USGS Geologic Map Schema Tutorial for AZGS

The USGS has created the Geologic Map Schema (GeMS). All USGS-funded maps must now conform to this schema. The USGS has provided ArcMap and ArcPro Toolboxes for validating if an ESRI File Geodatabase conforms to GeMS. This tutorial provides instructions on how Arizona Geological Survey mappers are expected to use this tool when making new STATEMAP products.

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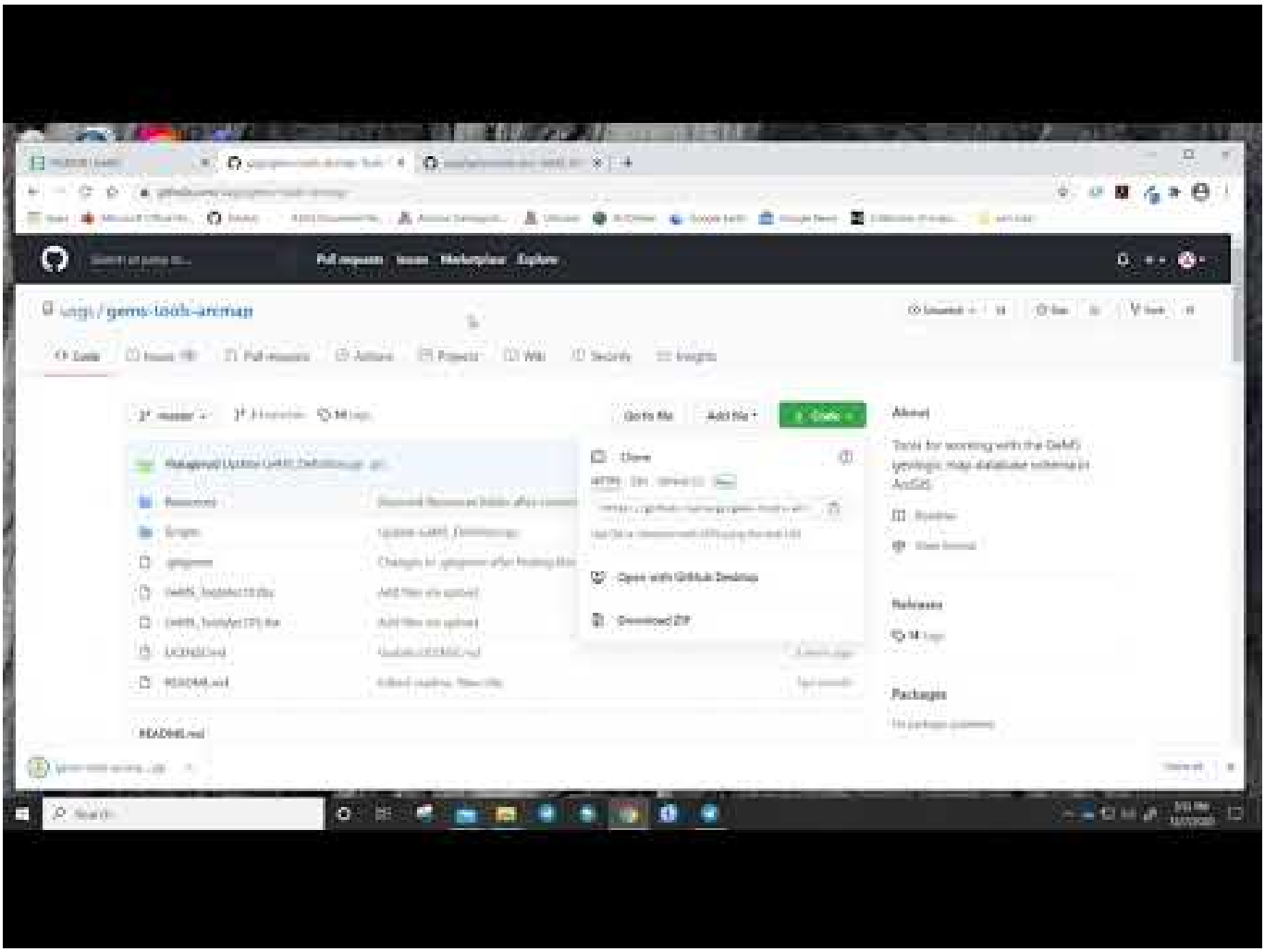
Installation and Setup

Here you will find videos detailing how to download, install, and run the ArcMap GeMS validation toolbox. We are not currently supporting the ArcPro version as we expect our own internal AZGS ArcPro toolbar will supersede the USGS toolbox. You can also follow the instructions provided by the USGS.

