WORKING WITH GRCA DIGITAL ELEVATION MODELS (DEM)

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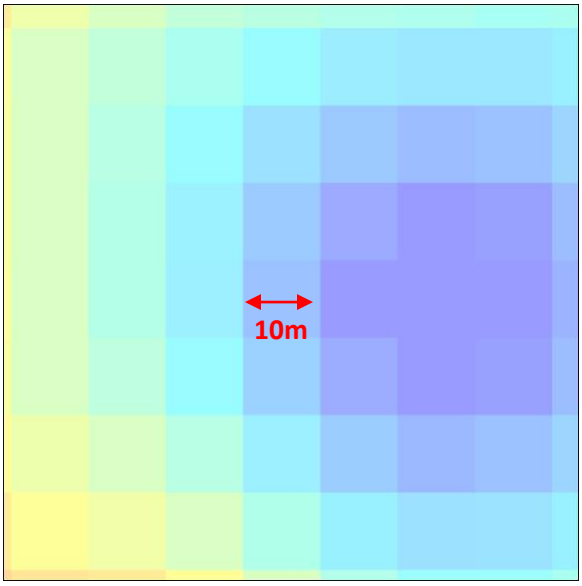
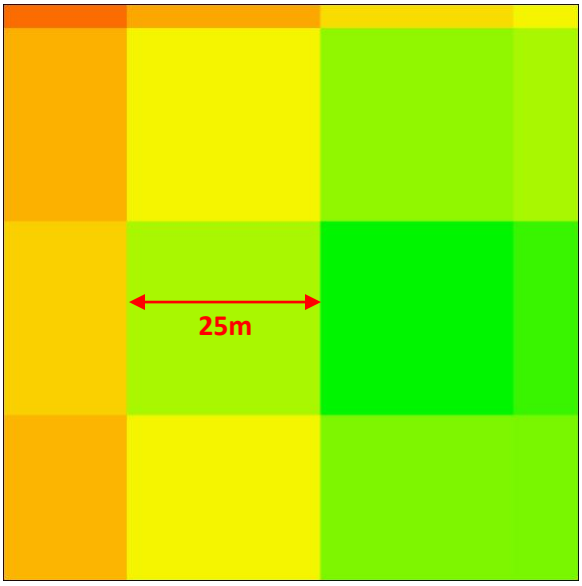
Step 1: Determine Which GRCA DEM is Best for You

The Grand River Conservation Authority maintains Digital Elevation Models in two resolutions: one 10m raster and one 25m raster. These resolutions indicate the size of each raster cell: in the 10m raster, each cell is 10m square; in the 25m raster, each cell is 25m square. To illustrate this difference, the images below each show the same 75m-square area:





Which DEM you should use depends on your needs and your computer's processing capacity. If your study area spans the entire GRCA jurisdiction, the 25m DEM will be adequate – but if your computer can handle it, perhaps the 10m DEM will yield better results. If your study area spans only a small area of the GRCA jurisdiction, use the 10m DEM.

Step 2: Clipping your DEM to a Smaller Area (Optional)

Occasionally, users of GRCA DEMs may need the DEM for only a small portion of the GRCA jurisdiction. In these cases, users may wish to clip the DEM to a smaller area for any number of reasons – to save disk space, to reduce geoprocessing time, or to make analysis results more manageable, for instance.

While clipping DEMs may be advantageous to the user in certain circumstances, care should be taken: clipping a DEM too closely to a study area *could* have negative implications on your analyses. Do try to capture the study area, as well as a 'buffer' around the study area to ensure ArcMap – and the eventual recipient of the analysis – has some context in which to perform and interpret the analyses.

There are two routes you may choose to take in clipping a DEM. You may either (a) permanently clip the DEM, or (b) only clip derivative products. Both routes are outlined below.

Route A: Clipping the DEM Permanently

To clip the DEM permanently to a specific area, in ArcMap, ensure the DEM and some polygonal clip feature are both in the table of contents. In the example presented below, the GRCA 10m DEM will be clipped to the municipal boundary of the Region of Waterloo, as shown below.

