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Arc Hydro: Project Development Best Practices

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Table of Contents

1.0   Introduction

Arc Hydro consists of a data model, toolset, and workflows developed over the years to support specific geographic information system (GIS) implementations in water resources. The initial implementation of Arc Hydro was in 2002 with the data model. It was accompanied by an Arc Hydro book published by Esri Press and a set of about 30 tools. Since then, Arc Hydro has been used in many projects, and in the process, new tools and workflows have been developed. There are more than 300 Arc Hydro tools now, and they continue to be expanded.

This document captures what works well when implementing Arc Hydro projects. It is based on many years' experience in implementing ArcGIS and Arc Hydro projects around the world; providing support and training for Arc Hydro users; and receiving specific feedback from some of our Arc Hydro users (which is always welcome). There are other recommendations that could/should be made, and this document will be expanded in the future to include them as they become apparent.

This document is not focused on a specific version of ArcGIS or Arc Hydro—it is a set of generic recommendations that transcend specific versions. Most of these recommendations will work well for any ArcGIS project, not just the ones based on Arc Hydro.

2.0   Arc Hydro−Basic Information

Here is some basic information about Arc Hydro to keep in mind:

- Arc Hydro is a system of tools and data structures that work in unison to provide a rich and effective experience for GIS users in the water resources community.

- If you are using Arc Hydro, you will most likely be doing analyses. There are important considerations for GIS implementation when doing analyses that require GIS for more than just mapping. Respect that.

- When using the tools, you are building a system, not just using a bunch of independent tools to produce some independent data.

    o   Of course, there are plenty of Arc Hydro tools that can be used apart from the system. Use them as such and enjoy.

- When starting an Arc Hydro project, think ahead about the system you will be building. Plan ahead, organize, then execute.

- You should keep the approach to Arc Hydro implementation simple. Ockham's razor is alive and well!

You may want to use the Arc Hydro mantra: "Analytical system, analytical system, analytical system . . .". Always consider how what you are doing fits into the system you are developing. Understand what was done before and what comes after the step you are working on.

3.0 Arc Hydro Tools Installation

When installing Arc Hydro tools:

- Arc Hydro's GeoNet home page will have links to the latest versions of Arc Hydro tools and specific comments related to the core version of the software (e.g. any required patches or service packs).

  o Go to community.esri.com/community/gis/solutions/arc-hydro/pages/overview.

- The Arc Hydro tool setup can change often. That does not mean that you need to upgrade each time a new setup is released—do it only if the changes are relevant to you (for a bug fix or for a new functionality that you would be using). If it ain't broke, don't fix it.

- Always uninstall old versions before installing new ones.

- Always check if there is a new release of Arc Hydro tools when upgrading to a new ArcGIS or service pack (SP) release. Do not assume that they are upward (or downward) compatible.

  o This is mostly the case between major core version updates, but sometimes SPs will need a separate version. Check Arc Hydro Installation—Versions and Documentation on the Arc Hydro GeoNet page for clarification on which Arc Hydro tools are compatible with which core version/SP combinations.

4.0 Data Organization

When organizing Arc Hydro data:

- Use a file geodatabase or special database engine (SDE) for vector data.

- Keep rasters out of the geodatabase.

- Do not use unprojected (geographic) data for analysis.

- Keep all the vector layers used in spatial operations and analytics in a single feature dataset. This recommendation has several corollaries (for analytical layers):

    o Do not use shapefiles.

    o Do not use data in different geodatabases.

    o Import data into a single feature dataset.

- Use the same spatial reference (projection) for raster and vector analytical data.

- Select the appropriate projection based on the analysis being performed (usually equal area or equal distance—something that minimizes distortions of the data that is relevant to the analysis).

- Note that layers used for mapping only, can be in different feature datasets or at the geodatabase level but have the same spatial reference as the one for analytical layers, if possible.

    o An exception is display layers that will be published on the web for display—in that case, use Web Mercator or a similar projection.

- Organize all the data for a project into a single parent folder if possible.

- Do not use the data over a network drive if possible. Instead, copy the data to the local machine, perform the analysis locally, then copy the data back to the central location.

    o The exception is if you have a specialized network drive with specialized network connection hardware.

