Watershed Modelling

Location: Mount Uniacke, Nova Scotia
MTM Sheet: 11D 13 West

Using Grid Modelling to delineate and understand watersheds.

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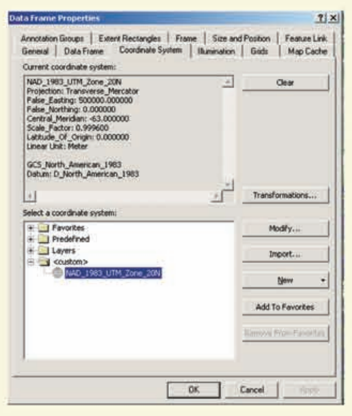
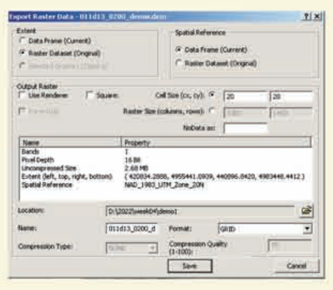
Applied GIS, GEOM 2022

Sources: NSTDB 1:50,000 NTDB, Introduction to Hydrological Modelling in ArcGIS by Mike Donnelly COGS, ESRI ArcGIS Help

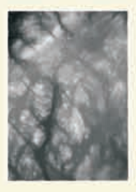
1. Importing and Projecting Data



Before adding your data set the Coordinate System to UTM 20 NAD 83 then add all the required shape files: contour_l, elev_pt_p, nts_lim_l, water_b_a, water_c_l, wetland_a



Export your DEM as follows to convert it into GRID.



2. Identifying & Filling Sinks: One Interation

STEP 1. Determine flow direction using Flow Direction command.
USAGE: FlowDirection(<surface_grid>, {o_drop_grid}, {NORMAL | FORCE})
Command: dem_fd1 = flowdirection ([dem1], #, normal)

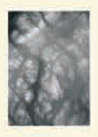
STEP 2. Find sinks using Identify Sinks command.
USAGE: Sink(<dir_grid>)
Command: dem_sink1 = sink([dem_fd1])

STEP 3. Find contributing area above each sink using the Watershed function.
USAGE: Watershed(<dir_grid>, <source_grid>)
Command: dem_sws1 = watershed ([dem_fd1],

STEP 4. Find depth of sinks. If within an acceptable limit proceed.
USAGE: ZonalMin(<zone_grid>, <value_grid>, {DATA | NODATA})
Command: dem_smin1 = zonalmin ([dem_sws1], [dem1])

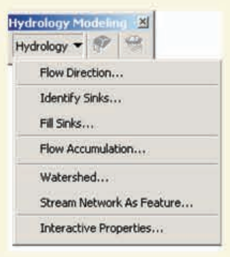
STEP 5. Fill sinks to the value of the lowest boundary cell in the watershed of each sink using the Spatial Analyst ZonalFill function.
USAGE: ZonalFill(<zone_grid>, <weight_grid>)
Command: dem_szfil1 = zonalfill ([dem_sws1], [dem1])

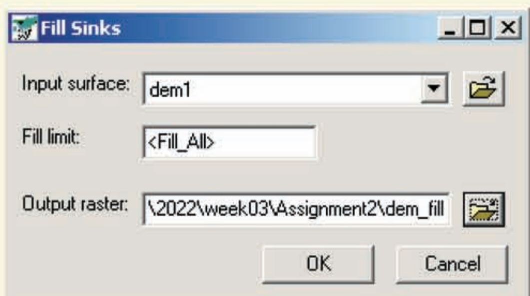
STEP 6. Determine sink depths from the difference
Command: dem_sdep1 = [dem_szfil1] - [dem_smin1]

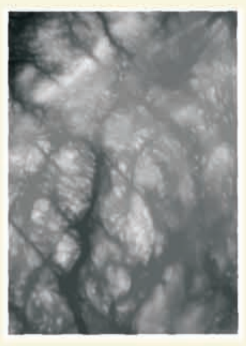


STEP 7. Add the sink depths to the original DEM using con and isnull functions to override NODATA.
Command: dem1st = con(isnull([dem_sink1]), 0, [dem_sdep1]) + [dem1]

3. Filling Sinks with ArcMap Hydrology Modelling Tool

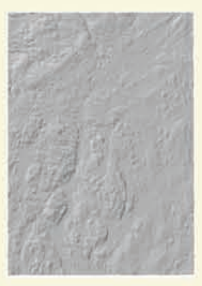






Using the Hydrology Modelling Tool shown above you can fill sinks in one step. It is accessed from the Hydrology Tool drop down menu and selecting Fill Sinks . . . . The dialog requires an input surface, a fill limit, and an output raster. The result from fill sinks is a depressionless DEM. This will complete all the iterations needed to fill any sinks.

