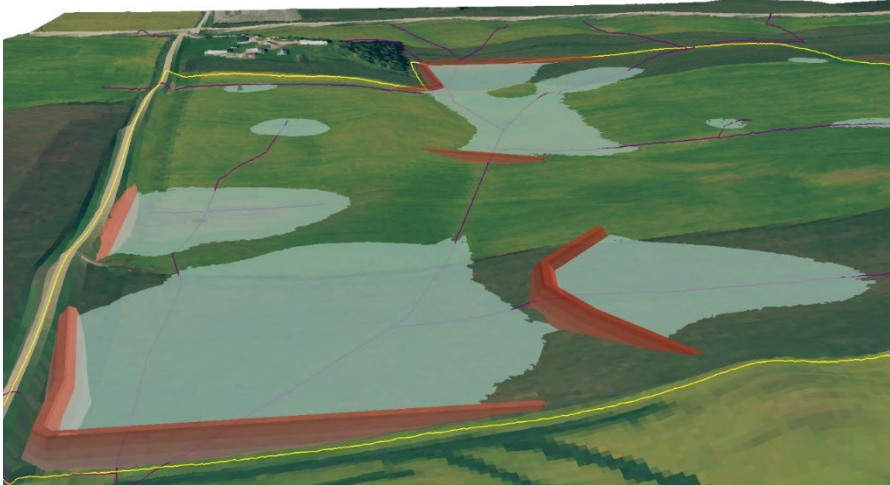
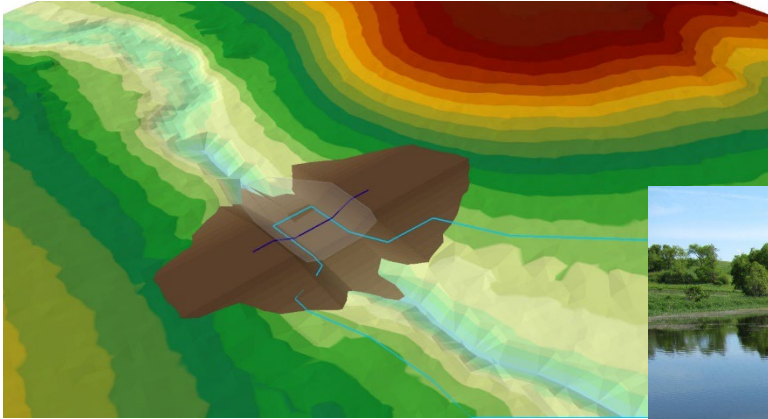


ESRI ArcGIS Pro Workflow for US Fish & Wildlife Service

Wetland Restoration Engineering & Design

By Scott Ralston, Wildlife Biologist USFWS Partners For Fish & Wildlife Program, Windom, MN.



Last Updated 2/27/2024 using version ArcGIS Pro 3.1.4

Available for download at: <http://skralston.com/USFWS/>

Specific data examples for habitat work in MN but transferable concepts to other areas.

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Introduction

Purpose: This tutorial is a workflow for United States Fish & Wildlife Service staff to map wetlands or other habitat features, import survey data and design embankments or spillways or other cut/fill volumes in habitat restoration projects. Although specific to this workflow you may find many of the steps usefully to modify to your own specific needs. Scott has been working with GIS in wetland mapping & restoration work in the Prairie Pothole Region of North Dakota and Minnesota since about 2001.

Disclaimer: This tutorial is develop by Scott Ralston as an individual not as an official publication by the US government or USFWS agency. Developed as a guide for my own project workflow and willing to share to help others but this does not represent any official policy, training or regulation by the agency. All engineering and design should be done by trained professionals and users accept their own liability in project designs. Free to share this tutorial just reference or credit where appropriate.

Introduction to ArcGIS Pro: This is a new platform for ESRI in GIS. The previous ArcGIS up to version 10x mainly used ArcMap as the functional mapping program. This tutorial and methods are an update from a previous version tutorial that was written for ArcMap so may refer to some similarities and differences. Major differences in ArcPro from 10x:

- ArcPro is designed more around working with online data seamlessly with local data and integrating geodatabases into the map workflow. Users used to stand alone shapefiles still will have that function but should learn what a geodatabase is and how to use one for more functionality as many functions are automatically integrated into a database.
- FWS users ArcPro can integrate FWS Portal data where ArcMap could only use AGOL and took extra steps to edit that.
- ArcPro uses ribbon menus and popup panes vs fixed toolbars so some tool options you may not see all the time unless you are on a specific layer or task where that tool is available.
- ArcPro has some enhanced performance and is better able to utilize your computers resources like 64 bit processing. It runs a bit smoother and faster.
- ArcPro can support many maps and layouts in a single project similar to the old original ArcView 3x. ArcMap was limited to 1 map and 1 layout in a project.
- ArcPro combines all the sub-programs into 1 program. ArcGIS 10x had ArcMap for the mapping, ArcCatalog for file management, ArcScene for 3d mapping etc. where all this is merged inside of ArcPro.

Setup & Customize Options & Create a Map:

Before diving into project there are many options and preferences you should try to setup and customize to make the rest of your workflow much easier. Setting shortcuts and other options and making a template to simplify future maps on similar projects.

1. **FWS User Resources:** USFWS users, all information or other resources for GIS needs can be found at the FWS Sharepoint page: <https://doimsp.sharepoint.com/sites/fws-gis> as well as on the Microsoft Teams FWS Geospatial Services team channel.
2. **Licensing:** We will assume you have a license available for ArcPro. If you are a USFWS employee then you do. Other organizations consult your IT administrators. For FWS you must be

connected to your DOI network either at an office with intranet connection or if remote must be on the VPN.

3. **Checking out a license for offline:** If you wish to work offline you have to first check out a license while you are still online and in the case of FWS must be on the intranet or VPN before you can work offline or off VPN.

- a. Open ArcPro
- b. On the Opening page hit Settings
- c. Choose Licensing from the left side
- d. Check the box that says Authorize ArcGIS pro to work offline. Can choose up to 90 days



The screenshot shows the ArcGIS Pro interface with the 'Licensing' tab selected in the left-hand menu. The main window displays the 'ArcGIS Pro Concurrent Use License' table and the 'Esri Extensions' table. Below these tables, the 'Settings' section is visible, with the checkbox 'Authorize ArcGIS Pro to work offline' checked and the 'Number of days' set to 90.

Name	Licensed	Expires
Basic	No	N/A
Standard	No	N/A
Advanced	Yes	Never

Name	Licensed	Expires
3D Analyst	Yes	5/23/2023
Aviation Airports	No	N/A
Aviation Charting	No	N/A
Bathymetry	No	Never
Business Analyst	No	N/A
Data Interoperability	No	N/A
Data Reviewer	Yes	5/23/2023
Defense Mapping	No	Never
Geostatistical Analyst	Yes	5/23/2023

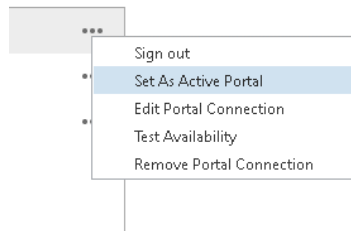
Settings
 Authorize ArcGIS Pro to work offline Number of days: 90

4. **Portals:** These are connections to online cloud data. FWS employees already have AGOL and FWS internal portal accounts by default. Contract your GIS administrator if you have questions or need additional publishing rights. Outside users check with your own GIS staff.

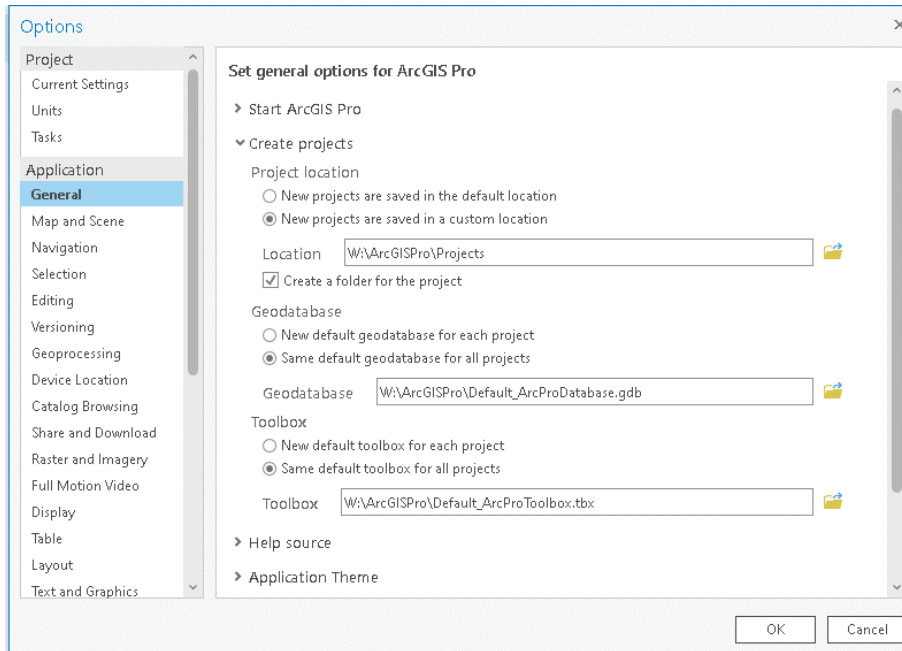
- a. Sign in to your available portals so they are available in all mapping.
- b. On the settings page go to portals and hit Add portal. FWS users have 3 available and are listed in this screenshot

The screenshot shows the 'Portals' section of the ArcGIS Pro interface. Three portals are listed: 'https://gis.fws.gov/portal/' (Signed in as scott_ralston@fws.gov), 'https://maps.fws.doi.net/portal/' (Signed in as scott_ralston@fws.gov), and 'https://www.arcgis.com/' (Signed in as scott_ralston@fws.gov_fws). An 'Add Portal' dialog box is open, prompting the user to 'Enter the URL of your portal' with a text input field and 'OK' and 'Cancel' buttons. Below the dialog, there is a checkbox for 'Sign in using' and an 'Add Portal' button.

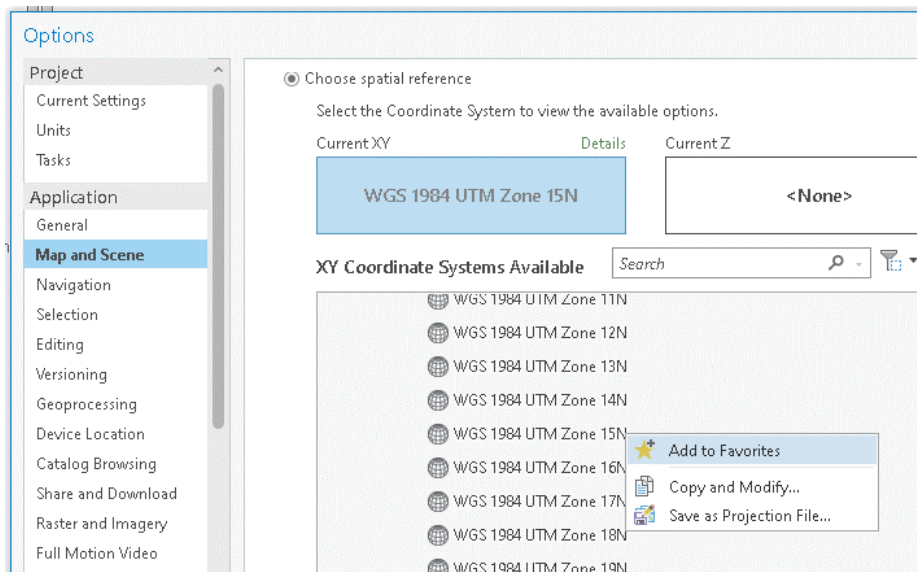
- c. AGOL – ArcGIS online is a server/service hosted by ESRI. Data is housed on their server under your account and can be shared with others publicly. Since this is on a public server the type of data you can share or host on AGOL is limited to non-sensitive data and if shared publicly must comply with public data standards such as 508 compliant. Address is simply [arcgis.com](https://www.arcgis.com/). You will log in with the FWS email and credentials. May need either your PIV card on government systems or Authenticator for 2 step verification. <https://www.arcgis.com/>
- d. FWS GeoPortal is a very similar. It is the same ESRI software platform product but is running and data housed on a FWS server behind a DOI firewall. This should be used for any sensitive data not open to the public. As such the content hosting is much more flexible on what you can put up. You must still follow agency guidelines for any PII. Address is <https://gis.fws.gov/portal/> and if prompted use the DOI or FWS account at login not AGOL.
- e. The 3rd is InsideFWSMaps. Very similar to GeoPortal as another internal server. <https://maps.fws.doi.net/portal/>. However, InsideMap is an older version being replaced by GeoPortal. It still has some data from previous projects so can use if needed but is being phased out so use GeoPortal for all new cloud hosting.
- f. Once all your portals are connected they should reconnect automatically when you open ArcPro if you are online. The internal servers might not log in automatically if you are on a public network so might need to use re-log in if they don't connect outside of the office. Data in your maps should be available from all portals at the same time. However if you want to edit any data it can only edit from the "Active" portal. Thus if you are editing a specific dataset then right click on that portal to set as Active



- 5. **Options/Preferences:** Go to the Options Menu for additional custom settings. Go down the list and set any defaults that are useful to your situation such as units, file locations etc.
 - a. **General:** Likely should set a new default location for your data. If not defined ArcPro tends to save to a local folder in your Windows Documents Folder. However, if you are in a collaborative workplace you might want it stored on a central server location or if others would open the Project they would be missing any data stored on your local hard drive. Specific maps you might want to later redefine individual geodatabases in each project folder specific to that project. You would do that here also. However, as a starting point I would make a default central folder, geodatabase and toolbox to point to.

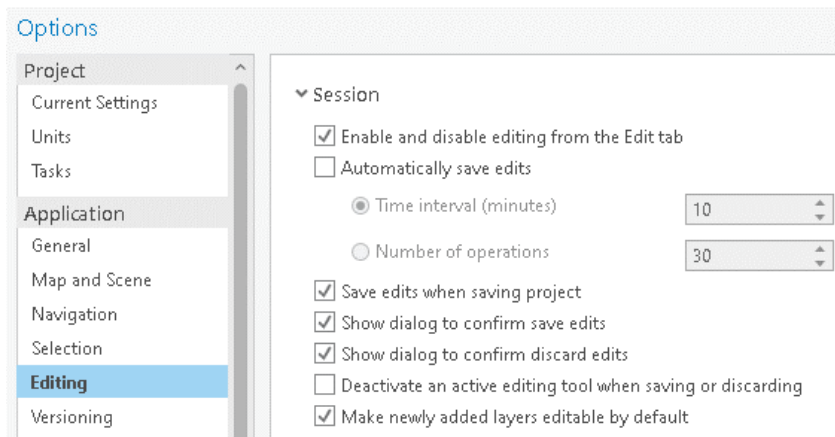


- b. **Map & Scene:** Main thing here is setting a coordinate system for the current map and your Favorites for future. Under Spatial Reference scroll through and find your desired coordinate system. Right Click on it and select add to favorites. This will be quicker than looking through the entire list every time.

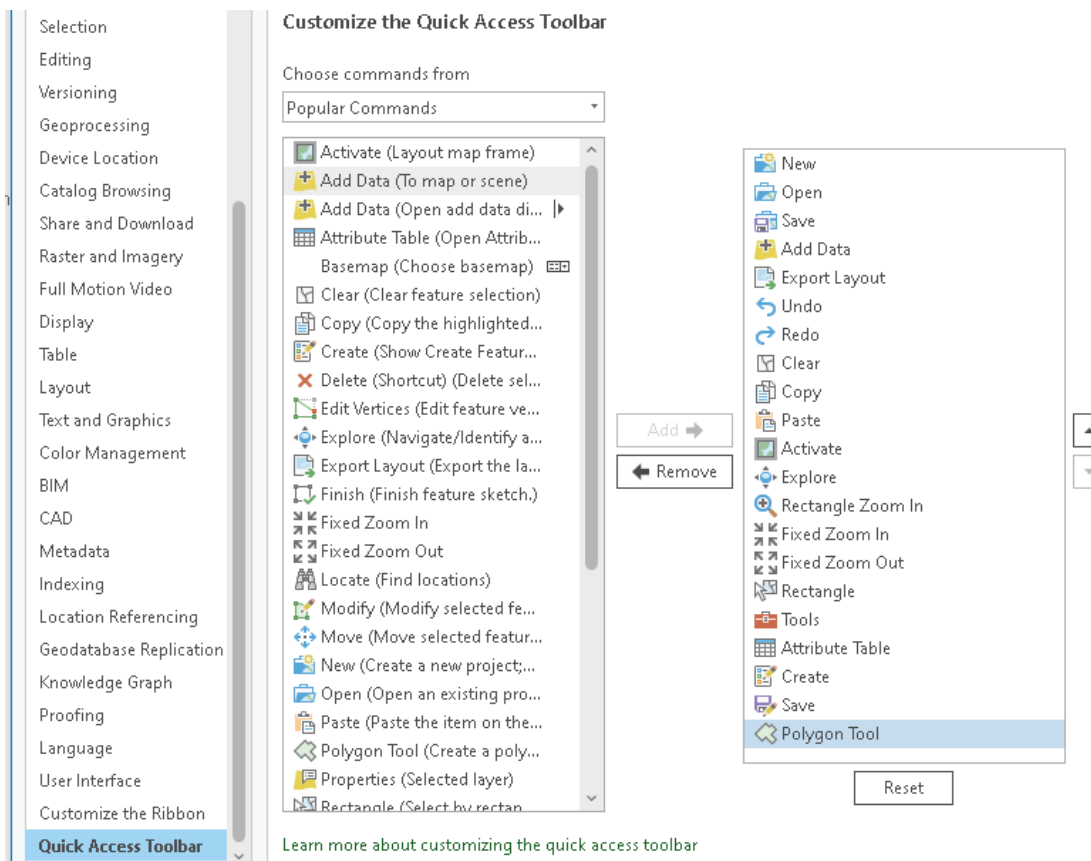


- c. **Editing:** ArcPro editing is different than ArcMap where essentially all layers can always be available in editing mode any time not just in an edit session. Thus there is a chance of editing by mistake if you aren't careful. Later we will cover turning off edit options for undesired layers. However, in the Options I like to keep "Automatically save edits" OFF. As well as "Enable and disable editing from the Edit tab" turned ON. These 2 features make editing a more intentional act so you both have to enable the edit mode like you did in ArcMap 10x as well as confirm saving a change in case you accidentally changed

something you didn't want to. This is an extra step so if you are confident in your workflow you can skip this and work faster just be aware of what you are doing.

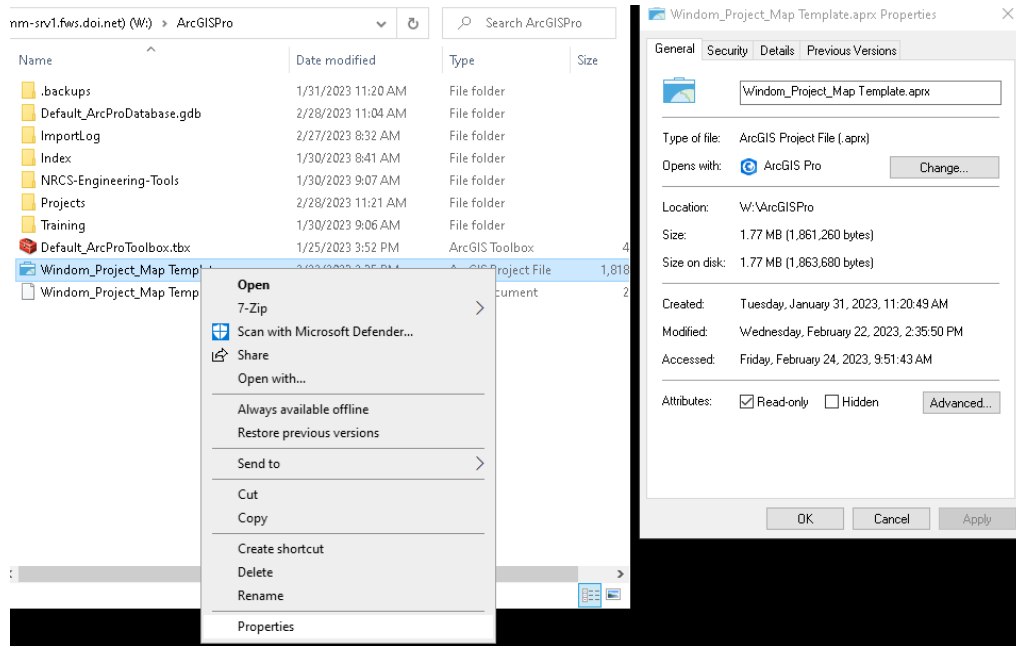


- d. **Quick Access Toolbar:** These are the tool buttons at the very top of the screen. Unlike the ribbons these tools don't move or change so are always available. My preference is have as many common tools available for quick access so I add and organize most of these available buttons.

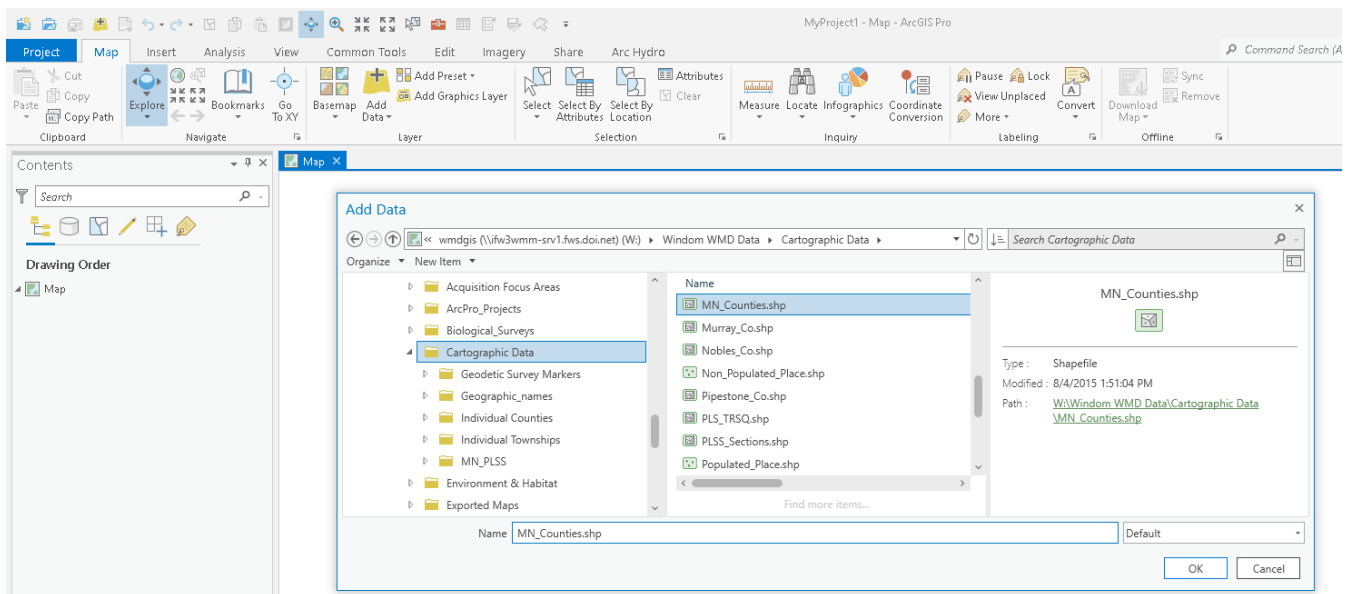


- e. You can also customize each ribbon if you want further tools rearranged. Right click on the Ribbon and choose customize.

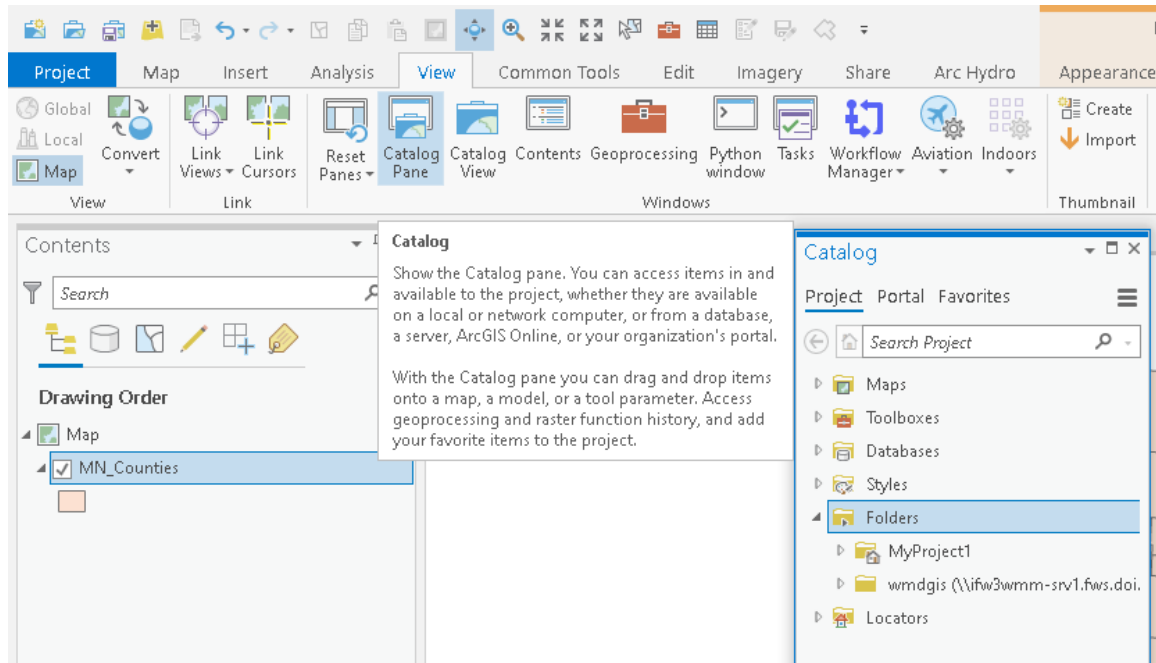
- New Map or Template:** Highly recommend setting up and using a map template. As most of your projects will probably start with similar data and similar layouts. Save time in recreating by setting up a general purpose map once and save it. Then reopen this map as your template to start from each time. Then use the Save As command to save it to a specific location for individual projects. If you want to secure this template so it can't be accidentally overwritten then just set it to read only in the file properties.



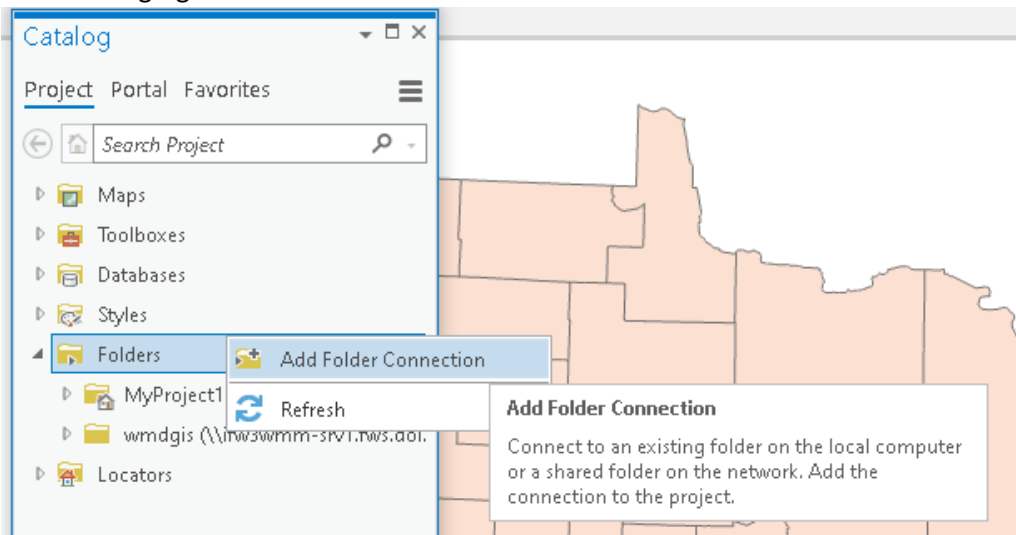
- Add Data:** Under the Map Ribbon hit the Add data button or if you customized the quick buttons at the top it may be there also. There are also additional options on the Add data drop down list (arrow on the bottom of the button). Navigate to your data and add to the map. Various predefined basemaps are also available on the basemap button and drop down list.



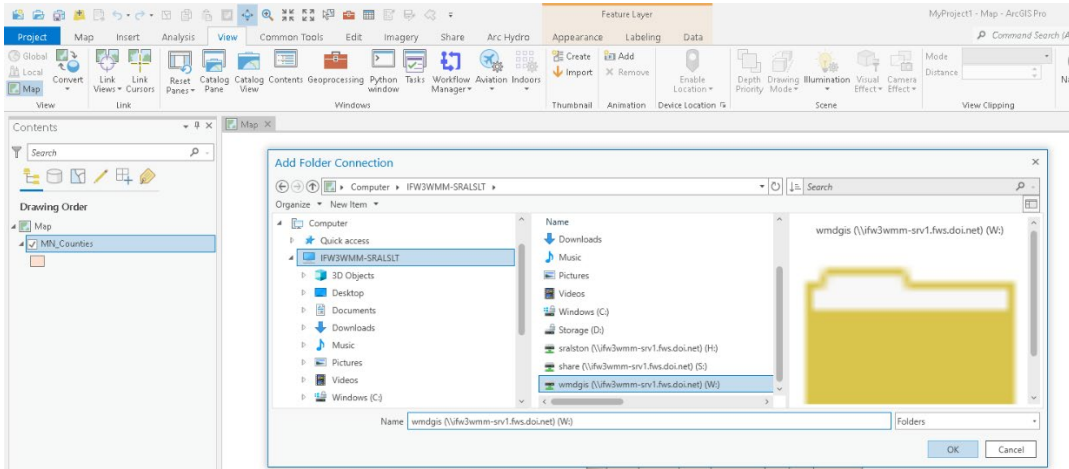
8. **Catalog Pane or View:** Use Catalog as another way to add data or a place to view files, move or create files. This is synonymous to ArcCatalog in the old ArcGIS 10x. On the View Ribbon you see 2 options for Catalog Pane or Catalog View. Pane opens a side toolbox that you can either drag around floating or dock it to the side. This is easier for dragging and dropping or viewing while also using the map display. Catalog View opens the Catalog on the entire view screen and is a Tab along with your maps and layouts available. Better if you are doing more file management and want a larger workspace for your files.