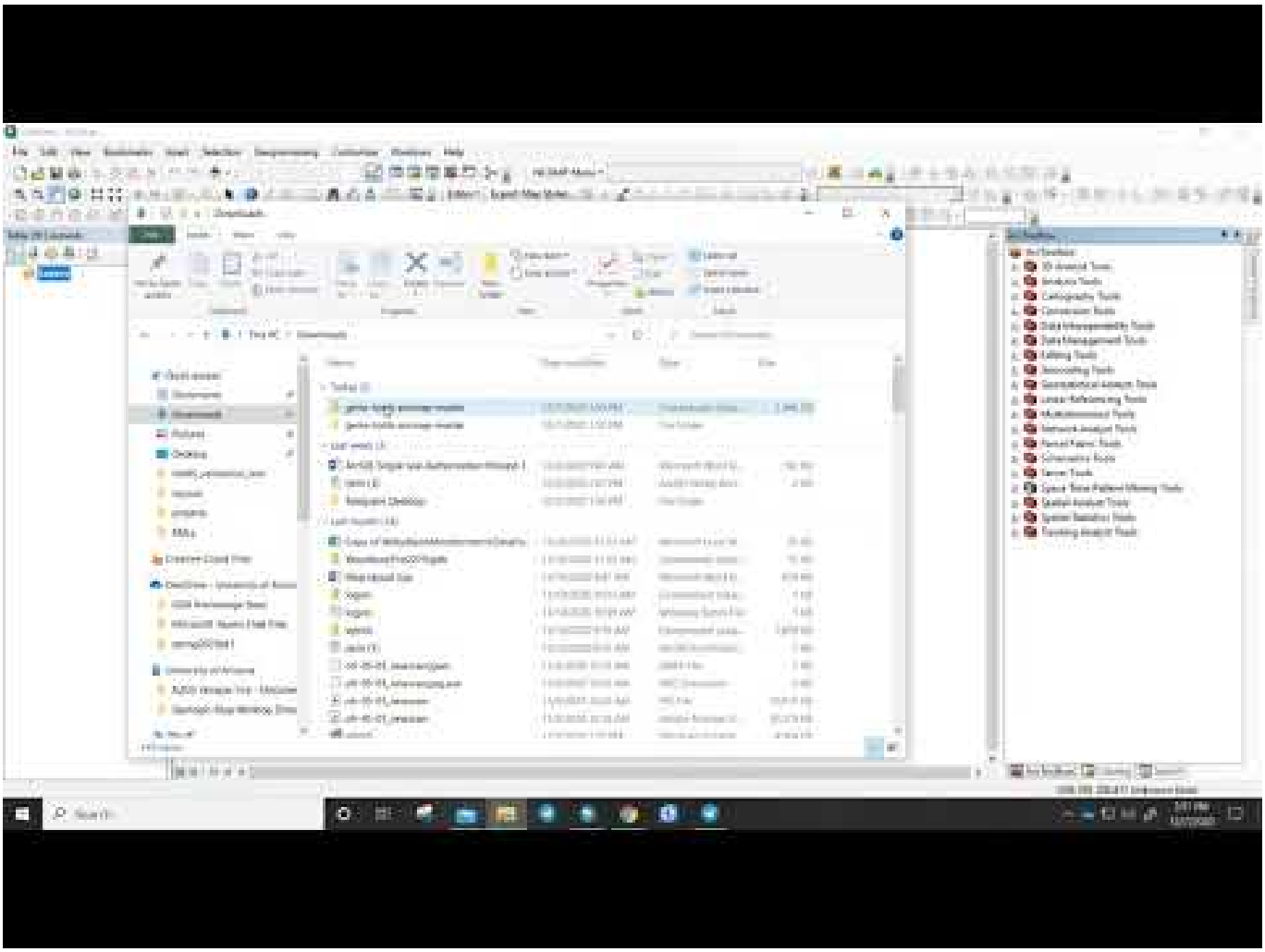
Downloading the Toolbox

You download the ArcMap toolbox directly from the USGS GeMS GitHub Page: https://github.com/usgs/gems-tools-arcmap. Click the large green button, "CODE", which should also have a download icon embedded within it. Then select Download Zip. A video demonstration is below.



