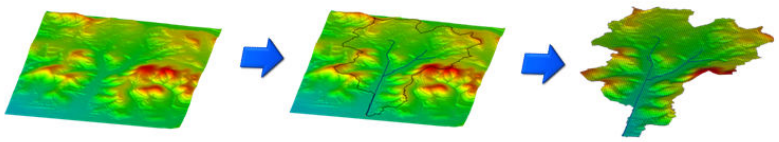
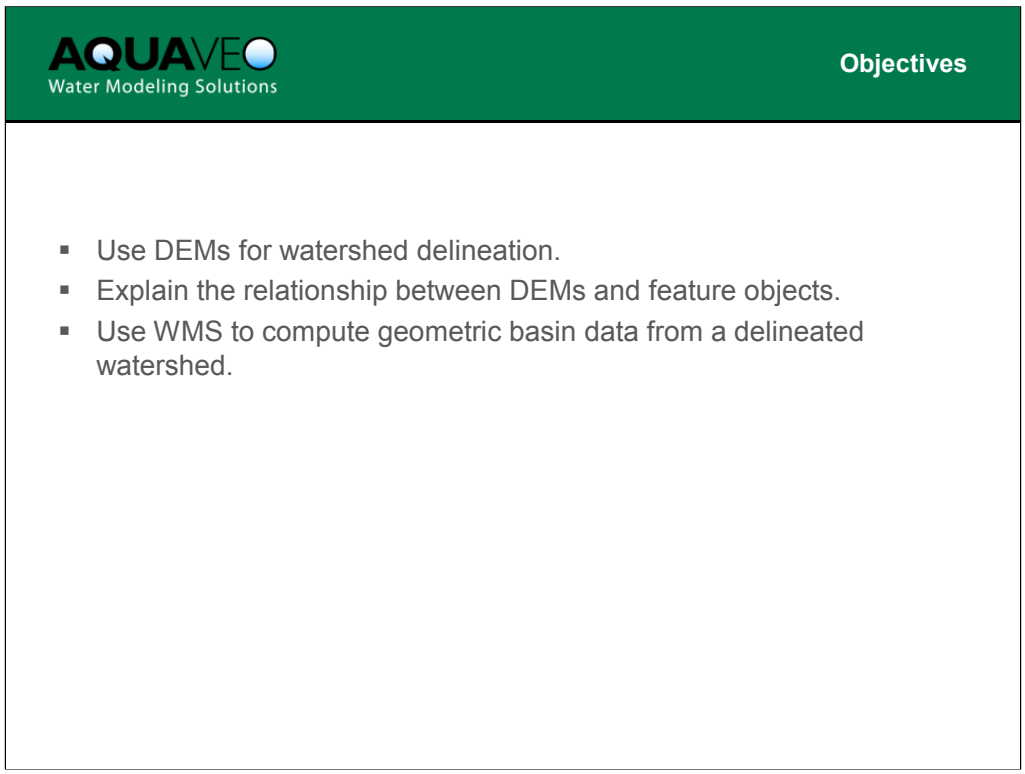
AQUAVEO
Water Modeling Solutions