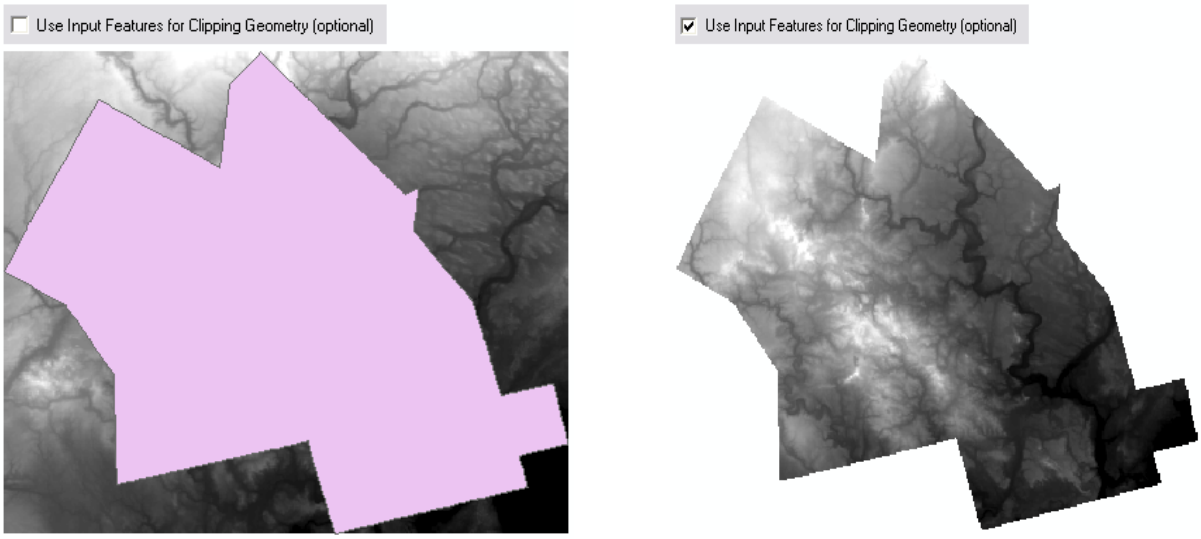
This route is most appropriate if you want the DEM clipped permanently, of course, but also if you intend to do your analysis over a long period of time, on different computers, or just in different ArcMap sessions or instances. This route is also most appropriate if you prefer to work with ArcCatalog or ArcToolbox.

In ArcMap, open ArcToolbox, then expand the '*Data Management*' toolbox. Open the '*Raster*' toolset, then expand the '*Raster Processing*' toolset. Open the '*Clip*' tool.

In the 'Clip' dialogue box, set the '*Input Raster*' to your converted or mosaicked DEM.

Set the '*Output Extent*' to your polygonal clip features, OR enter four bounding co-ordinates, in metres, in the appropriate UTM zone. If you're using a polygon feature class as the Output Extent, the bounding co-ordinates will automatically be filled in for you.

If you are using a polygon feature class as the Output Extent, you will be presented with the option to '*Use Input Features for Clipping Geometry.*' The following images illustrate the effect of this option:



If you leave the checkbox unchecked, the DEM will be clipped to the rectangular extent of the polygon feature class. If you check the checkbox, the DEM will be clipped to the extent of the polygon(s).

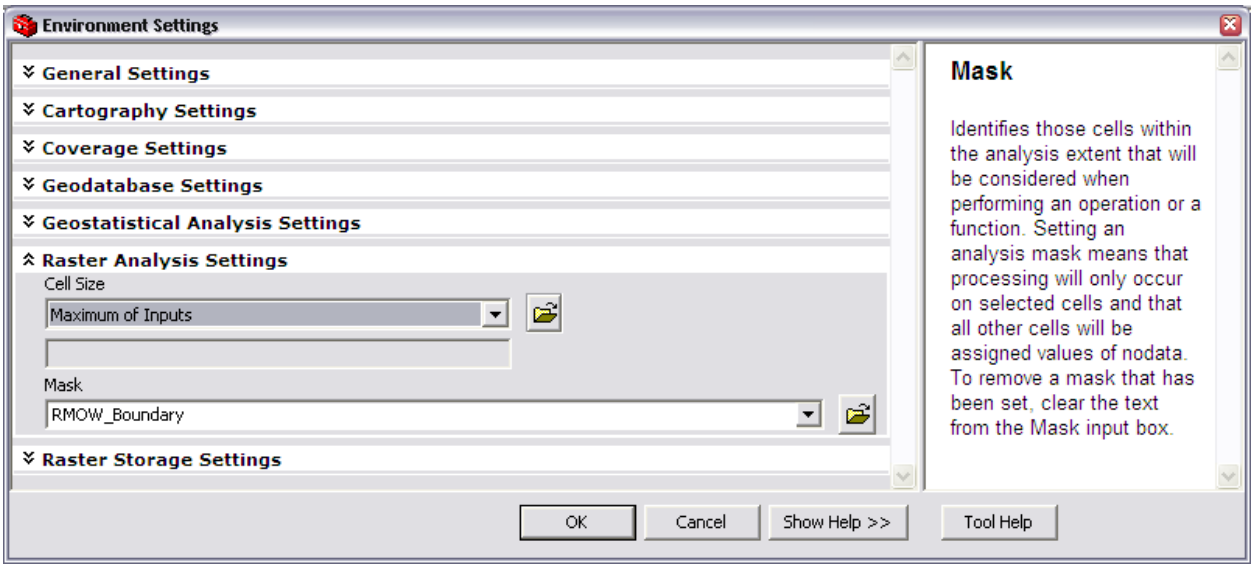
Assign an appropriate output location, file name, and extension, as described earlier, then click 'OK.' The clipped DEM will be added to your map automatically.