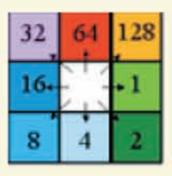
To create a hillshade of the new depressionless DEM shown above use the following command:
USAGE: HillShade(<grid>, {azimuth}, {altitude}, {ALL | SHADE | SHADOW}, {z_factor})
Command: Hillshde = hillshade([DEM], 315, 45), where 315 equals the azimuth and 45 equals altitude, which represents the suns position in the NW direction.

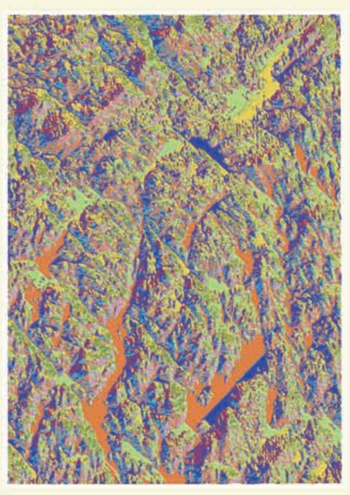


4. Flow Direction Grid

USAGE: FlowDirection(<surface_grid>, {o_drop_grid}, {NORMAL | FORCE})
Command: demfdir = FLOWDIRECTION([dem_fill])

There should only be flow direction of 1,2,4,8,16,32,64,128 –which represent the 8 compass points.





5. Flow Accumulation Grid

USAGE: FlowAccumulation(<dir_grid>, {weight_grid})
Command: demfacc = FLOWACCUMULATION([demfdir])

The Flow Accumulation function calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster.

Cells with a high flow accumulation are areas of concentrated flow and may be used to identify stream channels.

Cells with a flow accumulation of zero are local topographic highs and may be used to identify ridges.

6. Stream Threshold Grid

Command: streams = CON([demfacc] gt 2000,[demfacc])

Streams are identified by taking a "threshold value" and extracting them with the CON function. In this example flow accumulation greater than 2000 was identified as being cumulative enough to be "channelized" and therefore a stream.

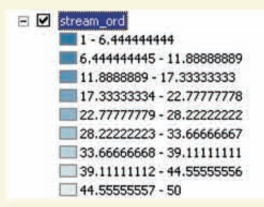
7. Stream Order Function

Assigns a numeric order to segments of a grid representing branches of a linear network created by thresholding the results of FlowAccumulation.
USAGE: StreamOrder(<net_grid>, <dir_grid>, {STRAHLER | SHREVE})

Command: streams_thr = CON([demfacc] gt 2000,1)

Use the streamorder function to determine stream hierarchy:

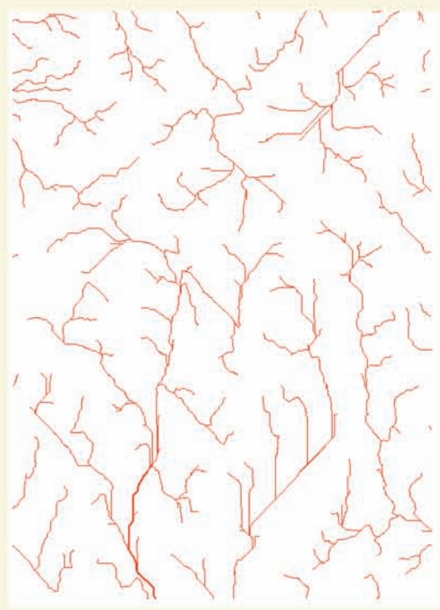
Usage: (out_int_grid) STREAMORDER (<net_grid>, <dir_grid>, {STRAHLER | SHREVE})
Command: stream_ord = streamorder([streams_thr], [demfdir], SHREVE)

