DIGITAL MAPPING TECHNIQUES 2024

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The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2024)
http://ngmdb.usgs.gov/info/dmt/

Adapting the GeMS Toolbox Tools to Work With Enterprise Geodatabases

Christian Halsted
Director, Earth Resources Information
Maine Geological Survey
93 State House Station
Augusta, ME 04333-0093
Christian.H.Halsted@Maine.gov

Abstract:

In 2022, the Maine Geological Survey (MGS) entered into a two-year Cooperative Agreement with the National Geologic Map Database project to modify the GeMS ArcGIS Pro Toolbox to work with Esri enterprise geodatabases (EGDB) as well as file geodatabases. This new functionality is particularly important to MGS because all mapping and business workflows at the survey have utilized an EGDB on Microsoft SQL Server since 2013. Additionally, the single map – single file geodatabase GeMS approach would be an organizational step backwards for MGS because the current mapping system is multi-map. This means that features classes contain features for all maps at a particular scale. For example, all map unit polygons for each 1:24,000-scale bedrock map in the state are contained in one feature class called Bedrock_Units.

With the establishment of the GeMS submission requirements for STATEMAP funded projects, MGS developed a data translation process that allowed mapping geologists to continue working in the MGS database. A few GeMS fields, such as the confidence values, were added to the MGS schema to be filled out by MGS users. Database scripts developed by MGS then transferred the map data to a GeMS compliant file geodatabase for submission. This process was successful – over 70 GeMS packages have been created – but it could be more efficient particularly at the GeMS Validation point in the process. The Validate Database tool is run on the generated file geodatabase but if there were any errors the data had to be corrected in the MGS database, reexported to the GeMS file geodatabase, and then validated again. This loop could easily take 20-30 minutes and it was common to have to perform this error correction loop at least 2-3 times for a map.

MGS decided that it was important to keep the geologic mapping workflow in an EGDB but that it was time to migrate from the MGS schema to the GeMS schema in the EGDB. This would require that mappers learn to work directly with the GeMS schema. A number of map templates and downstream web data products would also need to be updated. However, these negative short-term impacts are outweighed by the benefits of natively mapping in GeMS so that there are no database translation scripts that must be run and maintained and by allowing mappers to use the GeMS tools, especially the Validate Database tool, to get 'real time' feedback on potential errors in the EGDB.

A key requirement of this strategy is that the GeMS ArcToolbox tools must function when run against an EGDB. Fortunately, the Esri tools and the arcpy Python module methods can execute on file or enterprise geodatabase objects interchangeably. A new fork of the USGS GeMS Tools GitHub repository was created. Many of the tools required only minor pathing changes and logic to handle

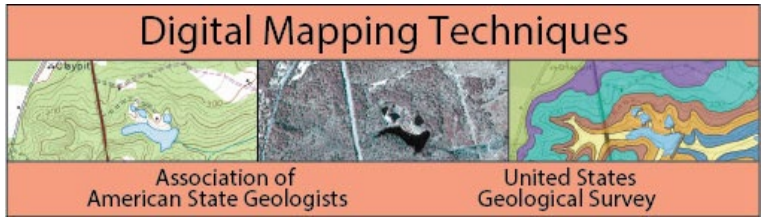
their tasks on EGDBs as well as file geodatabases. Most of the tools also had their interface updated along with some new validation code to allow for the addition of schema and map name dropdown boxes when working with EGDBs. These two data fields were necessary for doing selections on the multi-map feature classes to run the tool on only the data for the current map.

There were five tools that required or benefited from major code revisions. There were two primary reasons for this – limiting the usage of intermediate on-disk datasets and increasing performance. First, intermediate datasets are difficult to manage in an EGDB so intermediate output was created with in-memory objects, either Python lists or dictionaries or arcpy objects. Secondly, some processes could be run using database code rather than Python which dramatically increased performance because the I/O between the client and database is eliminated.

Three new tools were also developed to work with the muli-map GeMS schema and five tools were not updated because their functionality did not apply to an EGDB.

The goal for this project which ends in 2025, is to have all GeMS tools functioning with both enterprise and file geodatabases. Documentation and tool metadata will also be complete. And finally, a decision about managing the tools in GitHub, either as part of the current repository or as a long term fork, will be finalized and communicated.

Adapting the GeMS Toolbox Tools to Work With Enterprise Geodatabases



Christian Halsted
Director, Earth Resources Information
Maine Geological Survey
Christian.H.Halsted@Maine.gov

Project Scope

- MGS has a Coop Grant with NGMDB: Oct 2022 – Apr 2025
- Modify the GeMS ArcGIS Pro tools to work on File ***or Enterprise*** Geodatabases
  - Fork version of tools from GitHub
  - Update Python scripts
  - Determine if some tools can be replaced by RDBMS functions, stored procedures, and/or triggers.
- Possible GeMS schema enhancements
  - Tables for managing photos, citations, map text, photo captions, metadata
- Publish documentation for implementing GeMS in a RDBMS

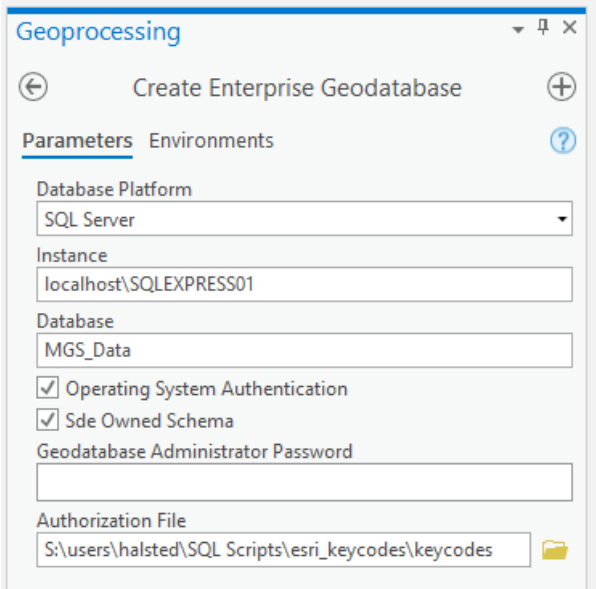
File geodatabase vs Enterprise Geodatabase

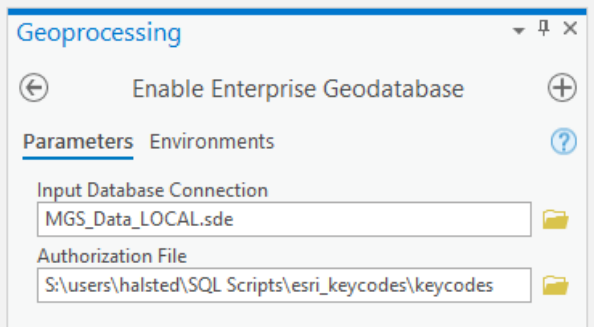
	Enterprise Geodatabase	File Geodatabase
Storage	Relational database	File system folder
Storage format	Microsoft SQL Server PostgreSQL Oracle	Each dataset is a separate file on disk. All the datasets that belong to one geodatabase are contained in a single folder.
Users	Multiple editors and multiple readers	Single editor and multiple readers
Size limits	Size is controlled by the DBMS – virtually unlimited	1 TB (can be raised)
Security	Managed through the DBMS	Managed through the operating system
SQL programming support	Yes	Limited