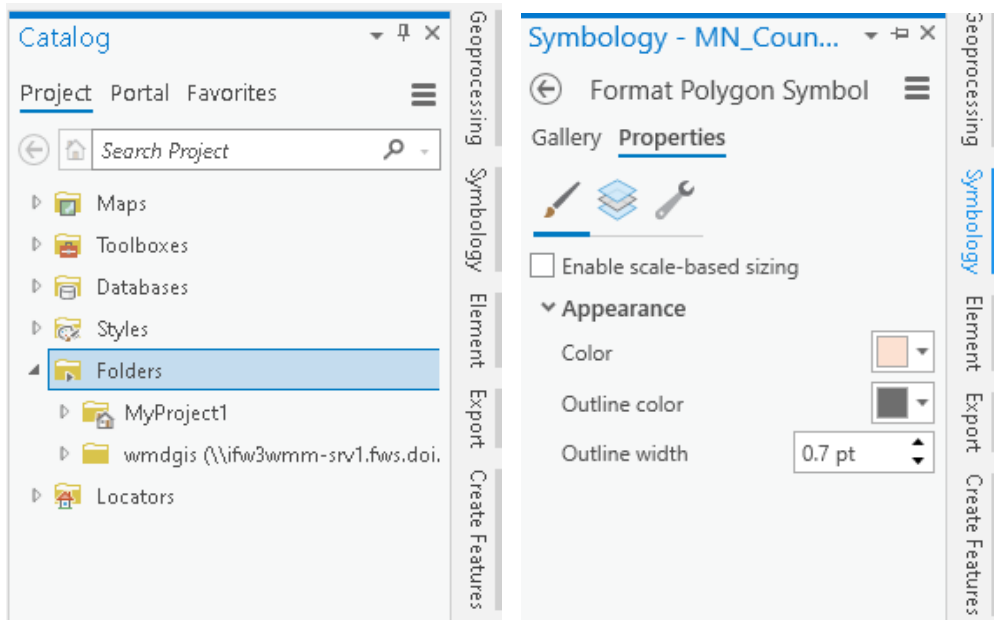
9. **Folder Connections:** In the Catalog it does not show the same Windows file structure you would see in explorer or in the Add data box. It only shows files or folders you are connected to. Thus, if you want a drive or a specific folder connected in Catalog you need to map it.
 - a. In Catalog right click on the Folders icon and hit Add Folder Connection



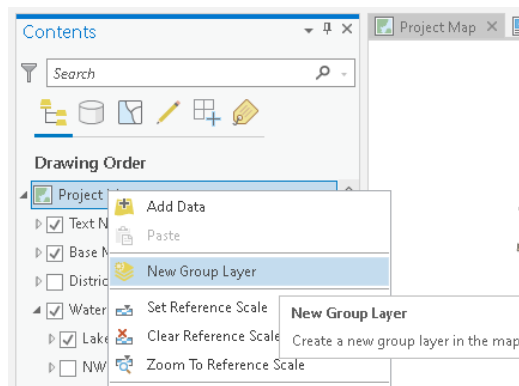
- b. Navigate to the drive or folder you want connected, select it and hit OK. Being more general like a whole root drive may be better if you will want items from multiple locations on that drive. If there is just 1 specific spot you want data from you can navigate down to subfolders which could be quicker to access but less broad.



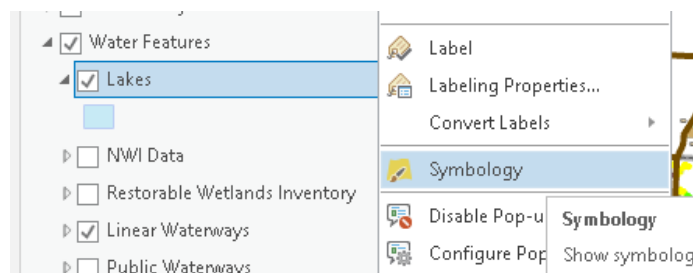
- Working with Panes:** “Panes” are popup windows with specific tools for various tasks in the map. Can include Catalog as we have just seen, geoprocessing tools, symbology, labeling. They will pop up when you click on something that requires more options. If closed with the X button in the top right corner they can come back when needed by hitting the originating button on one of the ribbons or right clicking context menus. However, I find it much more convenient to let them remain minimized/docked on the right hand side so they are quickly available as needed. Learn the habit of not closing them with the X. They will auto-hide if you just leave them and click on another tool or on the map. Sometimes they auto-hide too quickly when you still may want them visible. To dock it\hold it open, hit the pin button on the top of the tool. It will remain open until you unpin or X to close. To reopen just hit the tool listed along the right side.



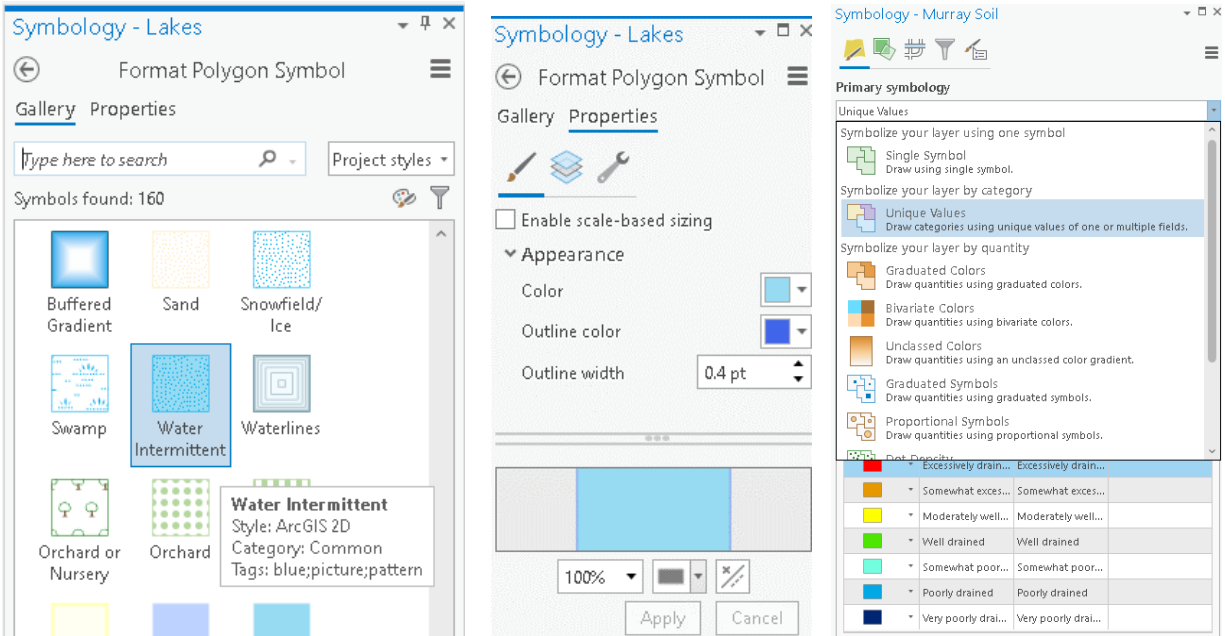
11. **Suggested Map Layers:** For the type of wetland work proposed in this tutorial, Map layers that would be useful include
- Road and other Transportation layers
 - Geopolitical boundaries such as Cities, County or State Lines, Townships and Sections
 - Hydrology such as Rivers, streams and Lakes, NWI and RWI data, State protected waters, judicial ditch systems, HUC12 watersheds.
 - Land ownership including Federal and State lands other conservation lands.
 - Easements including FWS easements as well as other programs such as RIM, WRP, CRP, State easements.
 - Environment & Habitat data such as Landuse/Land Cover, Natural Heritage or T & E data, Biological Survey data, prioritization maps.
 - Soils maps, particularly with drainage properties/hydrology. Excessively drained to Very Poorly drained. Using MUName attributes for soil name class.
 - Topography information including topo maps and any DEM LIDAR available at the highest resolution for your area. Much lidar includes 2ft contours and hillshade but we will clip and create this ourselves specific to a project location later.
 - Aerial Photography. Suggest as many years as available. Often see things in 1 year that you may not in others as well as span wet and dry periods. Some photos may be available in an un-georeferenced form. We will cover georeferencing in a later section.
12. **Group and name data:** Many layers in the map can clutter it and make it hard to find specific things. Group data by type under headings. Right click on the Project Map at the top of the list and choose New group layer. Rename it and drag layers into it. This way you can toggle entire groups on or off as needed. Rename all other data to be intuitive in the map not coded.



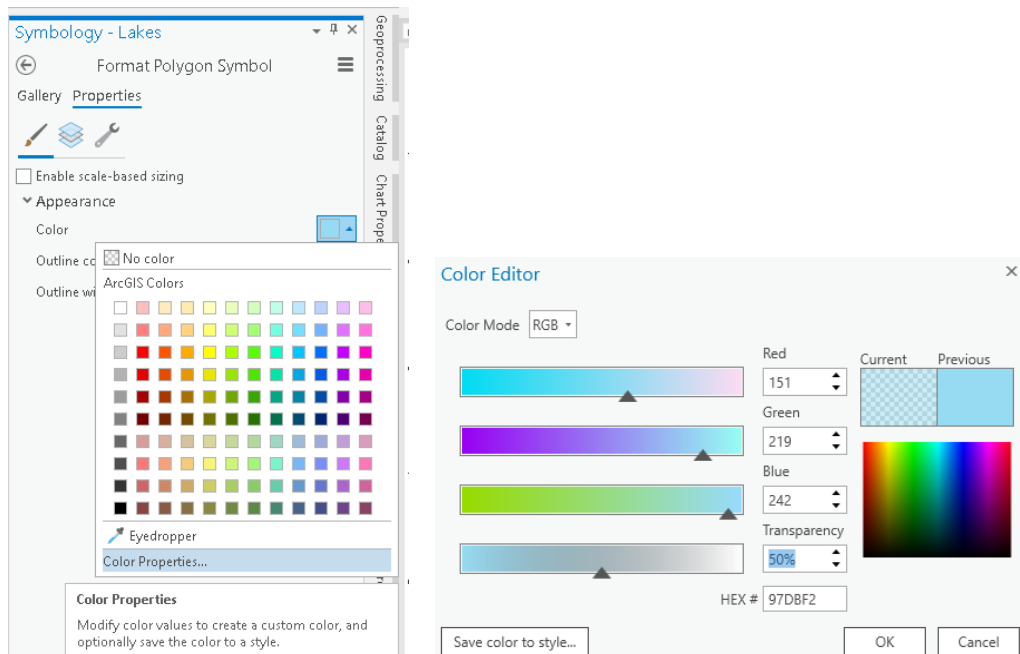
13. **Change Symbols:** Customize layer symbols. In your table of contents.
- Either click on the symbol which can make the Symbology Pane appear on the left or right click on the layer and choose Symbology.



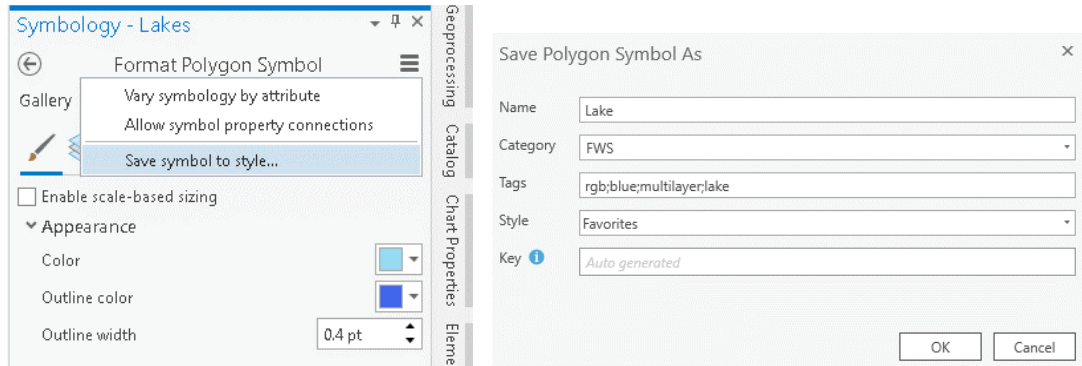
- Change the symbol either from the Gallery of predefined symbols or the Properties where you custom choose your own fill or outline.
- Symbol properties of the overall layer can also change if the feature is displayed as a single type or broken by unique Values or other categorizations.



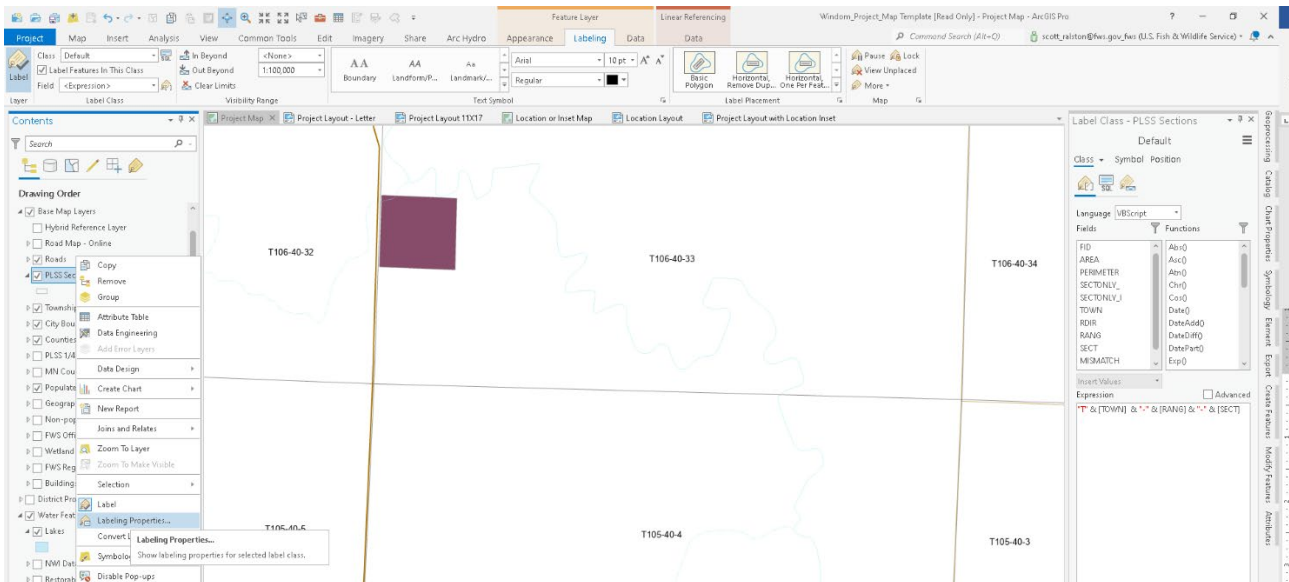
- Transparency** is a common feature. To make an outline or fill transparent, hit the drop down for the color and choose color properties. Then adjust the transparency in the properties.



- d. Save custom symbols. If you like a specific symbol and you want it quickly available in your symbol gallery, hit the menu at the top of the symbology pane and choose Save Symbol to Style. It will then be saved in your Gallery. I define the same Category for all my custom symbols so they are organized together.

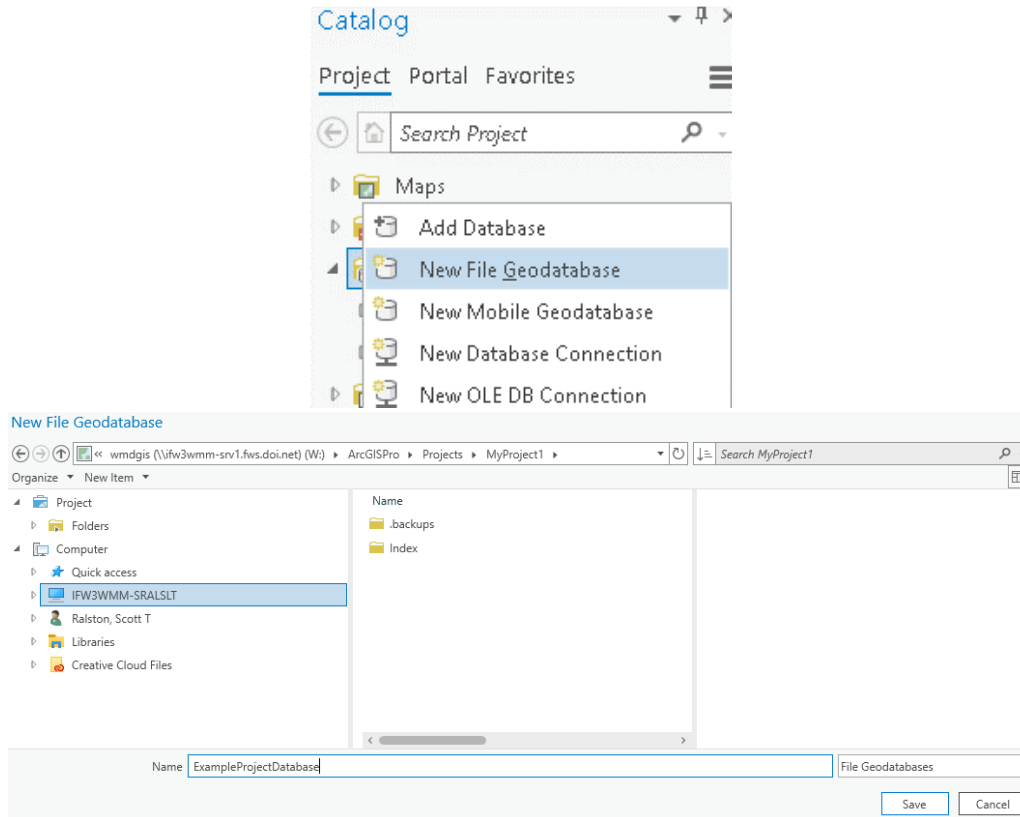


14. **Labeling:** Any features that need labels you can choose labeling options either by right clicking on the layer and choose Labeling Properties to open up the Label Pane or many features are available on the Label Ribbon tab at the top. Labeling can get pretty extensive with options. Much is trial and error or search many good video tutorials available online for specific functions.



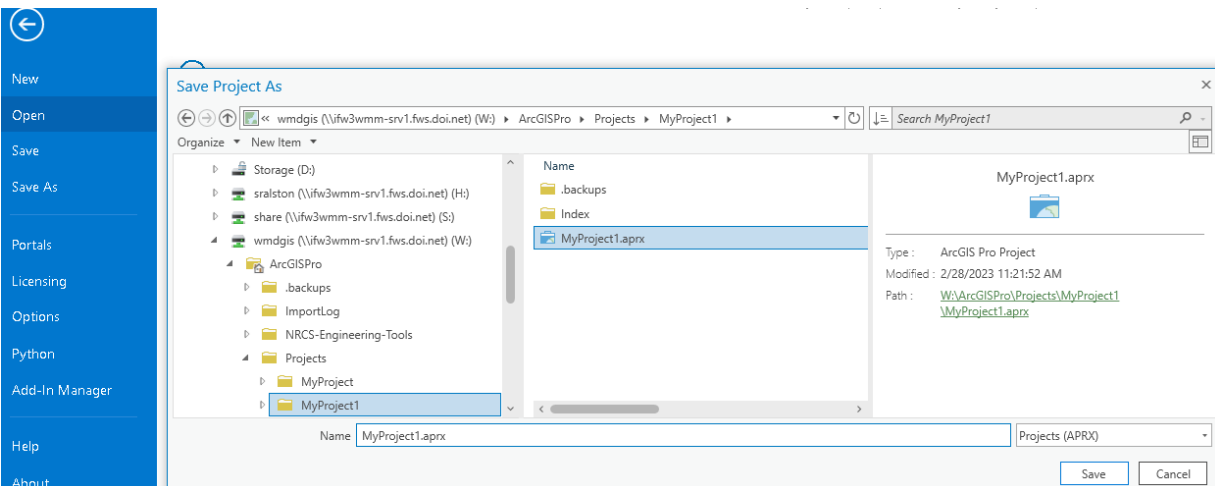
15. **Create a Project Geodatabase:** Many features of ArcPro are stored in a project geodatabase. Unlike ArcMap this is not optional. Every ArcPro project must have a database so if you don't define one then it will create a default database. However, if a default one is used it could be stored locally not associated with the rest of your map data which may reside on a server for others to also use causing error or missing information if opened later. Or if not associated with the map may be inadvertently overwritten or deleted. So it is best practice to just create a database for each unique project. If you are using 3rd party tools like NRCS Engineering toolbox you could skip this as it will create a geodatabase in the process of using that tool if you do it early in your map workflow then define that database as your default map database.

- Open the Catalog Pane or Catalog View
- Go to the Databases Folder and right click and hit New File Geodatabase
- Navigate to the folder where you will save your project. Best to have an individual file folder for each separate project. Keep all specific data and documents for that project together in 1 place. Give your database a name.



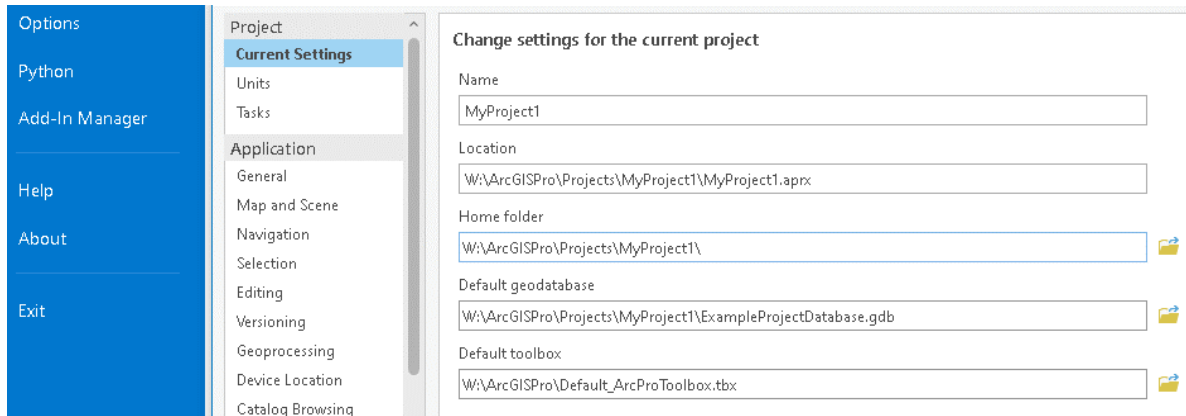
16. Save your Project:

- Use the Project tab at the top left and choose Save or Save As
- Save it in the same project folder as the rest of the database and documents or other files for this project.

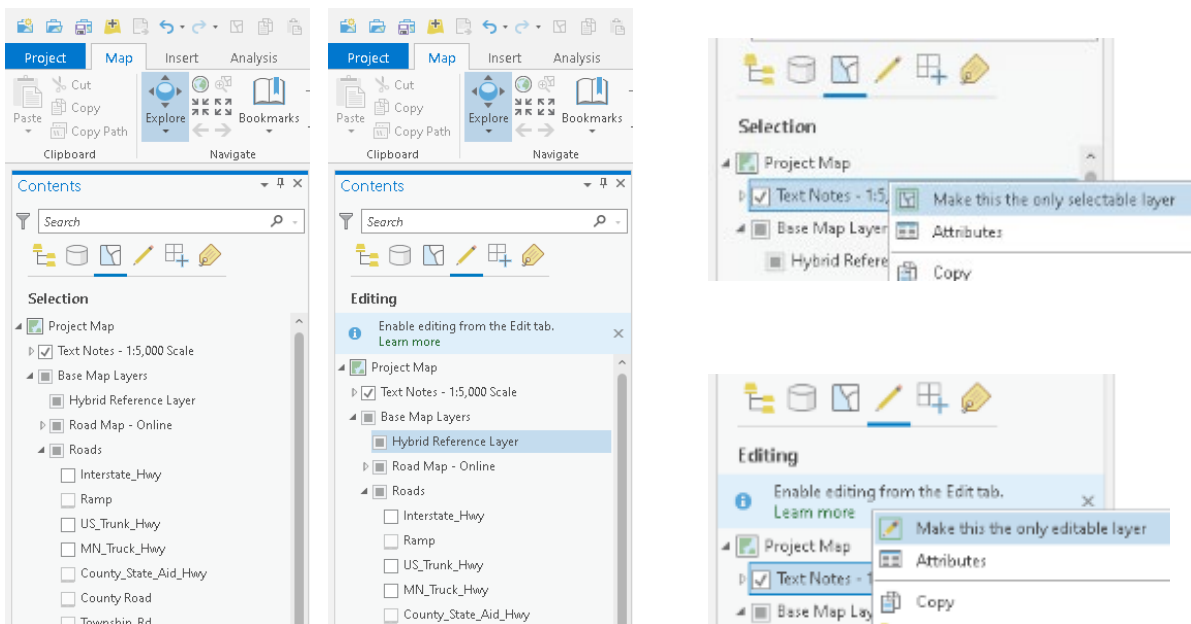


17. Set default project locations to the new project folder and geodatabase.

- a. This defines the default location for all future work to your project folder. Saves time in searching for locations to save or retrieve from as well as defines the new geodatabase to use when it stores things like annotations or other auto-created items.
- b. In the project tab at the top left choose options
- c. Under Project\Current Settings change each of the Location, Home Folder and Default Geodatabase to your project file.

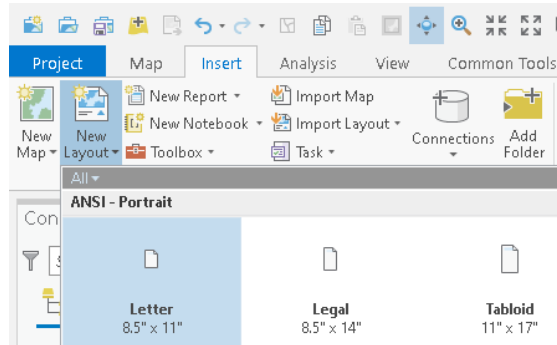


18. Set Selectable and Editable Layers: ArcPro makes it easy to edit almost everything. Often it is too easy and could edit feature you don't intend to or get cluttered while trying to work with a single feature. You may want to edit a wetland polygon but accidentally select and delete or modify a background road layer. Because of this it is best to set up your map right away to make most base maps or simple display features not selectable and not editable to avoid issues. On the Map view table of Contents there is a selection button and an Edit button. Go to each of these and toggle off all layers that you don't want selectable or Editable. Shortcut instead of toggling a long list is you can also right click on a layer and select make this the only selectable/editable layer. Same spot you can also toggle snapping layers if you want as well.

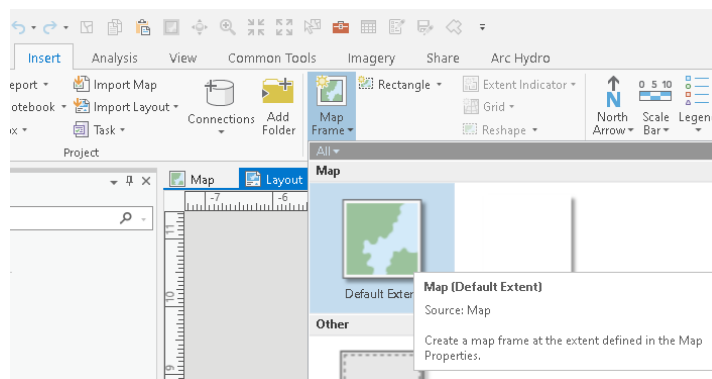


19. **Create a Layout:** The map view is where you do the full screen work and analysis. The layout is how it is displayed on a page which you can then print or export.

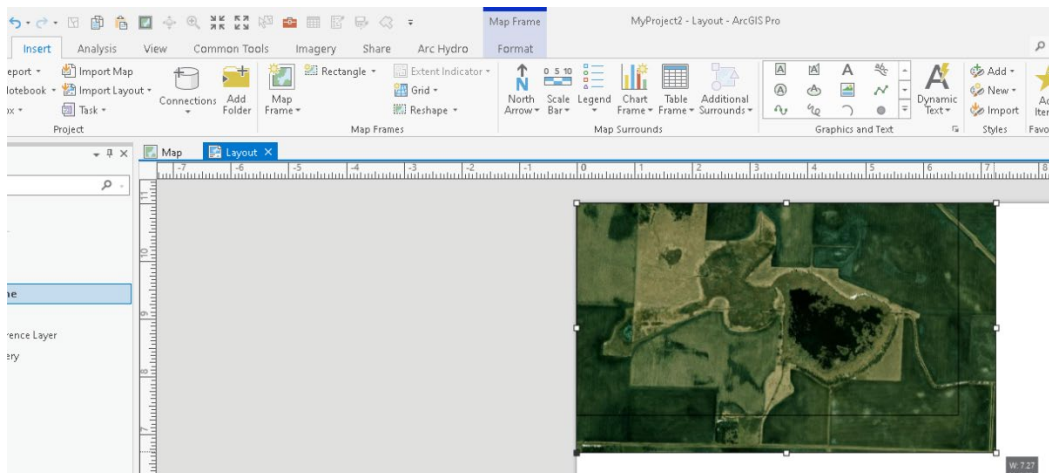
- a. This could be done now at the beginning of a project or template creation or done at the end of the project for final display.
- b. On the Insert ribbon at the top choose New Layout and pick your size format.



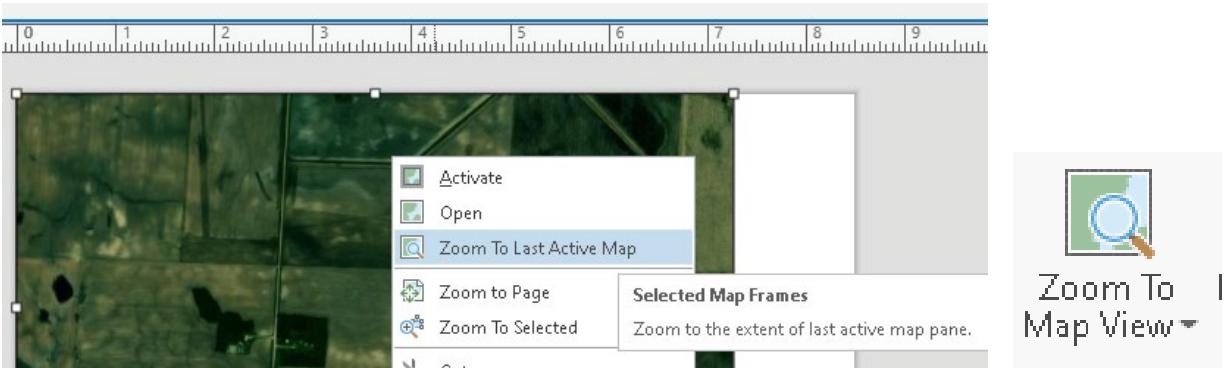
- c. On the layout tab you just created, again go to the Insert ribbon. Notice the buttons are different when on the Insert ribbon in a layout vs a map. Tap Map Frame. If you have more than 1 map in the project you can choose which one. Also can choose the extent from the list.