Watershed Modeling With DEMs

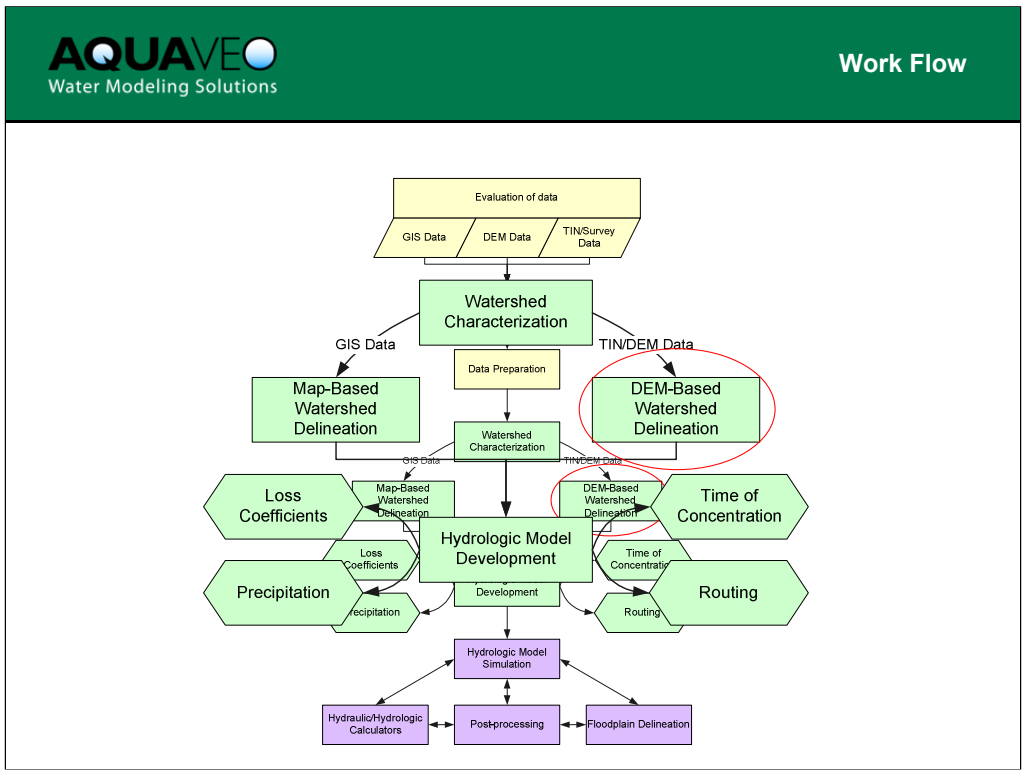
Lesson 6



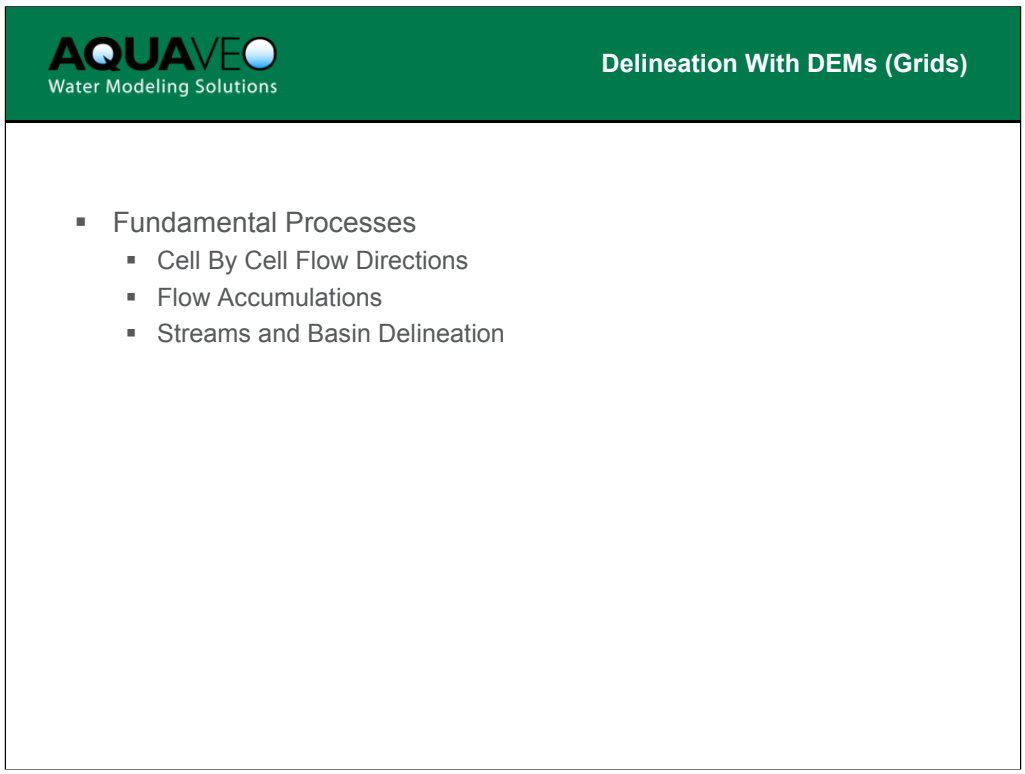


Upon completion of this module, participants will be able to:

1. Use DEMs for watershed delineation.
2. Explain the relationship between DEMs and feature objects.
3. Use WMS to compute geometric basin data from a delineated watershed.

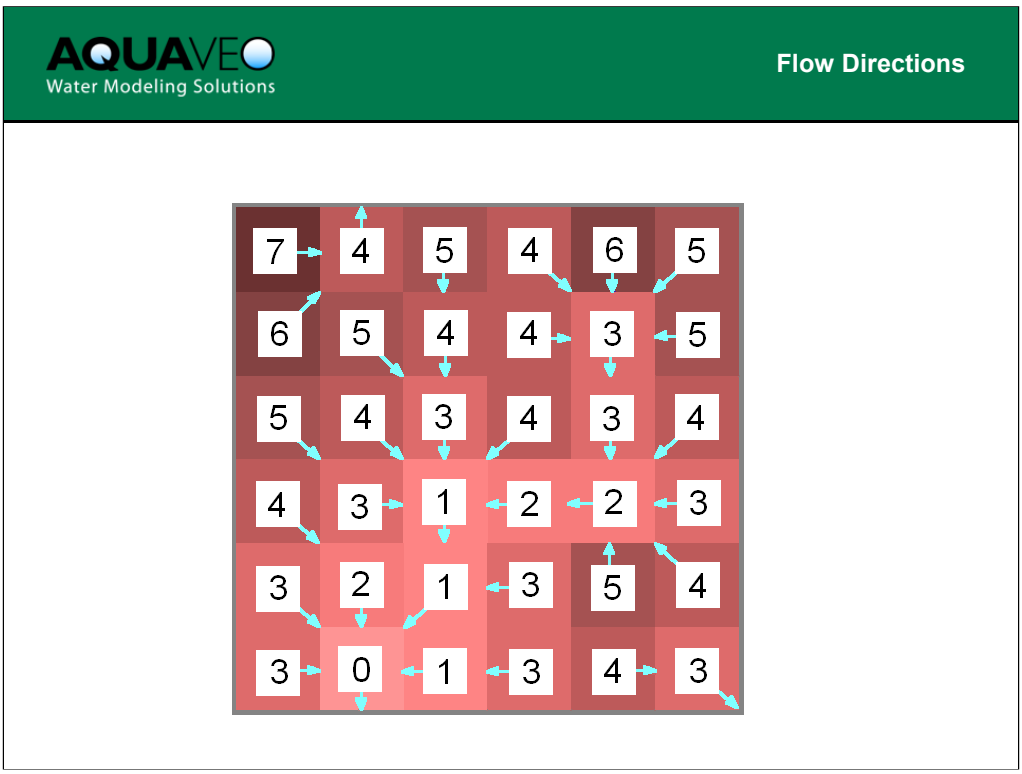


This lesson focuses on DEM based watershed delineation. You can see where it fits into the WMS work flow process from the chart above.



Three basic concepts are fundamental to watershed delineation from a DEM. An understanding of each of these is essential to follow the delineation process in WMS.

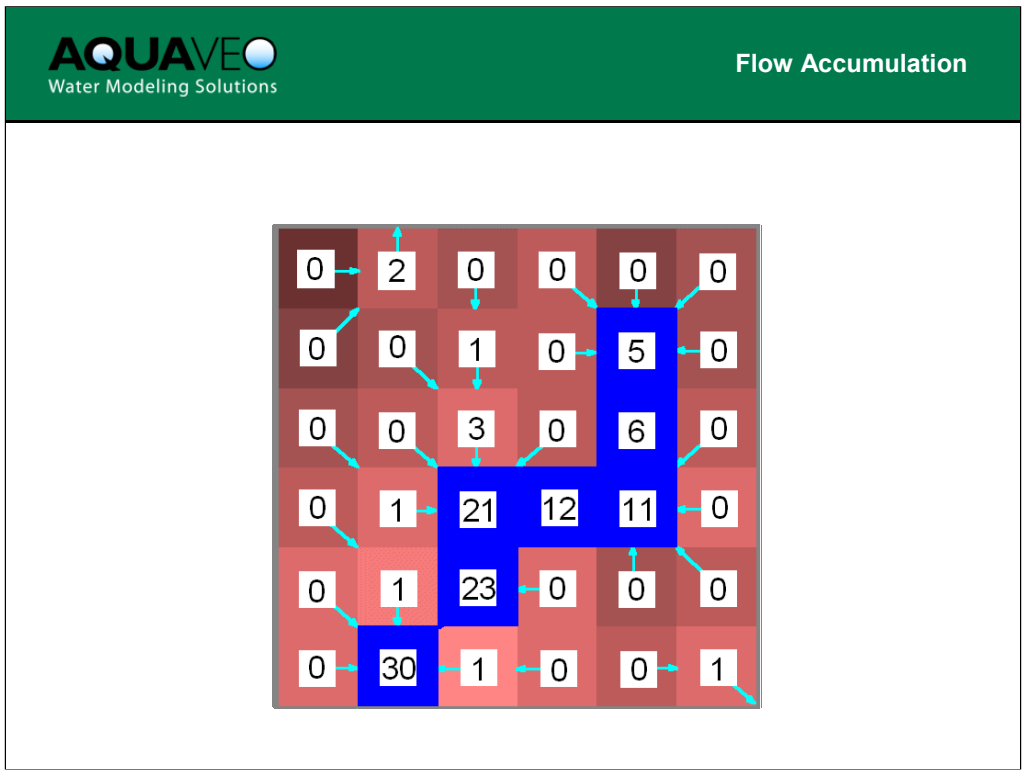
Each of these concepts will be discussed in detail in the following slides.