Route B: Clipping Only Derivative Products

Through this route, the input DEM is not clipped at all, but derivative products – for instance, slope or curvature rasters – will be clipped to the area you specify. This route is *not permanent* but session-based, and can only be used in ArcMap: meaning every time you open ArcMap to work with this DEM, you will have to run through this process again.

In ArcMap, open the '*Tools*' menu, and click '*Options*.' Navigate to the '*Geoprocessing*' tab, and click the '*Environments*' button.

In the Environments dialogue box, expand the 'Raster Analysis Settings' option. In the '*Mask*' drop-down menu, select the polygon feature class you wish to use as your analysis mask, as shown below:



Keep in mind that by setting these Environments, you affect every ArcToolbox tool: any analysis performed on any raster will be clipped to this Mask. You must remove this setting, either by going back in to the Environment Settings or by exiting and re-opening ArcMap, if you no longer wish to apply this Mask.

Deriving a Slope Raster from a DEM

Recall that a DEM is a raster dataset containing an elevation value for each of its cells. The first derivative of a DEM, then, is the change in elevation: slope. Slope rasters can be calculated in ArcGIS using either ArcToolbox or the Spatial Analyst toolbar. This tutorial explains only how to calculate a slope raster using ArcToolbox. The resultant raster contains a slope value for each cell, either as Percent Rise or Degrees.

In ArcToolbox, expand the '*Spatial Analyst Tools*' toolbox, then expand the '*Surface*' toolset. Open the '*Slope'* tool.

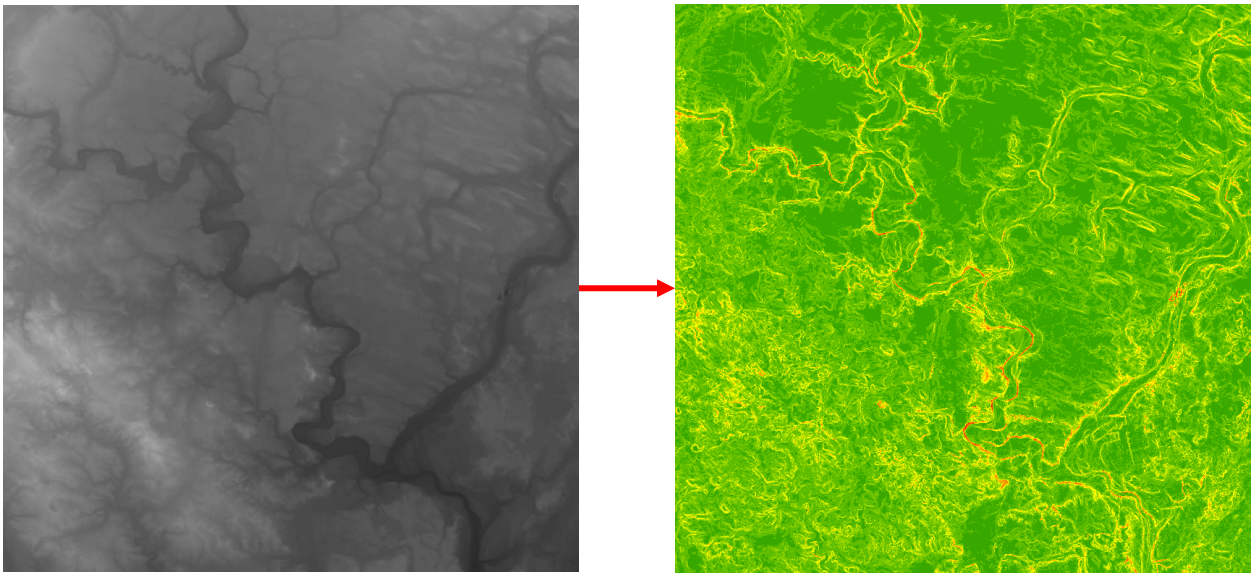
Set the '*Input Raster*' to your clipped or complete GRCA DEM.

In the '*Output Raster*' textbox, enter an appropriate location, name, and file extension for your Slope raster. Acceptable file extensions are *.img* for ERDAS IMAGINE images, or *.tif* for GeoTiffs, or no extension for GRIDs.

Select your desired '*Output measurement*' – either Degrees or Percent Rise. Degrees is the default. Percent Rise is calculated as *Rise/Run*; Degrees is calculated as *Θ(Tan) * Rise/Run.*

Leave the Z-Factor as 1. This Z-Factor is intended to compensate for differences in units of measurement between the ground and the elevation. Since our linear units are Meters, and our elevations are also in Meters, there is no compensation necessary. If our elevation was measured in feet, and our linear units in meters, for example, we would need to enter a Z-Factor of 0.3048 – because 1 foot = 0.3048 meters.