- Use an internal hard drive (HD) if possible (not USB).

    o Use an internal solid-state drive (SSD) drive if possible.

- Note that if you are using default Arc Hydro geodatabase/feature dataset creation capabilities, you must make sure that the first function that will create the geodatabase/feature dataset is picking up the right input spatial reference (from either the input dataset or the map data frame).

- Observe that once the initial project database is assembled, you will need to carefully manage HydroIDs if any of the input layers have them (they might have to be recalculated). Make sure you adjust the HydroID dispenser field (LASTID) in the APUNIQUEID table.

- Set vertical units for the digital elevation model (DEM) if they are not the same as the horizontal units.

  o It is recommended to keep the horizontal and vertical units the same.

4.1 Naming Conventions

The following naming conventions should be followed:

- Keep the names of directories, geodatabases, layers, and attributes short.

  o Do not have too many nested subdirectories containing your project folder.

- Do not use spaces or special characters in any of the names. An underscore (_) is the only exception.

- Start names always with a letter, never with a number.

- Do not use reserved keywords for names. This includes SQL and ArcGIS commands.

- Develop a standard layer nomenclature and apply it consistently (e.g., starting all flow direction rasters with "fdr" followed by a descriptor of what flow direction is based on— "fil" stands for a filled DEM, so "fdrfil" is a flow direction derived from a filled DEM).

- Include the threshold in the name of the layer (e.g., include "str50k" to indicate a stream grid based on a threshold of 50,000 cells) if you are using a specific threshold and there is more than one in the project.

  o This is not a bad idea even when a single threshold is used in the project.

- Keep raster names to no more than 13 characters (although this is not required for non-Esri grid formats such as TIF).

4.2 Initial Database/MXD File Organization

Standard Arc Hydro database/project organization consists of the following (recommended, not required):

- A project folder that will contain all the project data and MXD files—This excludes base data that can be anywhere. The project folder will include:

  o A subfolder called Layers. This folder is used to store all the raster data. Note the following:

- The DEM is usually the starting point of the analysis. Copy the clipped DEM raster into this folder. Clipping should be based on the relevant project area of interest. Apply projection if needed. Apply vertical unit adjustments if needed.

- If other rasters are used as inputs, copy them into this folder as well. Apply projection if needed.

- Use input rasters that have the same cell size, extent, and snap layout as the underlying analytical raster (e.g., DEM and/or flow direction).

- A project geodatabase.

- A feature dataset called Layers is created within the geodatabase using DEM's spatial reference. The input vector data used in the project is imported into this feature dataset.

- A project MXD file. Give the MXD file the same name as the geodatabase (e.g., aaa.mxd if you have a file named aaa.gdb).

- Follow this workflow if starting from a DEM and using Arc Hydro tools to generate project geodatabase:

  - Open a new ArcMap map. Add the project DEM to it first, before any other layer (or basemap). This will set the spatial reference of the data frame to the spatial reference of the DEM.

  - Save the project using the same name you want to give to the geodatabase. Arc Hydro tools will create the geodatabase and the Layers feature dataset when needed—you do not have to do it yourself. This will happen when the first Arc Hydro function that generates a vector output is run.

If using ArcGIS Pro version of Arc Hydro tools, review the document Arc Hydro—ArcGIS Pro Project Startup Best Practices. It includes different alternatives in ArcGIS Pro for project startup that will establish a well-defined Arc Hydro project structure.

5.0 General Items

Following these guidelines will improve your Arc Hydro implementation experience:

- Leverage Arc Hydro's GeoNet home page to interact with the broader Arc Hydro user community (including Esri's Arc Hydro development and maintenance team).

- o Go to community.esri.com/community/gis/solutions/arc-hydro/pages/overview.

- Perform Arc Hydro geoprocessing analyses through ArcMap (not ArcCatalog).

- Save your ArcMap project often.

- Save after each major subtask.

- Do not have multiple ArcMap projects (or ArcCatalog) open at the same time.

- Note that if you need to use ArcCatalog, you should use it from within ArcMap if possible instead of starting a separate instance of ArcCatalog.

- Start a new Arc Hydro project only from a newly opened ArcMap session (that is, start a new instance of ArcMap).

- Background processing will in general allow processing of larger datasets, but not necessarily any faster. And it can cause some functions to malfunction. If in doubt, test the function in the background with a smaller dataset first and if it completes, run it on the larger dataset.