The flow direction of each grid cell must be determined so that we can tell where water will flow on a DEM. The basic idea behind assigning a flow direction is to determine which of the eight neighboring cells has a lower elevation (the numbers in the figure above represent elevation) and then assign the flow direction to that cell (coded as an integer value in the flow direction grid). Actually, there are many subtleties that make the determination of flow directions more complex than described above:

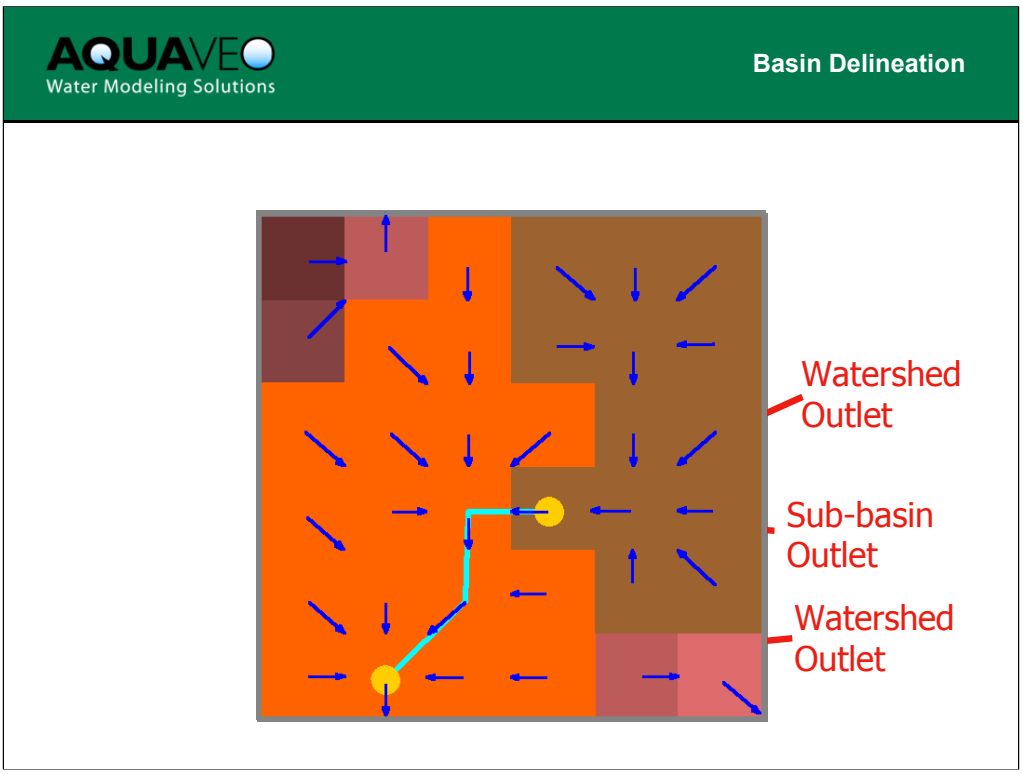
- Pits
- Multiple neighbors with the same elevations
- Flat areas

In the end each cell must have a flow direction before any hydrologic analysis can be done using a DEM. Thus, tools have been developed to compute flow directions – TOPAZ is a program that is the primary tool in WMS, but ARC/INFO and other GIS programs have tools to compute flow direction grids as well.

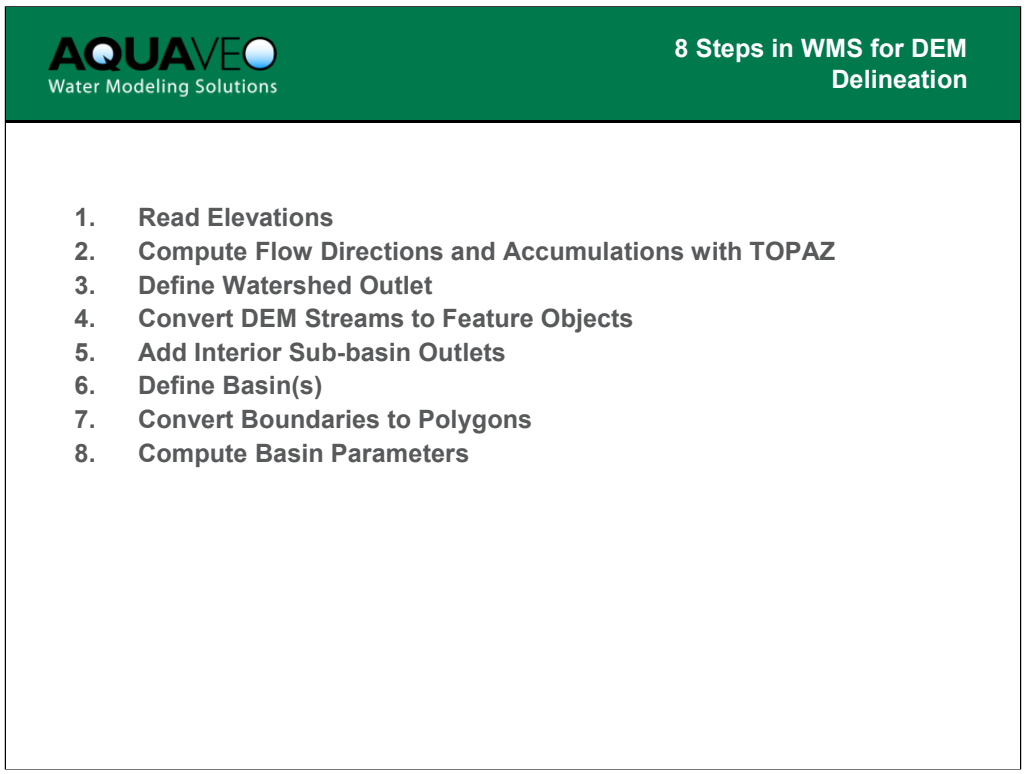


Flow accumulation tells us how much contributing area each cell has (the number of cells contributing times the area of a given cell). The cells that have high flow accumulation areas are possible stream cells on the DEM. Of course this is an empirical value since "high" is relative to the size of the watershed. You should remember that the flow accumulation only represents where streams are likely and not necessarily where a stream will occur.