Source: Esri

Creating an Enterprise Geodatabase

- Choose RDBMS software
- Install RDBMS on premises or in the cloud (or localhost for development)
- Use Esri ArcToolbox tools to do one of the following:
  - Create a new enterprise geodatabase instance
  - Enable an existing database instance as an enterprise geodatabase





- Esri license and keycodes for ArcGIS Enterprise are required

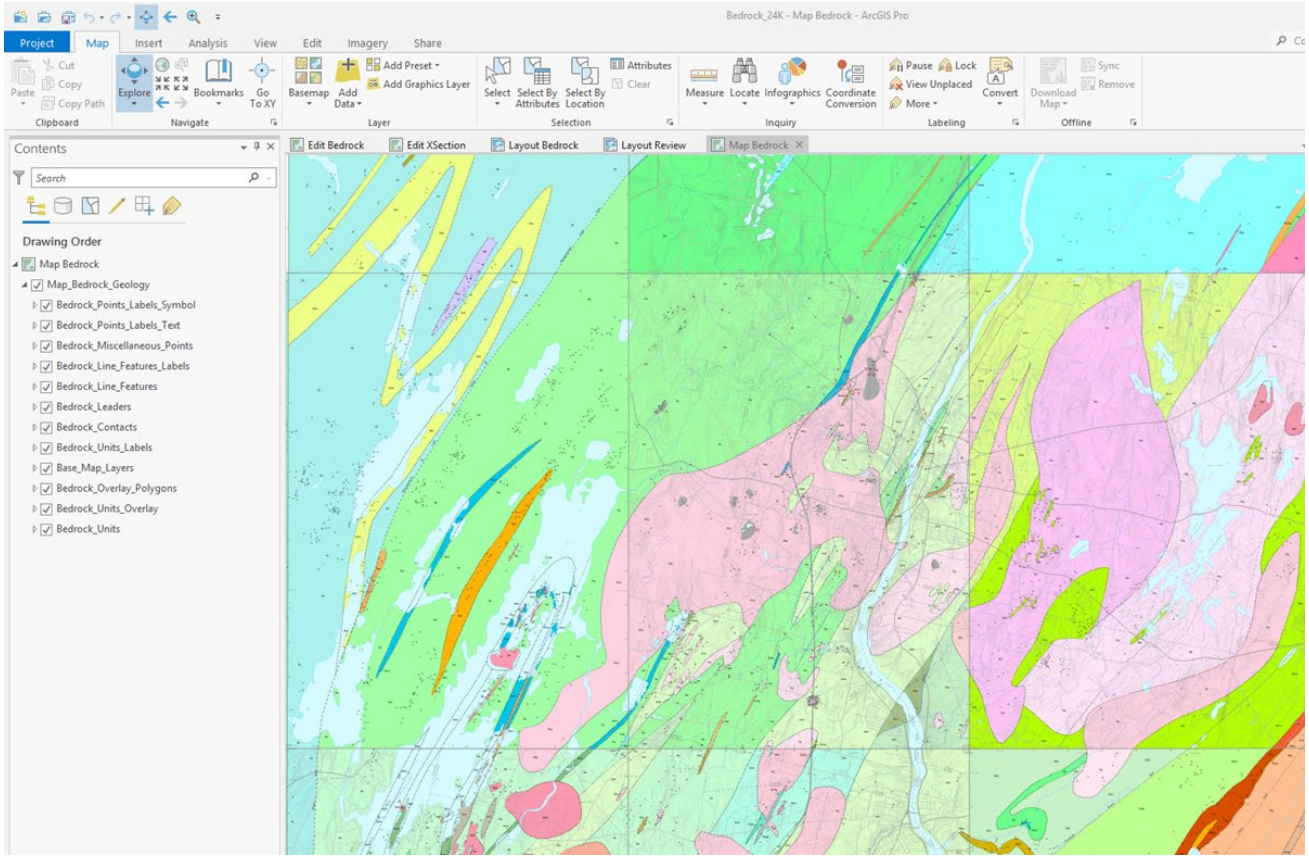
Why Does MGS Use Enterprise Geodatabases?

- Single source – all spatial and non-spatial data in one location and highly integrated
- Collaboration – concurrent multi-user editing, no database locking, all edits shared immediately with all users
- Data Integrity – uniform data structure, domains, relationships that is not editable by users
- Performance – data processing happens on database server, not locally or over a network, so is much faster
- Maintenance – centrally managed updates, patching, backups
- Multi-level security – full control, edit only, view only for different users on same data

Why Didn't MGS Transition to GeMS File Geodatabases?

Because…

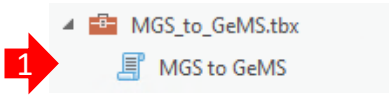
- File geodatabases would have been a major technological step backward
- Existing deep integration in a single RDBMS used by all staff, not just mappers
- 10+ years using SQL Server
- 30+ years using our schema
- Multi-map feature classes



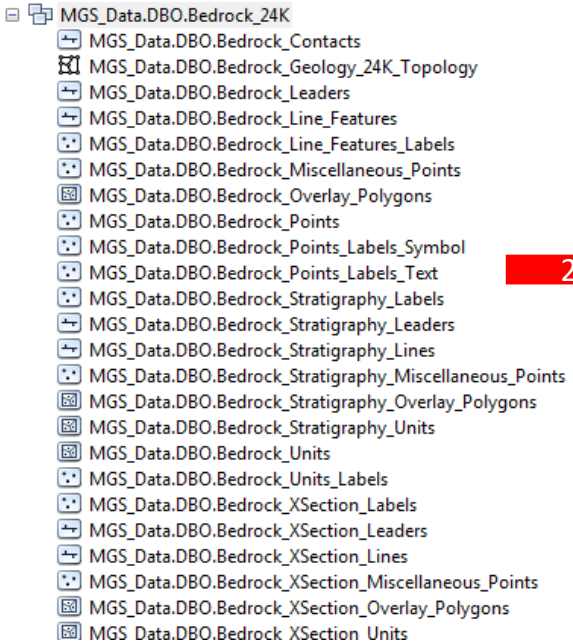
GeMS Compliance Challenge

How to get MGS schema EGDB data into GeMS schema in FGDB?

MGS developed a custom ArcToolbox tool and a stored procedure (4,000 lines of code!)



