must be covered By (Area-Line)	contacts_and_faults
contacts_and_faults	Must Not Self Intersect (Line)	
contacts_and_faults	Must Not Have Dangles (Line)	
fossil_points	Must Coincide With (Point-Point)	stations
orientation_points	Must Coincide With (Point-Point)	stations
contacts_and_faults	Must Not Intersect (Line)	
contacts_and_faults	Must Be Covered By Boundary Of (Line-Area)	map_unit_polys
contacts_and_faults	Must Not Intersect Or Touch Interior (Line)	

> "My process has involved going through each feature class one-by-one and checking that the fields are filled out correctly. I have not had to edit any line features or fix topology errors yet. I have had to add features from the original map that were overlooked during the contactor's first run through." — *DGGS*
>
> "I would upload a map package to our ArcGIS Online server and send a link to Mike and Chris. It would be downloaded and reviewed for errors. Chris would add points to the web service that I could load into my map for addressing comments. These points have a comment section that allow for clear communication. When Chris had finished the review, he would send a list of notes on general trends or specific instance of issues for me to address." — *Contractor*
>
> "The web service was very helpful for knowing where exactly the issues were and allowed me to change an attribute to 'resolved' once I had addressed it. The only con might be that the notes Chris added did not always correlate directly with specific points on the map. There were only 1 or 2 times that I asked for clarification on what the points meant." — *Contractor*
>
> "Not sure how we would have done QC without the web service." — *DGGS*
>
> "I had calls with both Mike and Chris about maps after they had been reviewed." — *Contractor*

“Learned a lot about how the data was going to flow. Quick reviews were helpful to get things done. [Geodatabases were] never sent back a third time—second submissions were always pretty tight, partly because QC was thorough.” — *DGGS*

Time and effort

Contractor and DGGS staff estimated the time they spent on various parts of the process (slide 12). Some of the maps were suggested to have fairly complicated linework and numerous features to digitize. In total, publications digitized by the contractor and then fully attributed in GeMS by DGGS staff were estimated to take an average of 62 hours per map. Maps with existing GIS converted to full GeMS by the contractor took an average of 56 hours per map, with the amount of time increasing for map complexity and additional map sheets. In both cases, GeMS conversion of straightforward map publications took less than two weeks per map.

When DGGS started documenting and using a production-based model to convert multiple geologic maps to GeMS in 2020, maps took 4–5 weeks to complete in GeMS. DGGS staff currently average about four weeks to complete a publication in GeMS. A few hypotheses regarding why adding a contractor to the process might have reduced production time so dramatically include:

- DGGS GeMS standards and processes have recently matured to the point that the conversion rate is faster, but the increased efficiency has not yet been documented by DGGS staff.
- DGGS staff are constantly revising documentation, involved in meetings, and distracted by other work tasks, which could add an undocumented amount of time to the processing of a map. Alternatively, the contractor may be able focus on specific work tasks and perhaps keep track of those tasks and time more successfully since they are billing for the time.
- DGGS staff may have been more conscious of time spent by the contractor on this project and sensitive to the project budget, therefore responding to the contractor and project tasks more quickly than on a DGGS-only staffed project.
- DGGS staff may have been more accepting of a 98 percent (and quicker) solution to project challenges while working with the contractor rather than devising and documenting a different and more comprehensive (and more time consuming) solution to the challenge.

“Time spent on GIS and digitization? About 16 hours. This is taking into account the learning curve and different sized projects. The amount of detail varies greatly between maps. Once I had a good work flow, the time/map nearly halved and the time on QC was also reduced. Plus ~2 hours for QC.” — *Contractor*

“Time spent on GIS and GeMS? About 30 hours. For the first map I did, the map that I was digitizing and converting consumed a lot of time and brought up the average. Similar to the pure digitizing, after the learning curve the maps started to go more quickly and there was less to QC. Plus about 15 hours QC.” — *Contractor*

“I have spent about a week editing and populating the digitized feature classes that Lars sent to us [to complete the full GeMS attribution]. Including, but not limited to, fully attributing the DMU, assigning random cartographic points to their appropriate feature class (geologic, fossil, etc.), and correcting location and feature confidence levels.” — *DGGS*

“The documentation is always evolving and is a large portion of this work. Estimate several hours a week per employee thinking about symbology, population of Frequently Asked Questions, data dictionary, and conversion documentation.” — *DGGS*

How well did our documentation and training prepare the contractor?