Flow directions must be computed before flow accumulations can be calculated.



Basin delineation is performed by analyzing flow directions in combination with outlets and streams. A flow path from the center of each cell is traced until it hits a stream (or outlet directly) or the edge of the DEM. Those that flow to a stream and therefore outlet are assigned to a basin and those that hit the edge of the DEM are assigned no basin. Cells not in a basin are referred to as the NULL basin.

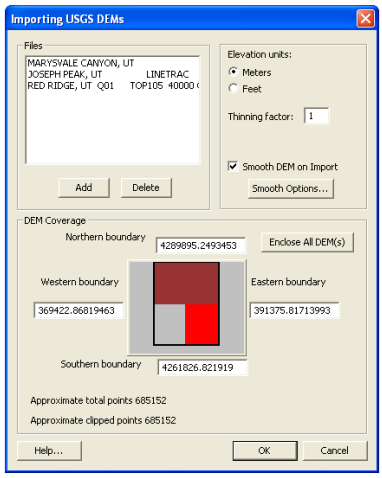


Because the DEM method is so straight-forward, you can use the following outline to delineate most watersheds.

AQUAVEO
Water Modeling Solutions

1. Read Elevations

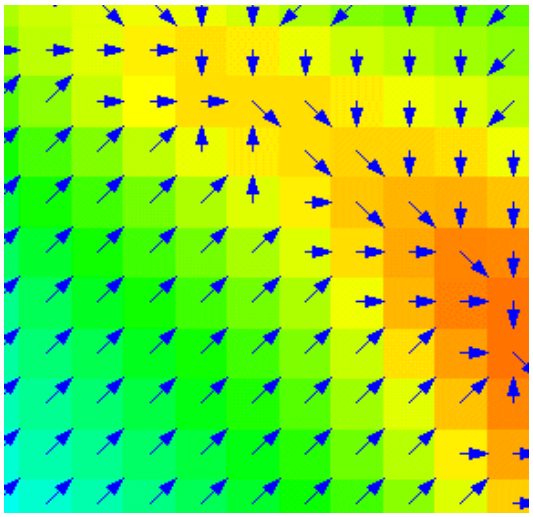
NED, USGS, ARC/INFO, or any supported format



Any of the DEM file types can be used. The DEM is automatically smoothed when it is imported in order to remove artificial, "stair-step" roughness.

AQUAVEO
Water Modeling Solutions

2. Compute TOPAZ Flow Data – Flow Directions

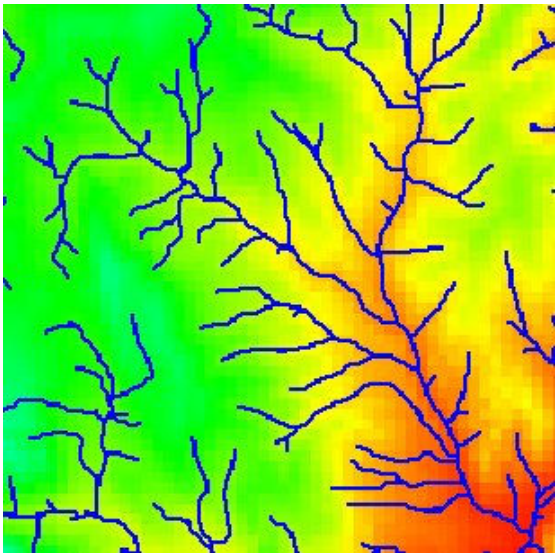


This is the primary purpose of running the TOPAZ program. The flow direction grid exported from TOPAZ is called flovec.dat.

Flow directions may also be imported from ARC/INFO. WMS will automatically read in the Flow Directions once they have been computed by TOPAZ.

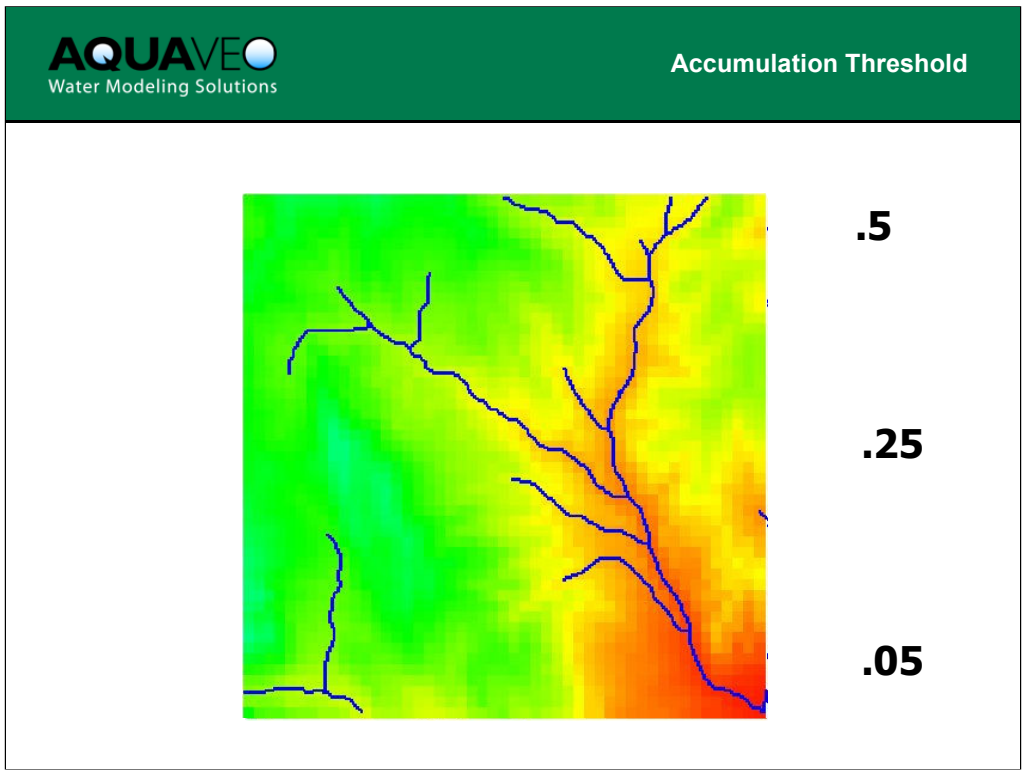
AQUAVEO
Water Modeling Solutions

2. Compute TOPAZ Flow Data - Accumulations



The flow accumulation grid allows the visualization of possible streams on the DEM.