  - o You need to have 64-bit geoprocessing support installed for background processing to have any effect.

- When functions that generate new feature classes have been executed (creating domains in particular), it is good to save and close the project (close all instances of ArcMap and ArcCatalog running), and then reopen the project.

- Do not change project name (e.g., choosing the Save As option).

- Wipe out the logs often if you are doing a lot of geoprocessing and do not need them. Alternatively, turn logging off (suggested only when working on datasets that were previously tested).

- Perform occasional directory cleanup. Geoprocessing in general and Arc Hydro in particular generate a lot of temporary files that are stored in the %temp% system directory. Wipe that directory clean from time to time (delete all the files in there that you can after closing all the apps).

- Do not use a default ArcGIS geoprocessing target location to store your results—be explicit about where results are to be directed (your project directory and geodatabase).

- Be aware that some of the Arc Hydro functions need higher versions of licensing.

- Improve the performance of geoprocessing tools that generate many intermediate layers:

o   Turn off all the layers in the map (no data is displayed).

o   Go to ArcMap Options > General, then uncheck the option Make newly added layers visible by default.

6.0 Debugging and Workarounds

Things will go wrong.

- They will not go wrong often if you are following the suggestions above.

- There are several types of problems you will face, and each will require a different approach to identifying and fixing or working around it.

- There will be hardware problems. Lack of system memory and/or hard drive space will often either generate an ArcMap crash or a generic error message that will be difficult to interpret. If something used to work but does not now, check if available resources have changed (HD space or available memory).

- Some raster functions fail on large integer rasters but work on smaller ones. Try to increase the maximum number of entries a raster attribute table can have. Note that while this can increase stability of the system, it might also somewhat degrade its performance.

  o   If you have administrator access, you can use ArcMap Advanced Settings Utility (you need to be administrator to configure some settings) and increase the attribute limit under the Raster tab from the default 65,536 to 1,000,000. This application can be found in the Utilities folder in the ArcMap installation directory (e.g., typically for ArcGIS 10.5 it is C:\Program Files (x86)\ArcGIS\Desktop10.5\Utilities).

  o   If you do not have administrator access, you can change this setting in ArcMap options. Go to Customize > ArcMap Options > Raster > Raster Dataset, then modify the Maximum number of unique values to render value. Note that on the Raster tab, under Options, there are five subtabs. Scroll to the left if you do not see the Raster Dataset subtab initially.

- There may be problems caused by a raster dataset. Use the Copy Raster option to copy the raster dataset that might be causing problems. Then use this copy in your work. This might be needed with some rasters that were not developed using Esri software.

- Data problems result when your data is bad. Do not expect tools to work. Fix the data.

- Clear selection on a layer when you want to process everything within that layer.

- There will be data problems if your data is too big. Divide and conquer—split the dataset into smaller chunks and process it in parts. This might also speed up the overall processing time, as processing times are nonlinear (especially in the raster domain).

  - In many water resources applications, watersheds are natural chunks and make a good starting point when considering how to chunk up the data. In the USA, WBD/HUCs are a great starting point for AOI definition.

- Procedural problems will be minimized if you follow both the best practices presented here (e.g., steps for eliminating projection mishaps) and well-established Arc Hydro processing workflows.

- There might be some tool bugs, especially after the release of new core software or major service packs. If you identify any bugs, please let us know and we will fix them (often you will have to provide the data if we cannot reproduce the bug on our test datasets).

- Gremlins—things that used to work in an existing project and suddenly do not—are usually related to file locking issues. Try applying fixes in the following order:

  - Make sure you have enough HD space and working memory (if you are not running 64-bit processing/background, you are limited to how much memory is accessible for processing within an ArcMap session).

  - Make sure there is only one instance of ArcMap open (this includes ArcCatalog).

  - Make sure the source and target locations and the layer tags are all properly set.

  - Close ArcMap, then reopen it.

  - Close ArcMap and all other apps, delete the content of the %temp% directory then reopen the apps.

  - Close all apps, reboot, then reopen them.

  - Delete the MXD file. Create a new map, add the data, and configure the layers by choosing Data Management. Set target locations by choosing Set Target Locations.