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Protocol for Establishing Sinuosity and Gradient for Streams in ArcMap

In order to calculate sinuosity and gradient for a stream site, you must generate two lines in ArcMap by tracing the stream channel as it appears on the LIDAR DEM and combined aerial photos (DOQs) of the site in question. The DOQs are, in most cases, more recent, and therefore a more accurate template for tracing the stream compared to what we had in the past.
The scale at which the stream is digitized is critical. Working at too coarse of a scale may reduce the accuracy of measurement of the stream trace, thereby affecting the accuracy of the final sinuosity and gradient calculations. In general, the streams should be digitized at scales of 1:1,000 or finer depending on the stream site. Zoom should be adjusted throughout the site so the DEM can be seen clearly, it does not need to be left at the same scale for the entire site. Care should be taken to trace the stream as accurately as possible, referencing the aerial photography /LIDAR overlay (but defaulting to the DEM). We are only required to make accurate stream traces that are 500 meters upstream, and downstream of the X point for a total length of 1000M.

To begin measuring sinuosity and gradient:

Navigate to the midpoint (x-point) of the stream reach you wish to trace.

If the X point is in the center of the stream, start on the point. If the point is on or near a bank, start the lines in the middle of the stream out from the point.

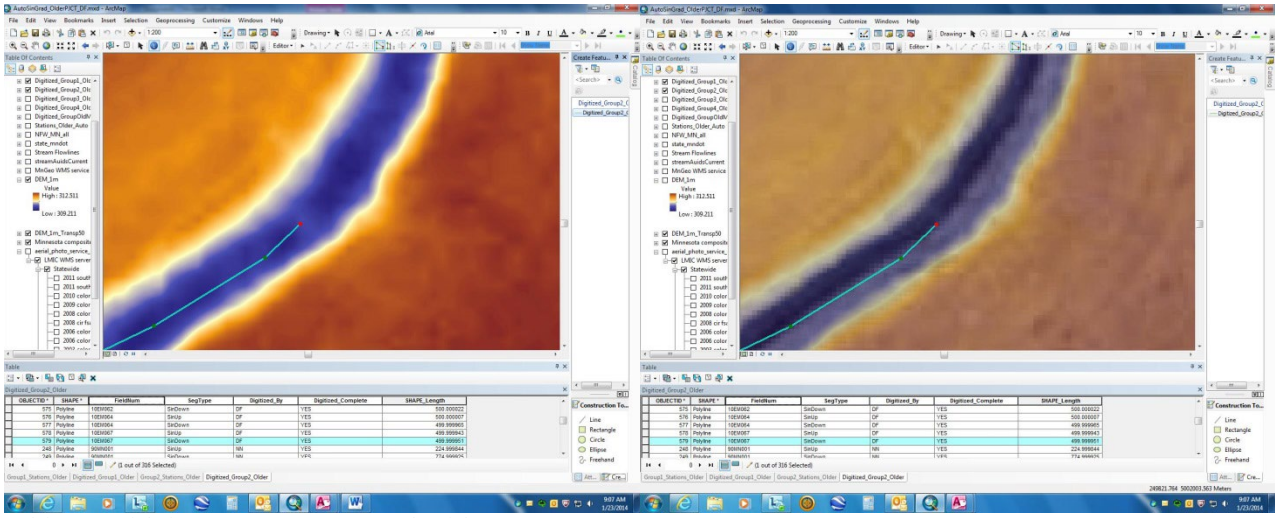
To measure sinuosity and gradient, you must draw a series of 2 lines:

1) X to Upstream stream arc (SinUp)-
   On the toolbar, click on editor-start editing-*the name of your assigned digitize group* (only edit in the assigned feature class).
   Begin at the midpoint of the reach. To begin the line select your digitize group from the Create Features window on the right side of the map project. If starting from the x point, make sure snapping is enabled to start the line directly on the point. If the x point is not in the center of the stream, begin the line straight out from the point in the center of the stream. Trace (draw) the centerline of the stream channel upstream to a length greater than 500 m. You can keep track of the length of line you draw on the screen by looking at the length value displayed in the lower left hand corner of the ArcMap window.
   Highlight (double-click) the line, then right click, and select "Trim to Length". Then trim by writing in exactly 500 meters, hit "enter" on the keyboard. Click off the line to see the shortened reach. If the length of this line is < 500 meters, continue tracing the channel upstream until the line is at least 500 meters in length. Do this by placing the strait segment cursor over the last vertex of the short line, which should enclose the cursor in a box. Right click, select Replace Sketch, and continue the line from the last vertex. You will need to delete the shorter line from the attribute table. Next, open the attribute table and enter the appropriate data (Field Number, SinUp, Initials, line complete and any comment). Save your edits.