TOPAZ will compute flow accumulations and export the grid to uparea.dat. Alternatively, flow accumulations may be imported from ARC/INFO or computed in WMS once flow directions have been imported. WMS will automatically read in the Flow Accumulations once they have been computed by TOPAZ. While the TOPAZ uparea.dat file indicates the number of grid cells, WMS will evaluate it by area so that streams can be defined relative to the size of the watershed, independent of the DEM cell resolution.

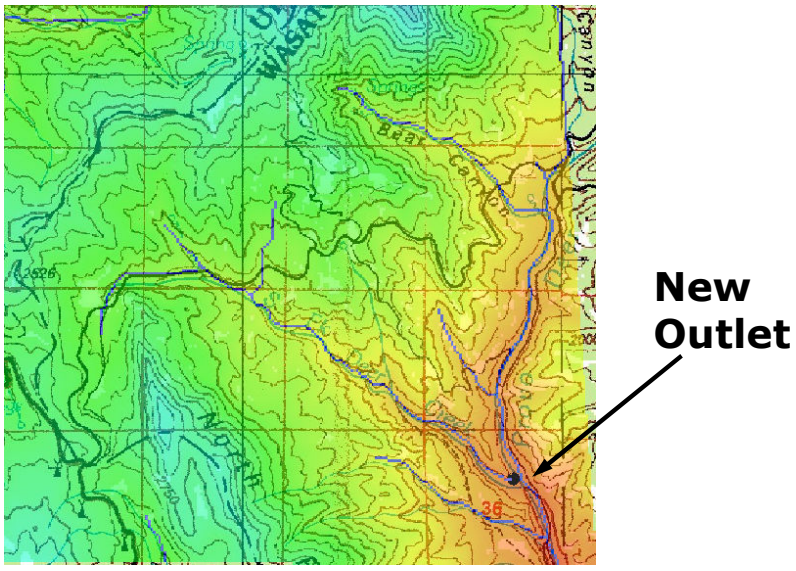


Accumulation threshold is a display option that determines how extensive the stream network will be when displayed as flow accumulations.

This same display threshold is used when converting flow accumulation cells to streams (feature objects). The threshold is based on the total upstream area that contributes to a given cell, so that it is independent of cell size.

AQUAVEO
Water Modeling Solutions

3. Define Watershed Outlet

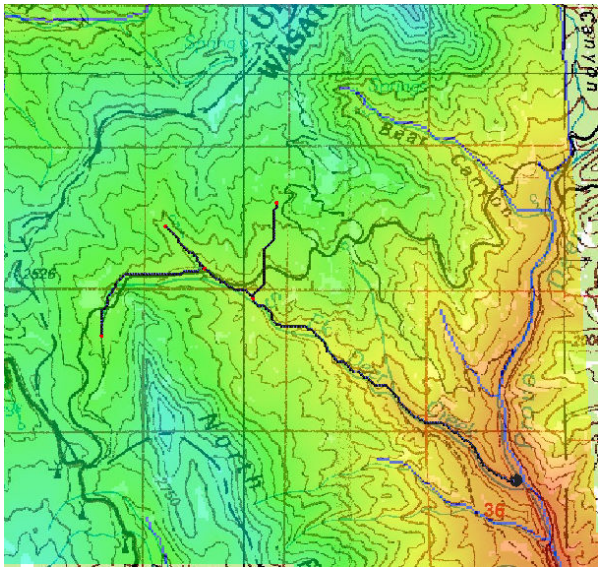


The outlet determines the most downstream point to be considered part of the watershed.

Some map module tools (such as create and select outlet points) appear in the Drainage module, but when used from the Drainage module they always define watershed attributes by default. Points are outlets, lines are streams, and polygons are basins. When creating a feature point in the Drainage module, points are automatically defaulted to be outlets, and they will attempt to snap to the nearest flow accumulation cell in order to ensure that they are within a "stream." If WMS does not find the nearest flow accumulation cell, you will get a warning message.

AQUAVEO
Water Modeling Solutions

4. Convert DEM Streams to Feature Objects



The accumulation threshold display option determines the complexity of the network to be displayed, but also serves as the default when converting the DEM based stream into a vector stream during this step.

When converting the DEM based streams to a vector representation two different options are available:

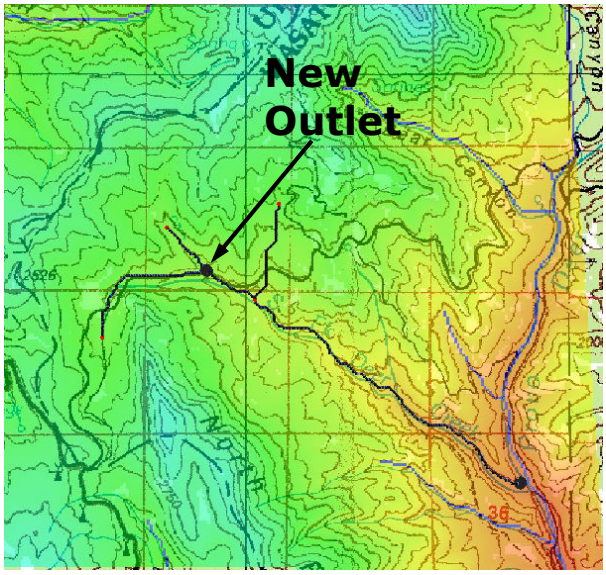
• The DEM based stream will be converted to a vector representation only from pre-defined outlet point(s) (this is the option illustrated in the above slide).

• All locations where DEM flow accumulation cells cross the DEM boundary.

In practice, the first option will almost always be used.

AQUAVEO
Water Modeling Solutions

5. Define Interior Outlets

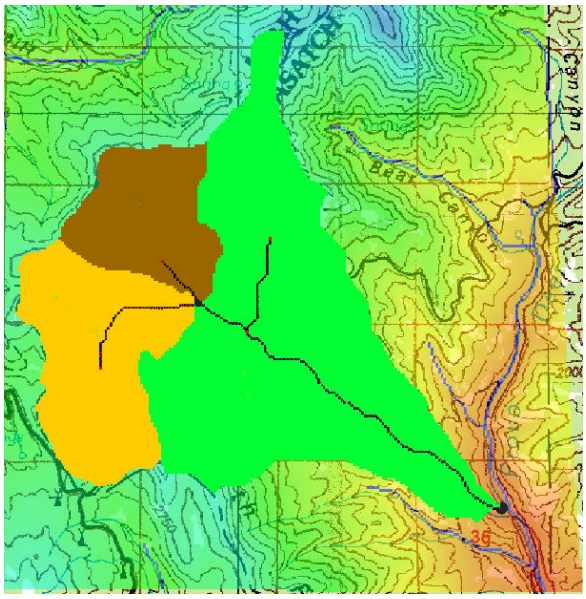


Interior outlets allow the creation of smaller sub-basins in a watershed. If you place an outlet point at the branching point of a stream, a sub-basin will be created for each branch.