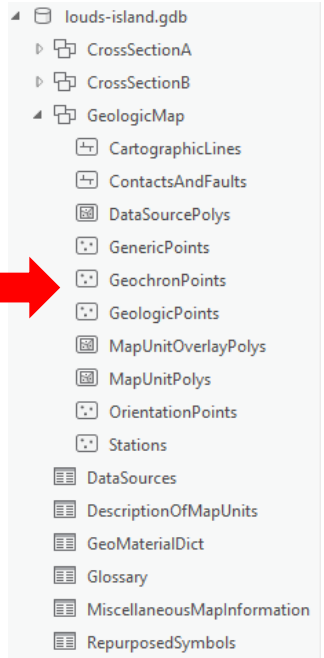
1



2

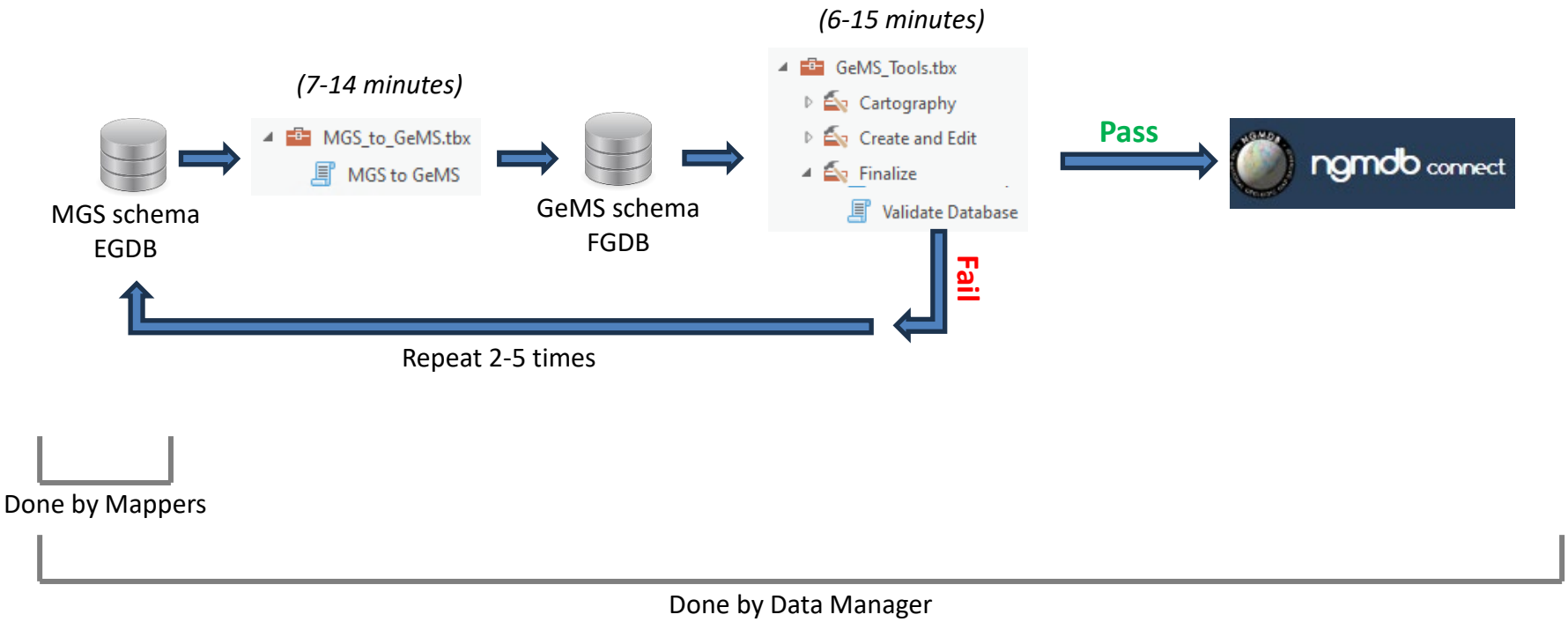
```
--##---MapUnitPolys-----------------------------------------------------------------------------------
TRUNCATE TABLE GEMS_MapUnitPolys;
INSERT INTO GEMS_MapUnitPolys
SELECT CAST(ROW_NUMBER() OVER (ORDER BY QUADNAME, Map, Scale) as int) AS OBJECTID
    ,[MapUnit]
    ,[IdentityConfidence]
    ,[Label]
    ,[Symbol]
    ,[DataSourceID]
    ,[Notes]
    ,[MapUnitPolys_ID]
    ,[Shape]
    ,[Symbol_MGS]
FROM (
    --Bedrock 24K
    SELECT
        REPLACE(REPLACE(REPLACE(REPLACE(REPLACE(REPLACE(UNIT,'C#','C'),'T#','T'),'M#','M'),'P#','P'),'Cz#','Cz'),'Pz#','Pz')
            --'C#'=cambrian, 'T#'=triassic, 'M#'=mesozoic, 'P#'=pennsylvanian, 'Cz#'=cenozoic 'Pz#'=paleozoic
            AS MapUnit
        ,IDENTITY_CONFIDENCE AS IdentityConfidence
        ,UNIT AS Label
        ,CAST(tbl_GEMS_Colors_MGS_to_FGDC.FGDC_Color AS nvarchar(50)) AS Symbol
        ,SYMBOLOGY AS Symbol_MGS
        ,(SELECT DataSources_ID FROM GEMS_DataSources WHERE SOURCE = 'this report') AS DataSourceID
        ,GEMS_NOTES AS Notes
        ,'MUP' + CAST(Bedrock_Units_evw.OBJECTID AS nvarchar(10)) AS MapUnitPolys_ID  --COMPID??
        ,SHAPE
        ,Bedrock_Units_evw.QUADNAME
        ,'Bedrock' AS Map
        ,'24000' AS Scale
    FROM Bedrock_Units_evw
        JOIN tbl_GEMS_Colors_MGS_to_FGDC ON Bedrock_Units_evw.SYMBOLOGY = tbl_GEMS_Colors_MGS_to_FGDC.ColorName
    WHERE Bedrock_Units_evw.QUADNAME = @Quad

    --Surficial 24K
    UNION ALL
    SELECT
        UNIT AS MapUnit
        ,IDENTITY_CONFIDENCE AS IdentityConfidence
        ,UNIT AS Label
        ,CAST(tbl_GEMS_Colors_MGS_to_FGDC.FGDC_Color AS nvarchar(50)) AS Symbol
        ,UNIT AS Symbol_MGS
        ,(SELECT DataSources_ID FROM GEMS_DataSources WHERE SOURCE = 'this report') AS DataSourceID
        ,GEMS_NOTES AS Notes
        ,'MUP' + CAST(Surficial_Geology_Units_evw.OBJECTID AS nvarchar(10)) AS MapUnitPolys_ID  --COMPID??
        ,SHAPE
        ,Surficial_Geology_Units_evw.QUADNAME
        ,'Surficial' AS Map
        ,'24000' AS Scale
    FROM Surficial_Geology_Units_evw
        JOIN tbl_GEMS_Colors_MGS_to_FGDC ON Surficial_Geology_Units_evw.UNIT = tbl_GEMS_Colors_MGS_to_FGDC.ColorName
    WHERE Surficial_Geology_Units_evw.QUADNAME  = @Quad

    --Bedrock 100K
    UNION ALL
    SELECT
        REPLACE(REPLACE(REPLACE(REPLACE(REPLACE(REPLACE(UNIT,'C#','C'),'T#','T'),'M#','M'),'P#','P'),'Cz#','Cz'),'Pz#','Pz')
            --'C#'=cambrian, 'T#'=triassic, 'M#'=mesozoic, 'P#'=pennsylvanian, 'Cz#'=cenozoic 'Pz#'=paleozoic
            AS MapUnit
        ,IDENTITY_CONFIDENCE AS IdentityConfidence
        ,UNIT AS Label
        ,CAST(tbl_GEMS_Colors_MGS_to_FGDC.FGDC_Color AS nvarchar(50)) AS Symbol
        ,SYMBOLOGY AS Symbol_MGS
        ,(SELECT DataSources_ID FROM GEMS_DataSources WHERE SOURCE = 'this report') AS DataSourceID
        ,GEMS_NOTES AS Notes
        ,'MUP' + CAST(Bedrock_100K_Units_evw.OBJECTID AS nvarchar(10)) AS MapUnitPolys_ID  --COMPID??
        ,SHAPE
        ,Bedrock_100K_Units_evw.QUADNAME
        ,'Bedrock' AS Map
        ,'100000' AS Scale
    FROM Bedrock_100K_Units_evw
        JOIN tbl_GEMS_Colors_MGS_to_FGDC ON Bedrock_100K_Units_evw.SYMBOLOGY = tbl_GEMS_Colors_MGS_to_FGDC.ColorName
    WHERE Bedrock_100K_Units_evw.QUADNAME = @Quad
```