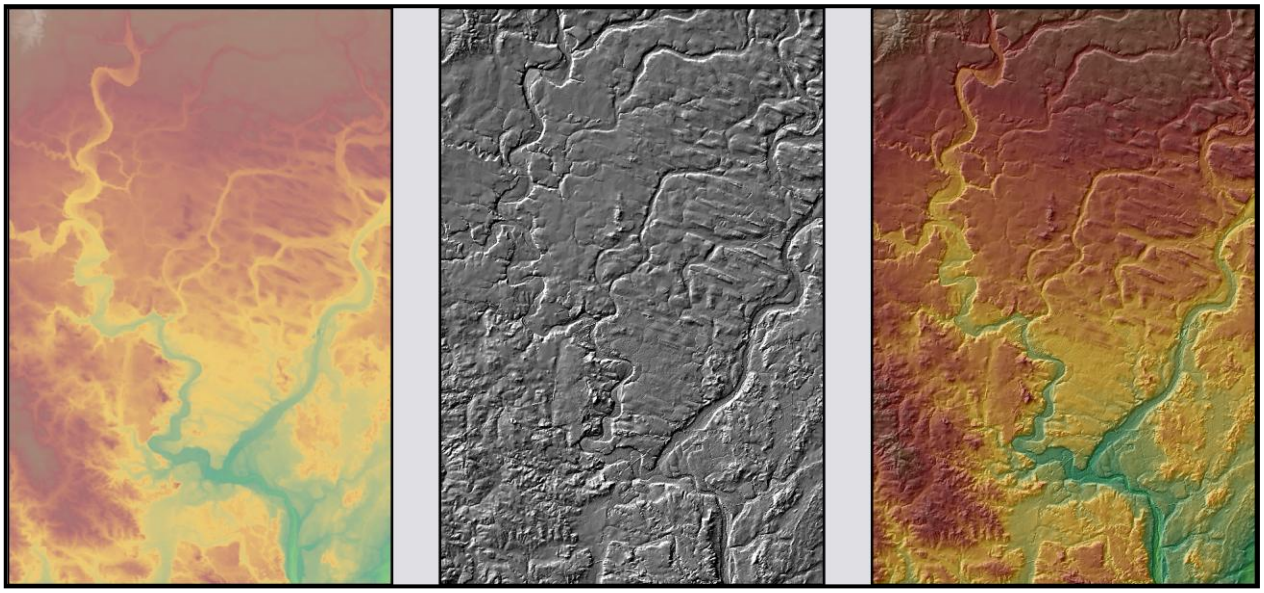
Click '*OK*' to begin calculating the slope raster. The resultant slope raster will automatically be added to ArcMap's display.



DEM **Slope**

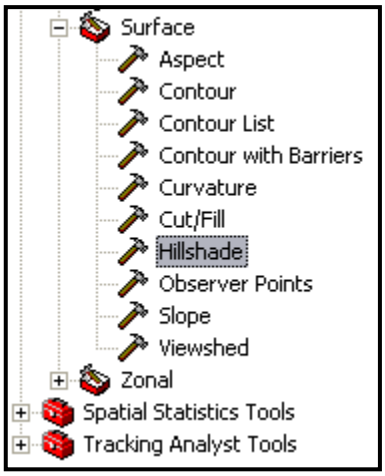
Deriving a Hillshade Raster from a DEM

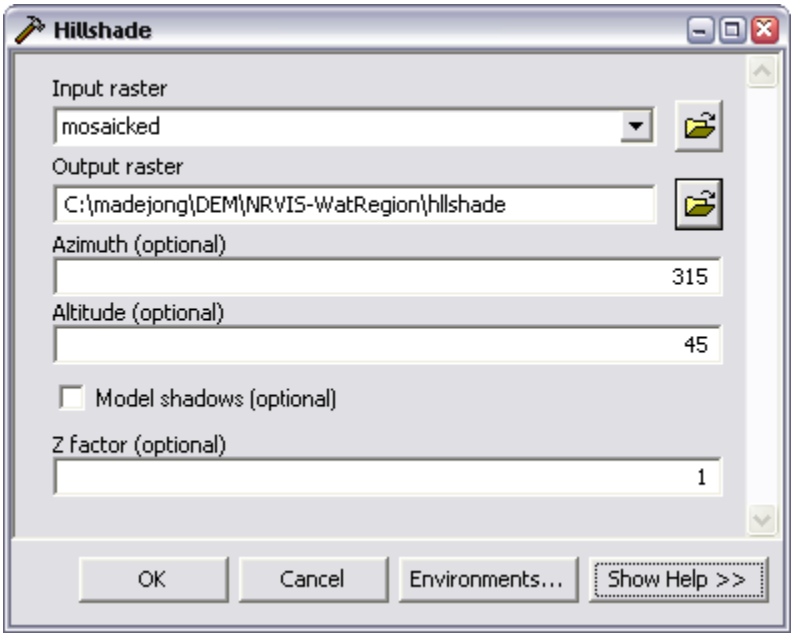
A Hillshade Raster is a hypothetical illumination of a surface which can be used to enhance the visualisation of a surface for analysis or graphical display. To produce a hillshade raster, a hypothetical 'sun' or light source is used to calculate the illumination and shadow values of each raster cell in the DEM, in relation to neighbouring cells.