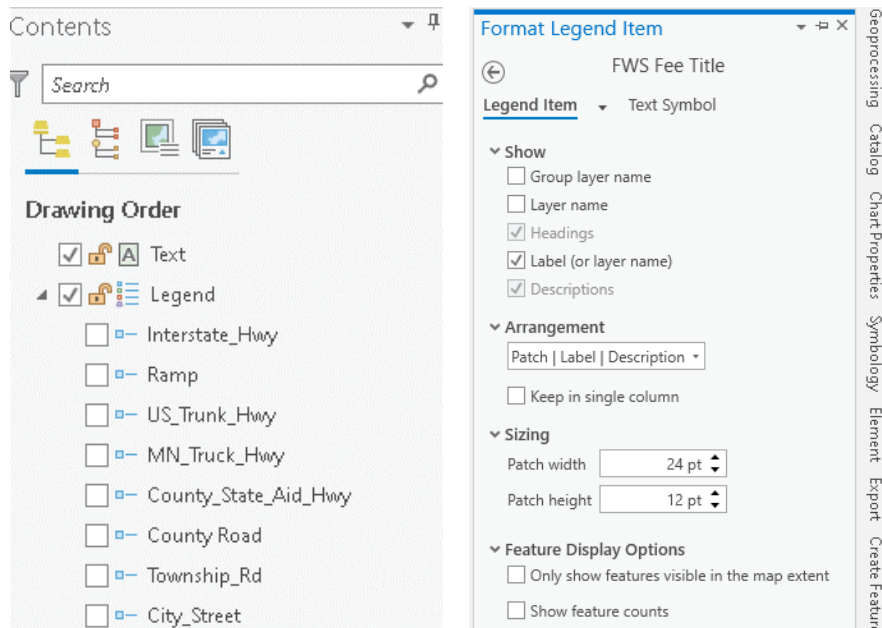
- d. Draw/Drag the Map frame on your layout page covering the whole page or part of it depending how you want it viewed.



- e. You could repeat this process if you want multiple maps on your layout such as if you want a main map and an inset at a different scale. The Map frames from the same source map will have the same features displayed with the same symbology, layers toggled on or off, labeling etc although they could be viewed at different scales or locations. If you want a different map for the inset you would need to create a New Map frame separately up on the Insert ribbon, then import that to your layout.
- f. Note your map frame in your layout navigates separately from your active map so zooming in or out to a feature in the map view won't translate to the layout. A quick shortcut in layout is right click on the map frame and choose zoom to last active map which brings you to the same location as the map view and you can adjust from there or also the Zoom to Map view button on the ribbon.

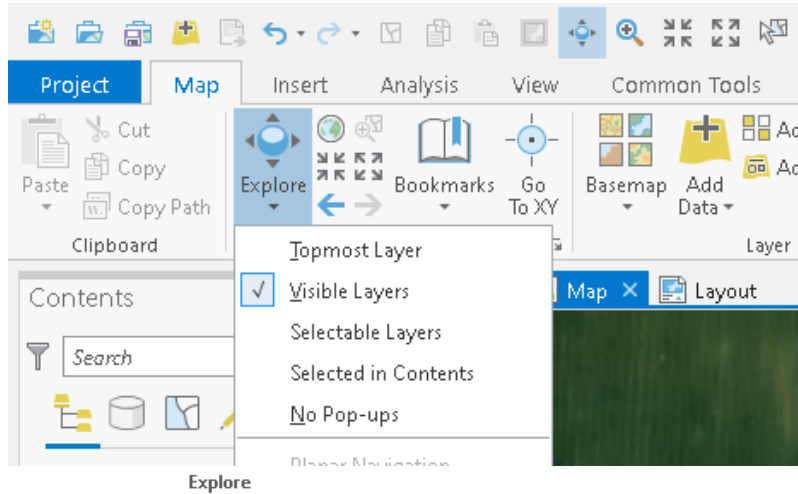


- g. Layout features like North arrow, Scale bar, Title and legend can be added from the Insert ribbon when in a layout view
- h. **Legend:** you probably don't need every layer in the map on the legend. Expand the Legend list in the Contents Pane and toggle off items you don't need. Double clicking any of the legend items opens a right pane for more individual options.



20. Navigation:

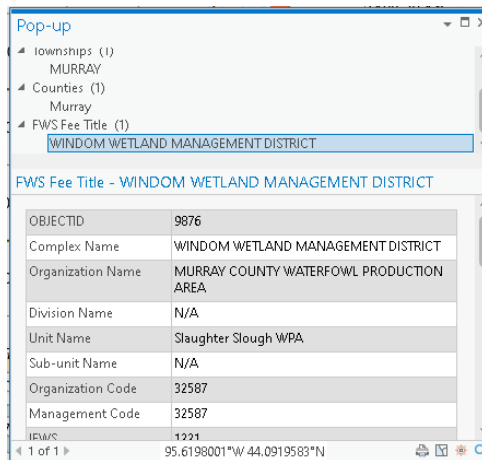
- a. Map view navigation is done with the Explore tool. This is located on the Map tab. Use the mouse scroll wheel to zoom in or out. Click and drag to pan. Hold down the shift key when you click and drag to get a rectangle zoom in box.



1. View pop-ups and pan
2. Zoom, rotate / tilt (3D-only)
3. Zoom continuous

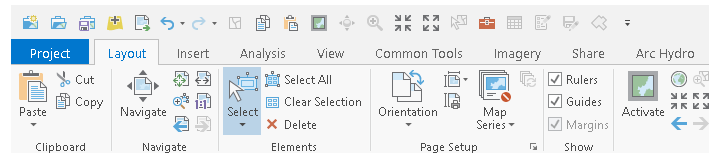
Quick shortcuts:
 Shift = zoom rectangle
 Ctrl = view pop-ups within rectangle
 N = point north
 B = look around (in 3D)
 C = explore when using another tool
 V = rotate / tilt
 Ctrl+Alt+C = quick enable

- b. **Identify** with the explore tool. If you click on the map without scrolling it works as an identify tool and will pop up a box with attributes about the layers you clicked on. You can change the way this identify tool works or disable it on the Explore drop down list.

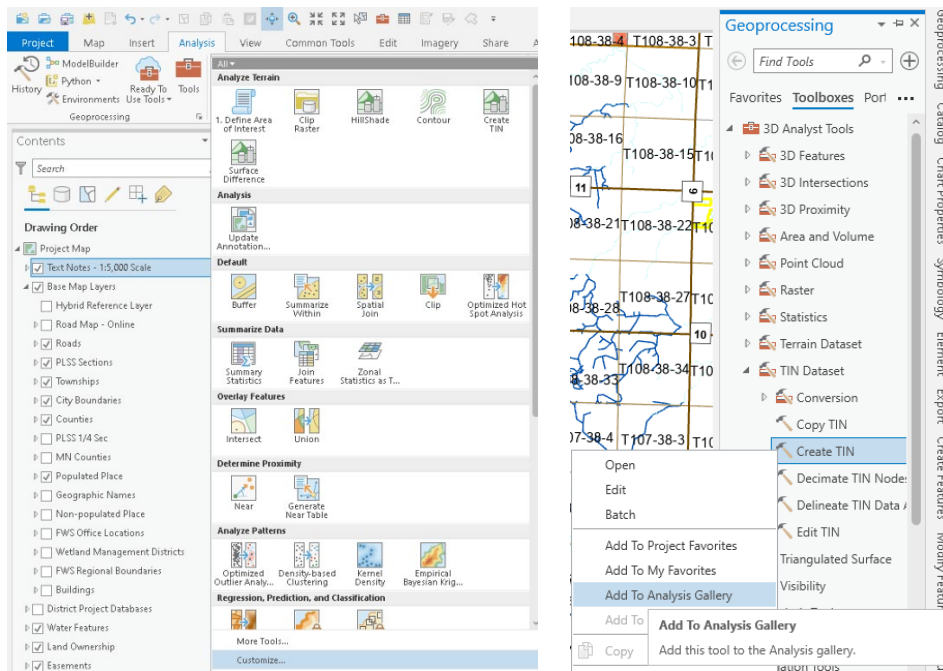


- c. Additionally on the Map ribbon if you enable the quick shortcuts, the explore tool and a few other navigation buttons can be available at the top of your screen.

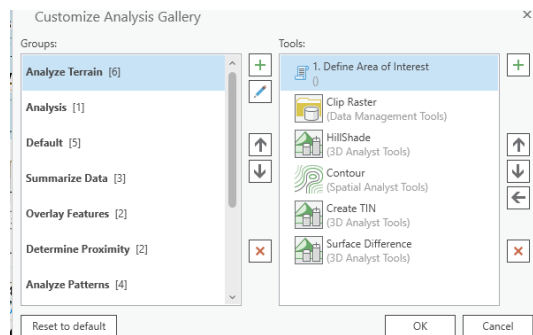
- d. **Layout navigation** is a little different. On the layout ribbon you see some navigation tools that navigate you around the layout page itself. In order to navigate in the Map Frame on the layout you need to first hit the Activate Map button on the Layout ribbon or on the toolbar at the top of the screen. Then you will be working in the map frame and can use the Explore tool to navigate in the map. Hit the button again to exit active map and resume layout navigation.



21. **Setup Analysis tools:** Geoprocessing analysis tools are available on the Analysis ribbon. Shortcuts in the dropdown gallery on the ribbon or a full suit in the toolbox by hitting the red Tools button on the ribbon.



- a. Add tools you use often to the gallery by locating in the toolbox and right click and Add to Analysis Gallery. Then at the bottom of the Gallery you can choose customize and rearrange if you want to.



- b. Suggested tools for wetland workflow:
 - i. Data Management tools > Raster > Raster Processing > Clip Raster
 - ii. 3D Analyst Tools > Raster > HillShade
 - iii. 3D Analyst Tools > Raster > Contour
 - iv. 3D Analyst Tools > TIN Dataset > Create TIN
 - v. 3D Analyst Tools > Area and Volume > Surface Difference
22. Your map should now be ready to use. Save any changes. This is either your template to create other maps from or possibly a new stand alone map. If you opened this map as a template then you already have all the layers imported and symbolized. You just need to do the final steps of creating the unique database and saving it all in it's own new file location.

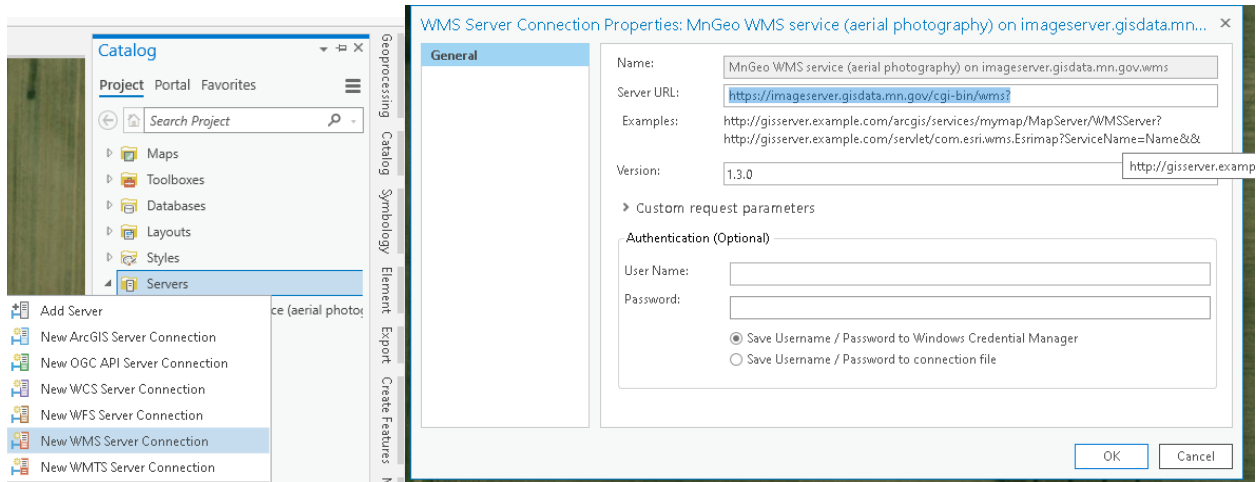
Aerial Photography & Other GIS Resources:

1. **Air photo uses:** Aerial photography may be one of the most useful tools in wetland and conservation work. Particularly a large span of years of air photos can show the history of a site or variations in hydrology with wet or dry cycles. May see the full extent of a wetland during wet years or how it looked pre-drainage. May also see a year that it was drained or certain years where features like buried drain tile show up well due to surface disturbance or vegetation changes. Seek as many air photo resources as you can find for a site.



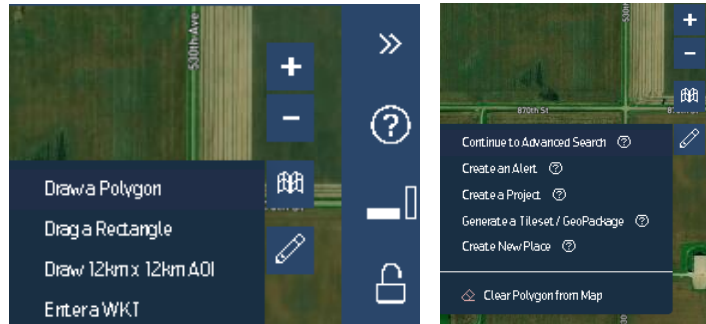
2. **Resources:**
 - a. **Basemap:** A few air photo options are available from the ArcPro basemap. Most of it is what they refer to a "Firefly" which is a cartography service that mixes various sources at different scales to get a full composite image across the globe. Has good coverage of almost anywhere and quickly available without additional downloads. Downside is for the most part you don't know when the image was taken and the image used may change for any particular location over time as they update their system.
 - b. **Map Services:** Various servers host their data through a server connection such as a WMS (Web Map Service) server. If you find a data site that mentions a server connection you can map to it in your catalog pane then add data from it like any other file location.

- i. Open the Catalog pane and right click on Servers and choose the type of service. In this example for Minnesota we use the MN Geo WMS Service. Type the Server Address. Some servers may require a User name and password. If not such as MNGeo then leave blank.
- ii. <https://imageserver.gisdata.mn.gov/cgi-bin/wms?>

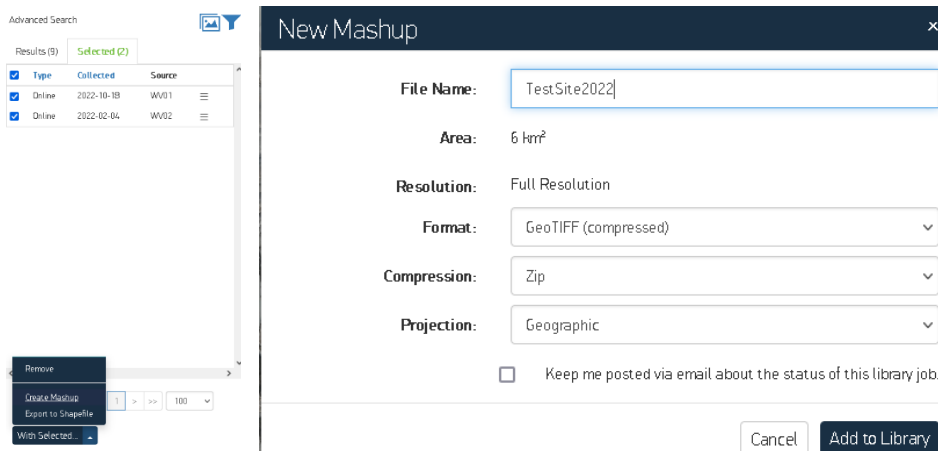


- c. **NAIP photos:** NAIP is a program run by the USDA FSA originally used for crop compliance but has expanded to many uses. Available across most heavy agriculture areas of the country and new imagery flow typically every 2-3 years for many areas. Available back to the early 2000's when the switched from slide film. It comes already georeferenced/orthorectified in mosaics covering usually at least by County but sometimes by full state depending where it is hosted. The MNGeo service listed above hosts the NAIP imagery so it can be served online from there. If you have a slower internet connection or otherwise prefer to download your data locally you can download NAIP from many sources. These are a couple.
 - i. <https://nrcc.app.box.com/v/naip/folder/17936490251>
 - ii. Choose your year, state, type (C refers to color infrared & N is Natural color, then the county file. Unfortunately NAIP hasn't adopted intuitive naming so their file names are a coded value. On the root directory look for a folder called reference files and within that a file called NAIP file names for the directory of state and county codes. Recommend renaming after you download to a State-County-Year file name.
- d. MNGeo: Aside from their map server can also download mostly FSA NAIP photos from here for MN. <http://www.mngeo.state.mn.us/chouse/airphoto/>
- e. Datagateway: Another place for mostly NAIP photos nationwide as well as other GIS layers. <https://datagateway.nrcs.usda.gov/>
- f. Digital Globe: Government agencies can get a free account. It has ongoing recent satellite imagery. (It has an option for smart card log in but don't use that as it is only for DOD, create a standard user account.) Often you can find images only a month old and good resolution.
 - i. <https://evwhs.digitalglobe.com/myDigitalGlobe/>

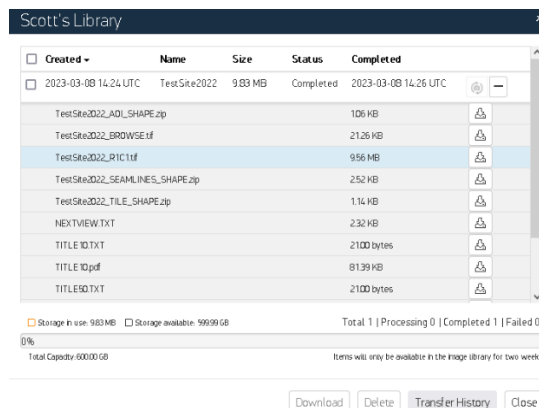
- ii. It is a little clumsy to use but essentially use the Map to zoom to the area of interest.
- iii. Use the Draw tool to outline the area you want to clip out which should then have a red box.
- iv. Then on the pencil icon hit Continue to Advanced Search.



- v. Choose the year/date available in the list you want and at the bottom of the list hit continue and With Selected "Create Mashup" and give it an intuitive name.

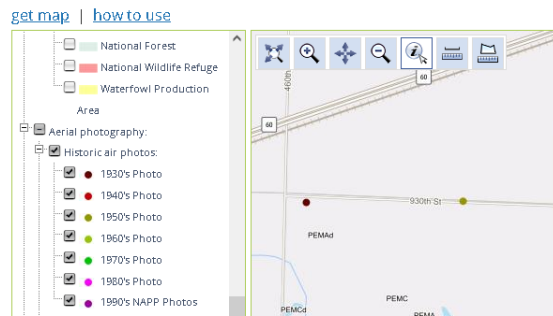


- vi. Once ready it will be available for download in the account Library.
- vii. There are many attribute files associated with it which you can use if you want to download the whole package but for simplicity all you really need to download is the largest TIF file which is the image itself.



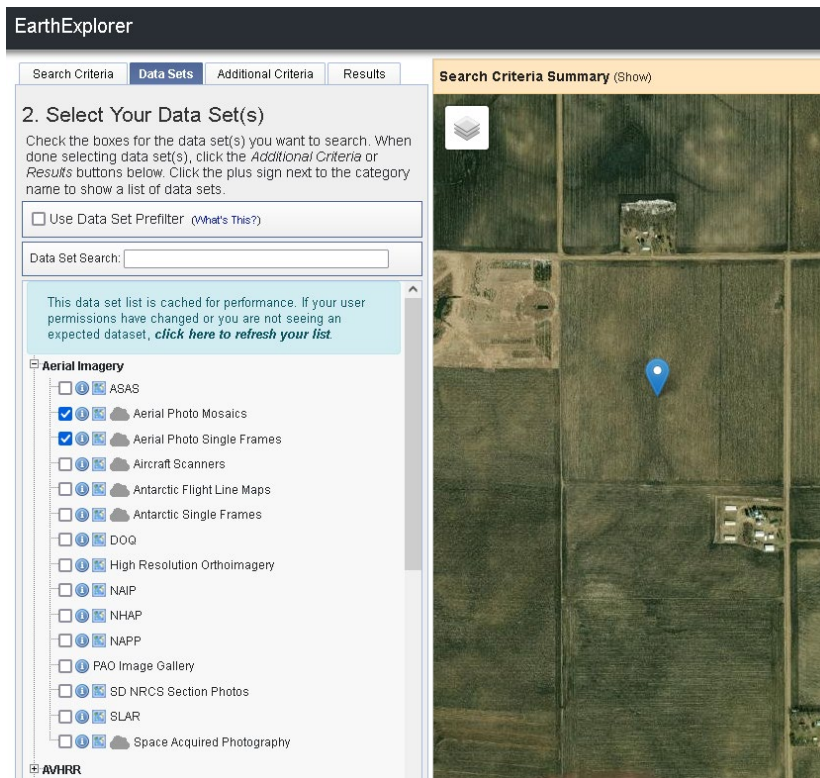
- g. **DNR Landview** for MN has historic photos you can download. On the map, zoom to the area of interest and turn on the Historical Air Photos index. Use the identify tool to select one of the dots and it will open a page you can download the image from. These are not georeferenced. For my area this is 1938 and 1954. The 38's are great as that is the oldest photos I have found and good to see historic conditions before some of the tile drainage work. <http://www.dnr.state.mn.us/maps/landview/>

Landview

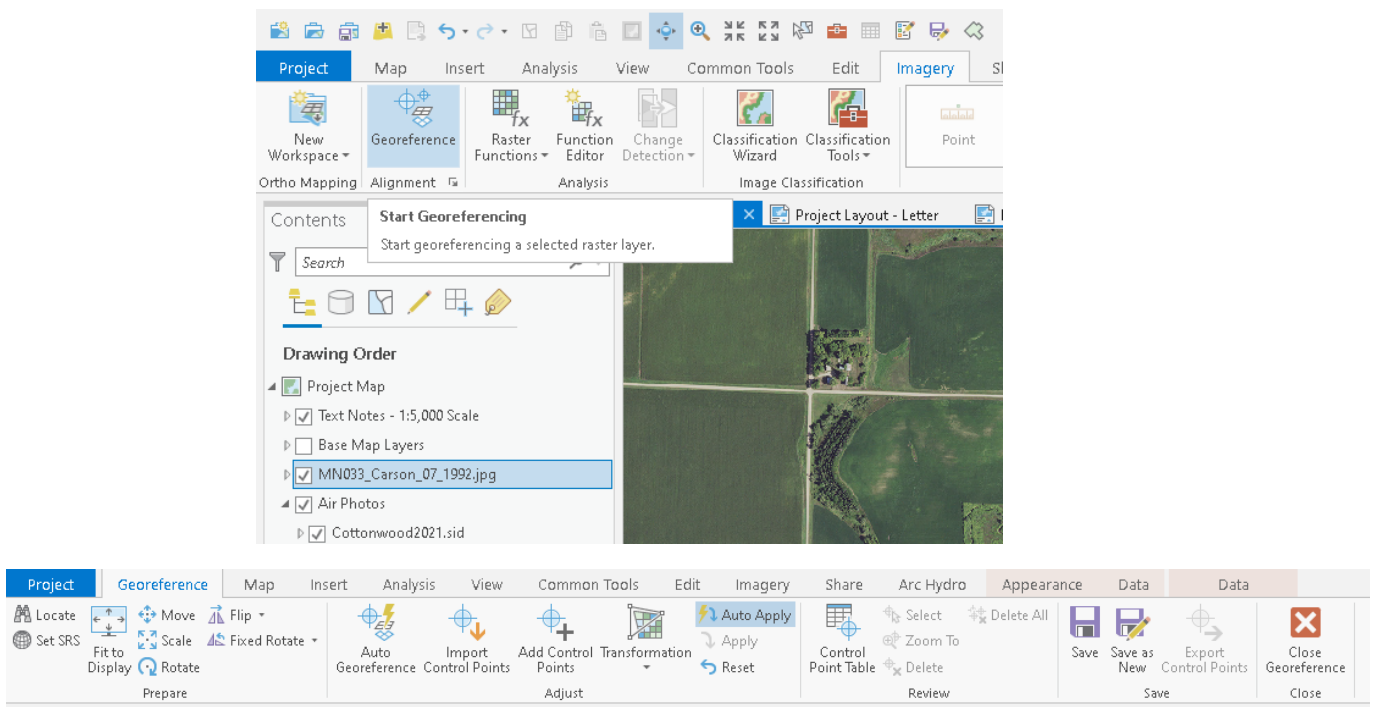


- h. **Earth explorer** has a lot of photos available from a broad time range nationwide but it is a little cumbersome at first. I found 1940's, 60's, 70's 80's color infrared used in the NWI program and 90's. Use the map, click on a location of interest, Click on data sets and check boxes for what you want to search. Most of the good stuff is under aerial imagery and aerial photo single frames as well as NAPP and NHAP. Then click results Click the foot icon to see the area it covers then download the ones you want.

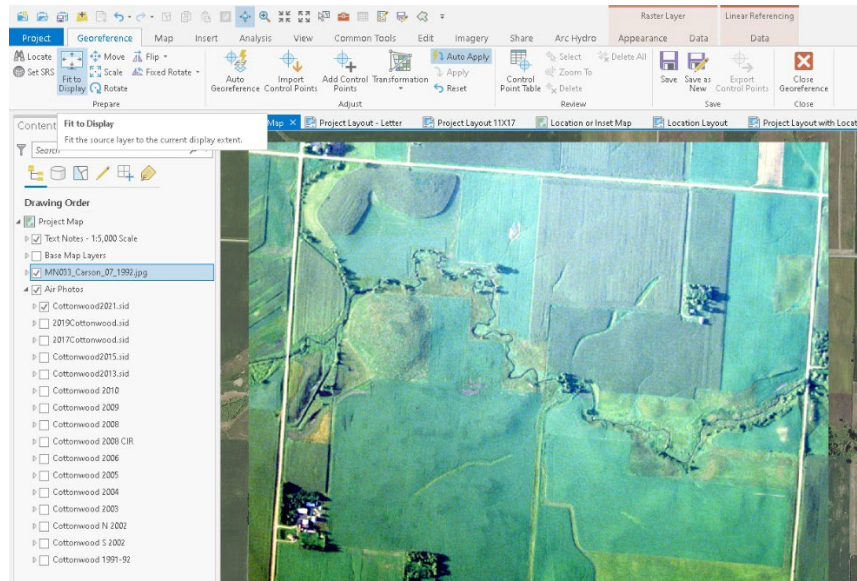
<https://earthexplorer.usgs.gov/>



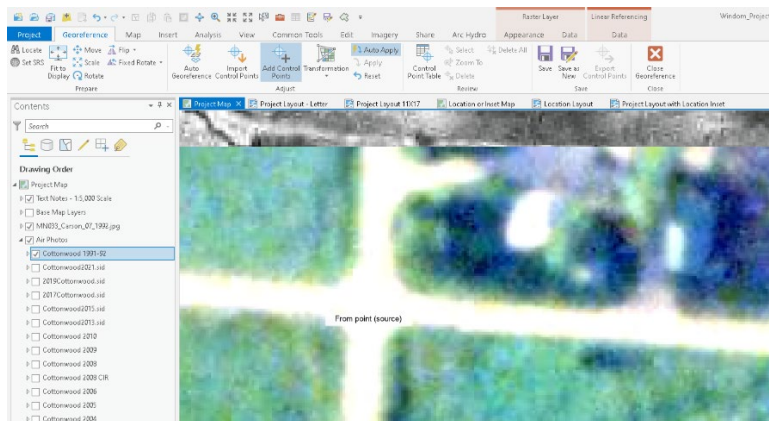
- i. **FSA Compliance Slides** have been scanned and cover much of the 1980's and 90's for MN. They are individual mile sections organized by county, township, section and year. Good Complete resource. A few errors here and there so double check the image. Some were turned or flipped when scanned so check the orientation and adjust in an image editing software if needed. These are non-georeferenced so would need to manually do it if needed. <http://geo.lib.umn.edu/> I would start in the AerialSlides2/ directory for most of the FSA slides. However you could explore other areas for additional data.
3. **Georeferencing:** This is giving spatial reference to the photo in GIS. Otherwise, it is an image with no indication of where it belongs on earth or scale. In addition, photos can be rectified in the process which is to adjust scale and curvature of the photo to lay properly over the landscape. Distortion can come from an angle of the photo relative to the ground if not perfectly perpendicular or from curvature of a glass lens more so on the outer edges of an image giving a fisheye type of distortion. These could affect how it lines up with other GIS layers as well as proper distance or area measurements referenced from the image.
 - a. Have a map open with your other reference layers such as an already referenced/rectified imagery. Often for a reference image it is best to use something of good quality and as close to the same year as you can for the desired photo so features haven't changed much.
 - b. Download your unreferenced photo such as from one of the resources listed above.
 - c. Add it to your map from the catalog or Add Data. Since it has no reference it will be in the contents but not displayed on the map.
 - d. Have your photo selected on the contents list, then on the Imagery Ribbon hit the Georeference button. This will open a new Georeference ribbon.



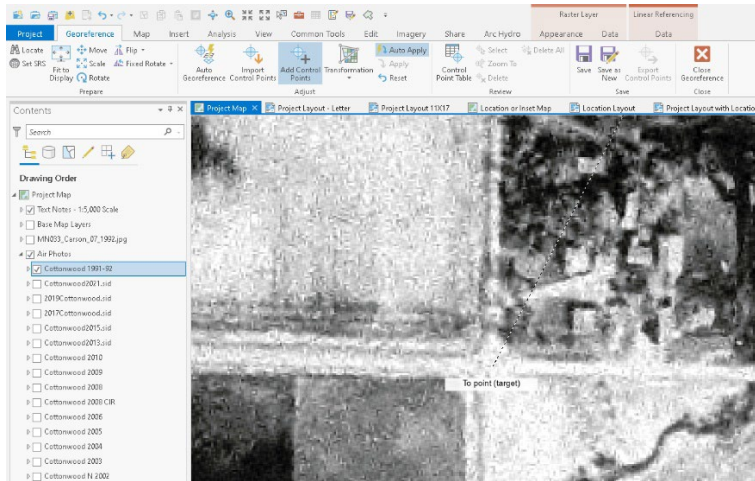
- e. Zoom/Pan your map display to approximately the space and scale the desired image will be. Have the photo selected in the contents and hit the Fit to Display button on the Ribbon. This will place your photo on the screen in your work area. Notice in this example the photo is tilted. That will be corrected in the rectification.



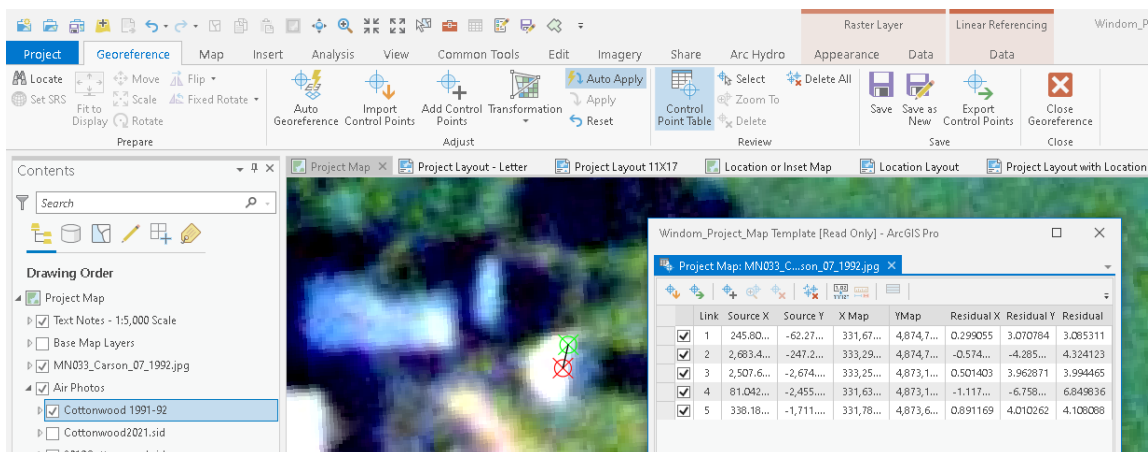
- f. Identify common features you can see in both the desired photo and your reference image. Again use a reference photo from the same time period if you can so land features may be similar. USGS DOQ (Digital Orthophoto Quadrangle) imagery is available for most areas. Often this is the earliest high resolution quality georeferenced/orthorectified imagery. For MN this is from the early 1990's so I often use this for earlier photos. They are black and white imagery but good quality. Find items like road intersections, buildings, prominent trees, etc. etc. Note items that might move slightly such as field borders or wetland edges may not be great. The smaller and more precise a feature is the better.
- g. Place control points linking features in the target image to the reference image.
- i. Zoom to your first feature such as a road intersection
 - ii. Use the "Add Control Points" tool from the ribbon.
 - iii. First click on the target image on your reference item.