3



GeMS Compliance Challenge

MGS to GeMS workflow is time consuming, not done by mapping staff, and requires maintaining a significant amount of code.

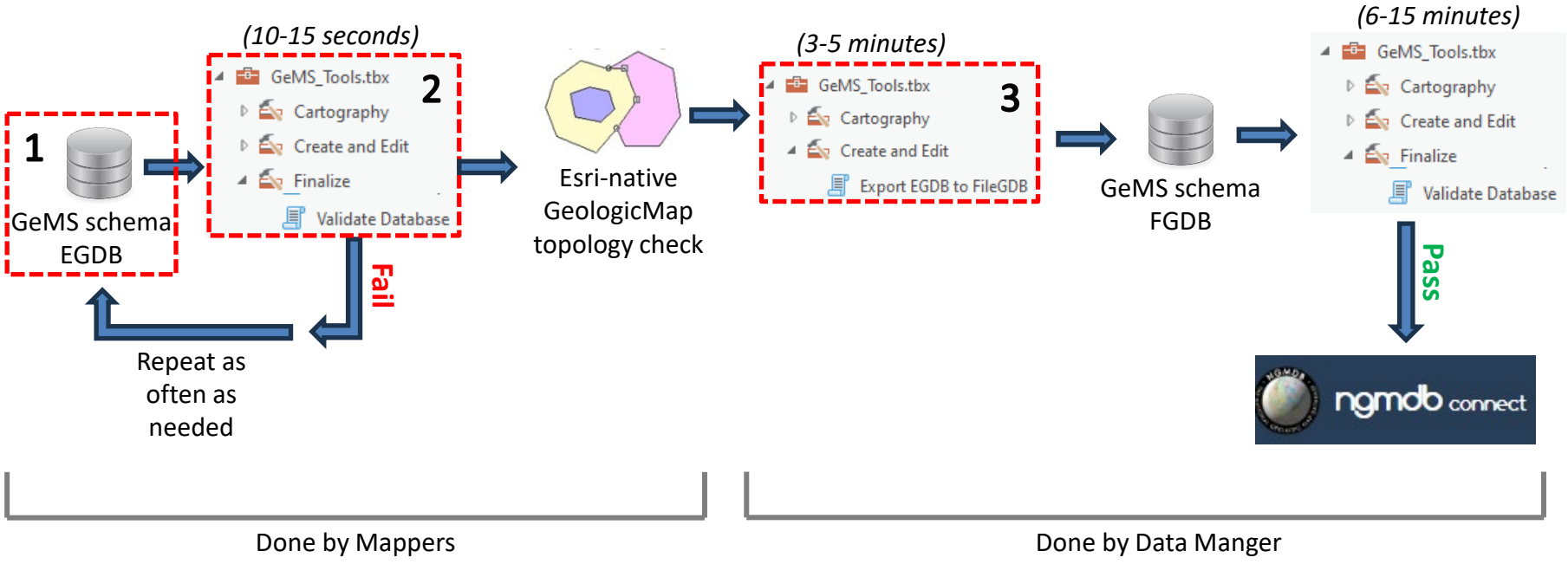


New MGS GeMS Workflow

Enable mapping staff to validate data quickly and repeatedly as they are mapping so data is exported to GeMS file geodatabase only once for final validation and submission.

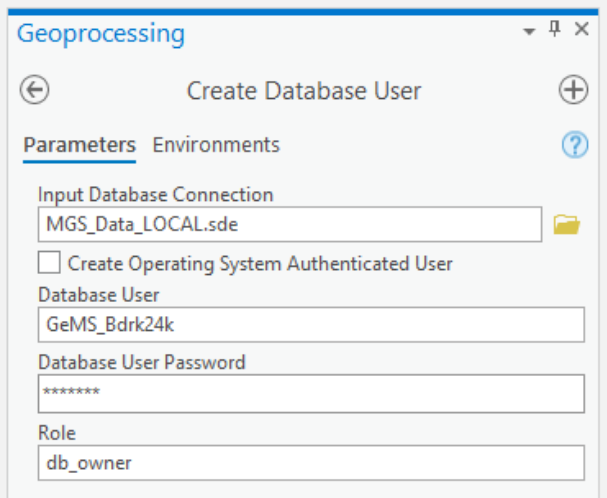
How to achieve this?

1) Migrate ~2 million records in the MGS EGDB from MGS to GeMS schema
2) Update GeMS tools scripts to work on enterprise geodatabases
3) New GeMS tool to export to file geodatabase

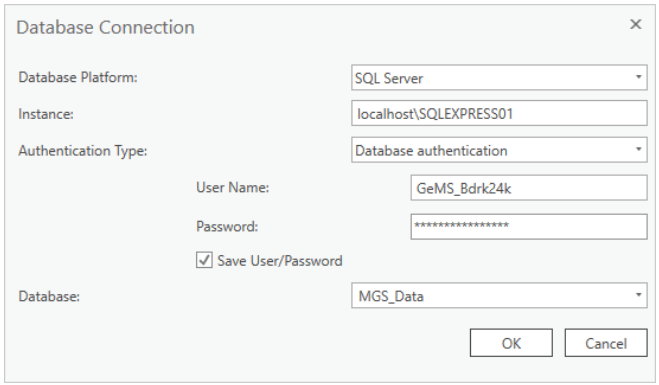


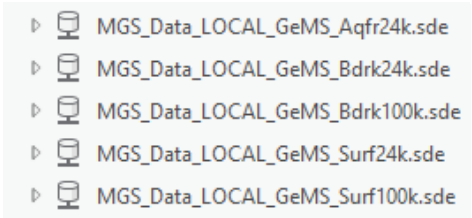
GeMS Multi-Map Schema in Enterprise Geodatabase