Installing the Toolbox

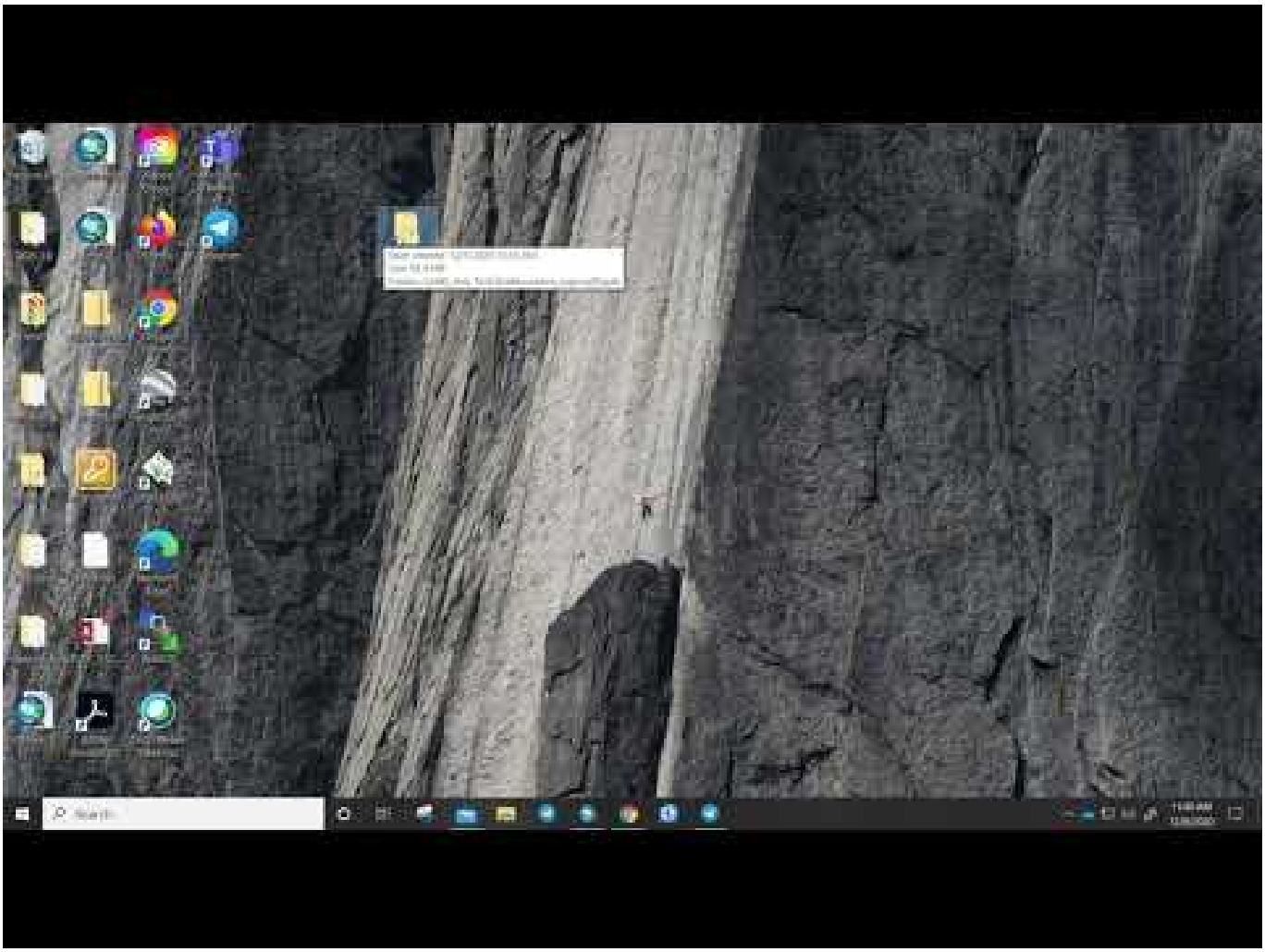
Select the ArcToolbox icon from the top ribbon, the icon looks like a red handyman's toolbox. Clicking this icon should bring up an ArcToolbox pane on the right side of your screen. Right click on a white space area and select "Add Toolbox". Then select the `GeMS_ToolsArc105.tbx` file for installation. A video demonstration is below.



> Warning: Note that that the ArcMap Toolbox that you download will come with two different .tbx files. You specifically want the Arc105 (Arc 10.5+) toolbox.

Running the Toolbox

Using the same ArcToolbox pane you used during installation, you should expand the "GeMS Tools for Arc 10.5" to view the provided tools. The USGS has provided many different tools as part of this toolbox, but the only tool that the geologists should use is the "Validate Database" tool. A video demonstration of how to run the tool is below.



> Warning: Note that the length of time needed to run the validate tool can take from as little as a minute to as much as several hours. The run time depends on the size and complexity of the map in question. Our experience for normal AZGS 1:24K maps is generally in the range of 3-10 mins.

> Addendum: The video erroneously says that the toolbox outputs a "Google Chrome Webpage" for the report. Although the report can be *opened* through Chrome (or other web browsers, FireFox or Edge), it is not a web page and will not be visible outside of your computer.