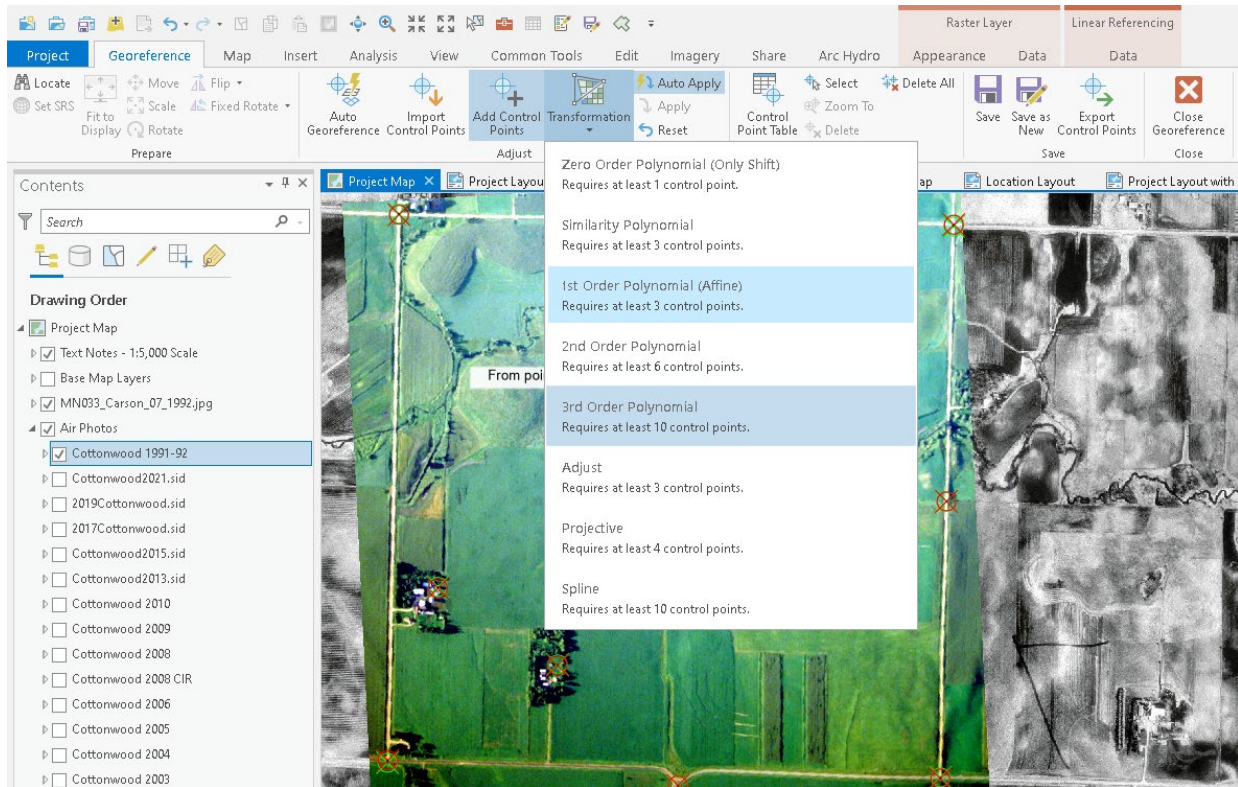
- iv. Then turn off the target image in the contents and find the same feature on the reference image and click on that same feature spot.




- v. You now placed your 1st reference point and the target photo should adjust to the new location.
- vi. Holding the C button allows you to click and drag/pan the map while in the same tool.
- vii. Repeat this process around the photo placing more control points. Best to start the 1-3 points as far distributed across the map as possible as this will best set the initial scale and orientation making the rest easier.
- viii. The first three only set scale and orientation so no distortion. As you place more you will notice the 2 points may not line up well. That is because of photo distortion which will be corrected later if you have more points. To get even warping of the image to correct distortion you need points distributed as well as possible across the whole image. Imagine taking a flat sheet of paper and laying over a globe. It will be wrinkled and not line up in spots. The rectification will turn that paper into a rubber sheet and stretch or warp areas to fit to control points.
- ix. Open the Control Point Table on the Ribbon which you can select individual points and delete them if you want or see which have high error and adjust.




- x. After placing as many good points as you can, go to the Transformation button on the ribbon. Choose the highest transformation you can with the number of points you have. Minimum is 3 to scale and orient the image. You should try for at least 6 to get a 2nd order transformation which will adjust minor distortion if not a 3rd order if you can. You will notice after the adjustment the image is warped into a shape to match the reference photo and control points.



- xi. If you are satisfied with the Georeference then hit Save on the ribbon and it will save that transformation to the image permanently. If not, add or edit more control points before saving. After Saving, Hit Close Georeferencing Button on the Ribbon to return to the rest of your workflow or repeat by selecting another photo.
- h. Notice if you ever transfer this photo and want to retain the reference information, there will be a file associated with it by the same name but with a “wx” extension to it. Transfer that world file with the image.

 MN033_Carson_07_1992.jgwx

 MN033_Carson_07_1992.jpg

This Georeference process could also be used on non-aerial images like tile drainage maps as long as you have some type of reference points. GPS readings could also be used for features if needed.

Other data sources important for mapping

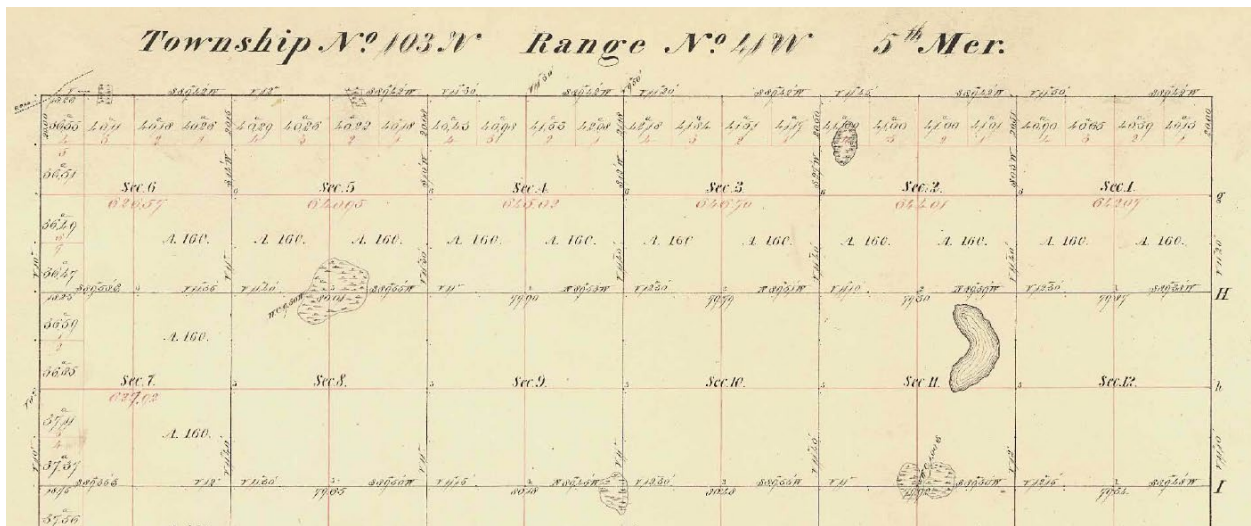
1. Historic Plat Maps & Topo Maps:

- a. Why? Old maps often reference land features prior to conversion so can identify locations or features that previously existed. Old maps may indicate features that are important in cultural and historical preservation reviews/Section 106 compliance. Sometimes features line early settlements, native American villages, old trails etc may be recorded.
- b. Original land survey. Mid to late 1800's. Can choose georeferenced Plat download option <https://www.mngeo.state.mn.us/glo/index.html>

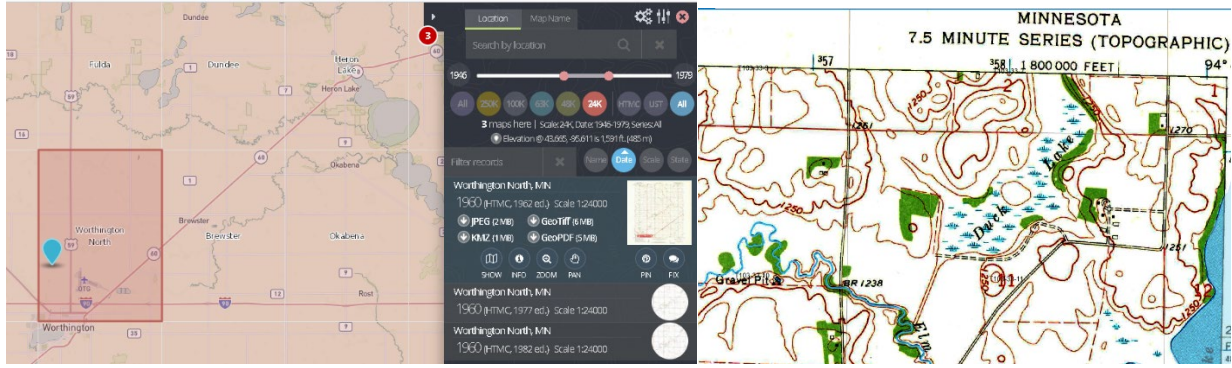


1 file found.

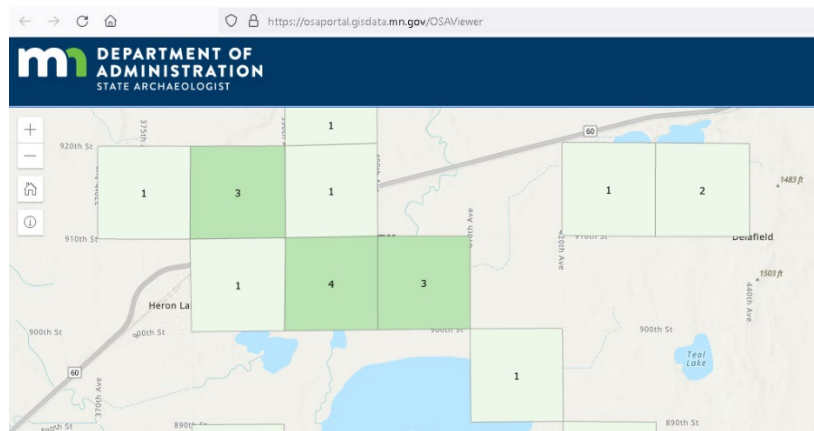
Township	Range	Litoral	Principal Meridian	Plat Type	Scan Side	MHS Plat ID	Survey Date	View Plat	Download Plat	Georeferenced Plat
103	41	West	5	Independent	Front	MHS2893	1868	resampled.pdf	pdf.zip	geojpg.zip



- c. USGS Topo Maps. 1:24000 scale quadrangles from the 1950's-1960's are generally good quality and have coverage across most areas. Can download georeferenced quadrangles <https://ngmdb.usgs.gov/topoview/viewer/>

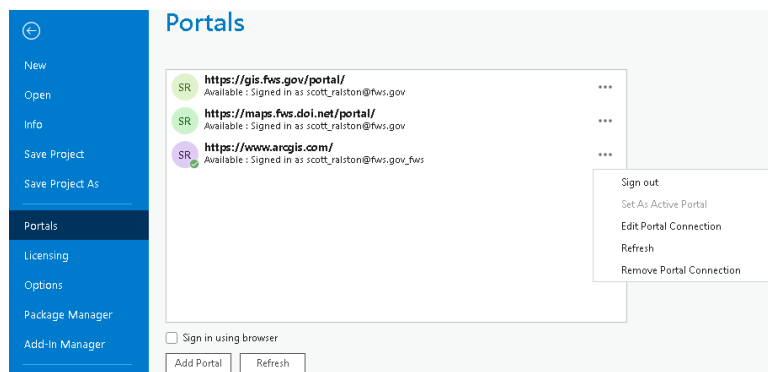


- d. Most cultural artifact sites are public for sensitive and private information. However, Mn has a tool to identify within a section if there are known sites. This is a web map not available in Arc GIS but can be useful to reference and cue you that there may be something more.: <https://osaportal.gisdata.mn.gov/OSAViewer>

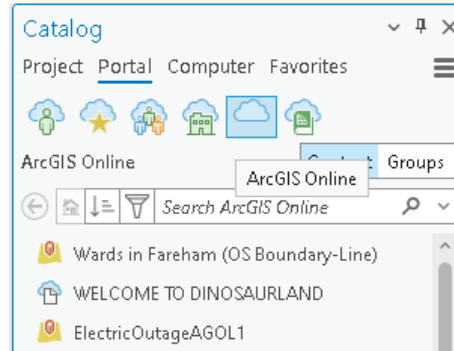


2. AGOL Public data

- Many layers have been published by other entities and shared publicly through ArcGIS Online or internally by your own agency. To add data from a public portal first make sure you are logged in to that portal and that the portal you wish to get data from is set as your “active portal”.
- From the Project Menu (top left), click on Portals, Add Portal if you haven’t already (See page 4 above). If you need to activate one click the 3 dots to the right of the name and “Set as Active Portal”

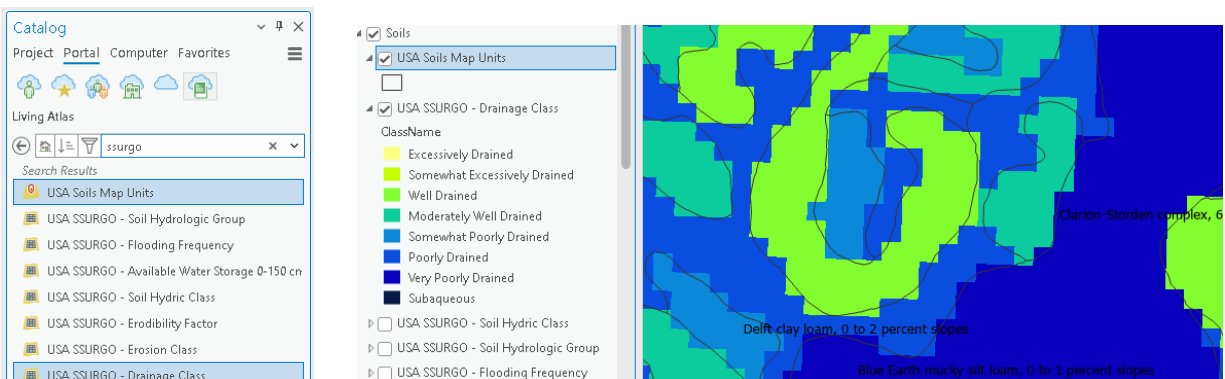


- c. Go to the Catalog Pane and Portal tab on the top of it. Various source headings are listed such as your own AGOL data if you published something, items from within your organization or AGOL public data on the Cloud button. Choose your source and can use the search bar if needed.

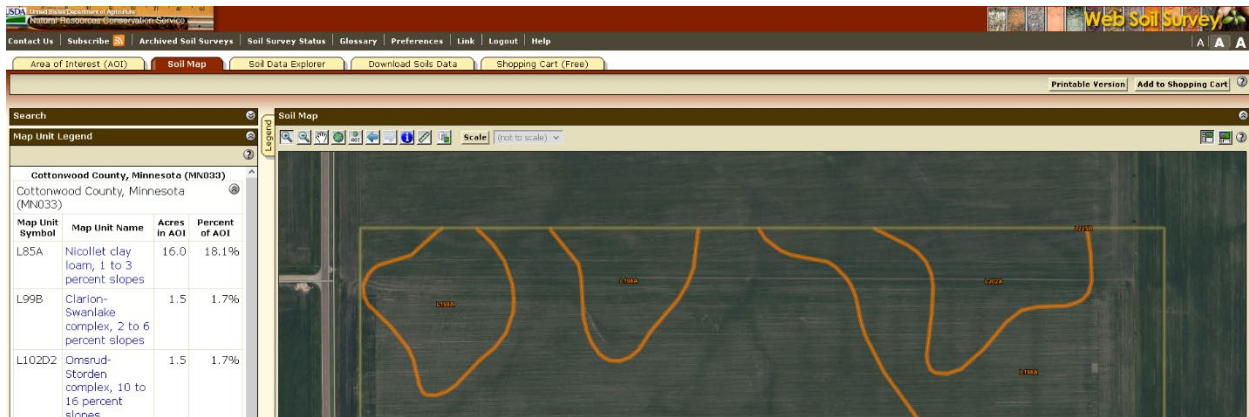


3. Soil Maps

- a. Why? Soils are the basis for many ecological function. Particularly view Drainage class to see how well this soil is drained or holds water. View soil map unit name to get general description of sand, silt, loam clay etc. Depression in poor soils may not hold water even if enhanced.
- b. Can stream from web in ArcPro. Directions above for accessing data from AGOL portal. In the Portal catalog go to the living Atlas which is the cloud icon with the book. Search for SSURGO. Many classifications listed there.
 - i. USA Soils Map Units are a vector layer that is a good outline of the soil unit. I would add, turn to just an outline for display and turn on “muname” as the label class to display the soil class name.
 - ii. USA SSURGO – Drainage Class. This will tell if the soil is dry to mesic to wet. Very helpful in upland seed mix planning as well as knowing if something will pond water well.
 - iii. USA SSURGO – Soil Hydric Class identify soils that were formed under wet conditions thus historically may have been ponded.
 - iv. USA SSURGO – Flooding frequency is only for areas along riparian zones identifying floodplains. I usually don’t use this one
 - v. USA SSURGO – Hydrologic group is only really needed if you are doing hydrologic modeling of runoff. It predicts infiltration rates.

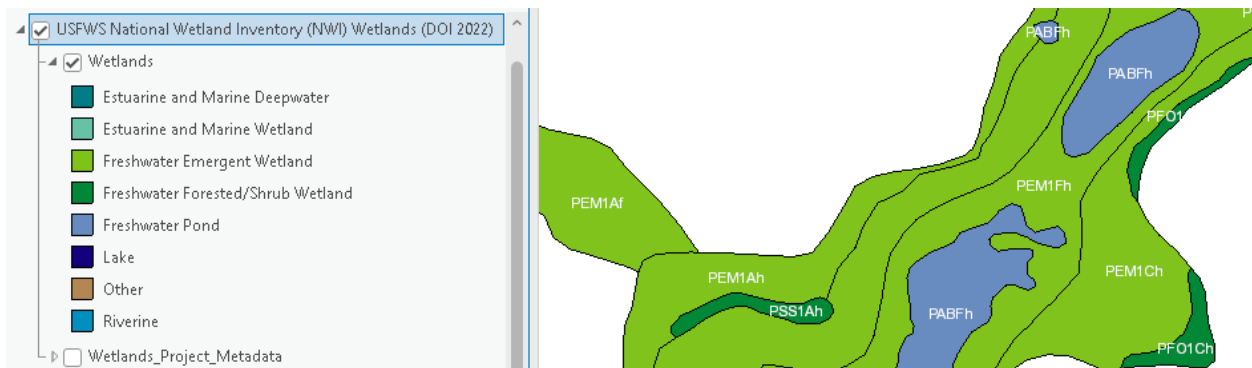


- c. Outside of GIS you can also run soil reports on the USDA web soil survey.
<https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>

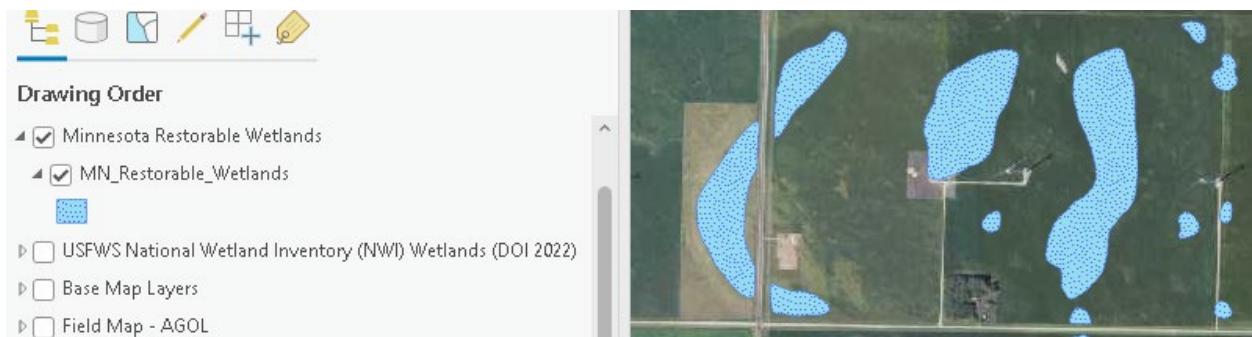


4. Wetland Inventories:

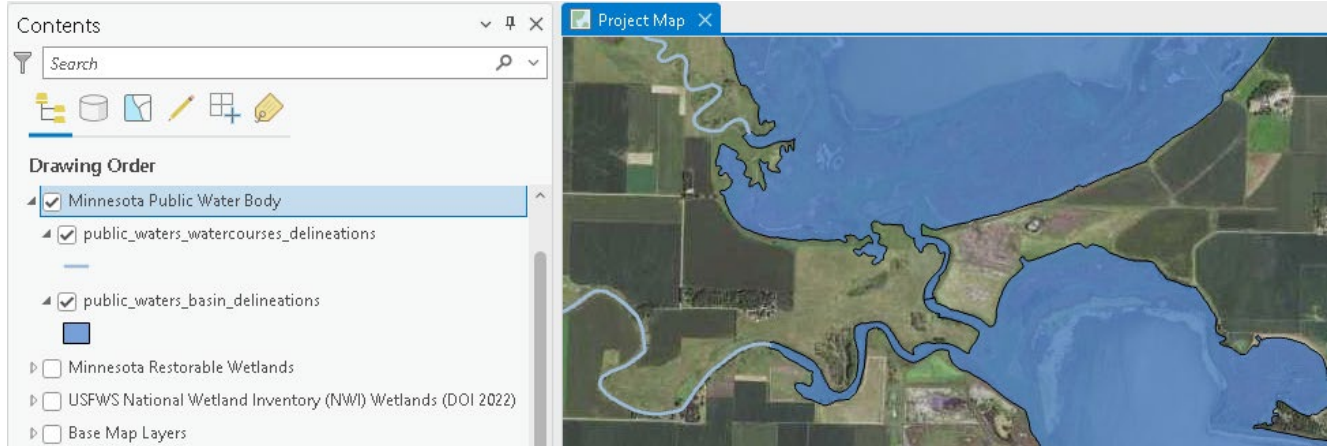
- a. National wetlands Inventory. Is a database that has a long history and available nation wide. It does miss a lot of small wetlands or drained wetlands but does include more the easily identifiable basins and provides a classification to them giving you an indicator of wetland types. Easiest sources is again from the AGOL portal. Search for “USFWS National Wetland Inventory



- b. RWI or Restorable Wetlands Inventory is a project initiated by Ducks Unlimited where potentially restorable basins were mapped using air photos and topographic data. Again not comprehensive and has error or missed basins as large scale rapid mapping projects are not an easy task but gives more detail than NWI and areas to cue in to. Easiest source is the AGOL portal searching for Minnesota Restorable Wetlands:



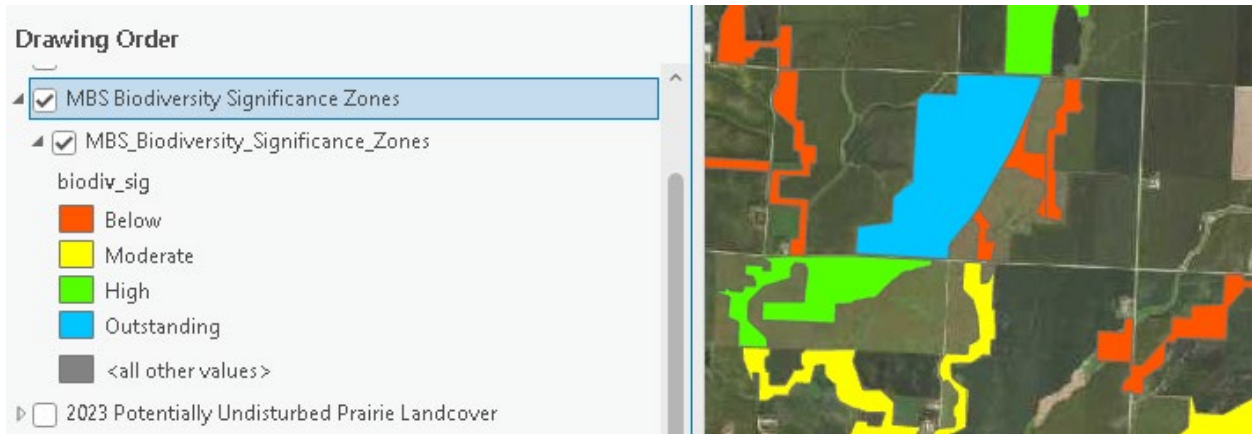
- c. State Public Waters: This is an important layer identifying those water bodies or water ways that are jurisdictional waters of the state. These means they are managed by the DNR and activities involved in those waterbodies are permitted through the area Hydrologist. Available on AGOL portal as “Minnesota Public Water Body”



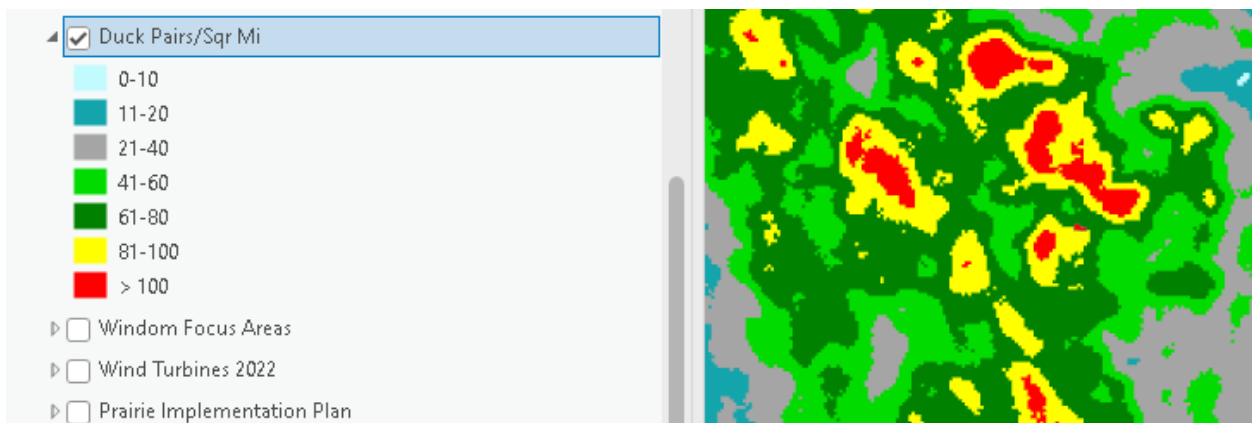
- d. County Drainage Systems: These are legal judicial ditches which may be open ditches or county tile lines. These are managed by the county or watershed districts with legal authority. Landowners benefiting from these lines pay ditch assessments toward their use and maintenance. Any modification to these lines must be done under permit and review by the drainage authority.
 - i. Unfortunately there isn’t a good single source for this data and every county is different is if they have ditches digitized and their willingness to share. Contact you local counties drainage authority to inquire on getting data.
 - ii. Some are listed here: <https://gisdata.mn.gov/dataset/water-public-drainage-systems>
 - iii. Also many counties host online maps that have county data such as tax parcels but many of those maps also have county ditches available to toggle on. Can’t use that in GIS but can view on the web map then transfer knowledge to your own map. Most Mn counties use a service called “Beacon” so search for that and your county. <https://beacon.schneidercorp.com/>
- 5. **Land Ownership & Easements:** Important to know who owns what or what easements might be covering areas.
 - a. FWS search in the Portal for “FWS National Realty Tracts” this will have up to date fee title and easements.
 - b. In MN most state data can be found here: <https://gisdata.mn.gov/>
 - c. Search for state DNR land, RIM, WRP, CREP easements. Prairie bank easements etc.
 - d. CRP layers are held by the FSA office and generally not made public due to their privacy sharing rules. FWS has had some opportunities to share layers in the past under specific licenses. Check with your regional GIS coordinator for current status or inquire at your local county office if you need to request a specific project if they are able to help with that. Would need landowner consent for that site to accompany the request.

6. Biological data

- a. Minnesota has “Potentially Undisturbed Lands” layer on AGOL. This was a mapping project in the prairie areas of MN identifying land without a cropping history that is likely “Native”.
- b. “MBS Biodiversity Significance” available on AGOL for MN are prairies that have had surveys done and rated the biodiversity found.