- Use the Esri ArcToolbox tool to create database authenticated users, and thus schemas, for each map series and scale combination



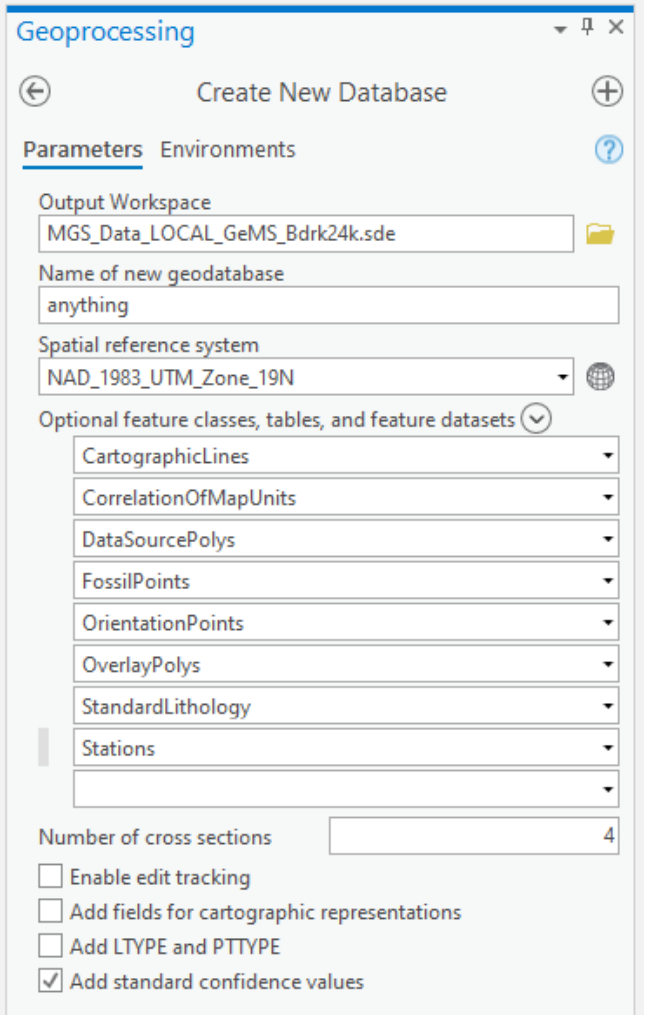
- Create ArcCatalog connection files to administer the schemas.





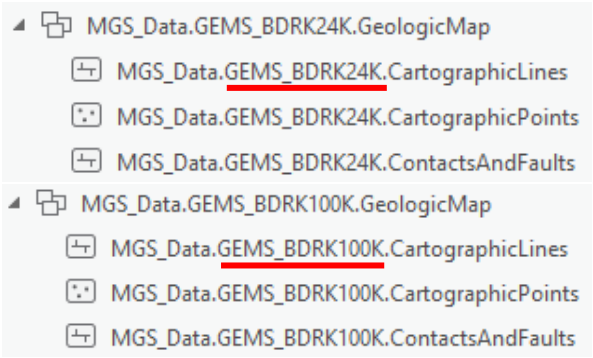
Create GeMS Objects in Enterprise Geodatabase

- Use newly updated GeMS Create New Database tool to add GeMS tables, feature classes and feature datasets to selected db schema
- Should be connected as the user/schema
- Name of geodatabase isn't used when creating EGDBs



Create GeMS Objects in Enterprise Geodatabase

- All GeMS objects will have the same base name as they would in a file geodatabase
- The database instance name and schema/username are appended with dot(.) notation allowing the same base name to be reused

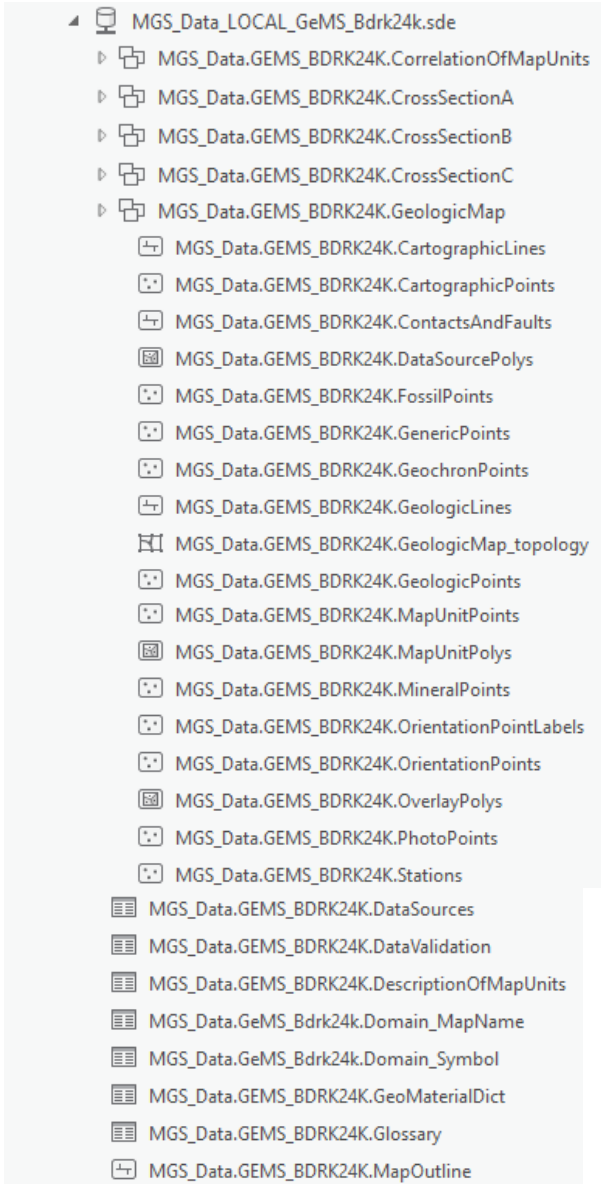


- Note: Esri is removing the database name in EGDBs created from ArcGIS Pro 3.x or upgraded to enterprise database version 11.x