DEM – 50% Transparent | **Hillshade – Symbolised by Standard Deviations** | **DEM – 50% Transparent – Overlaid on Hillshade**

In ArcMap, ensure the Spatial Analyst extension is turned on. Open ArcToolbox, and expand the *Spatial Analyst* toolbox, then open the *Surface* toolset. Double-click on the *Hillshade* tool.





Set the 'Input Raster' to your clipped or complete GRCA DEM, and specify an appropriate path, name, and extension for the 'Output Raster.' Acceptable file extensions are *.img* for ERDAS IMAGINE images, or *.tif* for GeoTiffs, or no extension for GRIDs.

The Azimuth refers to the horizontal angle of the light source – that is, the direction from which the artificial 'sun' is coming. Generally, the default 315° produces an adequate hillshade, but you may want to experiment with different values.

The Altitude refers to the vertical angle of the light source – when this angle is 0°, the light source will be at ground level; when it is 90°, the light source will be directly overhead. Again, the default 45° is usually adequate, but you may want to try different values.

The 'Model Shadows' checkbox allows you to specify whether or not the effects of shadows will be shown on the hillshade. If this box is left unchecked, the output hillshade will show light and dark areas, without any consideration of shadowing. If checked, shadows will be modelled. In some cases, modelling shadows produces a hillshade that is too dark to be of much use – in these cases, unchecking the box can help. However, checking the 'Model Shadows' box usually produces a more appealing hillshade.

When working with GRCA DEMs, leave the 'Z factor' set to 1, because the X, Y, and Z measurements are all in meters (see the section on 'Deriving a Slope Raster' for more information on Z factors).

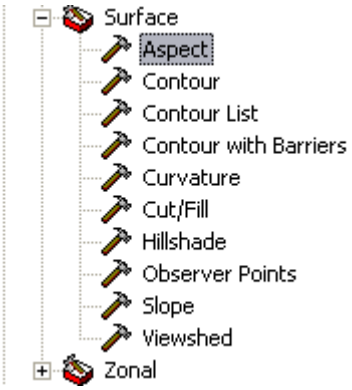
Click OK. The hillshade will be produced (this may take some time) and will be added to the map upon completion.

To display your new hillshade raster beneath other data, don't forget to increase the transparency of any polygon layer above the hillshade! To do so, simply double-click on the name of the layer to open the 'Properties' dialogue box. Navigate to the 'Display' tab, and enter a number (between 30% and 60% is usually adequate, but experiment!) in the textbox beside 'Transparency.'

Deriving an Aspect Raster from a DEM

An Aspect raster identifies 'the downslope direction of the maximum rate of change in value from each cell to its neighbours' (ESRI). In simpler terms, aspect can be thought of as the 'slope direction' – the values of the output raster will be the compass direction which a particular slope faces.

Deriving an Aspect Raster from a DEM couldn't be simpler. In ArcMap or ArcCatalog, open ArcToolbox and expand the '*Spatial Analyst Tools*' toolbox, then expand the '*Surface*' toolset.

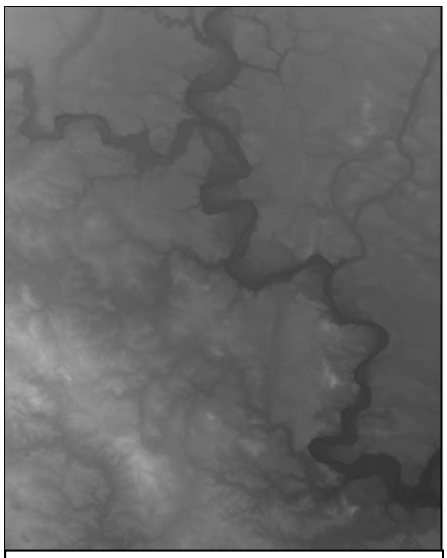


Open the '*Aspect'* tool.