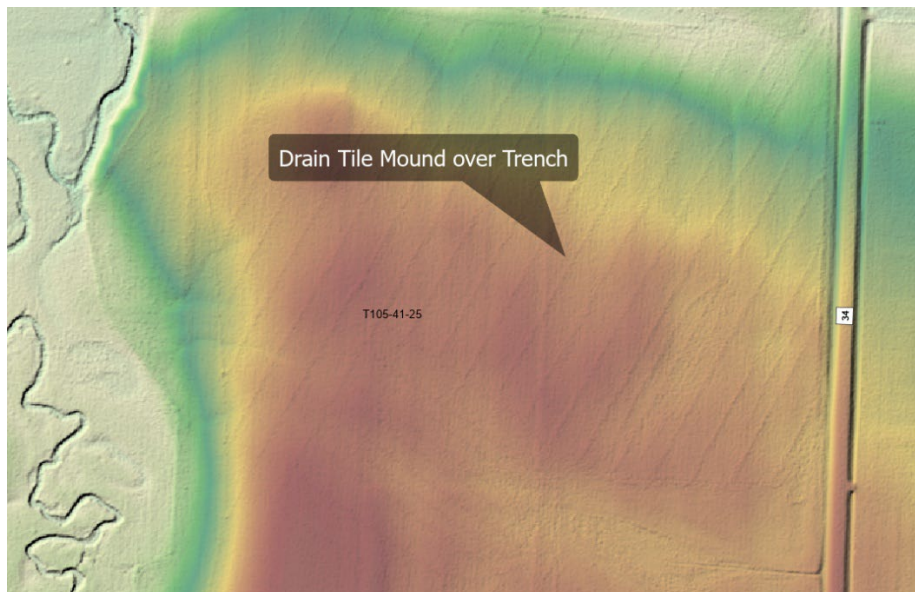


- c. Natural Heritage data: Threatened and Endangered species location data is often protected due to sensitive nature of it. Data can be acquired by your office for specific needs under a license or MOU from the state DNR. Talk to your regional GIS coordinator if you need access to such information.
- d. Critical Habitat is a less specific T & E identification. Can be found on AGOL under “FWS HQ ES Critical Habitat”. Identifies general habitat’s of concern not specific locations found.
- e. Other priority maps contact agencies or partners may provide information specific to project areas and goals. Examples may include the FWS HAPET office produces “Thunderstorm” maps of modeled waterfowl usage. Other focus area maps



LIDAR

1. **LIDAR** (Light Detection and Ranging) is crucial in wetland restoration design. It is essentially a laser scan of the earth's surface taking elevation readings in a grid of a given area. Many areas of the country now have LIDAR available and often at scales of 1 meter or better resolution.
 - a. **Advantages** of LIDAR is it is continuous coverage where it would take a ground survey a long time to grid an entire area. It is also available for project review right now in preliminary stages often before any field visit or survey even takes place. You can get a feasibility preview of a project from the desktop and save time and money on field work. On flat hard ground like exposed fields accuracy can often be within 6 inches or less. Good for general landscape and watershed scales.
 - b. **Disadvantage** is it is a single snapshot in time so doesn't account for features that may change. It doesn't penetrate water so only get water surface elevations. Readings through thick vegetation can be scattered so you may get the tops of some vegetation not ground so heavy vegetation like cattails or trees may not produce a good accurate reading. Keep precision in mind and even in good conditions I wouldn't assume better than 6 inch accuracy or often better to default to 1ft intervals. Not for use on small scales as the scan may not pick up small nuances like small ditch bottoms or narrow waterways etc.
 - c. Lidar can show many detailed topographic features from waterways to hilltops. Even drainage if the LIDAR was taken shortly after installation. In this example we see where drain tile was installed all across this field and the soil is left slightly mounded as they refilled the trenches over the tile. LIDAR picked up this variation and can see and map the drain tile from LIDAR.



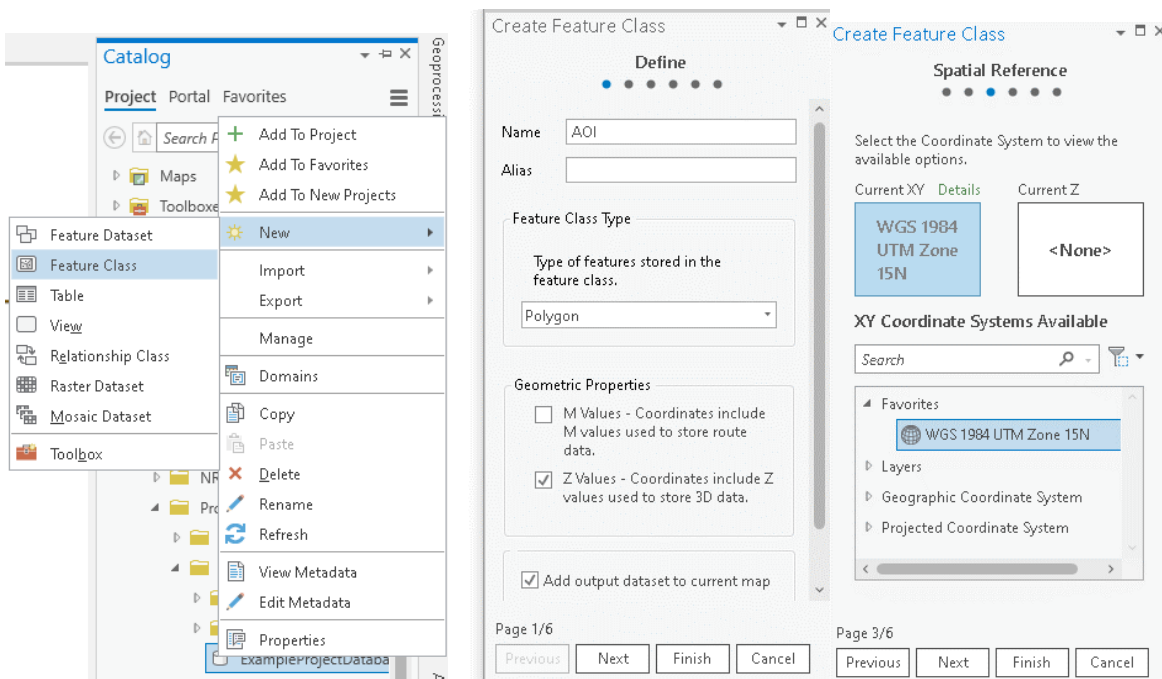
- d. In Minnesota LIDAR is available here under the FTP download area:
<https://www.mngeo.state.mn.us/chouse/elevation/lidar.html> Suggest using the county mosaic. Open the FTP link, County Folder and the elevation_data.gdb.zip file. They are

very large files for each county so best with high speed internet and ample storage. When downloaded, rename to intuitive naming as needed.

- e. Individual online Lidar maps can be made at <http://arcgis.dnr.state.mn.us/maps/mntopo/>

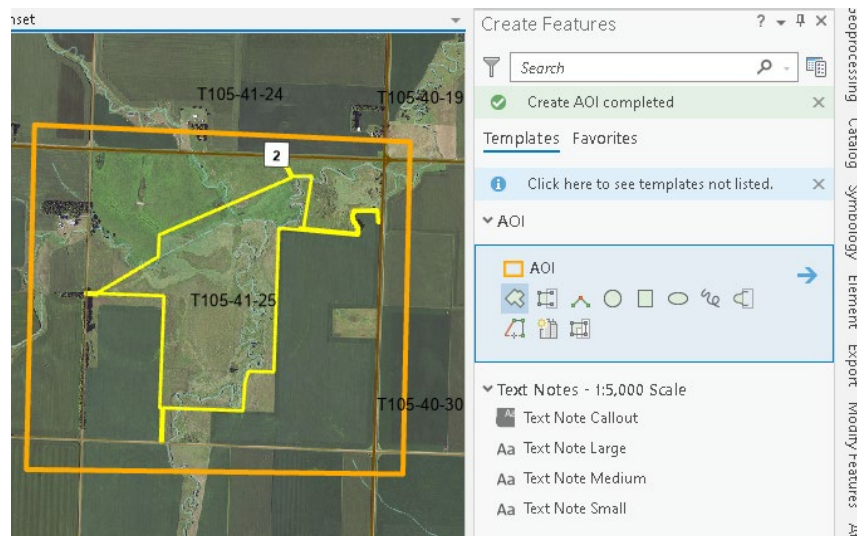
2. Clipping LIDAR

- a. If you are using NRCS Engineering tools skip all these next steps and go straight to step 3 (Page 33) describing the NRCS tool which automates and combines these steps.
- b. On a large scale such as a county sized file it can be very large and slow the processing of the computer as well as display can be less discerning at that scale. Thus best to clip LIDAR down to your specific project area. This can be done with individual geoprocessing tools built into ArcPro or there are 3rd party tools or scripts that you can add to automate some of these tasks such as the NRCS engineering toolbox.
- c. Assuming in your map setup you already have general base data such as air-photos, boundaries etc, a project folder is made where this project is saved and you have a default geodatabase made for the project in your folder.
- d. **Create a AOI (Area of Interest) Layer** which will serve as the clipping outline fore LIDAR.
 - i. In the Catalog pane navigate to the folder and geodatabase you created for the project. Right click and Choose New Feature Class
 - ii. Name it AOI, Choose Polygon as the Type, Hit Next Twice to get to the Spatial Reference page and choose the coordinate system you use for your project. Then hit finish

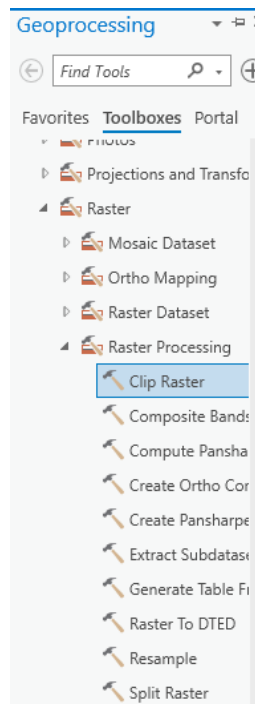


- iii. Change the symbology of the AOI layer if it helps you. Often a hollow outline.
- iv. Open the Editing Ribbon, Start Editing, Hit the Create Button, Select the AOI layer from the Create Features class list Pane.
- v. Draw the Clipping area. Suggest more than just the property boundary. You want all areas that impact your project particularly what drains into the project

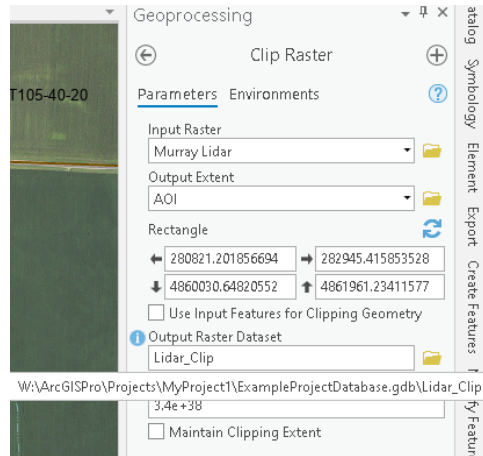
so you can see and anticipate possible drainage coming in or extent a project could back water over a property line during high water. If doing watershed modeling you may want the entire watershed area that flows into the project. HUC12 watershed layers can be helpful displayed while drawing. Draw a single polygon only in this layer.



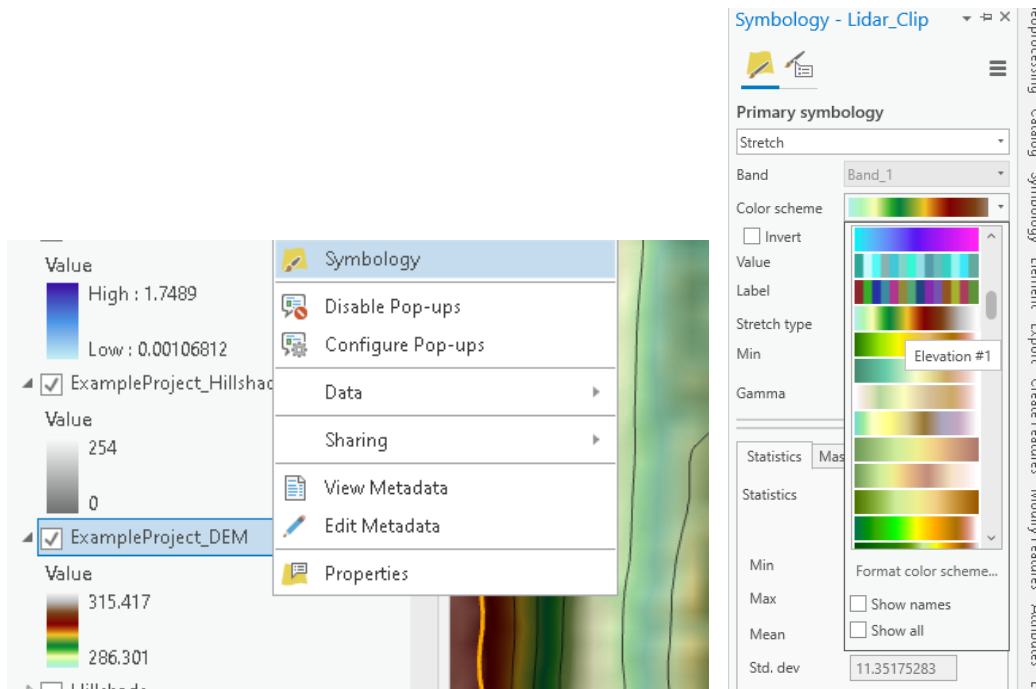
- vi. Saved edits on the Ribbon with the Save icon.
- e. **Clip Raster:** On the Analysis Ribbon, Hit the Tools Button
 - i. In the list of Toolboxes look for Data Management Tools\Raster\Raster Processing\Clip Raster. If you had setup this tool as a shortcut it may also be in your gallery tool list on the ribbon.



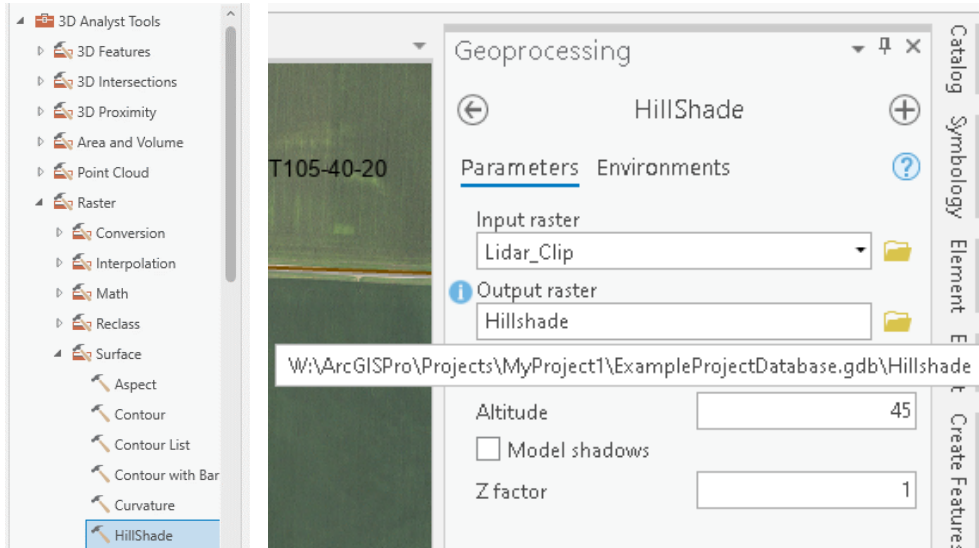
- ii. Input Raster pick the lidar layer to be clipped. Output Extent pick the AOI layer. Output Raster Dataset pick the location you want to save this clipped layer. Usually in your project folder or in the file geodatabase in that folder. Final option is the check box for “Use Input Features for Clipping Geometry” which is optional. Unchecked it will clip the raster to a square box encompassing the extent of your AOI. Checked it will clip to the exact AOI line regardless if it is square or not.



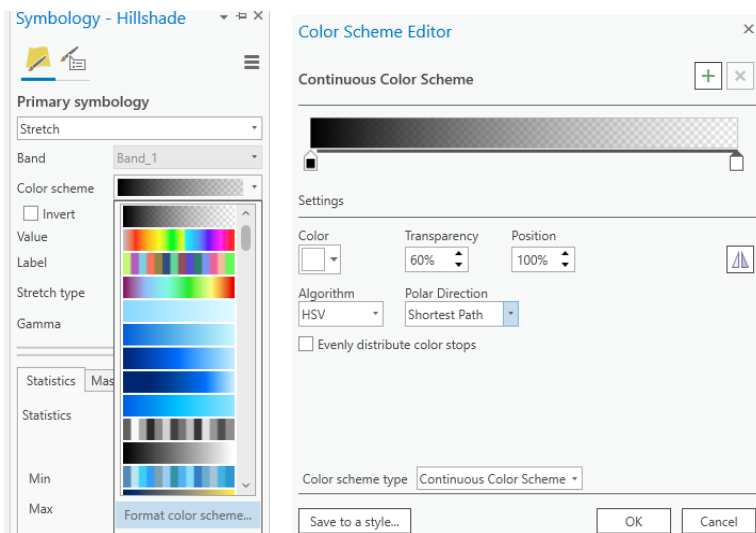
- iii. Hit run at the bottom of the toolbox to run it and when done it will add the clipped layer to the map.
- iv. For display purpose, suggest changing the symbology of the clipped lidar. Right click on the layer and choose Symbology to open the symbol Pane. By default it is greyscale. Most common color scheme is “Elevation #1” which uses a gradient of blue for lowest through green, yellow, brown then white as highest.



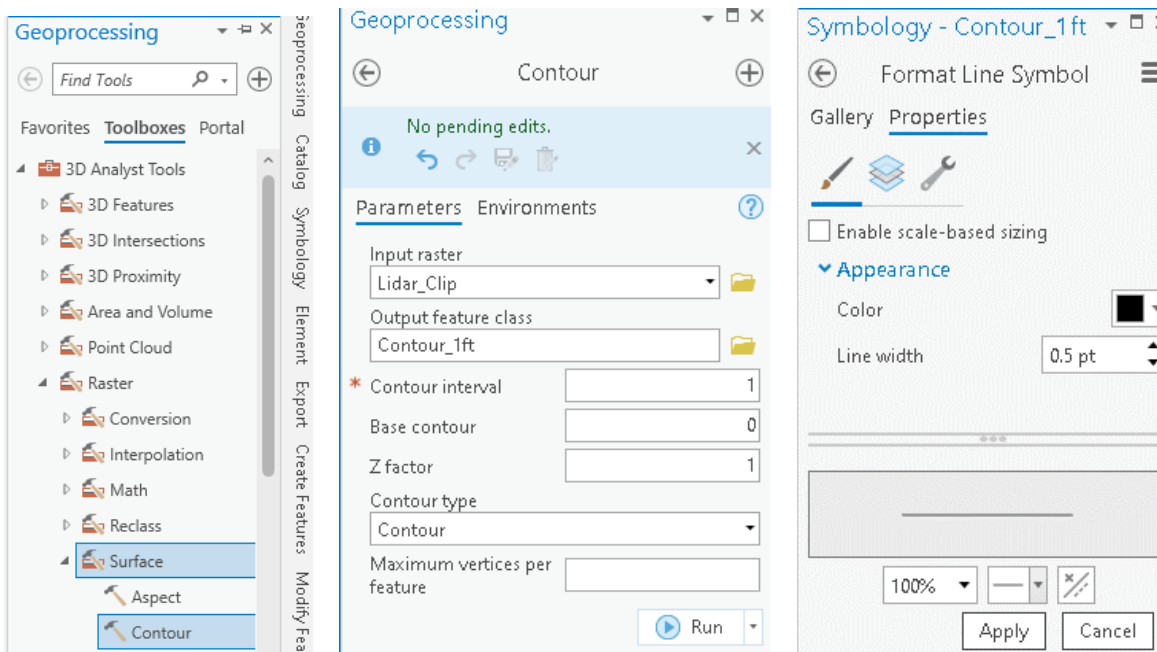
- v. Using your Explore Tool you could click on any spot on the LIDAR and get the elevation of that point in the LIDAR layer.
- f. **Hillshade:** Not needed for analysis but for better display you normally want to create a hillshade layer for your clipped LIDAR. This gives a shadowed sunlight direction perspective for the Lidar or can be used over aerial photos to give a 3D perspective.
 - i. On the Analysis ribbon hit Tools. In toolboxes go to 3D Analyst Tools\Raster\Surface\Hillshade Or may be on your gallery tools on the Ribbon.



- ii. Input raster is the clipped Lidar. Output Raster save in your project folder or geodatabase and call it Hillshade. Normally can leave other default settings. Hit Run at the bottom to finish.
- iii. For display a Hillshade needs to be set transparent. Open the Symbology for the Hillshade layer. Under the Color Scheme drop down list choose Format Color Scheme and set Transparency to about 60% or whatever you like to see for strength of effect.



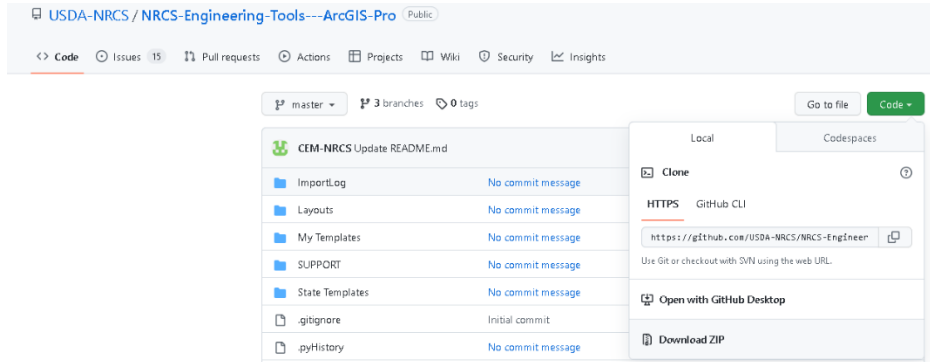
- iv. Keep the Hillshade layer higher in your contents list than the Lidar layer so the hillshade drapes over LIDAR or the same with air photos.
- g. **Contours:** These are topographic lines indicating elevation changes so all points along a single line are the same elevation. Very useful for quickly glancing at a map and seeing how much elevation change over an area or for wetlands to see a potential wetland edge outline or in embankment design to see where ends of a dike may join a natural hillside.
 - i. On the Analysis ribbon hit Tools. In toolboxes go to 3D Analyst Tools\Raster\Surface\Contours
 - ii. Input Raster select the clipped lidar. Output feature class this will be saved as a feature class or shapefile. Usually save in your project folder and in the geodatabase for your project. Call it something like Contours_1ft. (Can't start with a number and no spaces). Choose your interval which is normally 1ft. Lidar is probably not accurate enough to realistically get more than a 6 inch resolution so 1ft is decent confidence for real world application with still good resolution. Rely on field survey for anything more accurate. Usually leave other options default and hit Run at the bottom to finish.



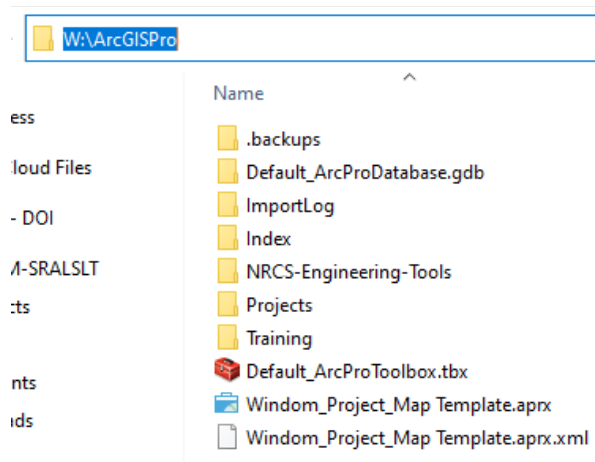
- iii. Suggest changing the symbology to a thin black line such as Black 0.5 thickness
- h. Your project LIDAR is now ready to use.

3. **NRCS Engineering Tool** (Alternative to built in ArcPro tools described above, Skip this section if not using this Add-in toolbox)
 - a. This is a handy tool for wetland work developed by the NRCS. It is an extension that can be added to ArcGIS Pro toolbox. There was a previous version for ArcGIS 10x. Make sure to download and install the Pro version as the ArcGIS 10x version will not work in Pro.

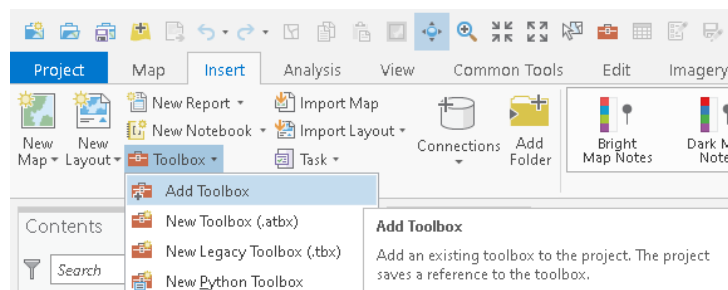
- b. Download from here: <https://github.com/USDA-NRCS/NRCS-Engineering-Tools---ArcGIS-Pro.git> A little confusing site but hit the “Code” button and choose Download from the dropdown to get the whole package instead of downloading individual file components in the list.



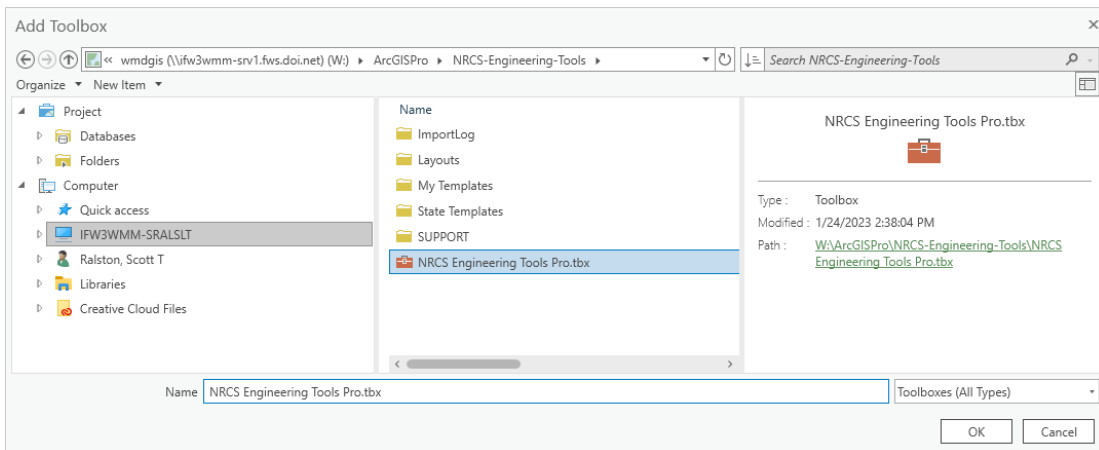
- c. Unzip the file and place the entire folder somewhere that will always be available when you open ArcPro maps. This could be on your root C: drive for individual use or if you want it to come up in your map template from any computer using that same template from a server then store on the server location such as the same location where your template file is saved. For me (W: is a local server drive for our office GIS), I have a W:\ArcPro\ folder which holds the project template map, default toolbox, default geodatabase and the NRCS Engineering toolbox folder.



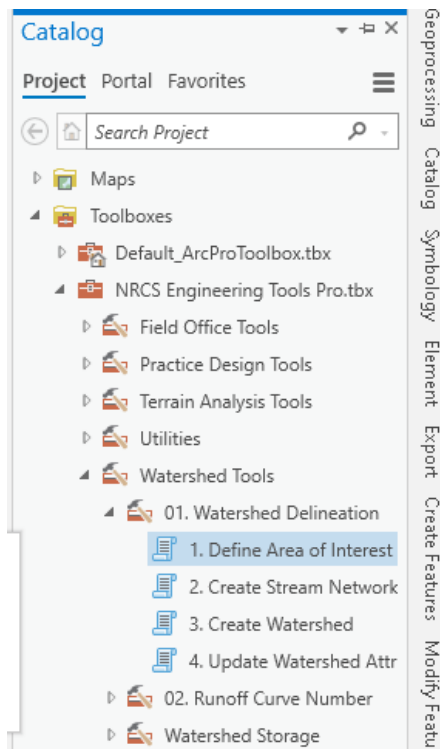
- d. Open ArcPro and install in your map template if you want this to be in all future maps or an individual project file. On the Insert Ribbon Choose Toolbox and Add Toolbox



e. Navigate to an Select the NRCS Engineering Tools Pro.tbx

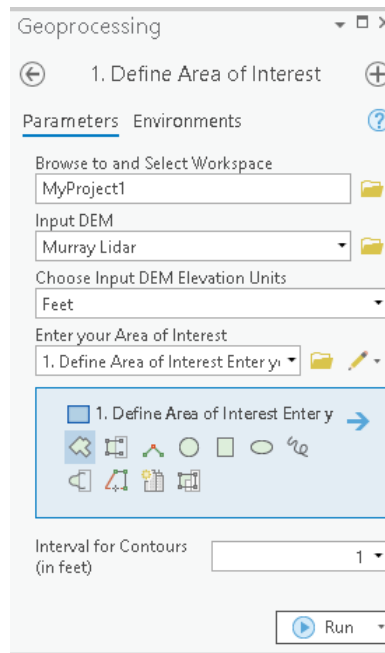


f. The toolbox will then appear under the Catalog under toolboxes. You could also add any of these specific tasks to the Analysis ribbon gallery as described in the Step 21 of the Original map setup and customization directions above.



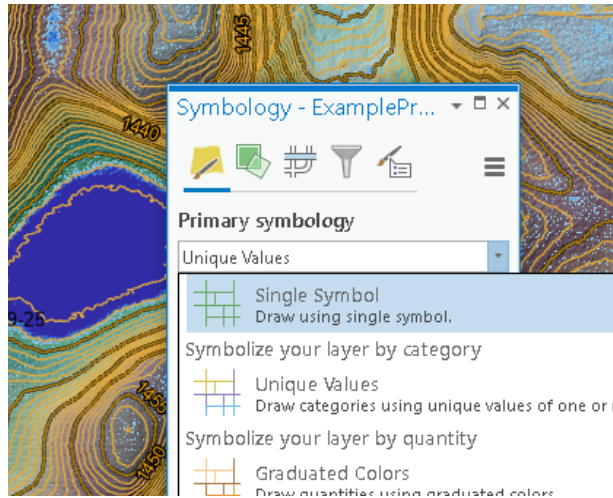
- g. Before using the NRCS tools, If you have the option to enable or disable editing on the Edit Ribbon you will need to **Enable Editing**. These tools automate some tasks which includes the need to be able to edit. Also if you were doing any other editing in your map you have to **Save edits** before running the tool. The tool can't create new files while an active unsaved edit session is going.
- h. Clipping and displaying LIDAR with the NRCS tool once installed as described above.

- i. Open the NRCS toolbox as displayed above and go to Watershed Tools, Watershed Delineation and Open the 1. Define Area of Interest script
- ii. Select Workspace is your project folder. The tool is going to automatically create a geodatabase in that folder using the project name and it will save the various layers it creates in that database. Important note, the NRCS tool will fail if there is a space or special character in the file name path. Make sure the entire file path has **no spaces** and use an underscore as a replacement if needed.
- iii. Input DEM is the original county level larger LIDAR you want to clip.
- iv. Pick what units your LIDAR is in which in my case is feet. And pick the contour interval which is usually 1 foot interval lines.
- v. The area of interest, if you already had created an AOI layer and drawn it you can use that but if not hit the pencil icon and it will create a new AOI layer for you and start an editing session. Use the polygon tool built into this toolbox and draw the area you want to clip on your map. Choose an area encompassing all topography that would affect the project. Any areas that you may want incoming drainage elevations from or see how far water might back up if impounded. If doing larger watershed scale work might want the whole watershed area outlined.



- vi. Hit Run to finish and create. This may take some time to process so let it run.
- vii. When done it will create a DEM clip of your LIDAR, a hillshade, a depth grid which shows potential depressional areas, a contour layer and the AOI layer.
- viii. I tend to turn off the depth grid unless specifically highlighting depressions or it can be used for wetland mapping. Also turn off the AOI outline.
- ix. Contours I suggest turn off labeling (Right click on the layer and hit "Label" or it will slow redraw every time you move the map. Whatever is comfortable to you but I find the major and minor contour lines distracting so I simplify in the

symbology pane to a single feature option and change the line type to black 0.5 thickness so it is visible but not distracting.