MGS_Data.GEMS_BDRK24K.Stations

becomes

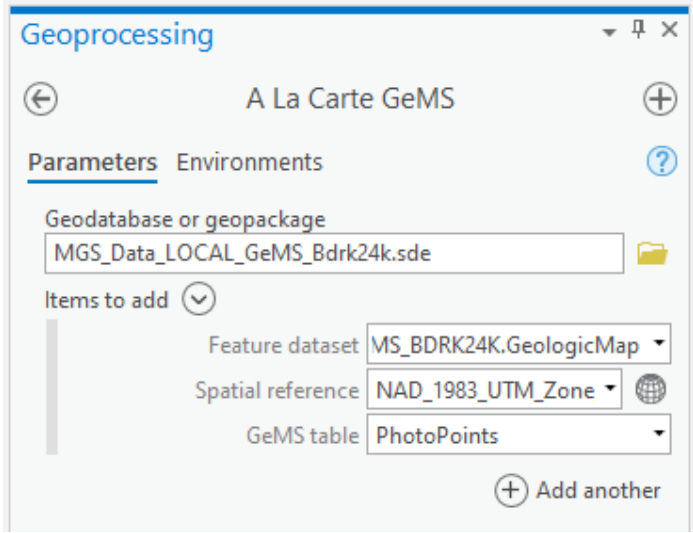
GEMS_BDRK24K.Stations



Create GeMS Objects in Enterprise Geodatabase

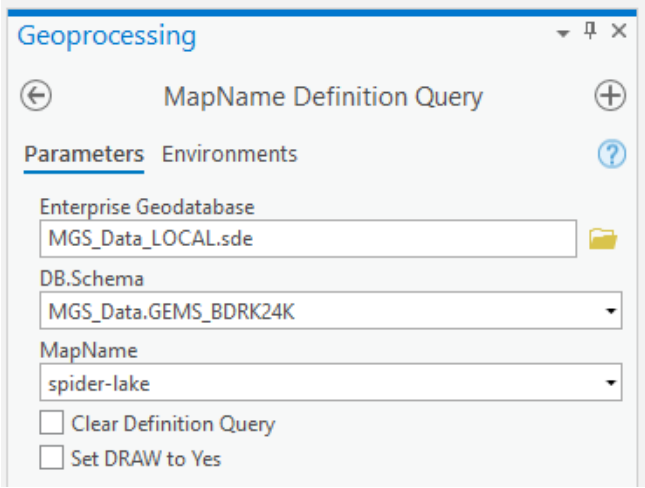
- New extension tables added to Create New Database and A La Carte tools
- GeMS_Definition.py file dictionaries updated – `startDict`, `shape_dict`, `entityDict`
- Applies to both file and enterprise geodatabases

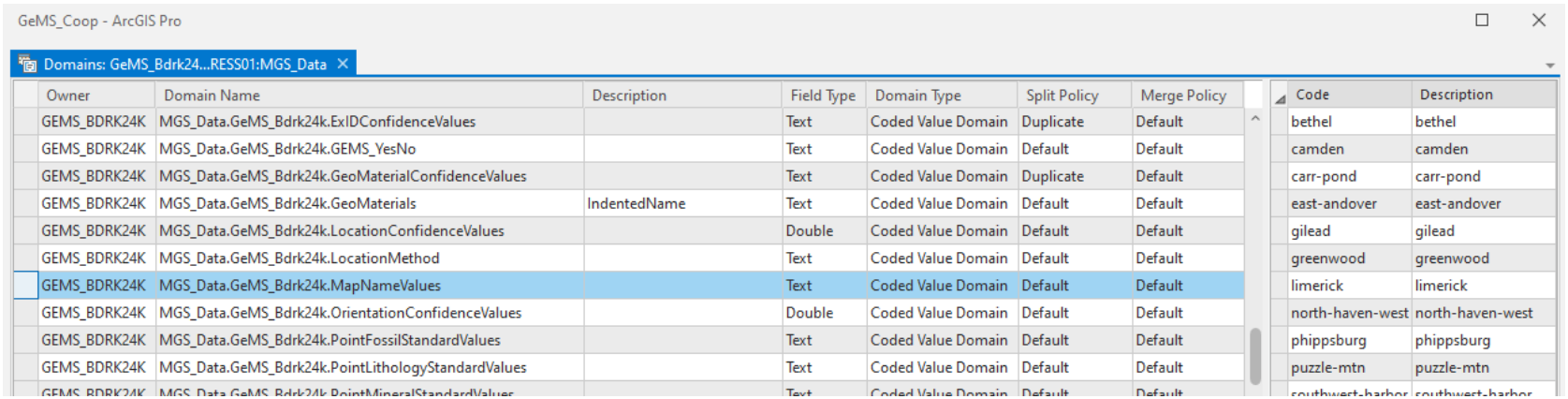
```
"PhotoPoints": [
    ["Type", "String", "NoNulls", defaultLength],
    ["StationsID", "String", "NullsOK", IDLength],
    ["MapUnit", "String", "NoNulls", mapUnitLength],
    ["Label", "String", "NullsOK", labelLength],
    ["Symbol", "String", "NullsOK", defaultLength],
    ["PlotAtScale", "Single", "NoNulls"],
    ["LocationConfidenceMeters", "Single", "NoNulls"],
    ["LocationSourceID", "String", "NoNulls", IDLength],
    ["DataSourceID", "String", "NoNulls", IDLength],
    ["PhotoID", "String", "NoNulls", IDLength],
    ["PhotoSubject", "String", "NullsOK", defaultLength],
    ["ViewDirection", "String", "NullsOK", defaultLength],
    ["ViewWidth", "String", "NullsOK", defaultLength],
    ["FileName", "String", "NullsOK", defaultLength],
    ["Notes", "String", "NullsOK", defaultLength],
],
```



Create GeMS Objects in Enterprise Geodatabase

- GeMS objects in EGDB will be multi-map enabled with new MapName field by default
- Usually, the MapName value is the quadrangle name
- A domain called “MapNameValues” will be created in the EGDB
- New GeMS MapName Definition Query tool will automatically set a definition query on every layer in a map window



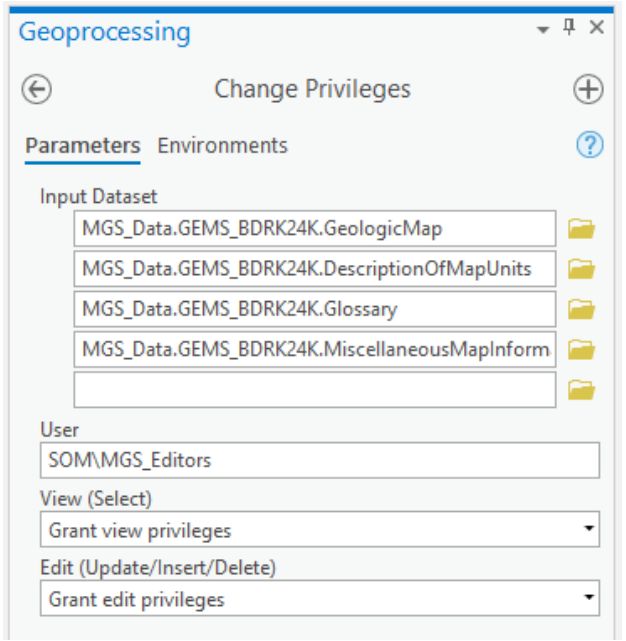


Owner	Domain Name	Description	Field Type	Domain Type	Split Policy	Merge Policy
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.ExIDConfidenceValues		Text	Coded Value Domain	Duplicate	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.GEMS_YesNo		Text	Coded Value Domain	Default	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.GeoMaterialConfidenceValues		Text	Coded Value Domain	Duplicate	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.GeoMaterials	IndentedName	Text	Coded Value Domain	Default	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.LocationConfidenceValues		Double	Coded Value Domain	Default	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.LocationMethod		Text	Coded Value Domain	Default	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.MapNameValues		Text	Coded Value Domain	Default	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.OrientationConfidenceValues		Double	Coded Value Domain	Default	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.PointFossilStandardValues		Text	Coded Value Domain	Default	Default
GEMS_BDRK24K	MGS_Data.GeMS_Bdrk24k.PointLithologyStandardValues		Text	Coded Value Domain	Default	Default