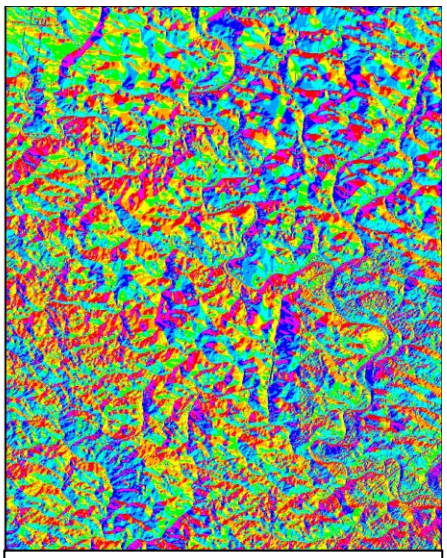
Set the '*Input Raster*' to your DEM. (**NOT** a slope raster!)

In the '*Output Raster*' textbox, enter an appropriate location, name, and file extension for your Aspect raster. Acceptable file extensions are *.img* for ERDAS IMAGINE images, or *.tif* for GeoTiffs, or no extension for GRIDs.

Click 'OK' to create the Aspect raster. Once processing is complete, the raster will be added to your map.



DEM

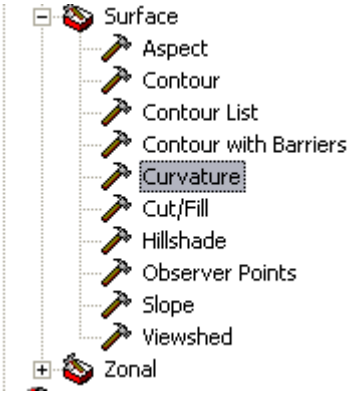


Aspect Raster

Deriving a Curvature Raster from a DEM

Curvature rasters can be used to describe the physical characteristics of a drainage basin in an effort to understand erosion and runoff processes. The slope affects the overall rate of movement downslope. Aspect defines the direction of flow. The profile curvature affects the acceleration and deceleration of flow and, therefore, influences erosion and deposition. The planform curvature influences convergence and divergence of flow.

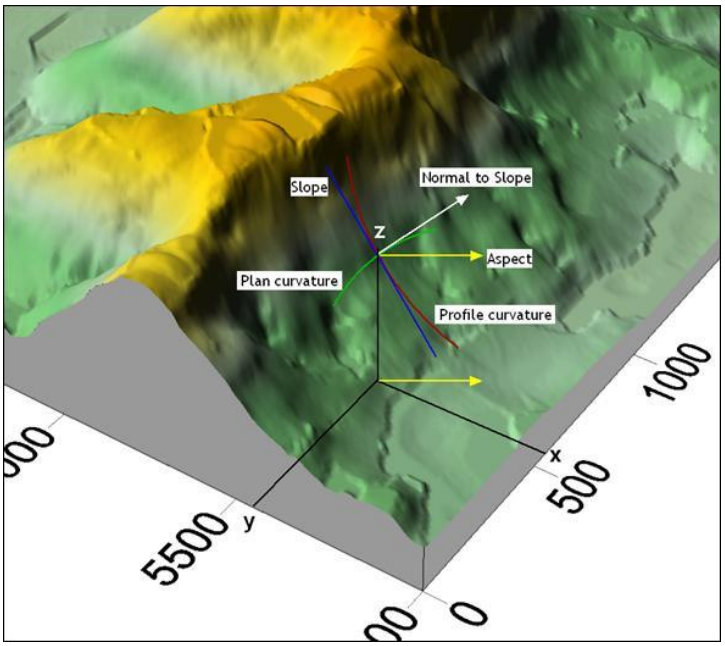
To derive curvature rasters in ArcMap or ArcCatalog, open ArcToolbox and expand the '*Spatial Analyst Tools*' toolbox, then expand the '*Surface*' toolset.



Open the '*Curvature'* tool.

Set the '*Input Raster*' to your DEM. (**NOT** a slope raster!)

Before proceeding any further, look at the other fields in the Curvature tool. Three outputs are possible from the Curvature tool. The first, the '*Output Curvature Raster*,' is simply curvature calculated on a cell-by-cell basis. *Profile* curvature is the curvature in the direction of the slope; *Plan* curvature is the curvature perpendicular to the slope. See the diagram below to aid in understanding this:

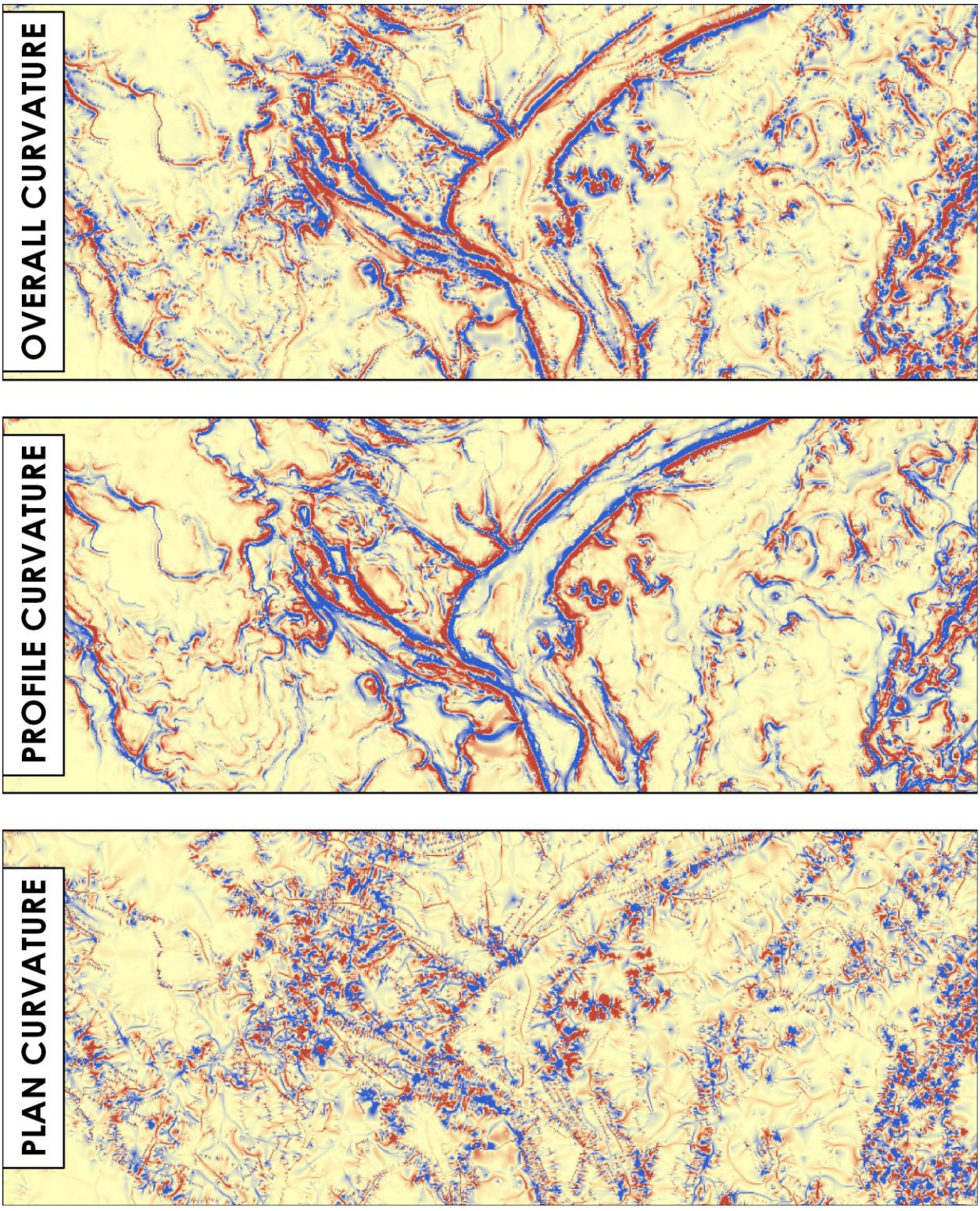


In the '*Output Curvature Raster*' textbox, enter an appropriate location, name, and file extension for your Curvature raster. Acceptable file extensions are *.img* for ERDAS IMAGINE images, or *.tif* for GeoTiffs, or no extension for GRIDs.

If desired, also fill in the *Output profile curve raster* and *Output plan curve raster* fields now.

For GRCA DEMs, leave the Z factor as 1.

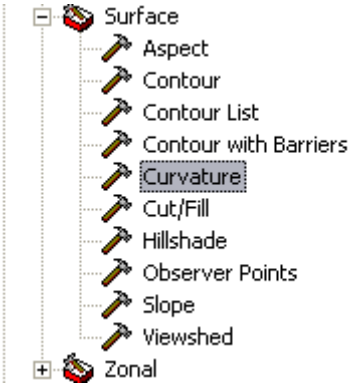
Click ‘OK.’ The curvature raster(s) will be automatically added to your map. Sample curvature outputs are shown below:



Deriving Custom Contours from a DEM

Custom contours can easily be derived from a DEM in ArcMap or ArcCatalog. While convenient, these contours should generally not be relied upon if a better alternative is available. Nevertheless, for visualisation and rudimentary analysis, the contours derived from DEMs can be quite useful.

To derive contours from a DEM in ArcMap or ArcCatalog, open ArcToolbox. Expand the '*Spatial Analyst Tools*' toolbox, then expand the '*Surface*' toolset.



Open the '*Contour*' tool.