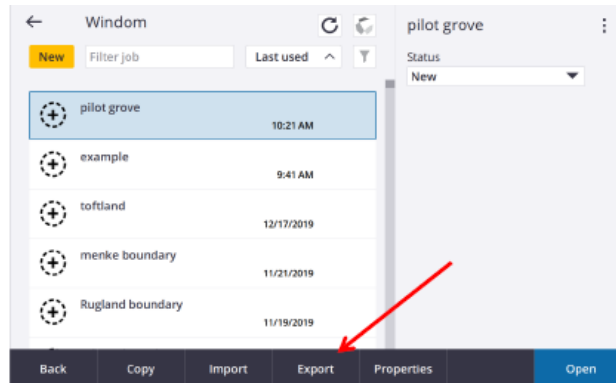


- i. Feel free to explore the other tools in the NRCS toolbox. Additional automation steps include creating a streamflow network and mapping the watershed which can be helpful in further design workflows. Other areas of the toolbox can be used for assisting with runoff curve calculations and more. With the toolbox download is a tutorial.
4. After creating your topography data I suggest lumping all that into a single new group layer in the contents list so they can all be toggled on or off as a single unit. With the LIDAR, Hillshade and contours.

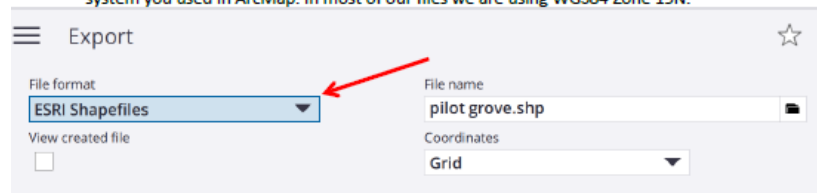
Importing Survey Data and merge with LIDAR

1. If ONLY using 1 elevation source like ONLY LIDAR or ONLY field survey, skip sections about merging data. Just Convert to points (Step 5) Calculate meters if unit conversions are needed (Step 6) and create TIN (Step 8)
2. **Purpose:** Lidar has broad coverage but sometime low detail. Field surveys have specific and high accuracy detail but often limited coverage. It is best to merge the 2 for final design planning to get more complete coverage.
3. **Field work:**
 - a. This tutorial will not cover field surveys as there is a lot of variation in hardware, software and methods. A previous tutorial was made for one method using Trimble R10 and TSC7 tools. This is available at <http://skralston.com/USFWS/> and look for "Using Trimble R10 and TSC7 data controller for VRS-RTK GPS surveys".
 - b. Key points for whatever method of field survey you do are:
 - i. Spend efforts on GPS for crucial points such as structures, intakes, outlets, flowlines. Important limiting factor locations like property lines that you can't back water beyond or liability and infrastructure.
 - ii. Survey areas LIDAR can't reach like narrow waterways, subsurface locations like tile lines or culverts. Below water lines or in thick vegetation where LIDAR may not have been accurate.

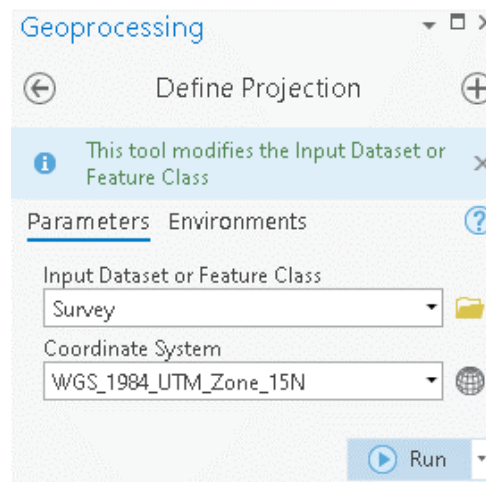
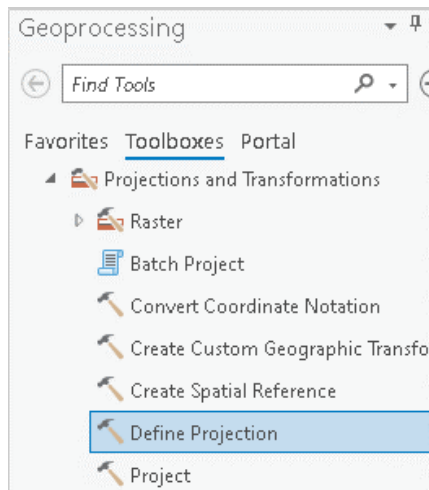
- iii. Can spend less field time in areas LIDAR captures well such as hard wide open surfaces or areas where being within + or – 6 inches isn't critical.
- iv. Grid your survey at a resolution equal to your LIDAR or close enough that you get the topographic definition required for proper design interpretation. More points in areas of greater change.
- c. Export your survey to a shapefile when finished. In Trimble Access this is in the Job menu.



- b. Highlight the job you want to export data from and hit the export button at the bottom
- c. Choose format ESRI shapefile, give a file name and Grid style coordinates. Note when you import to AcrGIS the coordinate system is not defined in the export so define the coordinate system you used in ArcMap. In most of our files we are using WGS84 Zone 15N.

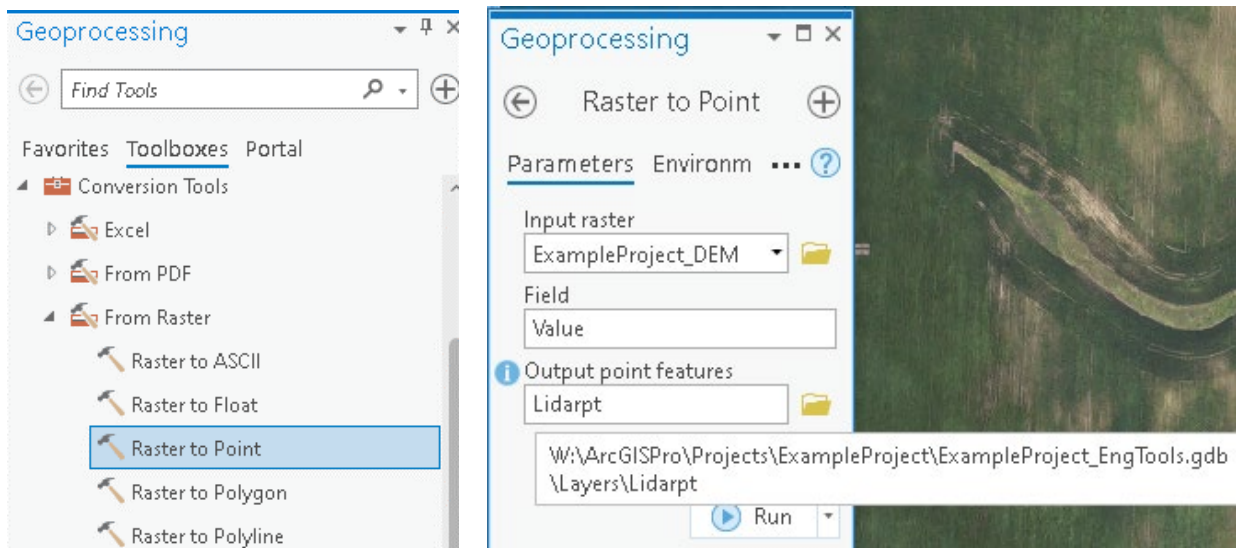


- 4. **Transfer** that shapefile into your ArcPro project folder then **Add** it to your map.
 - a. Define a coordinate System for the survey file. Some programs like Trimble don't have projection files imbedded as part of the shapefile export. If this is the case you need to define the projection.
 - b. From the Analysis Ribbon hit Tool button. In the Toolbox list go to Data Management Tools\Projections and Transformations\Define Projection

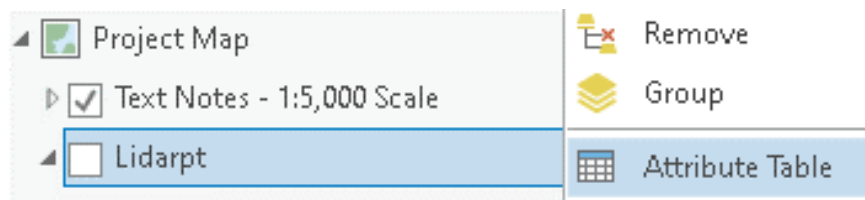


5. Convert LIDAR to Points

- a. You will convert your LIDAR DEM layer to a point layer. This is for a couple purposes. First it is easier to select and include/exclude vector point data to make a composite rather than dealing in rasters as well as it is easier to manipulate attribute tables for vector data which we may need to do unit conversions.
- b. Analysis Ribbon hit the tools button. In the list of geoprocessing toolboxes open Conversion Tools\From Raster\Rater to Point.
- c. Input choose the clipped Lidar layer. Output save as a feature class in the geodatabase in your project folder. Hit Run to finish. Could take some time depending on the size of the area.

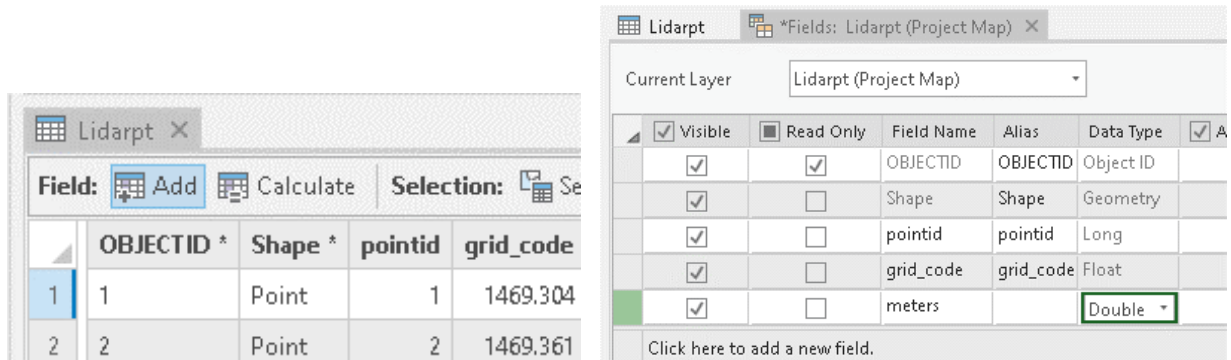


6. **Convert from Feet to Meters.** This is only if your LIDAR and/or the survey data is in feet or any other units aside from meters. Future processing we need units in meters. This also assumes you are working in a UTM type coordinate system where the units of the coordinate system are meters. Since we will be using this to calculate volumes think of the formula $L \times W \times H$. Length and width are latitude and longitude in a UTM coordinate system which are measured in meters. Thus for the calculation to work the height must be the same units as the L & W.
 - a. Right click on the Lidar Point layer and choose open attribute table.

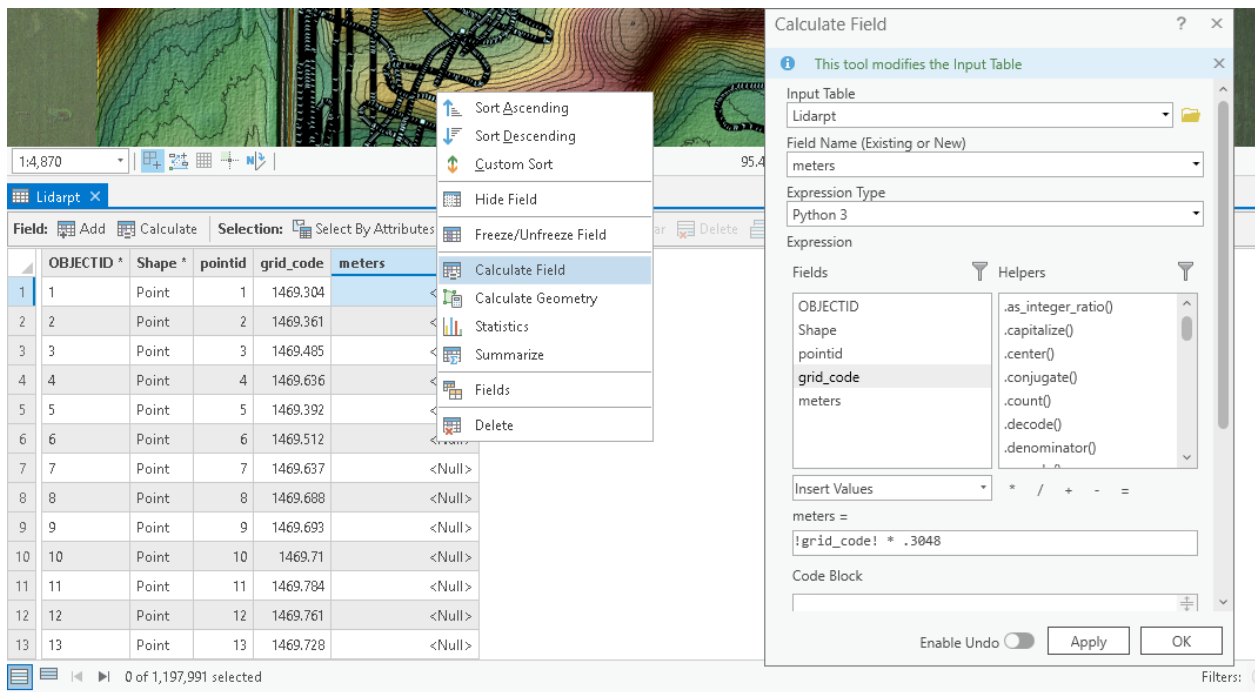


- b. Click the Add Button
- c. Make the Field name "Meters" and the Data Type Double (Double allows for Decimal places).
 - i. If you are dealing in a shapefile not a feature class, then Double may also need to specify Precision and Scale. Precision is total digits and Scape is number of decimal points so 10 & 5 may be a good number for this application.

ii. Hit the X to close the Fields tab and Choose save changes when prompted.



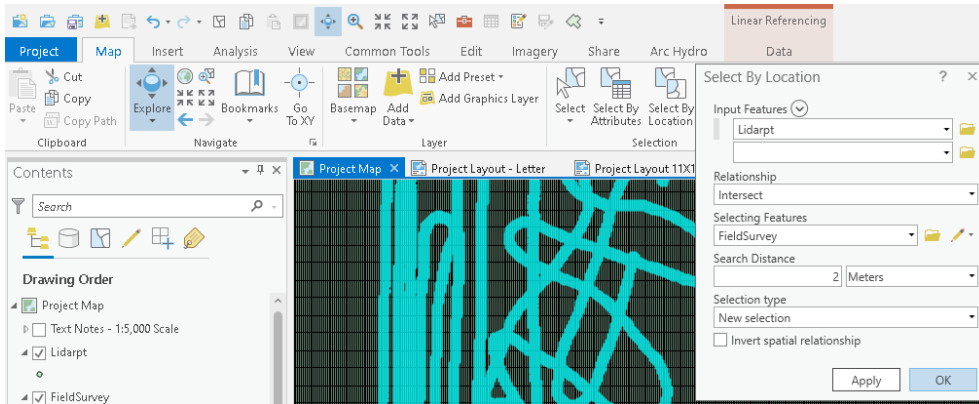
d. Right click on the meters column in the table and choose Calculate Field. As shown in this example The Input should already be set. Fill in your expression in the Meters = field. Double click the Field that contains your feet elevation value which here is grid_code. That adds that field to your expression. Then type or tap the multiplication symbol * and type the correct conversion which from feet to meters is 0.3048. Hit OK or Apply then OK and wait for it to finish the calculation.



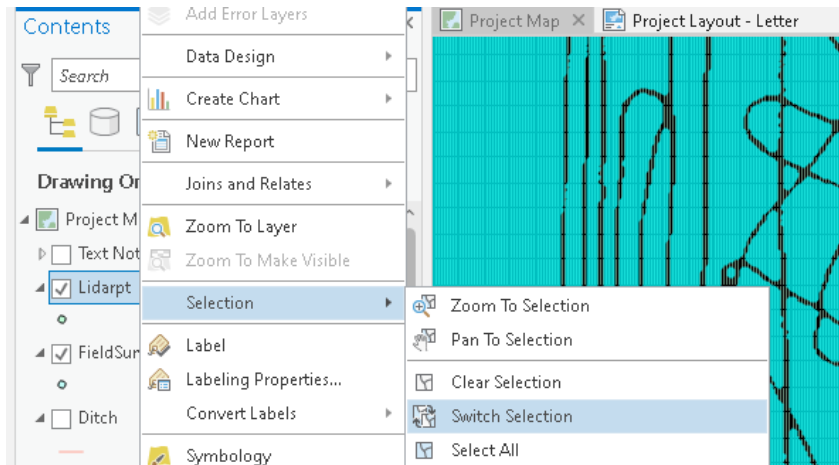
e. Repeat this process for your survey data if that is in feet units. Create a Meter field and calculate the feet to meters conversion.

7. **Select LIDAR that Intersects Survey Data:** We will select and remove LIDAR wherever we have better quality survey data to replace it. (Skip this if not using Field Survey data)
 - a. On the Map Ribbon open the Select by Location button
 - b. In the tool set the lidar point layer as the input. Your Field survey points as the Selecting Feature. For search distance decide how far out from your survey point you feel your

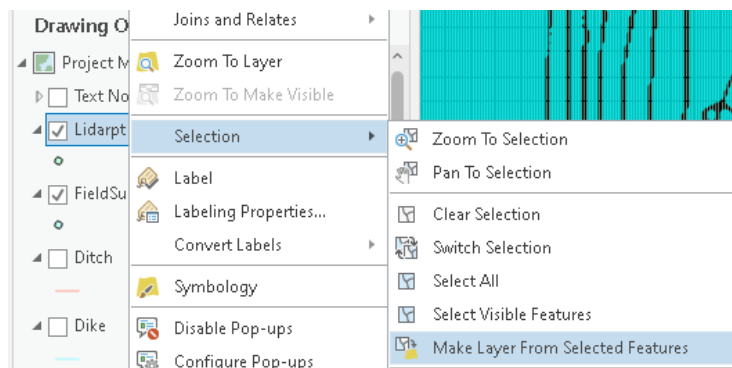
survey point should represent actual vs the LIDAR data. Most often I use about 2 meters (when I do detailed surveys I try to take a survey shot within less than a 2 meter grid).



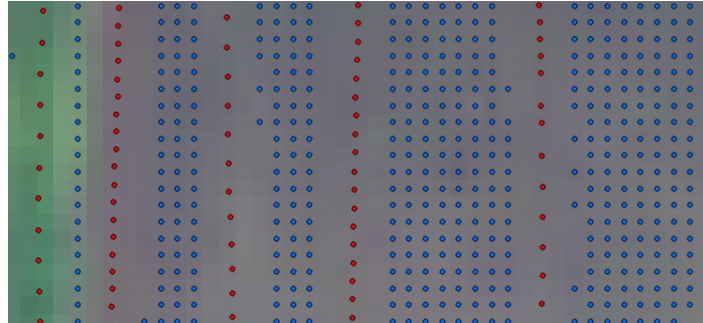
- c. You should now have all lidar points within 2 meters of a survey point selected. However, what we actually want is the opposite. We want to keep all LIDAR except those areas we have survey data. So right click on the lidar point layer and choose Selection\Switch Selection



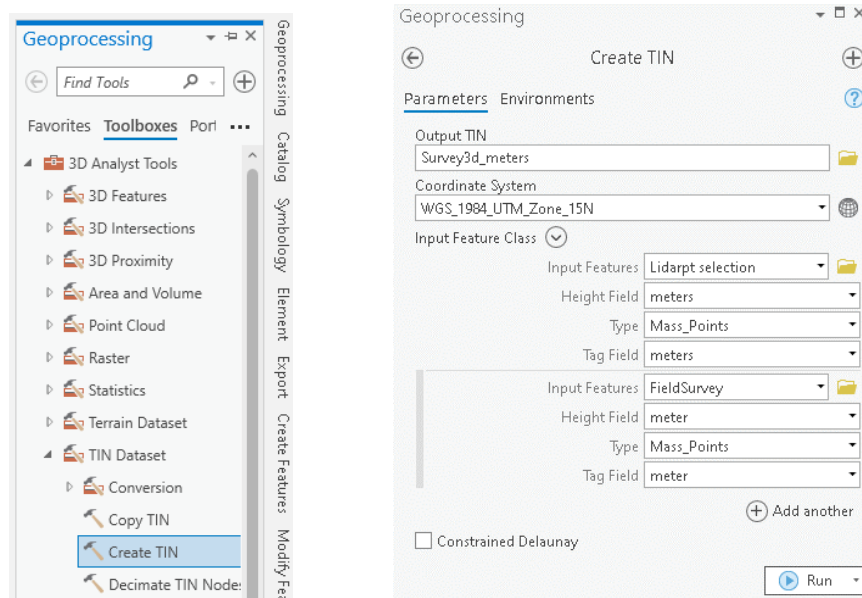
- d. Next we want to create a layer of just those LIDAR selected points. Right click on the lidar point layer and choose Selection\Create Layer from Selection



- e. You should now have something like this example where the field survey points here are red and the lidar points are blue. Refine as needed with manual selection or any other specific selections you need to get the appropriate combination you desire for survey data and lidar data representing your project area.



8. **Create TIN** which is a 3 dimensional landscape of your project area from your combined elevation data. This is a TIN (Triangular Irregular Network) or essentially 3 dimensionally placing all your features in space and draping a surface over them.
 - a. Under the Analysis Ribbon hit Tools (or possibly on your gallery tools shortcuts) and in the Toolbox list find 3D Analyst Tools\TIN Dataset\Create TIN.
 - b. Output TIN, save this in your project folder location. TIN can't go in a Geodatabase.
 - c. Choose your coordinate system
 - d. Input feature class include both the lidar point sub-selection layer you did AND include the field survey points. For both set the height and tag fields to meter which you had already calculated in a previous step for unit conversions. If you have multiple surveys or any other layers representing your landscape elevations include those as well. Run the tool to finish



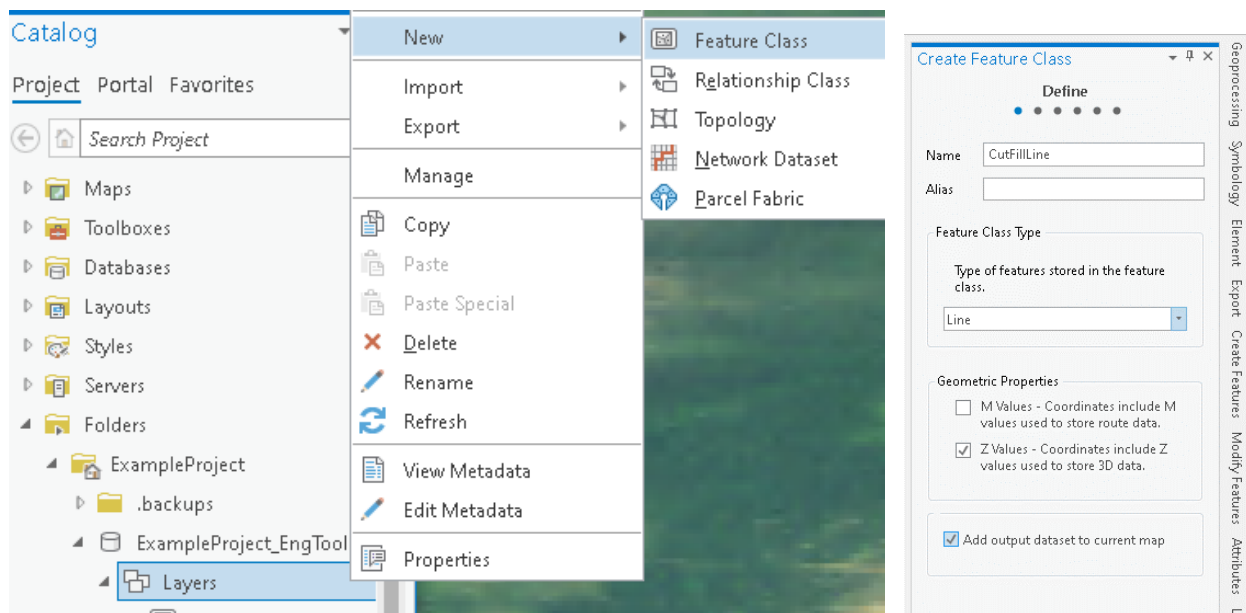
- e. If you want to use this merged LIDAR and Survey data layer for more than future analysis and it is easier to work in standard units like feet you can repeat this process

but choose the feet units field in those datasets. Just remember for later steps of volume calculations in UTM systems you must use the meters version of the TIN.

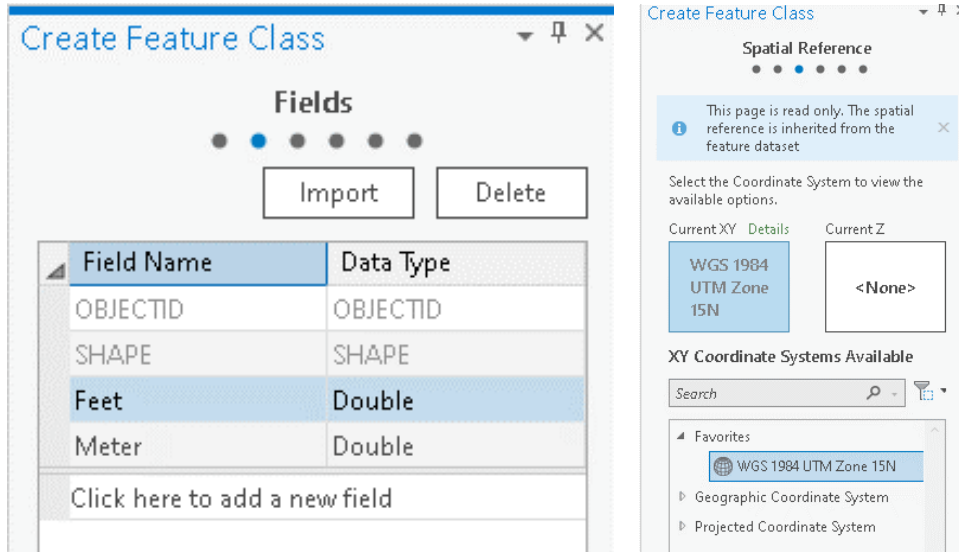
- f. Additional option if you are using the composite survey TIN for more you could also create contours for that surface. We previously created contours for just the LIDAR DEM but can do the same from a TIN. In the toolbox list it is under 3D Analyst\Triangulated Surface\Surface Contour.

Creating your virtual restoration feature (Dike/Spillway/Other Cut & Fill Areas)

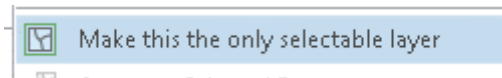
1. **Create Feature topo layer:** First step will be creating a layer that will represent the contour lines of your engineered feature. Think of this in terms of the same as reading a topo map.
 - a. Example: A single line will represent a single elevation so something like an empty circle will be a flat area inside the circle. Space between lines is a slope. Slope is defined as Rise/Run so if you have 2 lines with one drawn at the top of a dike being assigned elevation 100 and the other drawn at the bottom of a dike being 90 then there is a 10ft rise between them or 10ft tall dike. If there is 50ft distance between those 2 lines then the run is 50ft. Thus the slope is 1/5 or 20% or in terms of dike work the terminology is often inverse so they would commonly say a 5:1 dike slope.
 - b. Open the catalog Pane. Either minimized to the right side if you didn't close it or available to re-open on the View Ribbon.
 - c. Choose a location which likely should be in the Geodatabase in your project folder where other project layers are saved and right click in that location and choose New\Feature Class
 - d. Give it an intuitive name and make the feature type be a Line.



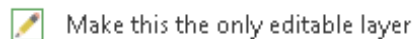
- e. In the Fields screen make 2 new fields. One called **Feet** and the other called **Meters**. Both should be set as **Double** for the data type to allow for decimal points. Fields could be added later from the attribute table but easier to do it from the beginning.
- f. Set a coordinate system then hit Finish to create it.



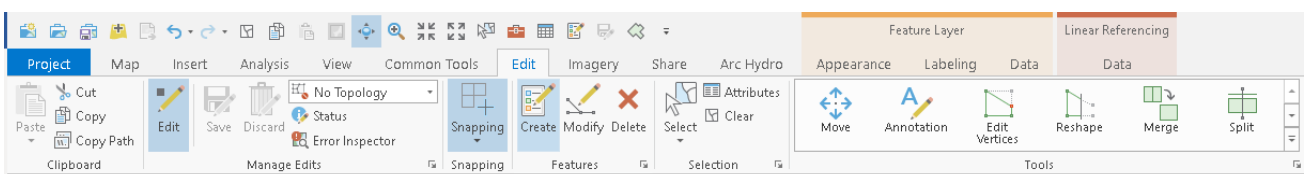
- g. Set symbology if you desire.
2. **Edit Feature:** This is where you will draw the contour lines representing the engineering feature.
- a. 2 optional items but I feel makes editing any layer easier is set the layer you are working on as both the only selectable layer as well as the only editable layer. ArcPro can by default make all visible layers selectable and editable which can cause confusion or edit the wrong item.
 - i. Right click on the layer and under Selection choose Make this the Only Selectable layer.



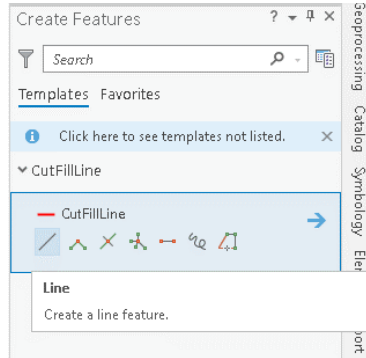
- ii. For Editing, on the top of the Contents box hit the pencil icon which brings you to the editing list. Either toggle all other layers off or Right click on your desired layer and choose Make this the only Editable Layer.



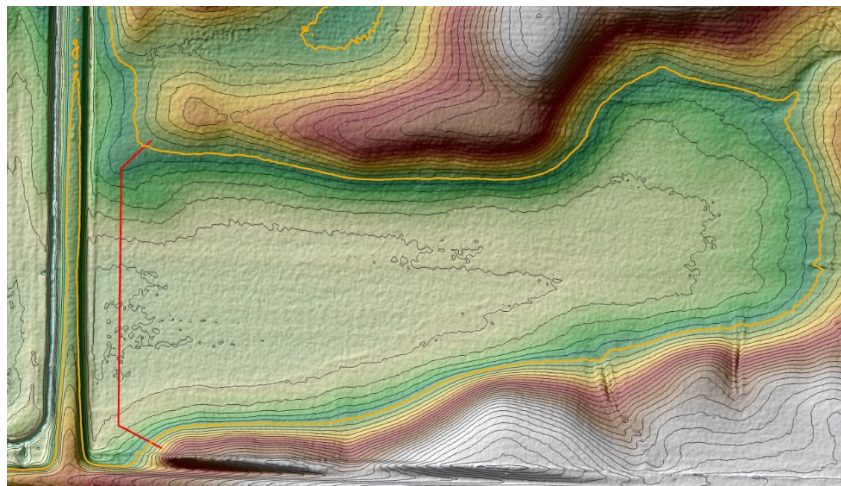
- b. On the Edit Ribbon if you have the option selected in the ArcPro options for manual control of Enable Editing then you first need to hit the Edit button on the Edit Ribbon to start editing.