Production rates and comments suggest our documentation and training worked well to prepare the contractor, though improvements could be made in several areas (slide 13). For example, the two initial 1-hour training sessions should have been conducted later in the project, after the contractor had additional experience with the nominal GeMS schema. These trainings could also have been broken up into smaller topical training sessions that might be easier to digest, with additional topics such as topology, boundary types, and the layer concept. The contracting of the work also prompted additional tools and documentation, most notably new feature templates that the contractor utilized immediately.

> "Anytime Mike makes a new script or tool to run in ArcPro, I wish I had it sooner! I think it is critical that we make the GeMS toolbox easily accessible to contractors to increase efficiency and flatten their learning curve. If the tool accurately populates fields for the contractor, then they won't have to spend so much time digging through the data dictionary looking for the correct info to enter. I guess this is what the feature template is for, and it seems to be a great help." — *DGGS*
>
> "One thing I will say, right off the bat, is that I was concerned about the information dump on an individual and their ability to take it all in – but Lars did an excellent job. And I think that also speaks to the quality of our documentation and the thoughtfulness of the project setup." — *DGGS*
>
> "The project was a good one for me because it provided the impetus to generate the feature templates, which have now been implemented more widely in our office and hopefully once complete, can be published and shared outside the org." — *DGGS*
>
> "Most helpful documentation was the two excel sheets *mp_170_AK_GeMS_Data_Dictionary* [Hendricks and others, 2021] and *AK_GeMS_Symbology_Documentation* [Ekberg and others, 2021], along with the FGDC symbology standard at https://ngmdb.usgs.gov/fgdc_gds/geolsymstd/fgdc-geolsym-allnocharts.pdf [Federal Geographic Data Committee, 2006]." — *Contractor*
>
> "The timing of the training meetings may have been a little too soon in the process. I had started to look at the maps but didn't have a great grasp of how much attribution was involved in the process. Once I had a better handle on how important building out the DMU was, everything else started to make more sense." — *Contractor*
>
> "At the time, [I was] thinking the presentations that they gave were too high level and should have focused on making a DMU as a place to start. Should have started with topology, [which might have reduced the number of] edits after the polygons were made. Some errors were created that needed to be fixed. Break up the training to be progressively more in depth." — *DGGS*
>
> "I would have liked to see smoother curves and more vertices in digitized data. We set digitization expectations iteratively and he did what we asked, but DGGS doesn't actually have a digitization standard. What would the standard look like? Maybe pictures with examples instead of a quantitative description of the number of vertices required?" — *DGGS*
>
> "Things I wish we had in place: while I don't do too much official QC for GeMS maps, this project would have been a good one to test out the new Data Reviewer in ArcGIS Pro. Unfortunately, timing wasn't on our side and those tools weren't quite ready for us to utilize." — *DGGS*

Project successes and challenges

We feel this project was very successful overall. Ideas for improvements will be very helpful for future, similar projects. As a final thought, the contractor noted that it is rare to have such a successful contractor–client team. We cautiously hope that this project was not an anomaly and future projects will be as successful.

Some thoughts in addition to those on slides 14–16.

> "The overall size and complexity of each map plays a large role in [whether digitizing or converting legacy data] may be more efficient. If the legacy data includes orientation points, then converting the data is worth it. The linework (contacts, faults, structure lines) can be fairly quick to digitize and may be a good solution for areas where the contacts and faults are NEARLY the same line but are actually two independent lines that cross each other hundreds of times [i.e., poor topology]." — *Contractor*
>
> "The other members of the group might have more insight into this, but I think this was a great first attempt at contracting this type of work. Our documentation and tools will continue to get better, so we need to just keep all of those files nice and tidy to hand over to the next contractor." — *DGGS*
>
> "The quality of the contractor is key." — *DGGS*

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