Geologist Responsibilities

The Validation Tool spits out a lengthy .html document that is broken down into a few different sections. If you want to see an example of a full report that we generated for our Tortolita Mountains map you can click here. However, the only section that you need to worry about is the section pictured below, the requirements for Tier 3 compliance.

LEVEL 3--FULLY COMPLIANT

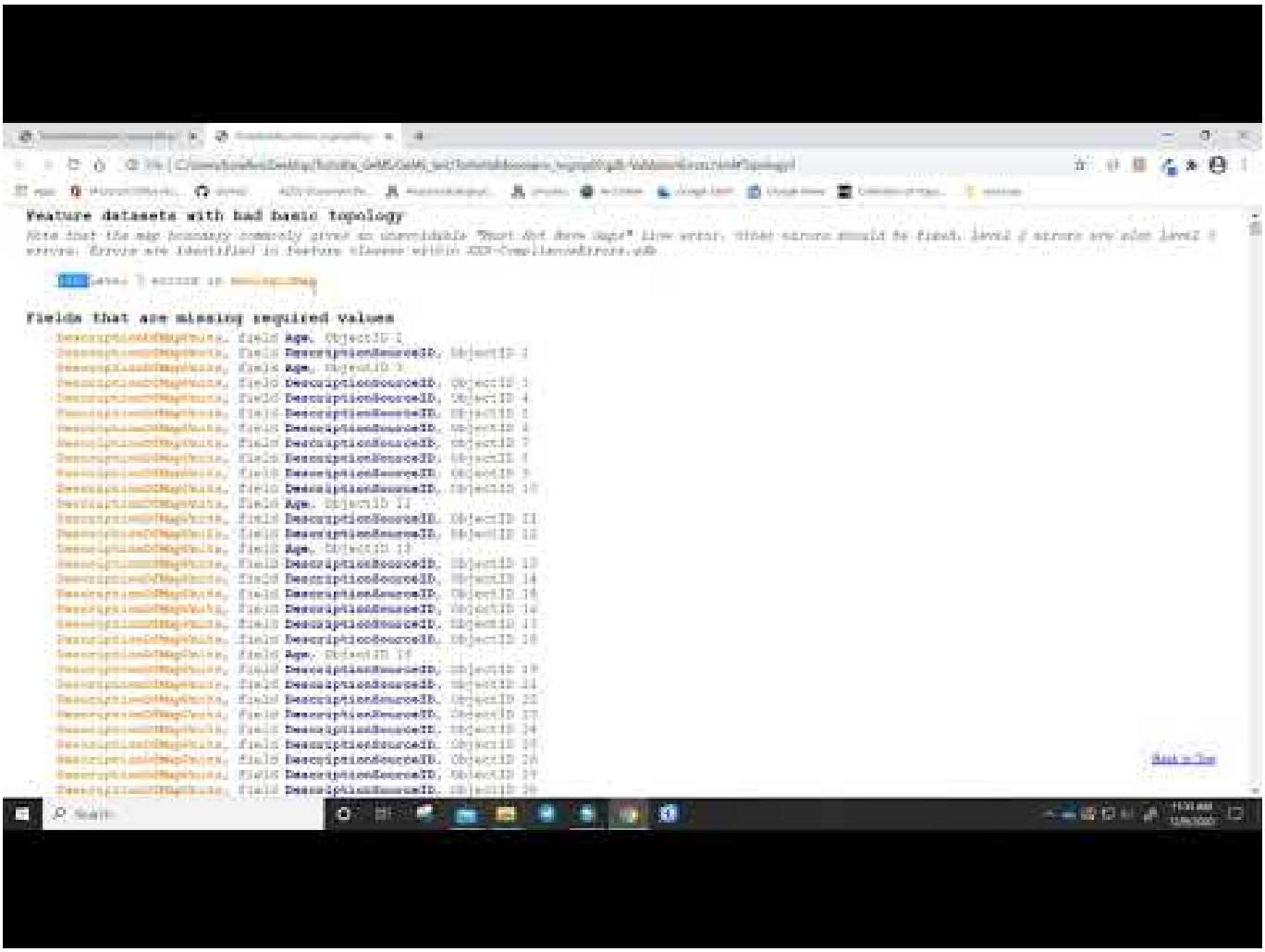
A LEVEL 3 GeMS database meets these additional criteria:

3.1 Table and field definitions conform to GeMS schema	FAIL 22 missing or mis-defined element(s)
3.2 All map-like feature datasets obey topology rules. No MapUnitPolys gaps or overlaps. No ContactsAndFaults overlaps, self-overlaps, or self-intersections. MapUnitPoly boundaries covered by ContactsAndFaults	FAIL 1 feature dataset(s) with bad topology
3.3 No missing required values	FAIL 28439 missing required value(s)
3.4 No missing terms in Glossary	FAIL 26 missing term(s) in Glossary
3.5 No unnecessary terms in Glossary	PASS
3.6 No missing sources in DataSources	FAIL 28 missing source(s) in DataSources
3.7 No unnecessary sources in DataSources	PASS
3.8 No map units without entries in DescriptionOfMapUnits	PASS
3.9 No unnecessary map units in DescriptionOfMapUnits	FAIL 3 unnecessary map unit(s) in DMU
3.10 HierarchyKey values in DescriptionOfMapUnits are unique and well formed	FAIL 134 HierarchyKey error(s) in DMU
3.11 All values of GeoMaterial are defined in GeoMaterialDict. GeoMaterialDict is as specified in the GeMS standard	PASS
3.12 No duplicate _ID values	FAIL 1 duplicated _ID value(s)
3.13 No zero-length or whitespace-only strings	FAIL 15318 zero-length or whitespace string(s)

As you can see, there are many different compliance checks. ***It is our expectation that the geologists will be responsible for running this validation tool and correcting any errors found in 3.2 (Topology), 3.4 (Glossary), 3.6, 3.8, and 3.9***. We will either work with you to fix other errors or the geoinformatics team will handle those errors for you.

Topology

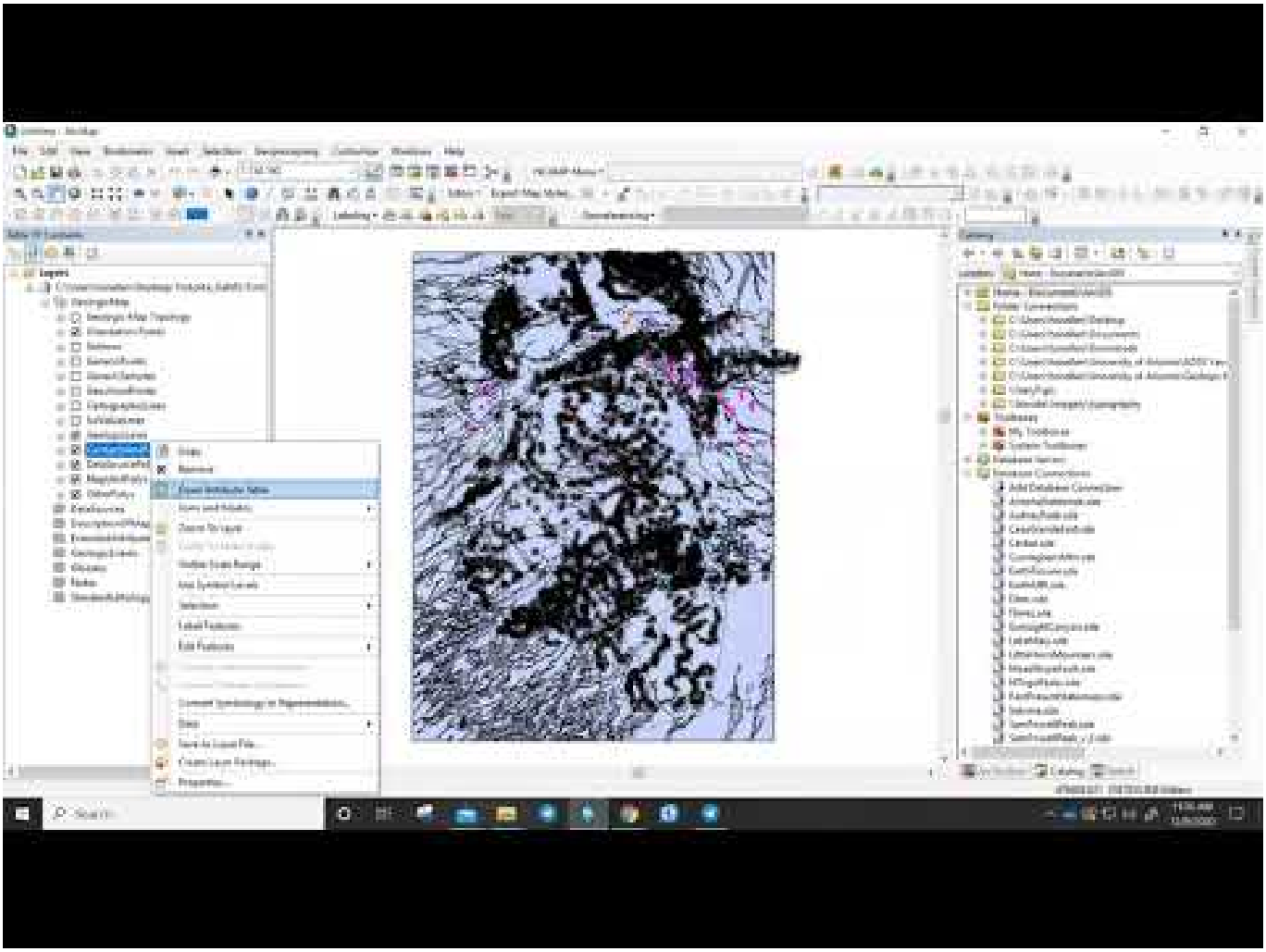
GeMS requires that there be no topology errors in either the ContactsAndFaults and MapUnitPolys features classes. In short, a topology error is whenver lines or polygons 1) overlap or 2) intersect themselves. The toolbox provides you with a detailed explanation of which feature classes and features need to be corrected and why. A video demonstration of how to view the topology report is below.