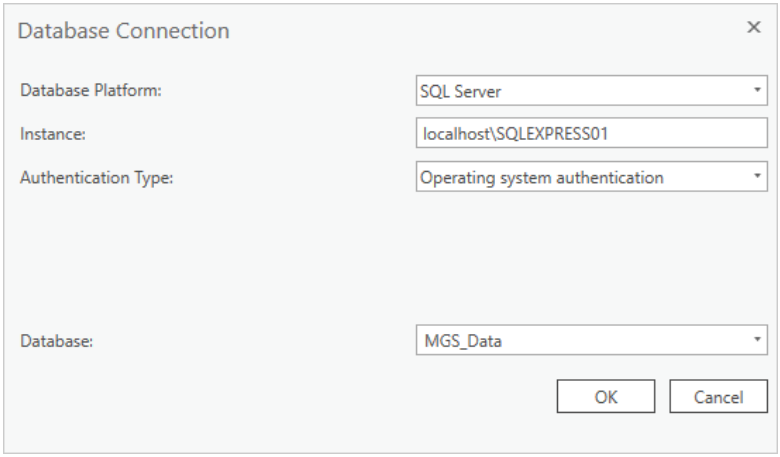
Code	Description
bethel	bethel
camden	camden
carr-pond	carr-pond
east-andover	east-andover
gilead	gilead
greenwood	greenwood
limerick	limerick
north-haven-west	north-haven-west
phippsburg	phippsburg
puzzle-mtn	puzzle-mtn

Create GeMS Objects in Enterprise Geodatabase

- Grant view and/or edit privileges on objects to database users



- Create ArcCatalog connection files for user access to database



Changes Behind the GeMS Tools for Enterprise Geodatabase Use

- Fortunately, Esri tools and arcpy module methods can execute on file or enterprise geodatabase objects interchangeably
- Many GeMS tool scripts required only minor path logic changes

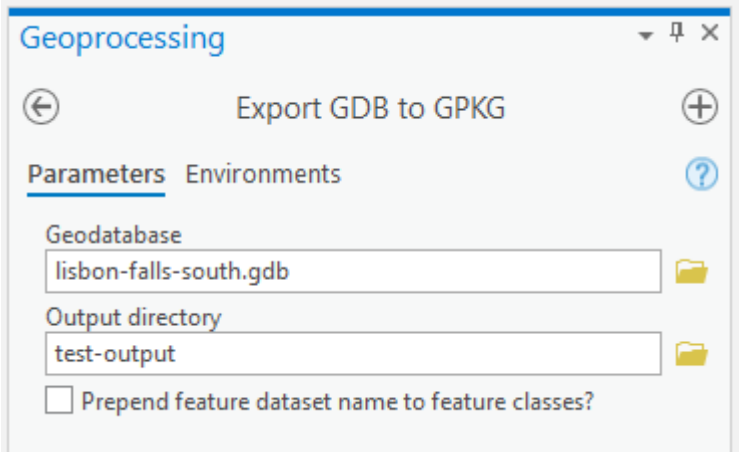
```
outputDir = sys.argv[1]
if outputDir == "#":
    outputDir = os.getcwd()
outputDir = outputDir.replace("\\", "/")

thisDB = sys.argv[2]
thisDB = thisDB + ".gdb"
```

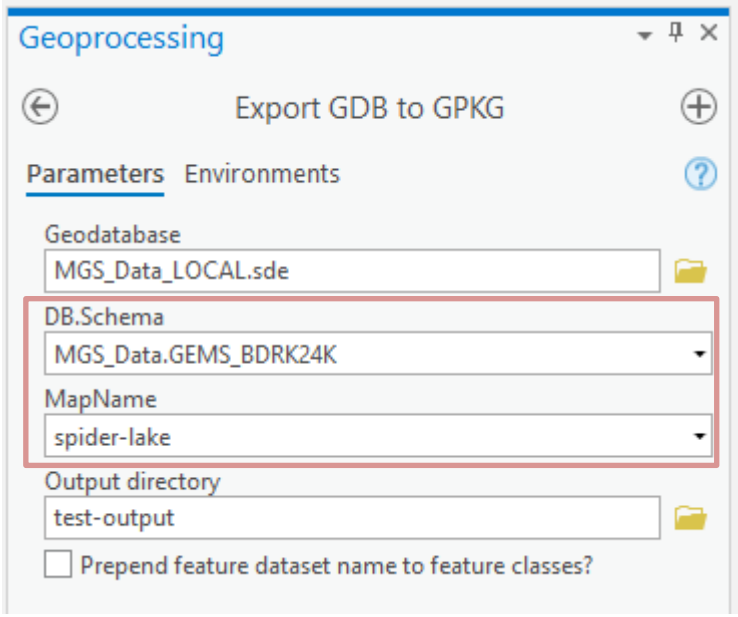
```
outputDir = sys.argv[1]
if outputDir == "#":
    outputDir = os.getcwd()
outputDir = outputDir.replace("\\", "/")

if getGDBType(outputDir) == 'EGDB':
    addMsgAndPrint('Creating GeMS database in enterprise geodatabase')
    desc = arcpy.Describe(outputDir)
    cp = desc.connectionProperties
    dbUser = cp.user
    dbName = cp.database
    dbNameUserPrefix = dbName + '.' + dbUser + '.'

thisDB = sys.argv[2]
if getGDBType(outputDir) == 'FileGDB':
    thisDB = thisDB + ".gdb"
```

- New `getGDBType` function added to GeMS_utilityFunctions.py for global use

Changes Behind the GeMS Tools for Enterprise Geodatabase Use

- Many tools have updated validation scripts to conditionally show the DB.Schema and MapName fields when the Geodatabase input is an enterprise geodatabase rather than a file geodatabase