To create new outlet points select nodes or vertices (already a part of the stream network feature objects) you want to convert to outlets and choose Node <-> Outlet from the DEM Drainage menu.

AQUAVEO
Water Modeling Solutions

6. Define Drainage Basins

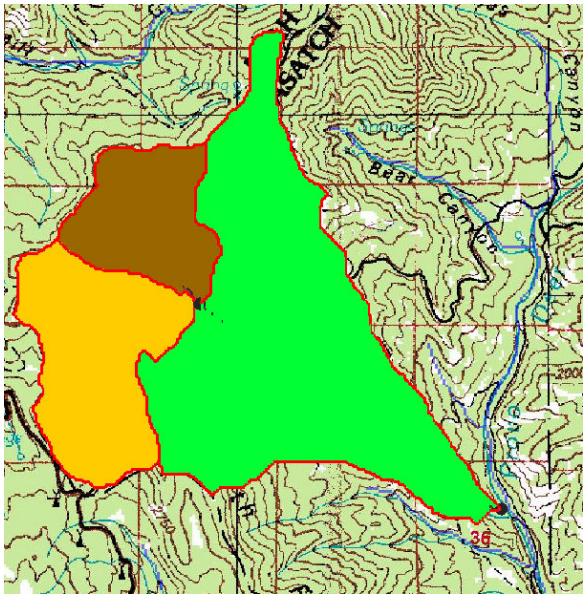


Drainage basins are determined from defined feature streams. Each DEM cell that flows to a feature stream is classified as a basin cell.

Defining basins by aggregating all cells that flow to a given outlet point is an intermediate representation. Ultimately the boundary cells will be converted to polygons.

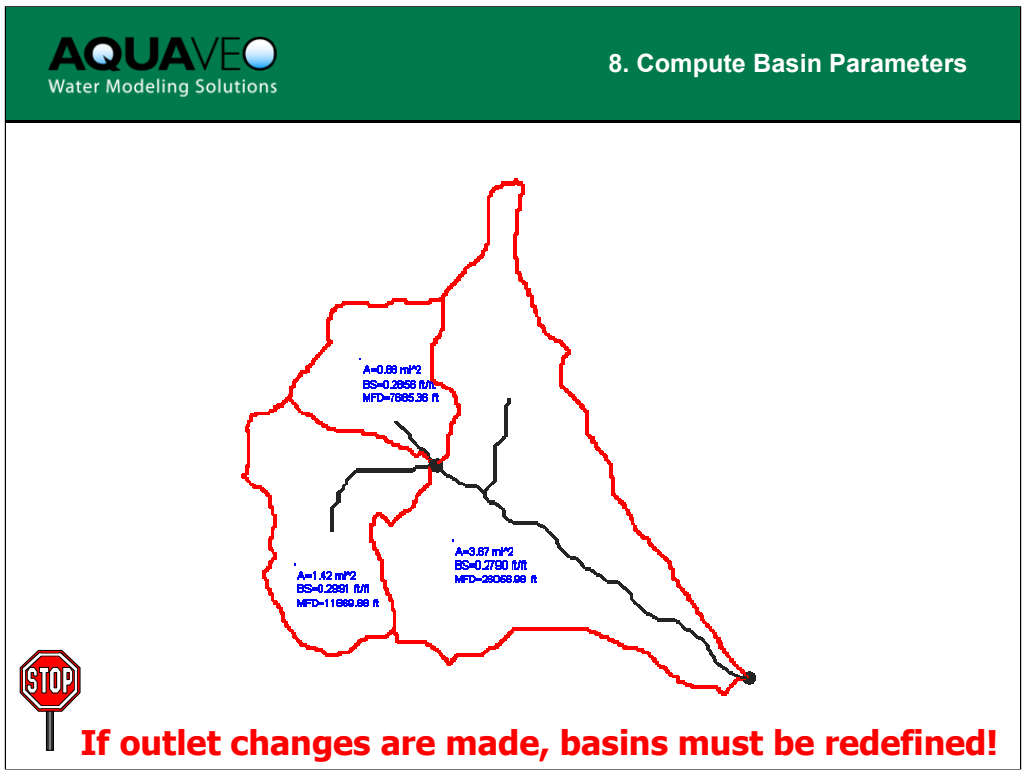
AQUAVEO
Water Modeling Solutions

7. Convert Boundaries to Polygons



This operation is performed because a single polygon representing each basin is much more efficient for storage than a raster (gridded) basin.

To accomplish this task, basin boundary cells (cells that are a part of a basin but adjacent to a cell that is part of a different basin or outside of the watershed completely) are converted to feature arcs, then drainage polygons are created from the bounding arcs.

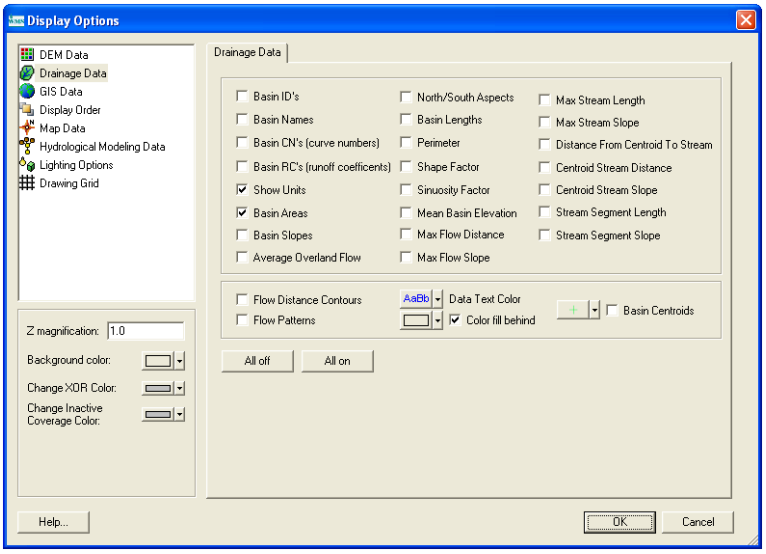


Hydrologic watershed parameters (area (A), slope (BS), maximum flow distance (MFS), stream lengths, etc.) are computed from DEM elevations and flow directions. These computed parameters are then stored with the drainage polygons.