Set the '*Input Raster*' to your DEM.

In the '*Output polyline features*' textbox, set an appropriate path and name for the output polyline Shapefile.

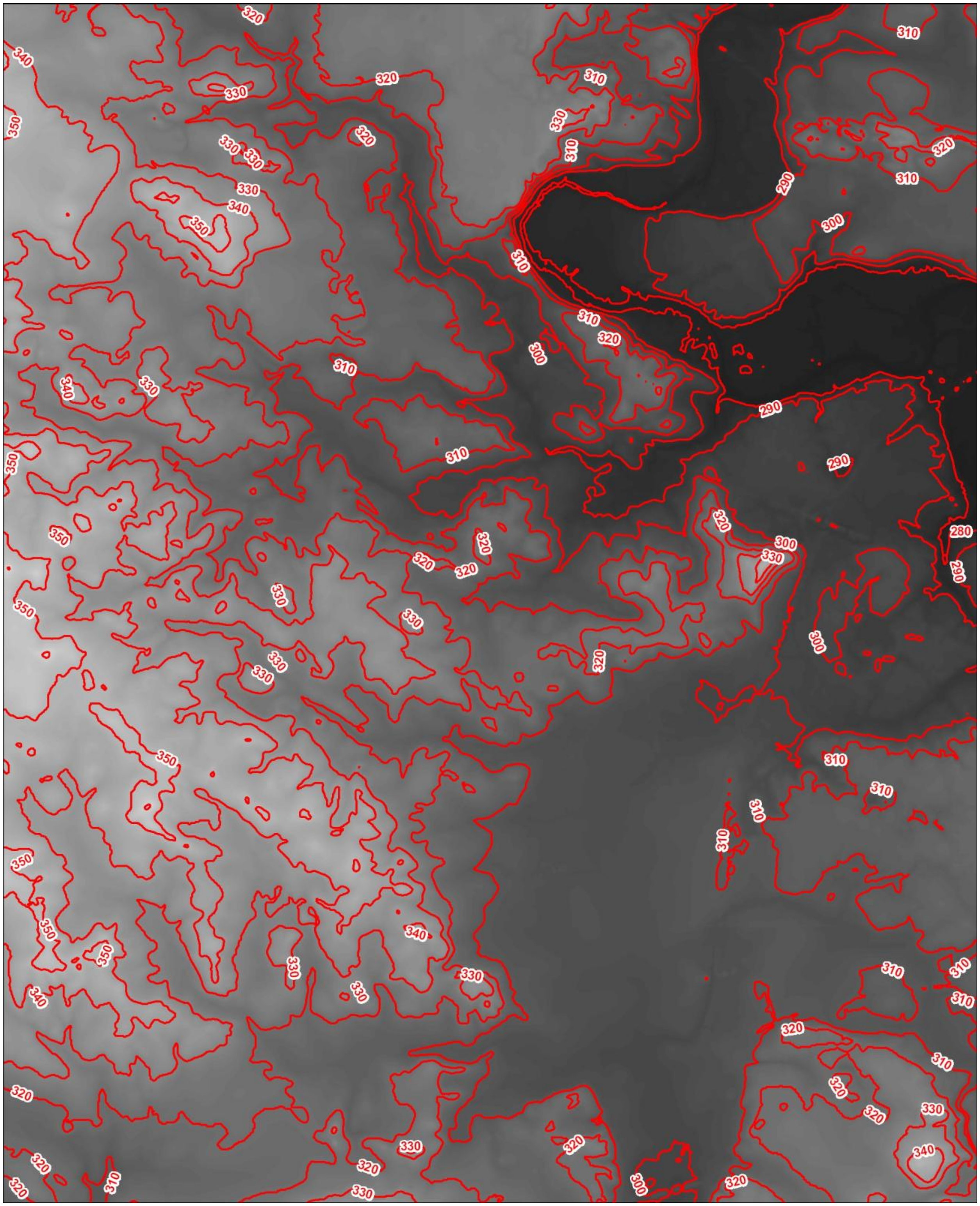
In the '*Contour Interval*' box, enter an interval in meters. GRCA DEMs contain elevation in meters; as such, the contour intervals must also be in meters. Use decimals if deriving contours with intervals less than 1m.

If desired, enter a value for the '*Base Contours*.' This base contour value will be the starting point for all other contours – for instance, if you have entered a contour interval of 5m and a base contour of 28m, then contour lines will be generated at 18m, 23m, 28m, 33m, 38m, etc.

Leave the Z Factor as 1 if using a GRCA DEM as an input.

Click 'OK.' Depending on the extent of the DEM and the contour interval, processing could take quite some time. Once the contours have been generated, they will automatically be added to your map.

The image on the following page shows a portion of a DEM in Waterloo Region and 10m contours derived therefrom: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