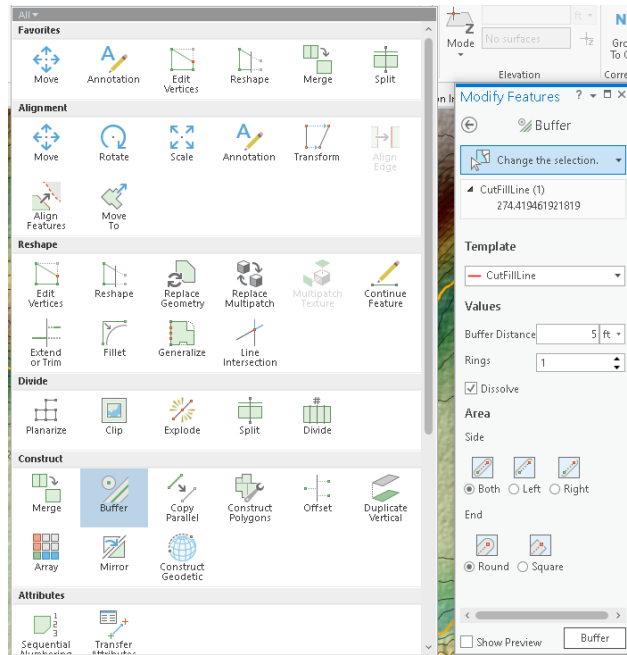
- c. Hit the Create Button to start drawing a new feature. A Create Features Pane will pop up on the right side. I like to Pin this Pane so it doesn't minimize while editing. To do so just hit the pin icon at the top of the window Then my editing layers are quickly available instead of having to reopen the pane any time I need to switch layers or tools.



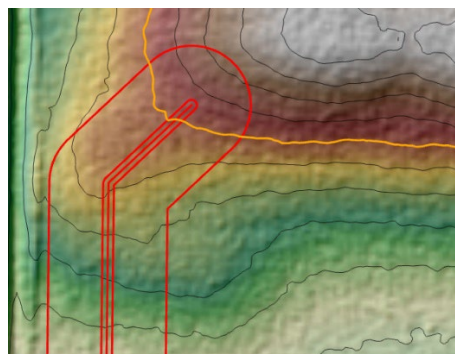
- d. **Draw your centerline:**
- e. **Basics of drawing cut/fill contour features:** You want your feature to **overrun the ground level**. Don't end a contour line short of where that contour is on the representative ground level or essentially you are saying part of your landscape is suspended in mid-air or it is cut off. In this example I want my dike top to be 1439ft elevation. On my topo map I will draw a centerline contour line starting at or above the 1ft contour lines of 1439. Doesn't hurt to overshoot as anything higher than that dike top level will be selected out during the cut/fill analysis because it will calculate no fill for what is already below ground. Same for the bottom of the dike your lowest contour should be below ground or you are calculating a suspended or cut off dike and will get a wrong value in your fill volume. If you are calculating a cut like a spillway you want the opposite so your contour lines must overrun ground level above ground.
- f. In this visual example. We are building a dike to restore the wetland (right) but keep water off the road (Left). Red is the planned centerline of the dike which the dike top will be 1439ft elevation. Orange is the landscape contour line of 1439. Other thin black lines are 1ft contour lines. Notice my dike centerline is drawn past the 1439 orange contour line.



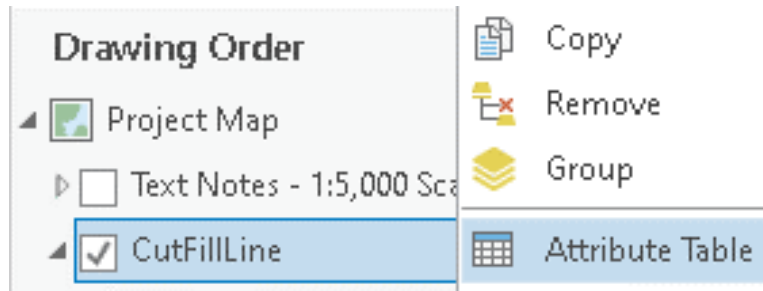
- g. **Create the Dike top:** This is easiest by buffering your centerline if your feature is symmetrical. So if I want a 10ft wide dike top I buffer 5ft around my centerline (5ft each side of the line for a total of 10ft). Make sure your centerline is selected. On the Edit Ribbon Look in the Modify Feature Tools list for Buffer. Fill in your buffer distance and any other options desired and run the tool.



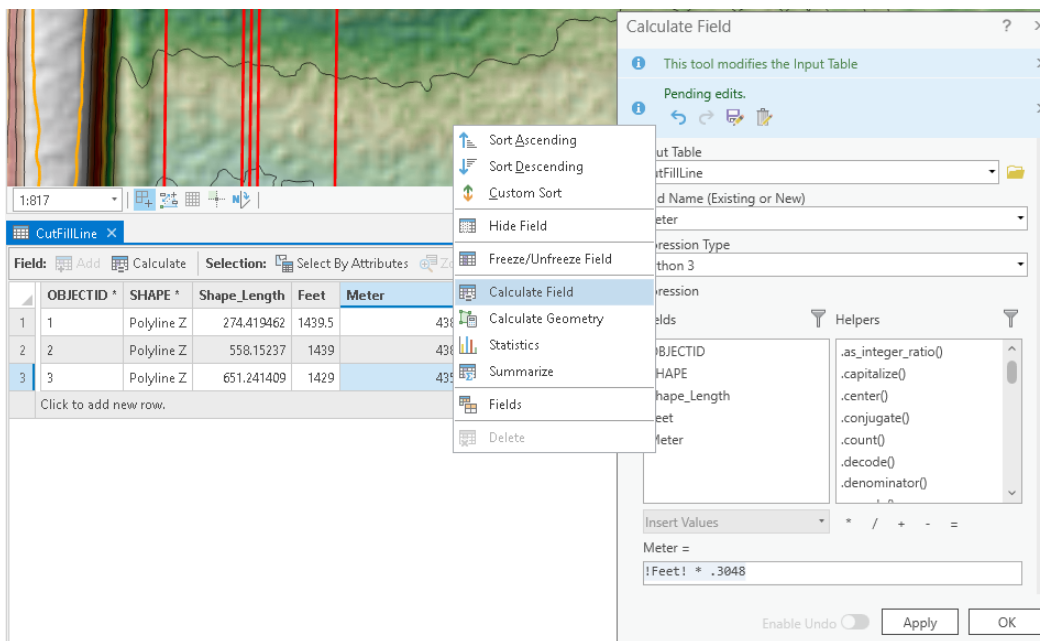
- h. **Repeat this buffer to create the slope.** Select the dike top line you just created and open the buffer tool again. First check about how tall your dike will be from top to the lowest point on the ground. This can be a simple estimate based on counting 1ft contour lines. In this example the dike is about 6ft tall. As previously mentioned we want to make sure the virtual dike we build extends below ground so I know here my bottom dike contour line needs to be greater than 6ft below the top. For simplicity I usually round up to the nearest 10 so I know my rise is 10ft for this virtual dike. Assume you want an even slope, pick whatever your slope dimensions will be. In this example we are building a dike with a 5:1 slope. With that slope we multiply $5 \times 10 = 50$ ft of total run from the edge of the dike top to the bottom toe of the virtual 10ft tall dike (4ft below ground). Thus we enter 50ft as the buffer around the dike top and run the tool.
- i. **Now you have 3 lines.** Centerline, edge of dike top and bottom toe of the dike.



- j. Assign Elevations to your lines: Right Click on the Cut/Fill layer and choose Attribute Table



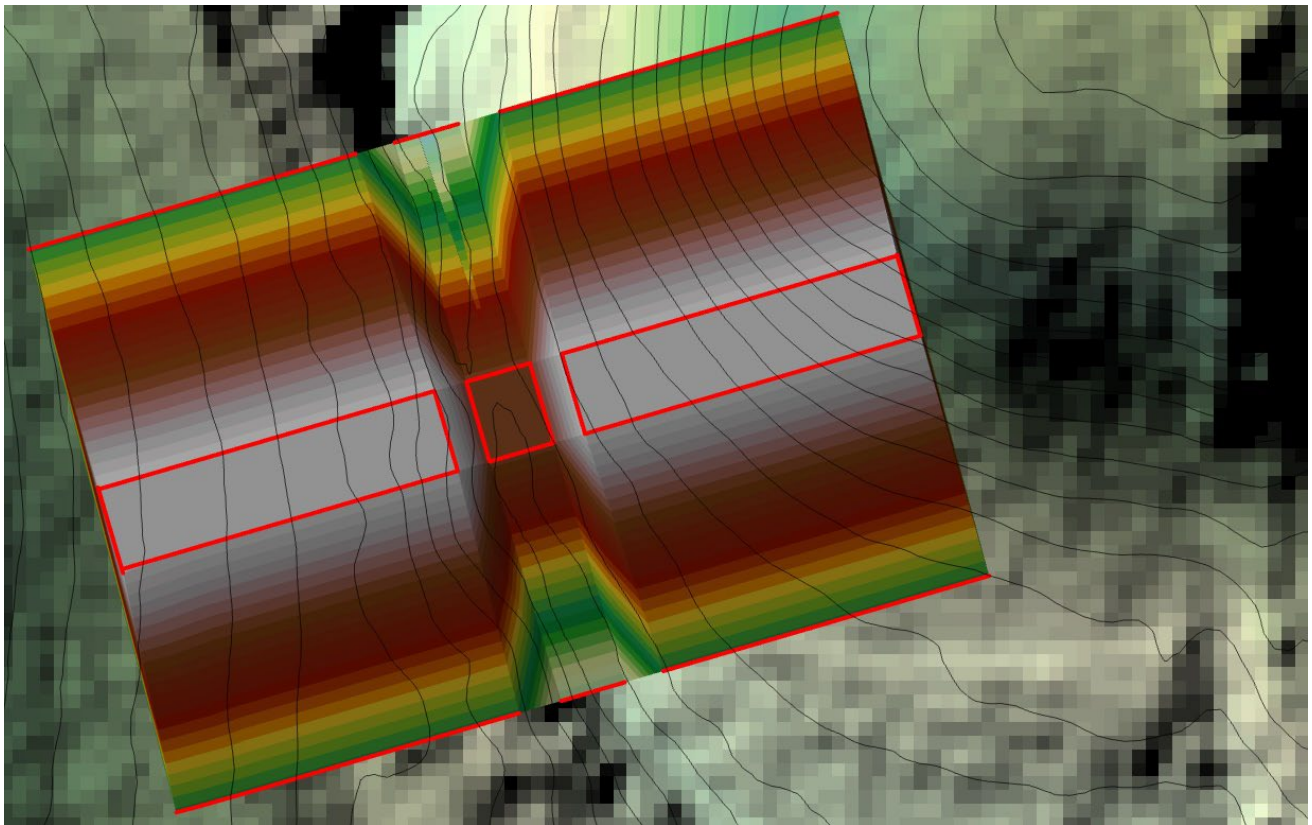
- k. In the Attribute table enter in the Feet column whatever elevation each line should be. In this example I want a dike top of 1439 but want a 6 inch crown on it. So the centerline is 1439.5, The dike top edge is 1439. Then since I am overestimating to make sure the virtual dike is below ground my dike height for the 50ft buffer ring and a 5:1 slope is 10ft tall so the bottom elevation is 10ft below the top at 1429.
- l. Next convert those feet values to meters. Right click on the meters and choose calculate field. Fill in the Meters = field by double clicking on Feet to add it to the expression. Then manually type the conversion * 0.3048 and hit OK.



- m. The Dike contour line is now complete. Choose SAVE on the Edit Menu



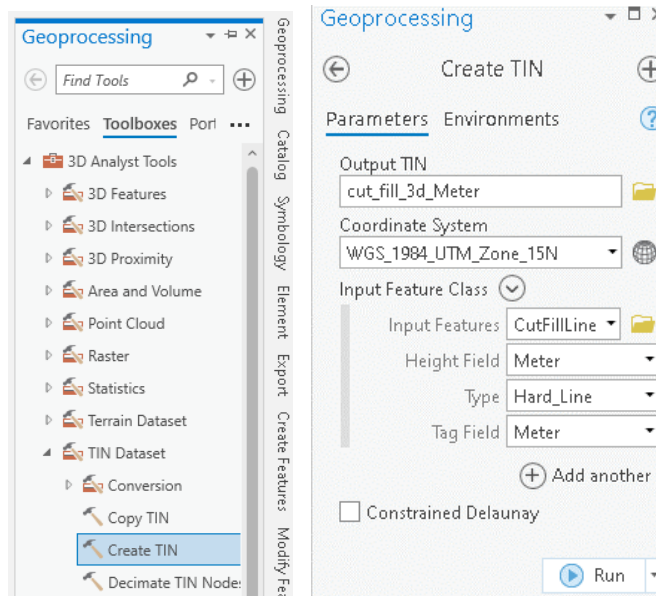
- n. You could add more if your project has multiple cut/fill areas. As long as the lines don't overlap. If they do overlap then you could do them separately and run separate analysis.
- o. A cut like a spillway would work the same as the dike. Centerline the bottom. Buffer to get the flat width part of the channel. Buffer to get the top and overestimate but this time since it is a cut you add instead of subtract from the spillway bottom.
- p. A bench like off a road edge would be similar to a dike just only need to buffer 1 side.
- q. Uneven dikes such as a 10:1 front slope and a 5:1 back slope you would just have to do multiple buffers and use additional Edit Vertices or Split editing functions to remove or modify portions of the line for unequal sides.
- r. Excavating a polygon like a wetland you want cut down to a certain elevation use a similar process but you would start by drawing the wetland edge contour line all the way around and joining the ends of the line to make more of a polygon ring. Then buffer the inside by whatever slope distance you need down to the wetland bottom elevation.
- s. Drawing contours can get as complex as you want. Just envision where elevations are the same and draw with a line and the space between 2 contours of different values is a slope. This example is a virtual dike with a spillway in the center with entrance and exit ramps. The red lines were the contour lines used to draw it.



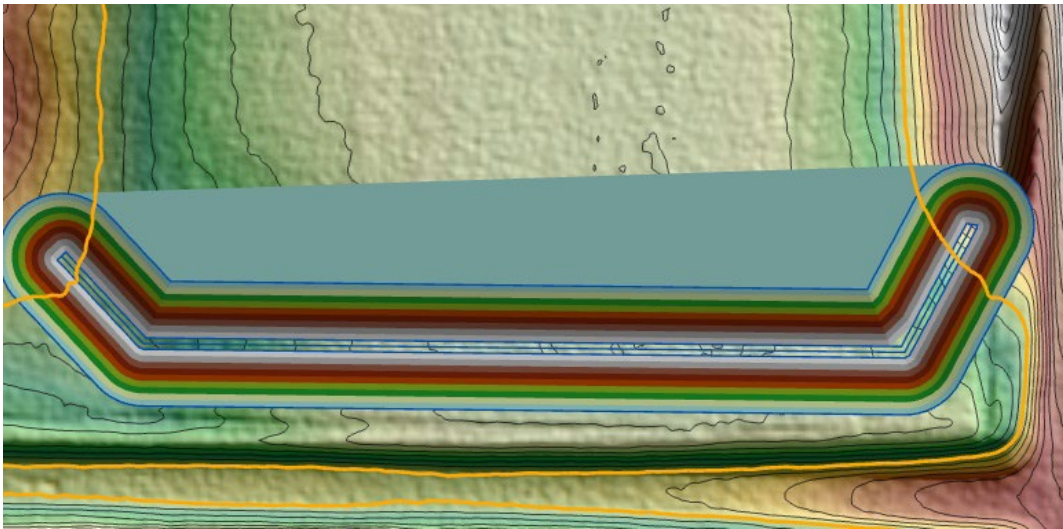
3. Convert your virtual dike/Feature to a TIN

- a. Under the Analysis Ribbon hit Tools (or possibly on your gallery tools shortcuts) and in the Toolbox list find 3D Analyst Tools\TIN Dataset\Create TIN.
- b. Output TIN, save this in your project folder location
- c. Choose your coordinate system

d. Set the Height and Tag fields to Meters and Run it.



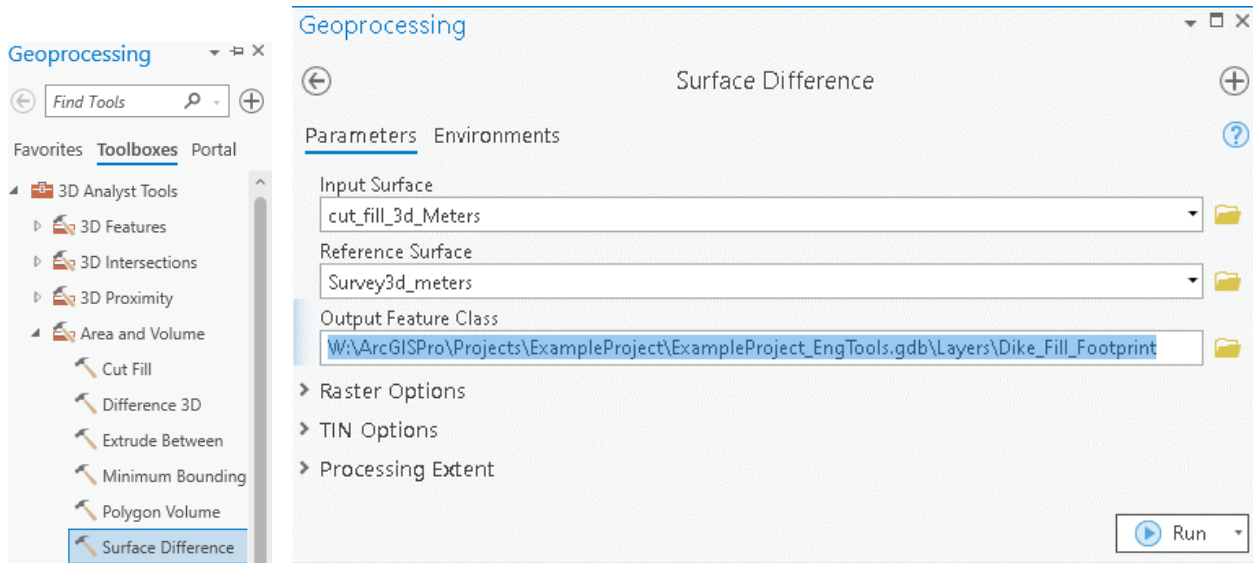
e. You should now have a 3d model of your construction feature.



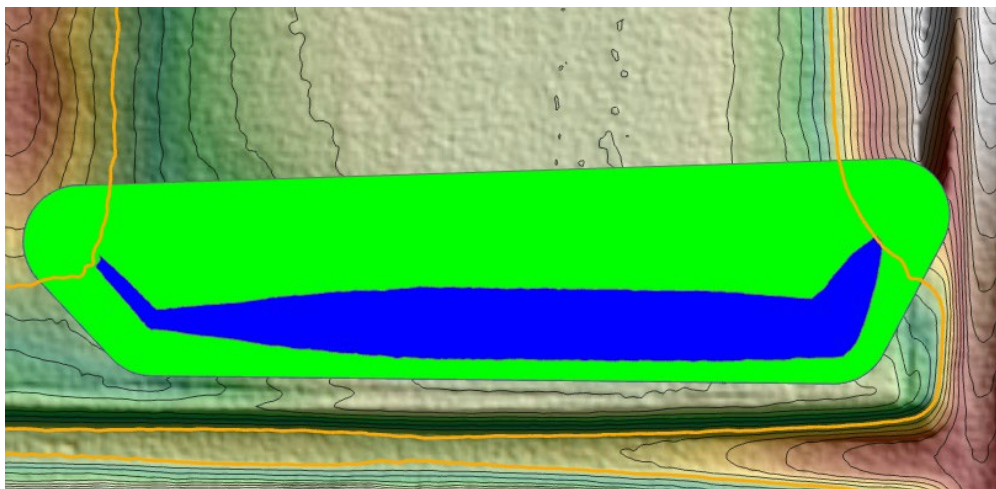
Calculate Cut or Fill

1. We now have a virtual model of our dike or other construction feature. We also have a virtual surface of the landscape from the LIDAR and/or field survey. Final step is to compare the difference between the 2 in order to calculate cut and fill volume and area.
2. **Run the Surface Difference tool:** From the Analysis Ribbon open Tools and from the Toolbox list choose 3D Analyst Tools\Area and Volume\Surface Difference.
 - a. For the calculations to work correctly in a UTM coordinate system your units in the input and reference layers need to be in meters. We can convert to others later.
 - b. Input Surface choose the Cut/Fill 3d TIN layer you previously created.
 - c. Reference Surface choose you Survey/LIDAR 3d TIN layer.

- d. Output should be in the geodatabase of your project folder and name it intuitively.
- e. Run the tool

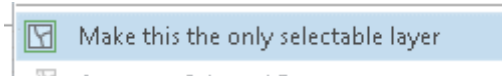


3. You should finish with a polygon layer that shows cut and fill areas.
 - a. In this example it displays by default, fill areas as blue and cut areas as green. For a dike like this the cut will be ignored and discarded as below ground.
 - b. You should have your Fill feature entirely surrounded by cut areas as seen here which indicates you extended your virtual dike far enough for the slope to reach the ground and encompasses the whole extent of what you need to construct. If this is not the case and you see blue with no green surrounding it on all sides you may need to redo your Contour line creation for the feature and extend it further so the toe slope is not cut off.
 - c. If your ground isn't even you may have multiple polygons. Also if there were other areas of the TIN that overlapped non construction areas you might have extra cut and fill polygons that are irrelevant to the actual construction feature and can be discarded.

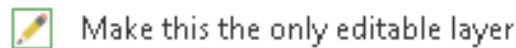


4. **Edit to cleanup** the Cut\Fill layer.

- a. From the edit menu, start editing.
- b. Reminder on editing it is often simpler to restrict editing to only 1 feature as well as selection to that feature to avoid editing errors.
 - i. Right click on the layer and under Selection choose Make this the Only Selectable layer.



- ii. For Editing, on the top of the Contents box hit the pencil icon which brings you to the editing list. Either toggle all other layers off or Right click on your desired layer and choose Make this the only Editable Layer.



- c. Use the Select tool from the Edit Ribbon and select any areas that are not part of the actual construction feature you want to keep. In this example we are selecting any green areas not part of the dike and deleting them. Once selected either use the delete button on your keyboard, Delete button on the Ribbon or Right click on the polygon and delete.
- d. Alternative for cleaning up is open the attribute table for that layer and can select features by selecting rows. Code field has a -1 value which indicates those are cut areas which in the case of a dike and cut areas (Code -1) can be discarded and deleted.
- e. Save your edits on the Edit Ribbon

5. **Fill in attributes, subcuts and conversions:**

- a. Right click on the cut\fill layer and choose open attribute table.
- b. Notice the Volume field which because we are in UTM coordinates was calculated in cubic meters.
- c. We want to add fields for unit conversions as well as can do sub-cut calculations
- d. Hit the Add button the attribute table menu

 A screenshot of a software window titled "Dike_Fill_Footprint" showing an attribute table. The window has a menu bar with "Field:", "Add", "Calculate", "Selection:", "Select By Attributes", "Zoom To", and "Switch". The table has the following data:

	OID *	Shape *	Volume	SArea	Code	Shape_Length	Shape_Area
1	2	Polygon	3755.538105	4255.045542	1	527.992882	4184.327248

 Below the table, there is a text prompt: "Click to add new row."

- e. At the bottom of the field list click add new field.
- f. Determine whatever units and steps you will need. In this example we will make 4 new fields. Give each a name and suggest using Data Type as Double for decimal places.
 - i. CY – this is to convert from cubic meters to cubic yards
 - ii. Acres – Could be any surface area units but need a surface area footprint.
 - iii. Strip6inCY – In this example I will calculate a sub-cut of the dike area of 6 inches which is to take the top sod/vegetation off the surface before building up. Units will be in CY.

- iv. TotalFill – This will be to take the original geometric volume calculated and add the subcut as we need to replace that volume lost for the total dike fill.

Visible	Read Only	Field Name	Alias	Data Type	Allow NULL	Highlight	Number Format	Domain	Default	Length
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	OID	OID	Object ID	<input type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Shape	Shape	Geometry	<input checked="" type="checkbox"/>	<input type="checkbox"/>				
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Volume	Volume	Double	<input type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input type="checkbox"/>	SArea	SArea	Double	<input type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Code	Code	Long	<input type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Shape_Length	Shape_Length	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Shape_Area	Shape_Area	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input type="checkbox"/>	CY		Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>				
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Acres		Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>				
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Strip6inCY		Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>				
<input checked="" type="checkbox"/>	<input type="checkbox"/>	TotalFill		Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>				

- v. Hit save on the top Fields Ribbon or just close the fields tab and save when prompted.
- g. Calculate the fields.
 - i. For Acres use the Calculate Geometry Option. Right click on the Acres field and choose Calculate Geometry. Fill in Property as Area and Area Unit as Acres, Set the coordinate system and hit OK.

- ii. On the attribute table right click on the field you want to calculate and choose Calculate Field. Build your expression. To add a field to your expression double click it from the list. Type in other math functions.
- iii. $CY = Volume * 1.30795$ (The unit conversion from cubic meters to cubic yards)

- iv. $\text{Strip6inCY} = \text{Acres} * 1613 * 0.5$ (1 acre 1ft deep is 1,613CY. We are sub-cutting half a foot so multiply by 0.5)
- v. $\text{TotalFill} = \text{CY} + \text{Subcut}$

	OID *	Shape *	Volume	SArea	Code	Shape_Length	Shape_Area	CY	Acres	Strip6inCY	TotalFill
1	2	Polygon	3755.538105	4255.045542	1	527.992882	4184.327248	4912.056064	1.03397	833.896878	5745.9

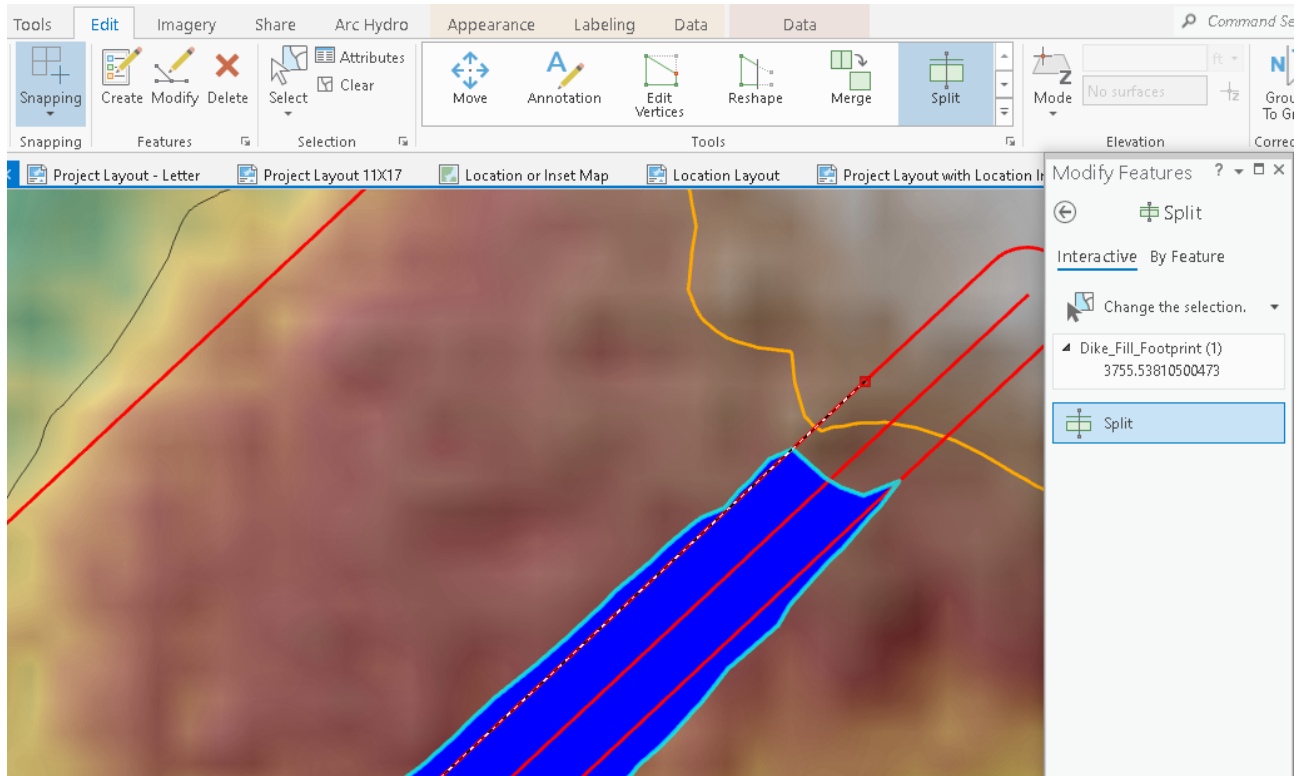
The image displays three sequential screenshots of the 'Calculate Field' dialog box in a GIS application, showing the process of calculating new fields based on existing data.

- First Screenshot:** The 'Input Table' is 'Dike_Fill_Footprint'. The 'Field Name (Existing or New)' is 'CY'. The 'Expression Type' is 'Python 3'. The 'Expression' is `!Volume! * 1.30795`.
- Second Screenshot:** The 'Field Name (Existing or New)' is 'Strip6inCY'. The 'Expression Type' is 'Python 3'. The 'Expression' is `!Acres! * 1613 * 0.5`.
- Third Screenshot:** The 'Field Name (Existing or New)' is 'TotalFill'. The 'Expression Type' is 'Python 3'. The 'Expression' is `!CY! + !Strip6inCY!`.

- 6. You now have an outline polygon of your cut\fill construction feature along with volume and sub-cut calculations ready for your scope of work.