Changes Behind the GeMS Tools for Enterprise Geodatabase Use

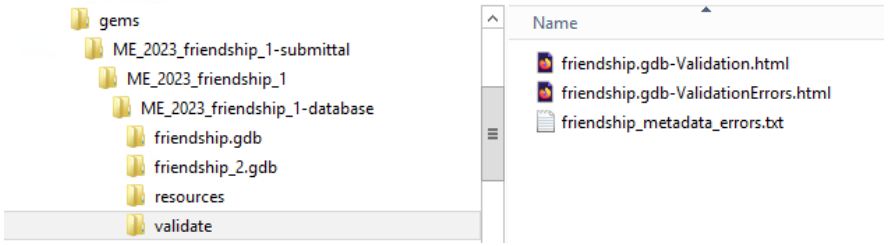
- Some tools had major rewrites to:
  - Convert intermediate file outputs to in-memory objects

```
    ## MAP OUTLINE
-   # make XY file for map outline
-   addMsgAndPrint("  writing map outline file")
-   genf = open(os.path.join(scratch, "xxxbox.csv"), "w")
-   genf.write("LONGITUDE,LATITUDE\n")
-   genf.write("{},{}\n".format(str(minLong), str(maxLat)))
-   genf.write("{},{}\n".format(str(maxLong), str(maxLat)))
-   genf.write("{},{}\n".format(str(maxLong), str(minLat)))
-   genf.write("{},{}\n".format(str(minLong), str(minLat)))
-   genf.write("{},{}\n".format(str(minLong), str(maxLat)))
-   genf.close()
-
-   # convert XY file to .dbf table
-   boxdbf = arcpy.CreateScratchName("xxx", ".dbf", "", scratch)
-   boxdbf = os.path.basename(boxdbf)
-   arcpy.TableToTable_conversion(os.path.join(scratch, "xxxbox.csv"), scratch, boxdbf)
-
-   # make XY event layer from .dbf table
-   arcpy.MakeXYEventLayer_management(
-       os.path.join(scratch, boxdbf), "LONGITUDE", "LATITUDE", "boxlayer", xycs
-   )
-
-   # convert event layer to preliminary line feature class with PointsToLine_management
-   arcpy.PointsToLine_management("boxlayer", "xxMapOutline")
-
-   # densify MapOutline
-   arcpy.Densify_edit("xxMapOutline", "DISTANCE", 0.0001)
-  arcpy.Project_management(
-      "xxMapOutline", "MapOutline", outSpRef, geotransformation, xycs
-  )
```

```
+   addMsgAndPrint("  writing map outline feature")
+   sr = arcpy.SpatialReference(text=outSpRef)
+   if outgdb[-4:] == ".gdb":
+       arcpy.management.CreateFeatureclass(outgdb, 'MapOutline', "POLYLINE", None, "DISABLED", "DISABLED", sr, '', 0, 0,
+
+   array = arcpy.Array([arcpy.Point(minLong, maxLat),
+                        arcpy.Point(maxLong, maxLat),
+                        arcpy.Point(maxLong, minLat),
+                        arcpy.Point(minLong, minLat),
+                        arcpy.Point(minLong, maxLat)])
+   #spatial_reference = arcpy.SpatialReference(4326)
+   polyline = arcpy.Polyline(array, xycs)
+       geotransformation = None # "WGS_1984_(ITRF00)_To_NAD_1983"
+
+   polyline_projected = polyline.projectAs(sr, geotransformation)
+   arcpy.edit.Densify(polyline_projected, "DISTANCE", "1 Meters")
+   if outgdb[-4:] == ".gdb":
+       cursor = arcpy.da.InsertCursor(outgdb + '\MapOutline', ["SHAPE@"])
+       cursor.insertRow([polyline_projected])
+   elif outgdb[-4:] == ".sde":
+       edit = arcpy.da.Editor(outgdb)
+       edit.startEditing(False, True)
+       edit.startOperation()
+       cursor = arcpy.da.InsertCursor(outgdb + '\\' + input_schema + '.MapOutline', ["SHAPE@","MapName"])
+       cursor.insertRow([polyline_projected, input_mapname])
+       edit.stopOperation()
+       edit.stopEditing(True)
```

Changes Behind the GeMS Tools for Enterprise Geodatabase Use

- Some tools had major rewrites to:
  - Use database stored procedures instead of arcpy, for example Validate Database



MGS_Data.GEMS_BDRK24....DataValidation

Field: Add Calculate | Selection: Select By Attributes Zoom To Switch Clear Delete Copy | Rows: Insert

	OBJECTID *	MapName	Level_Check	ValidationStatus	ErrorDetail
1	2469	spider-lake	2.01 Has required elements: nonspatial tables DataSourc...	Pass	<Null>
2	2545	spider-lake	2.02 Required fields within required elements are present...	n/a	unnecessary in an EGDB
3	2543	spider-lake	2.03 GeologicMap topology: no internal gaps or overlaps...	n/a	topology should be validated with database schema topology
4	2470	spider-lake	2.04 All map units in MapUnitPolys have entries in Descri...	Fail	SsldbX
5	2471	spider-lake	2.04 All map units in MapUnitPolys have entries in Descri...	Fail	SSltX
6	2472	spider-lake	2.05 No duplicate MapUnit values in DescriptionOfMapU...	Fail	Duplicated MapUnit: Dss
7	2547	spider-lake	2.06 Certain field values within required elements have e...	Pass	<Null>
8	2473	spider-lake	2.07 No duplicate Term values in Glossary table	Fail	Duplicated Term: Limit of mapping
9	2474	spider-lake	2.08 All xxxSourceID values in required elements have en...	Fail	DESCRIPTIONOFMAPUNITS-DescriptionSourceID: DAS11111
10	2475	spider-lake	2.08 All xxxSourceID values in required elements have en...	Fail	CONTACTSANDFAULTS-DataSourceID: Null
11	2544	spider-lake	2.09 No duplicate DataSources_ID values in DataSources...	Pass	<Null>
12	2548	spider-lake	3.01 Table and field definitions conform to GeMS schema	n/a	unnecessary in an EGDB

Status of the GeMS Tools for Enterprise Geodatabase Use

- Public fork at GitHub https://github.com/chhalsted/gems-tools-pro
- Late alpha or early beta stage as of May 2024
- Fork merging to parent still to be determined

- Minor, mostly pathing updates
  - Inclination Numbers
  - Set PlotAtScale values
  - A La Carte GeMS
  - Create New Database
  - DMU to .docx
  - Export GDB to GPKG
  - Make Topology
  - Topology check
  - Fix string values
  - Geologic Names Check
  - Symbol to RGB
  - Translate to Shapefiles
- Major updates or functionality changes
  - Make Polygons
  - MapOutline
  - Project Map Data to Cross Section
  - Validate Database
- Not yet upgraded
  - Set Symbol Values
  - .docx to DMU
  - Attribute by Key Values
  - Deplanarize CAF
  - Reset ID values
- Upgrade not needed
  - Compact and Backup
  - Rename ID fields
  - Submission Directory Tree
  - Build Metadata
  - Relationship Classes
- New tools
  - Export EGDB to FileGDB
  - MapName Definition Query
  - MapName Domain Update

Next Steps

- MGS schema to GeMS schema production migration – summer 2024
- Possible GeMS schema enhancements
  - Tables for managing photos, citations, map text, photo captions, metadata
- Update GeMS Toolbox tool metadata for EGDB usage
- Write documentation for implementing GeMS in a RDBMS
- Decision on GitHub merge commit

Questions?

THANKS!