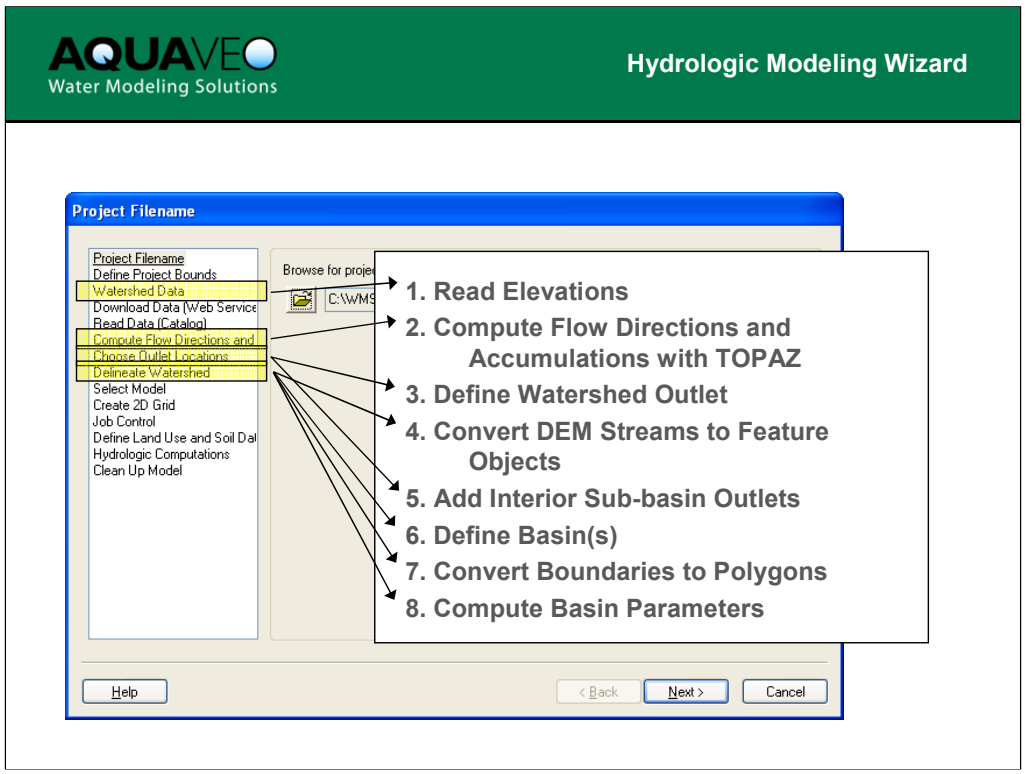
Note: If changes are made (outlets added/removed or moved), drainage basins must be redefined and converted to polygons. Then parameters should be recomputed.

AQUAVEO
Water Modeling Solutions

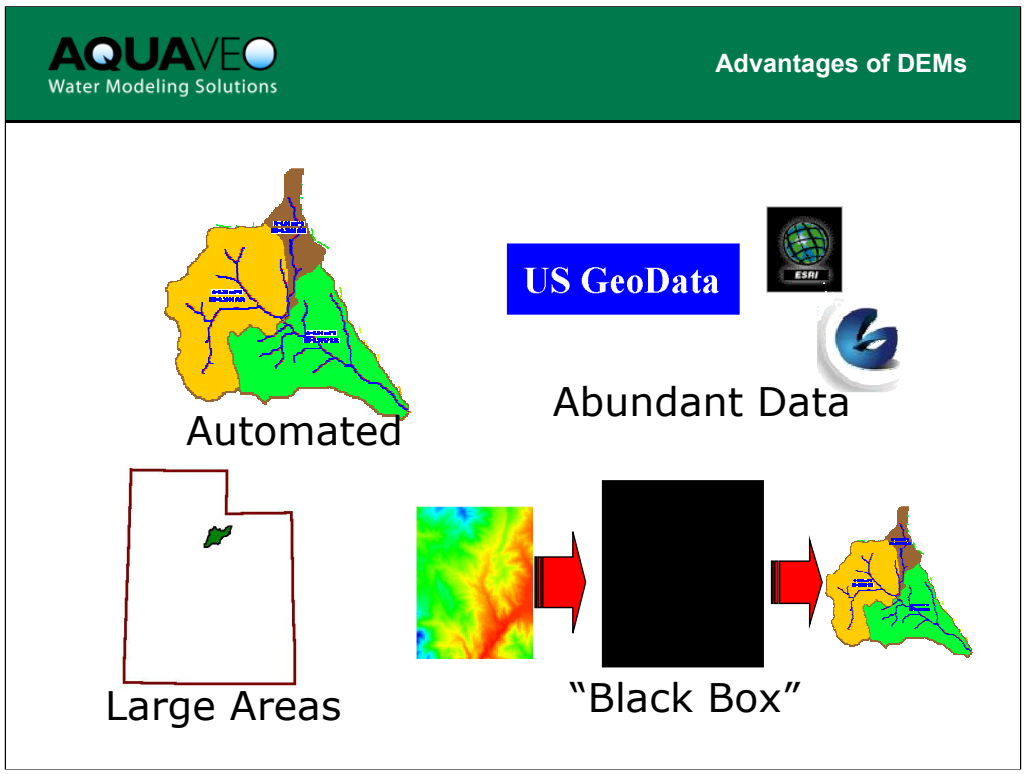
Geometric Computations



After computing basin data WMS will display the drainage area, but there are many other parameters computed that are useful for developing parameters of hydrologic models. The dialog shown in this slide is part of the Display Options and can be used to turn the display of any of these parameters on. Many of these parameters are used in empirical equations for computing lag time and time of concentration.



Use the Hydrologic Modeling Wizard to guide you through the eight steps of DEM watershed delineation.