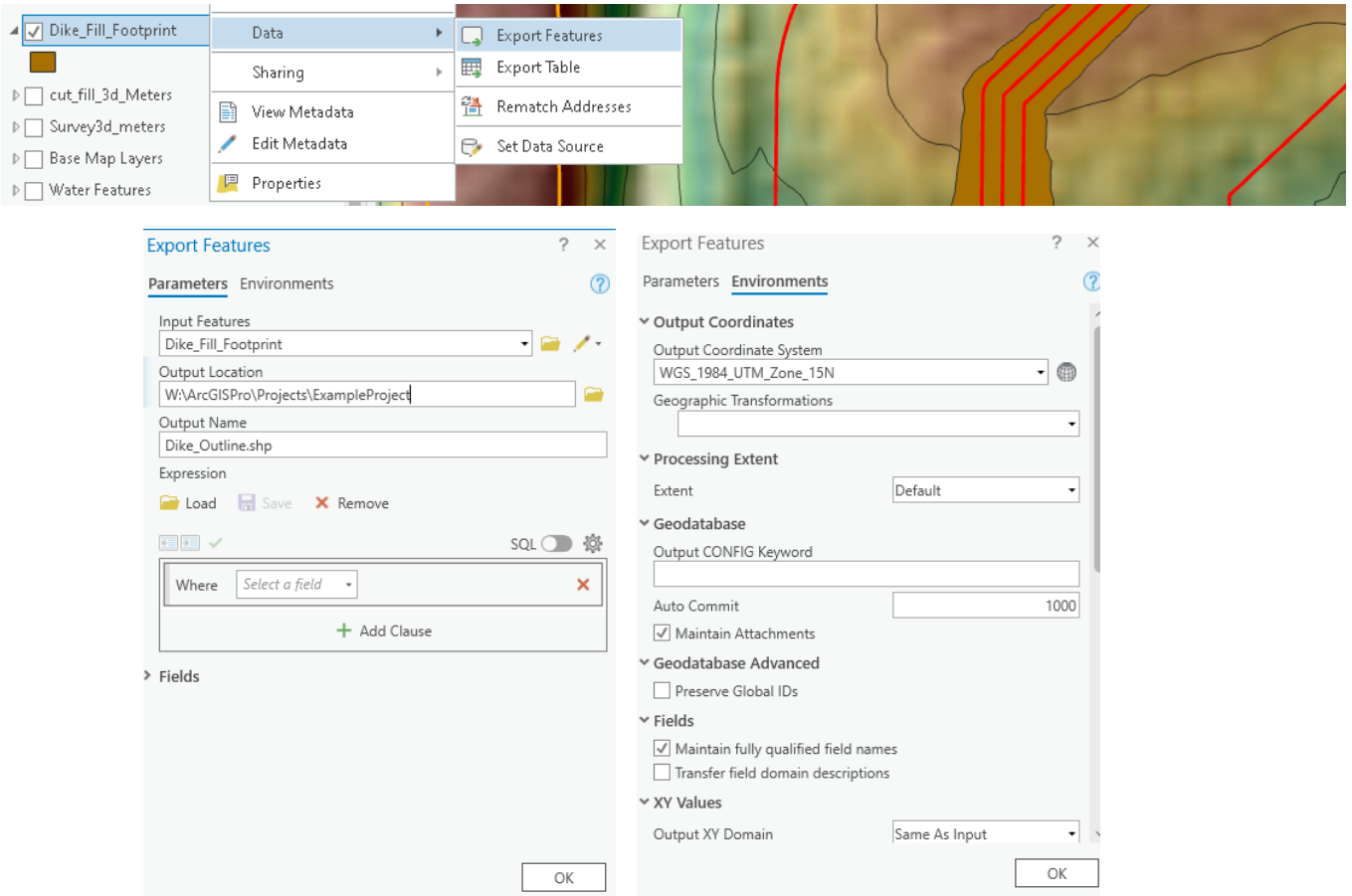
Preparing for construction staking

1. Assuming you used survey grade GPS to gather your site data as well as have survey grade GPS for construction staking you can take this design data to the field for construction staking to mark toe slopes and centerlines etc.
2. **Centerlines or Breaks:** If you want the dike top or centerline, either export the dike outline and your dike contour line separately, OR prior to export edit the dike outline, use the Split tool to trace over the design contour line so the dike outline polygon is cut into segments divided by the contour lines. Edit from the Edit Ribbon. Select the dike outline and use the split tool. As long as you have Snapping turned on, your edit cursor should be able to snap to the line as you trace over it.

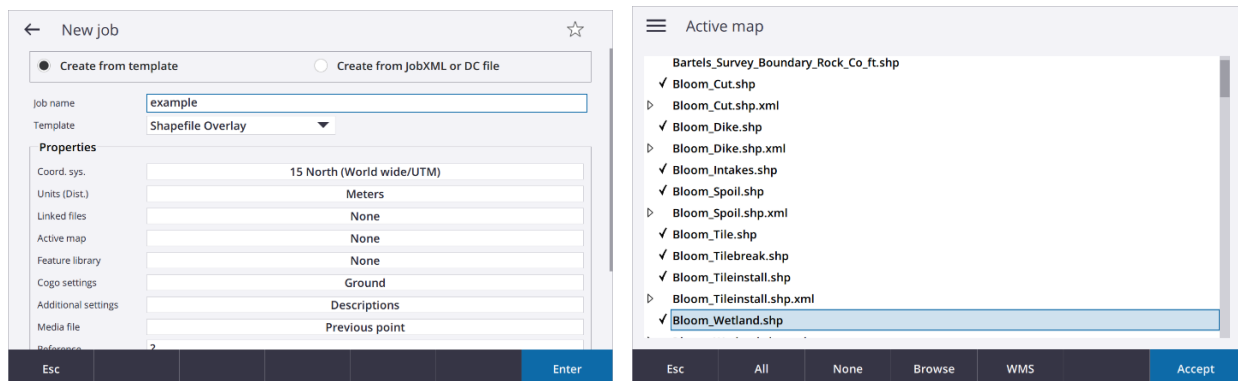


3. **Convert to shapefile:** Many GPS units can not handle geodatabase feature classes but can use simple shapefiles.
 - a. In the export process if any thing in that feature is selected it will only export the selected feature. If you want everything to export then make sure nothing is selected.
 - b. To convert your feature class to a shapefile, right click on the layer and go to Data\Export Features.
 - c. Choose your output location. If you want it to be a shapefile instead of a feature class then save to a folder NOT inside of a geodatabase.
 - d. Give it an intuitive name with no spaces.
 - e. Many GPS units can not reproject layers so they only work in the one defined coordinate system setup for that job. So any layers you wish to import to your GPS must be in the same coordinate system that is defined on your device. By default GIS will export the same

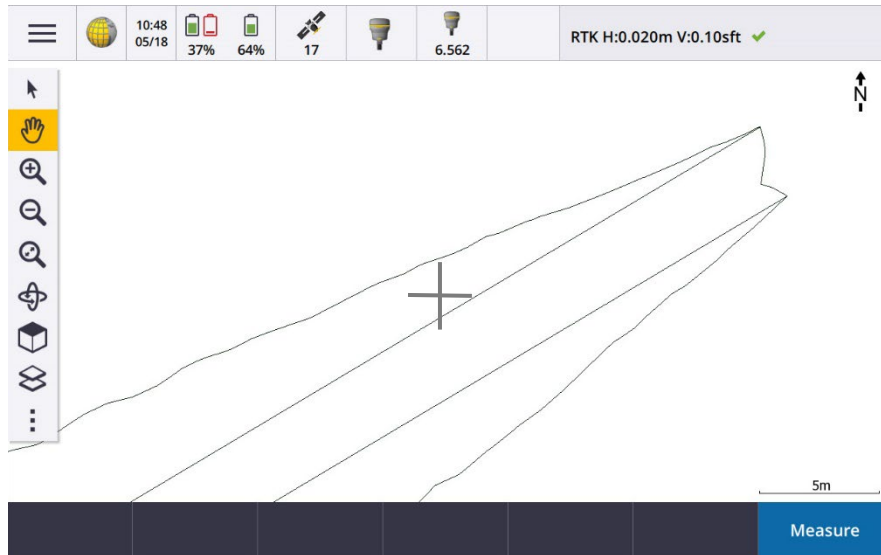
coordinate system as the original file. If you need to change this during the export then see the Environments tab during your export and change systems during the export.



4. Copy your shapefiles to your GPS unit into the data file location for your unit.
5. Trimble Access GPS software has the option to bring shapefiles into your job file. In the Job setup look for “Active Map” and from the Active Map list you can select available shapefiles.

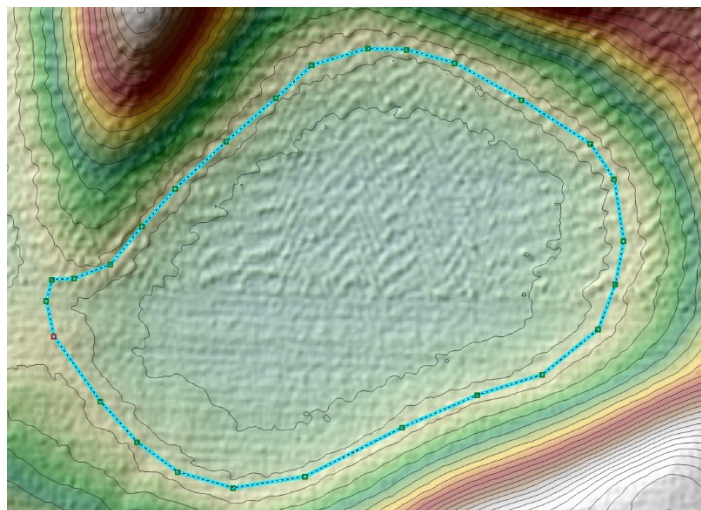


6. You can then navigate on your unit to your drawn features to stake or check locations of the construction feature.

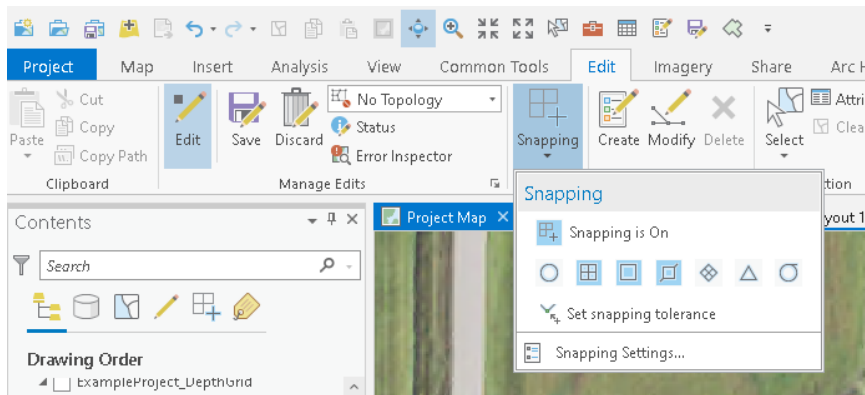


Miscellaneous Tools & Features

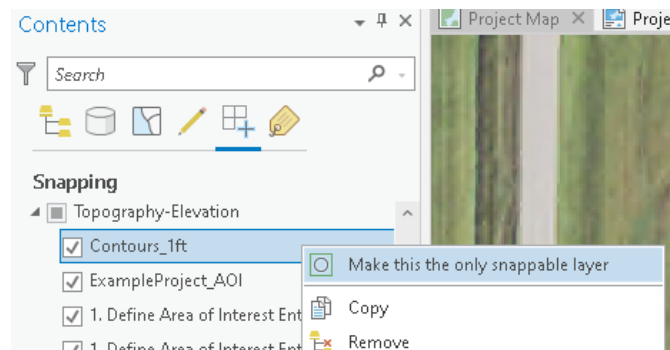
1. **Wetland Mapping:** Drawing wetlands or any other feature uses the same creation of a new feature class and edit function described above in creation of other layers in this tutorial.
 - a. Use your topo map for the best wetland delineation tool or the depth grid. Soil maps may also help.
 - b. Find the outlet point which is the lowest point around the basin and follow that contour around the basin. This is unless the wetland is controlled by a drainage structure or sand/gravel seam at a lower elevation or a dike is built at the outlet which will raise above the natural runout.



- c. Many air photos should be used in wetland delineation. Depending on your purpose may map the highest extent seen in any recorded year or may be an average extent.
 - d. Keep in mind wetlands are dynamic systems. They change depending on climate, precipitation, vegetation, landuse and drainage or manipulation. Mapping a wetland is a representation but may not reflect reality at any particular time.
2. **Snapping:** During editing snapping can be handy. It will stick your cursor to any visible feature that is close which can make it easier to trace another object. However, at times you may want to draw independently and not snap to a nearby object.
- a. Snapping can be toggled on or off on the Edit menu with the snapping button. Additional options on the button drop down.



- b. Choosing which layers get snapped to can be controlled on the Contents pane snapping list.

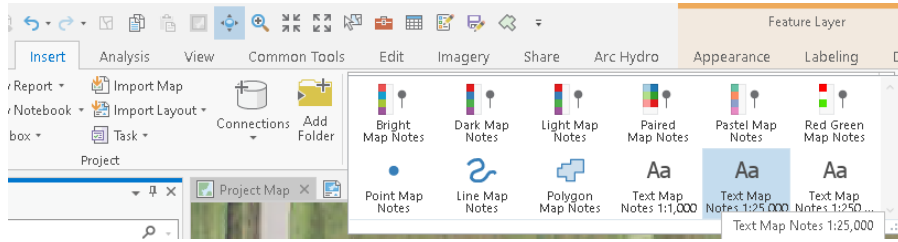


- c. While drawing you can hold the Space Bar down at any time to temporarily disable snapping while the bar is held.

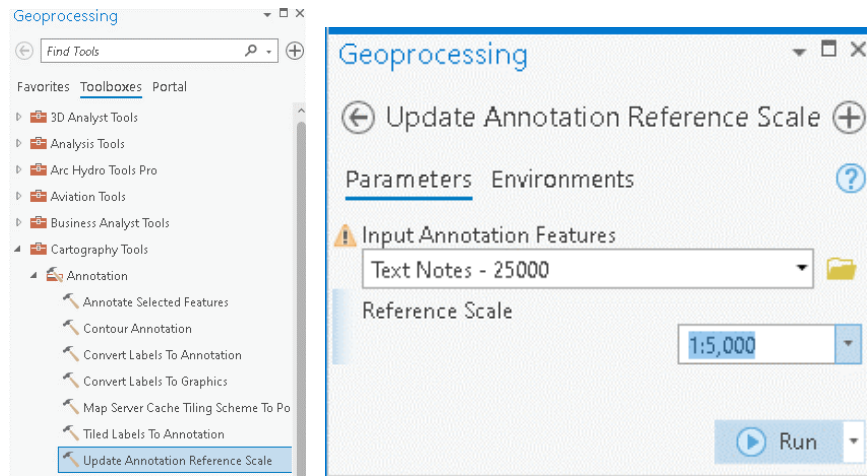
3. Map Callout Text boxes

- a. ArcPro does not have the option for standard drawing/graphic features like text callout boxes in the map view like ArcGIS 10x did. This is unfortunate as it was a very common used feature for placing a quick reference note on your map when doing a GIS desktop review. Their new solution is suggesting to create a feature class point layer and setup labels which can be a bit cumbersome and time consuming when you just want to place a sticky note to reference something.
- b. The fastest and easiest option is to use the Layer Templates on the Insert Ribbon. See the dropdown list of premade templates and use the Text Notes at whatever scale is close to your project. We can change this scale later. This will create a new annotation layer in the

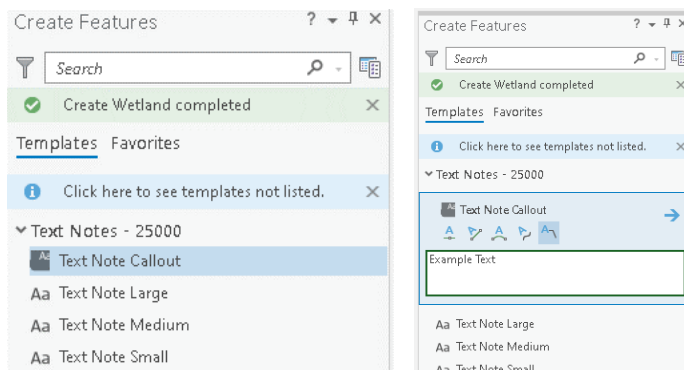
geodatabase that you have assigned as the default database for the project (From your project options settings). This is why you should have an individual database assigned at the beginning of each new project.



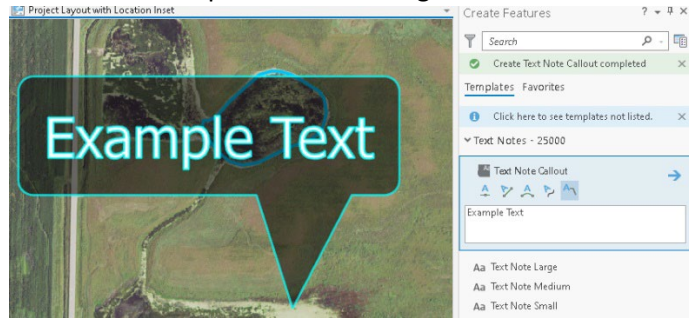
- c. You will see the Text Notes Layer in your Contents.
- d. Limitation to this option is it stays only at a specified scale by default so as you zoom in or out the text doesn't change with it but could get very small or very large. You can individually resize which we will show below but for the default you must decide a scale that you will be working with your map the most. I find about 1:5000 fairly comfortable.
- e. To change the scale of the Text Notes Annotation. Go to Analysis Ribbon Tools button. In the Toolbox list Find Cartography Tools\Annotation\Update Annotation Scale. (If you use this a lot you may want to add it to your favorites list on the gallery tools.) Pick your layer and set the desired scale and run it.



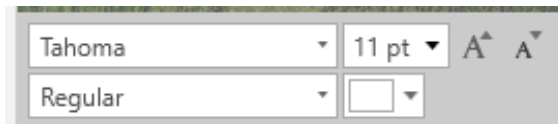
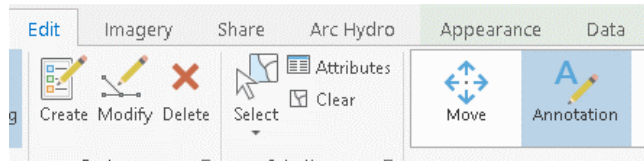
- f. To create notes on the map just use the Editing function. Edit Ribbon, hit create. On the Create Feature Pane select Text Note Callout which will expand. Type your Text



- g. Then Click on the map wherever you want the point of the callout to be, Drag around to wherever you want to callout box placed and click again to finish.

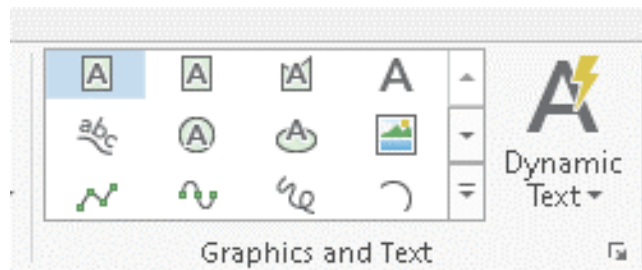


- h. If you want to modify the position or format the text, Select it with the Editor selection tool and Hit the Edit Annotation button on the top toolbar. You will then have handles to move or adjust the callout and at the bottom of the screen a box will have the font and size.

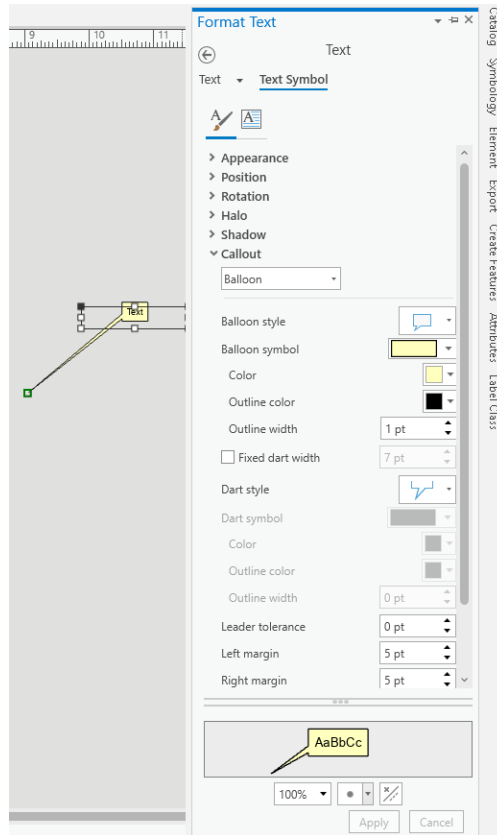


4. Callout Text boxes in Layout view:

- a. Callout boxes in layout are available as drawing object similar to the older ArcGIS 10x versions. However, they give you the quick access text but need to do additional formatting to get the callout bubble.
- b. In Layout view go to the Insert Ribbon. Look for the Graphics and Text tools on the Ribbon.
- c. Click on a Text Box and place it on your layout map.



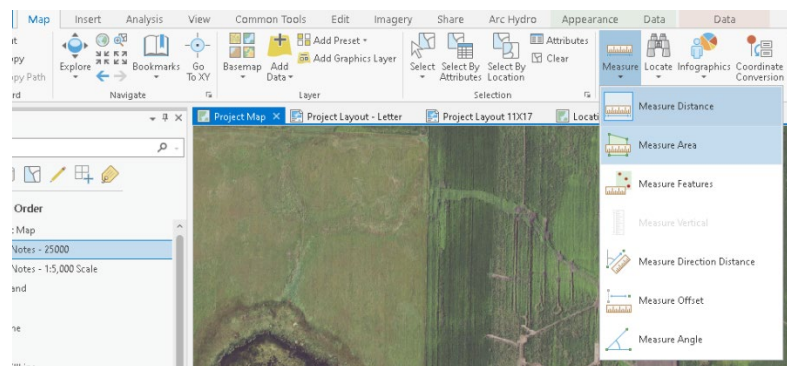
- d. Right click on that text and choose properties or see the Format Ribbon at the top. From there under Text Symbol you can format the color font etc. Farther down the list is the option for Callout which you can choose callout options.



- e. Because this process is cumbersome to create a callout. I suggest creating 1 in your initial map template so it is available for all new maps created from that template. Have it on the side of your map in the layout so it is available. Then when you want to use it select and hit copy (or Ctrl+C) and Paste (Ctrl+V) to just copy the one premade and move and change the text. It will be much quicker than recreating from scratch each time.

5. Measure Tools:

- a. Drawing shapes were often used in ArcMap for a quick measurement of acres without creating a new feature class/shapefile and calculating acres. This function is built into the measure tool for ArcPro.
- b. On the Map Ribbon find the Measure tool

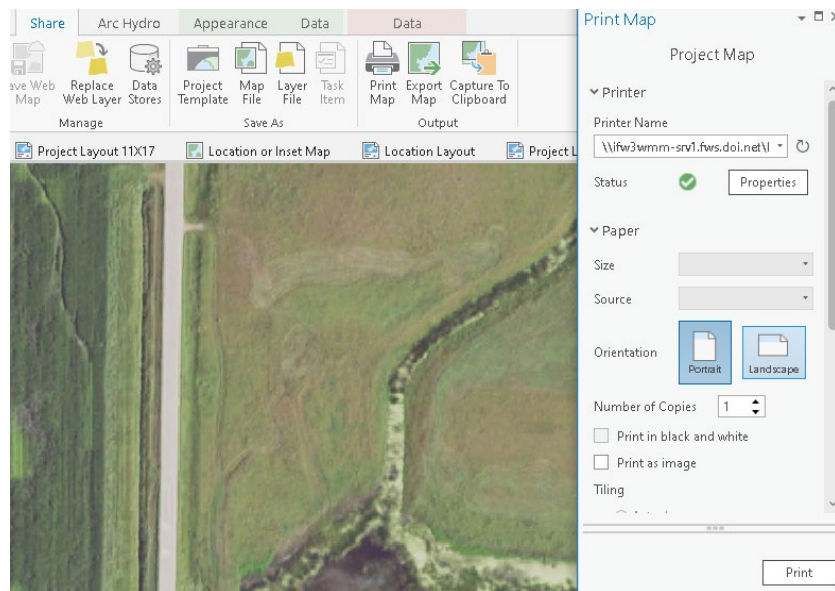


- c. Can choose length or area. On the tool pick your units and draw the measurement area on the map.



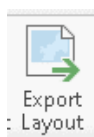
- d. Unlike the drawing tools in Arc Map, once done measuring the polygon does not remain on your map so used for quick measurement only. If you want polygons you need to create a Feature class.

6. **Print Map:** Print options are found on the Share Ribbon and Print Map button

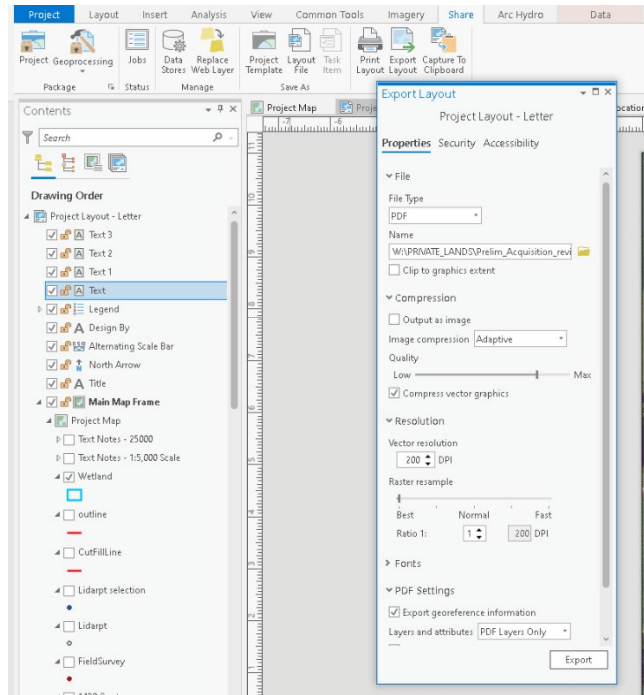


7. **Export to PDF or Image:** This is also found on the Share Ribbon

- a. Hit the Export Layout (or Map depending on your view) button on the Ribbon

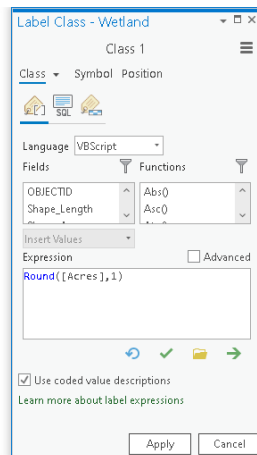


- b. File type choose PFD or another image format and any other quality setting you need.
- c. Choose an output location. Note when you open the dialog box for the location it shows a Save button to close which is often confusing but this only save the name and location you chose but did not actually export it yet. Hit the Export button at the bottom to run the export.



8. Label Decimal points

- a. Using the Double Field type allows for decimal points in your values but sometimes too many places and can clutter a map.
- b. Open the label properties for a layer (Right Click on the Layer)
- c. Use the VBScript Language or lookup alternative commands for other languages.
- d. In the Label Expression use the Round() command. Place the field you want to label and round in the parenthesis. After the field place a comma and the number of decimal places you want to round to such as `Round([Acres],1)`. Hit Apply to finish



5.6

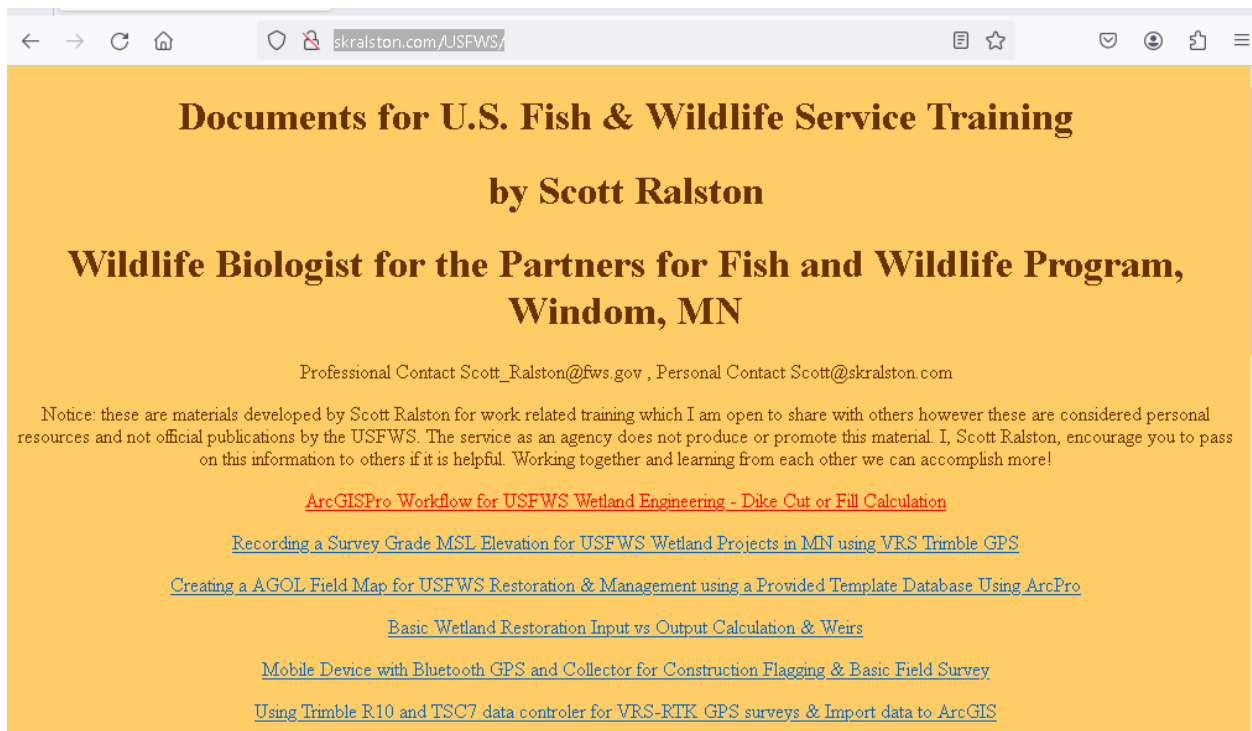
Other Tutorial Resources:

Other similar style tutorials are available at <http://skralston.com/USFWS/>

Please feel free to use and share these if they are useful to your projects.

Subjects directly related to the workflow of this tutorial include:

- Collecting GPS data with Trimble survey grade GPS
- Creating and using a AGOL database and map to work between ArcPro and mobile devices
 - Flagging and staking construction with mobile GIS
 - Basic wetland restoration 101 techniques
 - Wetland flow calculations



The screenshot shows a web browser window with the address bar displaying "skralston.com/USFWS/". The page content is on a yellow background and includes the following text:

Documents for U.S. Fish & Wildlife Service Training
by Scott Ralston
Wildlife Biologist for the Partners for Fish and Wildlife Program,
Windom, MN

Professional Contact Scott_Ralston@fws.gov , Personal Contact Scott@skralston.com

Notice: these are materials developed by Scott Ralston for work related training which I am open to share with others however these are considered personal resources and not official publications by the USFWS. The service as an agency does not produce or promote this material. I, Scott Ralston, encourage you to pass on this information to others if it is helpful. Working together and learning from each other we can accomplish more!

[ArcGISPro Workflow for USFWS Wetland Engineering - Dike Cut or Fill Calculation](#)

[Recording a Survey Grade MSL Elevation for USFWS Wetland Projects in MN using VRS Trimble GPS](#)

[Creating a AGOL Field Map for USFWS Restoration & Management using a Provided Template Database Using ArcPro](#)

[Basic Wetland Restoration Input vs Output Calculation & Weirs](#)

[Mobile Device with Bluetooth GPS and Collector for Construction Flagging & Basic Field Survey](#)

[Using Trimble R10 and TSC7 data controller for VRS-RTK GPS surveys & Import data to ArcGIS](#)