> Warning: This is the *most* important criterions for GeMS compliance. A geologic map will not meet even the barest level of passability if it fails these topology checks, so the geoinformatics group will be extra strict about this particular check and we **will not accept or publish maps that fail the topology checks**.

Glossary

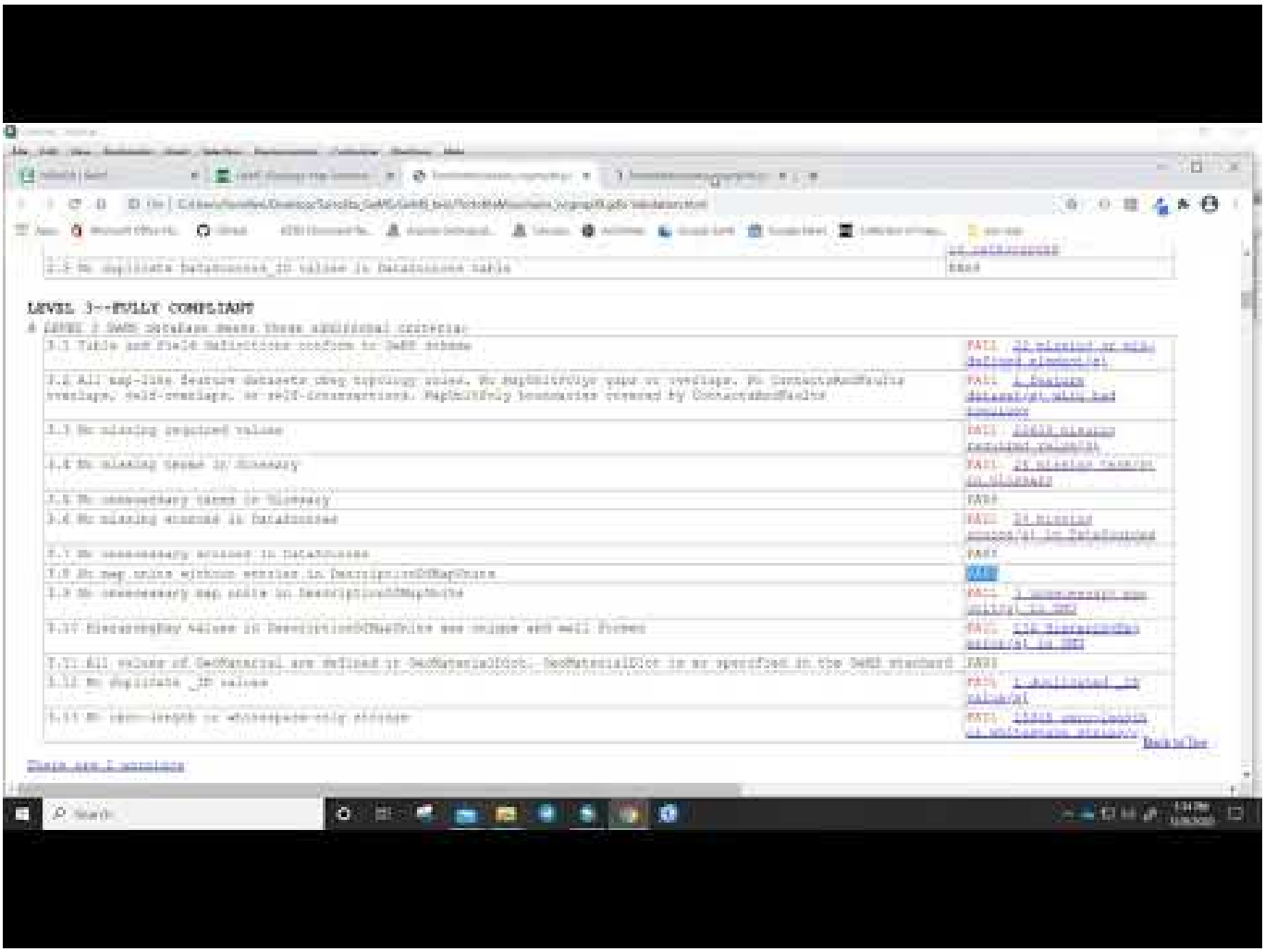
GeMS requires that certain vocabularies and fields be defined in the Glossary table. This was also required under NCGMP09 but we were very lax about it. Which fields and which terms need to be defined in the glossary is very complex and would be impossible to go through concisely in this tutorial. Luckily, the USGS toolbox identifies needed terms for you as part of the report (section 3.4). A video demonstration of how to run the glossary report and fix needed glossary entries is below.