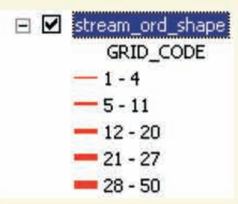


8. Stream Shape Function

Usage: (out_shape) STREAMSHAPE (<net_grid>, <dir_grid>, {NOWEED | WEED})

Command: stream_ord_shape = streamshape([stream_ord], [demfdir], NOWEED)

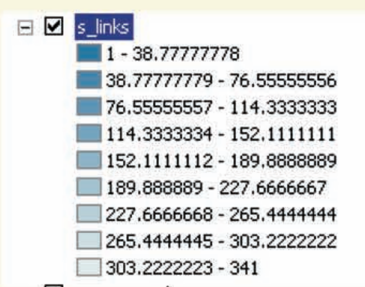




9. Streamlink Function

Stream links may be used to find sub basin points for analyzing with the watershed command.
Some of the best sub-basin watershed output can be obtained from streamlink watershed analysis.

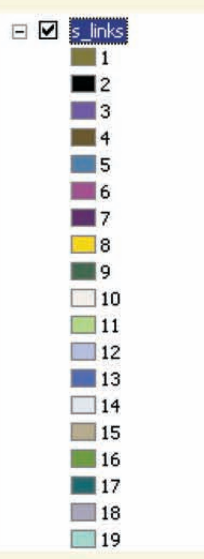
USAGE: StreamLink(<net_grid>, <dir_grid>)
Command: s_links = streamlink([streams], [demfdir])



10. REGIONGROUP

Use Regiongroup to aggregate the streams by connectivity, however, we first have to make all streams the same value. This is done by con([s_links] >= 0, 1). This can be nested in the regiongroup command as follows:

Usage: (out_int_grid) REGIONGROUP (<grid>,{out_remap_table},{FOUR | EIGHT}, {WITHIN | CROSS},{excluded_value},{LINK | NOLINK})
Command: streams_id = regiongroup(con([s_links] >= 0, 1), #, EIGHT)



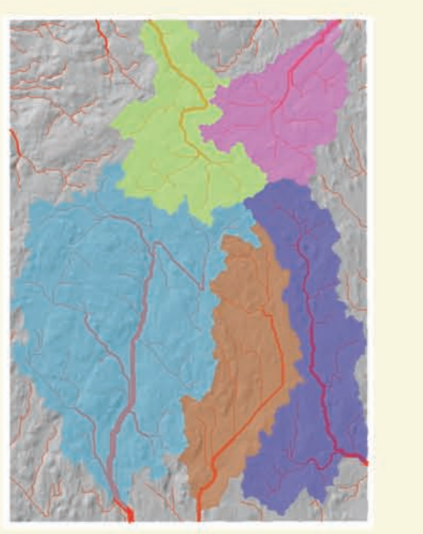
11. Finding Outlets

Use ET GeoWizards in ARCMap to create a point shape file and add the Stream Threshold Grid to assist in picking precise locations or outlets. Also use the Nova Scotia Watershed shapefile to help you. Once you have selected the points add a field to the attribute table called RECNO and calculate unique values for each outlet. RECNO = FID +1. Convert the outlets into Grid using Features to Raster. Make the grid size 40m instead of 20m to ensure locations cover the flow accumulation Grid.

12. Watershed 1: Using the Watershed Function

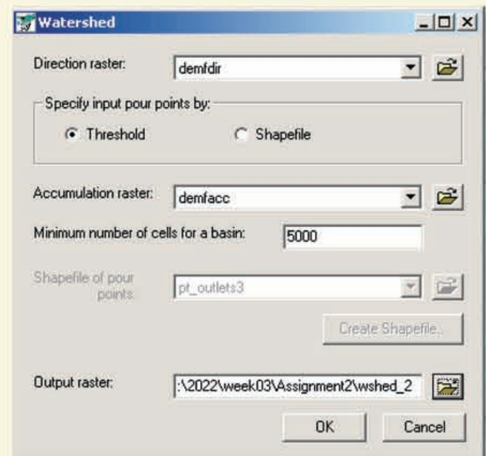
USAGE: Watershed(<dir_grid>, <source_grid>)

Command: wshed_1 = WATERSHED([demfdir],[gr_outlets3])



13. Watershed 2: Using the Hydrology Modelling Tool

The THRESHOLD method creates sub basins.



