# Watershed and Stream Network Delineation Exercise
# Synopsis of Class 10, GIS in Water Resources

The purpose of this exercise is to illustrate watershed and stream network delineation based on digital elevation models using the Hydrology tools in the ArcGIS Geoprocessing toolbox. In this exercise, you will perform drainage analysis on a terrain model for the San Marcos Basin. The Hydrology tools are used to derive several data sets that collectively describe the drainage patterns of the basin. Geoprocessing analysis is performed to recondition the digital elevation model and generate data on flow direction, flow accumulation, streams, stream segments, and watersheds. These data are then be used to develop a vector representation of catchments and drainage lines from selected points that can then be used in network analysis. This exercise shows how detailed information on the connectivity of the landscape and watersheds can be developed starting from raw digital elevation data, and that this enriched information can be used to compute watershed attributes commonly used in hydrologic and water resources analyses.

**Learning objectives**

- Identify and properly execute the geoprocessing tools involved in DEM reconditioning.
- Describe and quantitatively interpret the results from DEM reconditioning as a special case of quantitative raster analysis.
- Construct profiles using 3D Analyst.
- Create and edit feature classes.
- Identify and properly execute the sequence of Hydrology tools required to delineate streams, catchments and watersheds from a DEM.
- Evaluate and interpret drainage area, stream length and stream order properties from Terrain Analysis results.
- Develop a Geometric Network representation of the stream network from the products of terrain analysis.
- Use Network Analysis to select connected catchments and determine their properties.
- Do a watershed delineation using an online hydro base map and geoprocessing services.

**Synopsis**

The exercise is divided into the following activities:

1. DEM Reconditioning
2. Hydrologic Terrain Analysis
3. Network analysis
4. Online watershed delineation

**DEM Reconditioning**

DEM reconditioning is a process of adjusting the DEM so that elevations direct drainage towards the vector information on stream position, that in this case is the blue line stream features obtained from NHDPlus. DEM reconditioning is only suggested when the vector stream information is more reliable

than the raster DEM information. This may not be the case here, but reconditioning is done nevertheless to illustrate the process. DEM reconditioning as done here involves a sequence of ArcGIS geoprocessing functions. The strategy is to first convert vector stream features to a raster dataset of grid cells on the streams that has exactly the same dimensions (rows, columns, cell size) as the DEM raster. This exposes you to a number of new geoprocessing tools (Feature to Raster, Greater Than, Reclassify) as well as Environment Settings to control raster cell size, extent and snapping. Then the Euclidean distance from each grid cell to the nearest stream is calculated and a Map Algebra expression used to perform the reconditioning which involved lowering the elevation of all grid cells along the streams by 20 units and grid cells near the streams by a value that tapers from 10 to 0 units based on the distance from 0 out to 500 units. The results are then visualized using 3D Analyst. By doing this you get some experience using the ArcGIS geoprocessing tools to derive new spatial data from the original DEM and vector streams and a small glimpse into the powerful geospatial analytical capability that these functions enable.

**Hydrologic Terrain Analysis**

This activity will first guide you through the hydrologic terrain analysis steps of Fill Pits, calculate Flow Direction, and calculate Flow Accumulation. The resulting flow accumulation raster then allows you to identify the contributing area at each grid cell in the domain, a very useful quantity fundamental to hydrologic analysis. Next an outlet point and cell will be created and used to define a watershed as all cells upstream of the outlet. Focusing on this watershed, streams will be defined using a flow accumulation threshold within this watershed. Hydrology functions will be used to define separate links (stream segments) and the catchments that drain to them. Next the streams will be converted into a vector representation and more Hydrology toolbox functionality used to evaluate stream order and the subwatersheds draining directly to each of the eight stream gauges in the example dataset. The result is quite a comprehensive set of information about the hydrology of this watershed, all derived from the DEM.

**Network Analysis**

Some of the real power of GIS comes through its use for Network Analysis. A Geometric Network is an ArcGIS data structure that facilitates the identification of upstream and downstream connectivity. Here we step through the process of creating a geometric network from the vector stream network representation obtained above, and then use it to determine some simple aggregate information such as length and contributing area of parts of the stream network. This serves to expose you to some of the analysis enabled by having a geometric network.

**Watershed Delineation Online**

A current trend in GIS is the transition from desktop analysis to analysis online in a cloud environment. Watershed delineation is executed as a GIS processing service to define a watershed from a point location on the stream network. To help you know where the streams are, ESRI has developed a global online hydro reference map of the world's rivers. You'll delineate the watershed of the San Marcos Basin and compare some of its properties with those you've derived in earlier exercises.