> Addendum: You may find it difficult or reptetitive to define certain terms. To facilitiate this, we have access to a list of common geologic terms and definitions used by various state surveys (including AZGS) that can be found here. You may wish to check here first to see if the terms you need/want to identify are already defined by the AZGS or another survey. You are **not** required to use these definitions and can edit them freely or write your own.

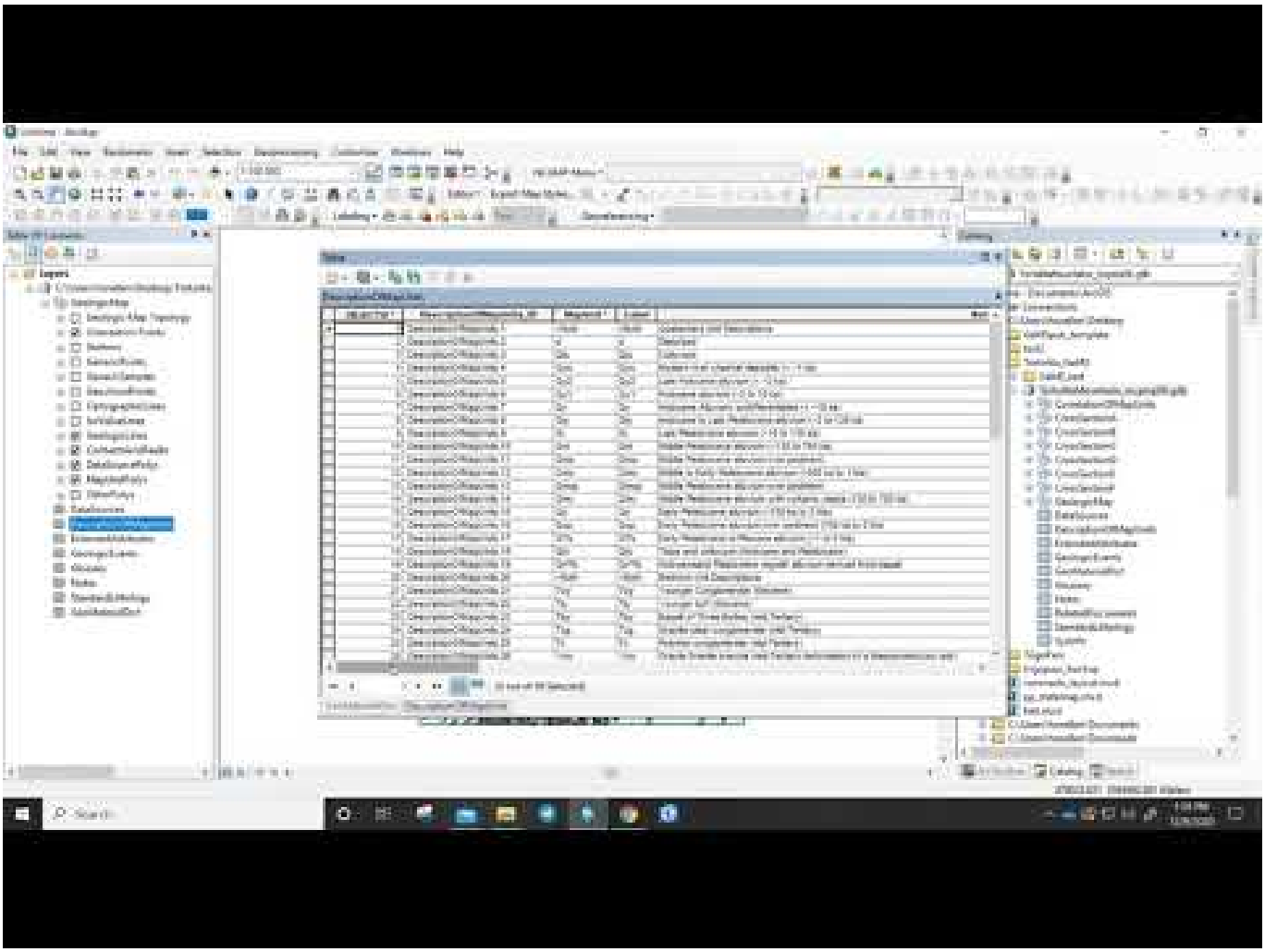
Map Unit Checks

Every map unit must be defined in the `DescriptionOfMapUnits` table and no units should be in the `DescriptionOfMapUnits` that are not in the MapUnitPolys feature class.