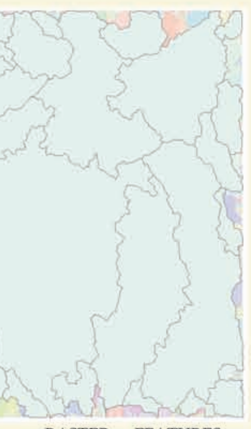
14. Watershed 3: Using the Basin Function

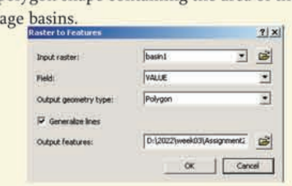
The Basin function identifies ridge lines and interprets outlets from Flow Direction.

1. Larger basins can be extracted by using a threshold for the number of cells for a minimum basin size:
basin1 = basin([demfdir]).

2. Open the attribute table and select records with COUNT >= 5000.

3. You can now use RASTER to FEATURES to create a new polygon shape containing the area of the drainage basins.





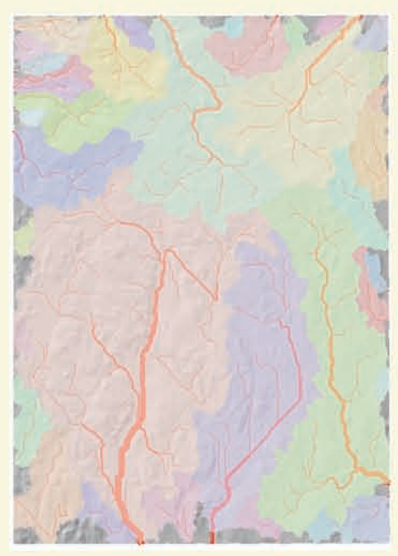
15. Watershed 4: Using Streamlink Method

Stream links can be used to find sub basin points for analyzing with the watershed command. The input grid from step 9 is used.
Usage: (out_int_grid) WATERSHED (<dir_grid>, <source_grid>)
Command: w_shed4 = watershed([demfdir], [s_links])

16. Watershed 5: Using Watershed Function

Using the Watershed Function create watersheds with unique ids for each stream aggregated by connectivity. Use input item from Step 10.

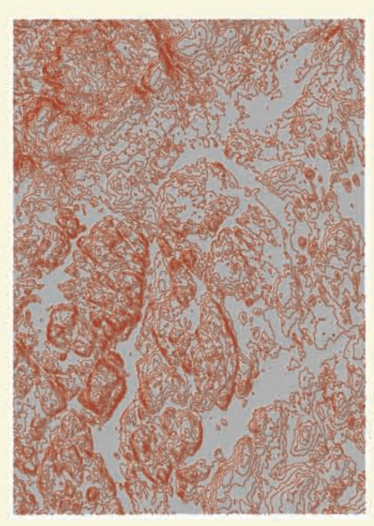
w_shed5 = watershed([demfdir], [streams_id])



17. Contour Function

Creates a coverage of contours or isolines from a grid.

USAGE: Contour(<grid>, <INTERVAL>, <interval>,{base})
Contour10 = contour(DEM, interval, 10, 0)



18. Comparative Analysis

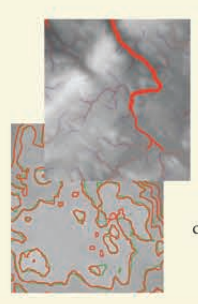
Watershed #1
-built with watershed function, and 5 identified pour points.
-clearly defines major watersheds.

Watershed #2
-built with Hydrology tool, using threshold.
-method creates sub-basins.

Watershed #3
-built with Basin Function.
-identifies ridge lines and interprets outlets from Flow Direction.
-similar results to #1 however more watersheds identified.

Watershed #4
-built with Steamlink Method.
-finds detailed sub-basins.

Watershed #5
-built with Watershed Function.



b. Original NTDB 1:50,000 streams(blue) and output from StreamShape(red).

c. Original NTDB 1:50,000 contours(green) and the DEM derived contours(red).

nscc
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