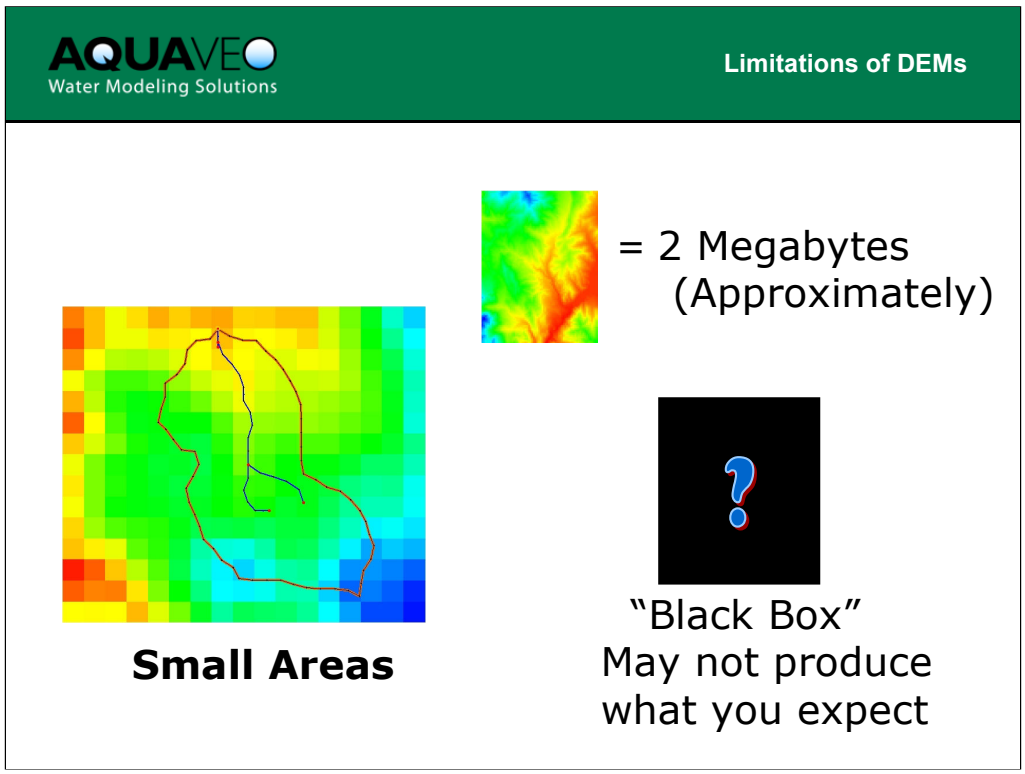
The most important question that needs to be answered at this point is why would we want to use a DEM for basin delineation in the first place? To answer that question we should examine the relative advantages of using DEMs.

• Important watershed parameters are computed automatically in WMS when using a DEM for basin delineation.

• Data in DEM format is available from several sources. The US GeoData website provides DEM data for the entire US in a few scales and formats. Data may also be created and exported from GIS software.

• DEM data are good for delineation of large areas where small variations in flow patterns are insignificant.

• Delineation in WMS from a DEM is mostly automated, requiring little interaction. DEM delineation is organized as a "black box" procedure with very specific steps and not much variation; thus, to delineate a watershed from raw DEM data is fairly quick and easy.



Despite the ease of using DEMs, some limitations must be understood to effectively model a watershed with gridded data.

These limitations include:

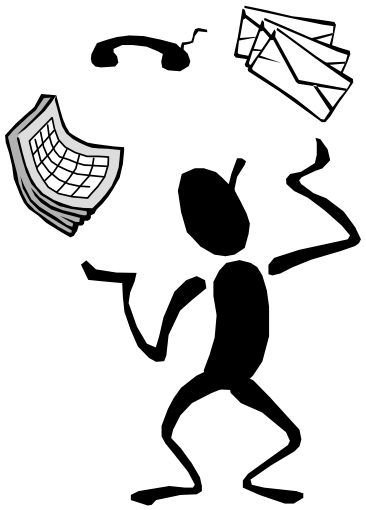
• In small areas, resolution of the DEM may not be sufficient to represent the flow direction variation.

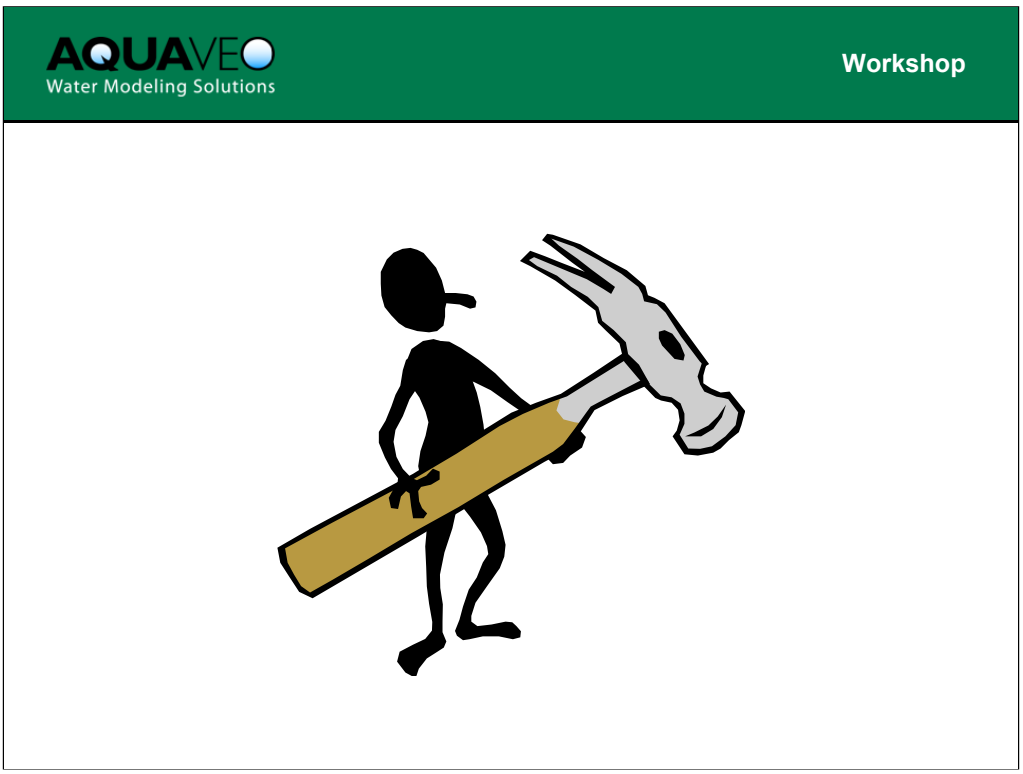
• The rigid data structure of a DEM can require a lot of memory. A typical 7.5 minute DEM from US GeoData is 1-2 megabytes.

• Watershed delineation with DEMs is rigid – as the user you have little control over what happens inside the "black box". You may not get exactly what you expect from a DEM and it is hard to alter the results of the delineation. Although with some of the new editing tools this is less of a problem as it has been historically.

AQUAVEO
Water Modeling Solutions

Demonstration





The files that will be used for this workshop can be found in the tutorials directory in the folder named **demdelin**.

AQUAVEO
Water Modeling Solutions

Review & Discuss

- Objectives
  - Use DEMs for watershed delineation.
  - Explain the relationship between DEMs and feature objects.
  - Use WMS to compute geometric basin data from a delineated watershed.
- Applications