Geomaterials

A **new** requirement of GeMS is that that each Map Unit in the `DescriptionOfMapUnits` table must be assigned a `GeoMaterials` classification and a `GeoMaterialsConfidence` (how confident you are in the classification). A list of possible GeoMaterials to choose from can be found in the new `GeoMaterialsDict` table. You **MUST** pick a geomaterial that roughly describes your unit from this list and you **CANNOT** deviate. You can view the list of possible GeoMaterials and their definitions by opening the GeoMaterialsDict table in your geodatabase. A video demonstration can be found below.



> Warning: You may find other versions of the GeoMaterials dictionary floating around the internet. You should always use the one provided with your geodatabase as those other versions may be obsolete.

In addition to picking a GeoMaterial that describes your units, you must also state how confident you are that this GeoMaterial actually describes your unit. The possible values for GeoMaterialConfidence are inlcuded in the table below.

Table 1–1. Values (and their definitions) that populate the GeoMaterialConfidence field in a DescriptionOfMapUnits table.

[Note that, when creating a new database, the script *GeMS_CreateDatabase_Arc10.py* (available at https://github.com/usgs/GeMS_Tools) or its replacement inserts these GeoMaterialConfidence terms and definitions into Glossary table. See also, table 14]

Term	Definition
High	The selected term in the GeoMaterial field (and its definition) *adequately characterizes*[1] the overall lithologic nature of rocks and (or) sediments in the map unit
Medium	The selected term in the GeoMaterial field (and its definition) *generally characterizes* the overall lithologic nature of rocks and (or) sediments in the map unit, but one or more significant but minor lithologies are not adequately described by the selected term
Low	Either (1) the overall lithologic nature of rocks and (or) sediments in this map unit is not adequately classifiable using the available list of GeoMaterial terms (and their definitions), but the selected term is the best available, or (2) this map unit is not sufficiently known enough to confidently assign a GeoMaterial term

[1]Regarding the subjective term "adequately characterizes", please refer to the context and objectives of this classification as described above in the "Scope and Intent" section of this appendix.

Shared Responsibilities

The majority of the remaining GeMS requirements will be handled by the geoinformatics team. However, there is one area, in particular, where there will need to be some back and forth between the mappers and

the geoinformatics team.

Scenario	Type	IsConcealed	LocationConfidenceMeters	Symbol
Wrong Way	approximate contact, concealed	NULL	NULL	1.1.7
Right Way	contact	Y	50	1.1.7

In the old days, we often used the `Type` field to include information as to whether a contact was approximate/accurate and/or concealed. However, we are supposed to be placing that information in the relevant field. For example, if it is concealed there should be a "Y" for yes in the `IsConcealed` column.

Historically, what we have done to fix this in data preservation maps is go through after you are done and use the field calculator to batch correct the entries from the "Wrong Way" to the "Right Way". We can and will still do this, however, there are a couple of caveats to keep in mind.

1. When you are filling out the glossary, the validation tool will ask you to define "approximate contact", "concealed contact", "accurate contact", "concealed accurate contact", and all other variants of contact that you placed in the `Type` column when you only really need to define "contact". So it is to your benefit to just fill it out correctly from the beginning so you aren't prompted with a bunch of false positives.
2. Many of you have expressed that the reason you do not like to fill out the `LocationConfidenceMeters` field is because you do not have a precise measurement. The GeMS specification gives guidance on this below with some suggested conversions from qualitative descriptors like Accurate, Approximate, Uncertain, etc. into meters.

Value	Definition
10	Appropriate for well-defined features located by clear-sky GPS, or by inspection of high-resolution topography (e.g., 1m or 2m lidar DEMs), or by inspection of largescale, well-rectified orthophotographs (e.g., NAIP images)
25	Reasonable value for locations established by inspection of 1:24,000 scale map, or by digitizing paper source maps of that scale
50	May be appropriate for some “approximate” lines on 1:24,000 scale maps. Other “approximate” lines on the same map may have value of 100 meters, or larger
100	Appropriate value for features digitized from 1:100,000 scale paper source maps
250	You really don’t know where a feature is! Or you captured its location from a 1:250,000 scale source map