2) X to downstream arc (SinDown)- follow the same procedure as the upstream arc except you are tracing the reach downstream. The second line should "snap" to either the X point or the other line, allow it to do so. Not "snapping" the lines can leave gaps resulting in calculation errors. Always start at the midpoint, otherwise the line will trim from the wrong end. Make sure it is 500 M and label the segment type as "SinDown" and fill in all other appropriate attributes. Save your edits.

3) Things to keep in mind:

Default to the DEM layer, we are using the DEM to calculate the gradient values, not the aerial photos. If the stream appears to have a different route between the DEM and the aerial photos, use the DEM. However the aerial images can be a good reference when it is unclear which direction the stream continues or as a guide to where the banks are. They can be especially helpful in low gradient areas where the DEM is harder to interpret. The line should look like a stream. Do not rush through a line, make sure there are enough vertices and the line is "boxy" and full of sharp angles. **Cutting off bends and not matching the channel closely will change where the endpoint falls and thus effect the sinuosity and gradient values**.

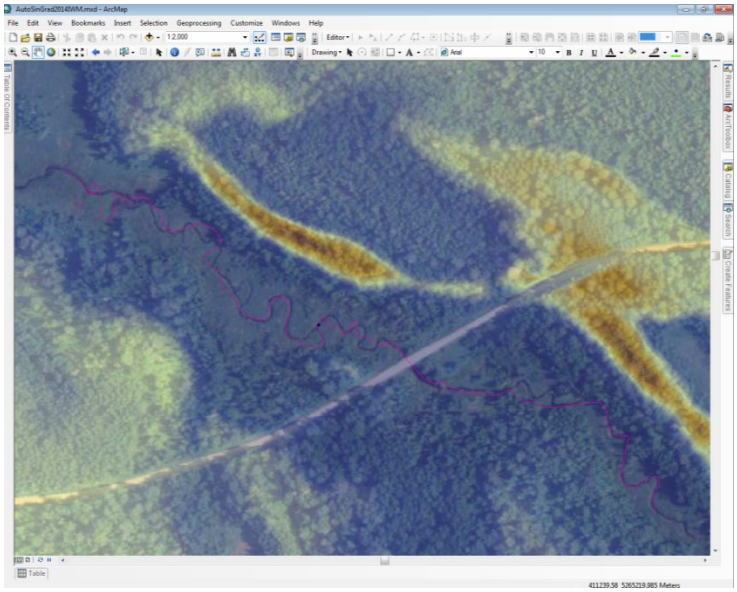


Left is DEM, right is 50% transparent DEM and aerial.

The scale should be 1:200-1:1000 as you are drawing the arc. Follow the middle of the channel. Complete both arcs. **Do not zoom in when finishing the arcs to find the "deepest" point**, this can lead to incorrect representations of the stream and gradient. Check the endpoint values to make sure the gradient change is positive and seems representative of the stream (the upstream endpoint should be larger than the downstream endpoint). It is possible the difference could come back negative, especially in low gradient areas.

If a gradient is negative shift the line, but never more than 500m. Double clicking on the line will allow you to move the end point to a "deeper" location. Lines should be representative of the stream and not directed at the bank in order to achieve a gradient change. A gradient of 0 is OK, but needs to be noted in the comments.

Wetland/low gradient areas can be challenging. Try to use all available layers to ensure the best sinarc possible. Sometimes, bing and the drg layers are your best option for tracing. See below



In the end, for each site, you should end up with a total of 2 new lines, all assigned with the Field Number associated with that site. The final set of records for each site should appear similar to the following:

OBJECTID	FieldNum	SegType	Digitize_By	Digitize_Complete	Comment	SHAPE_Length
1	04LM014	SinUp	MM	Y	Line shifted	500.000
2	04LM014	SinDown	MM	Y		499.999

Notice that the length of each of the lines that you have drawn (SHAPE_Length) is automatically entered in the database.

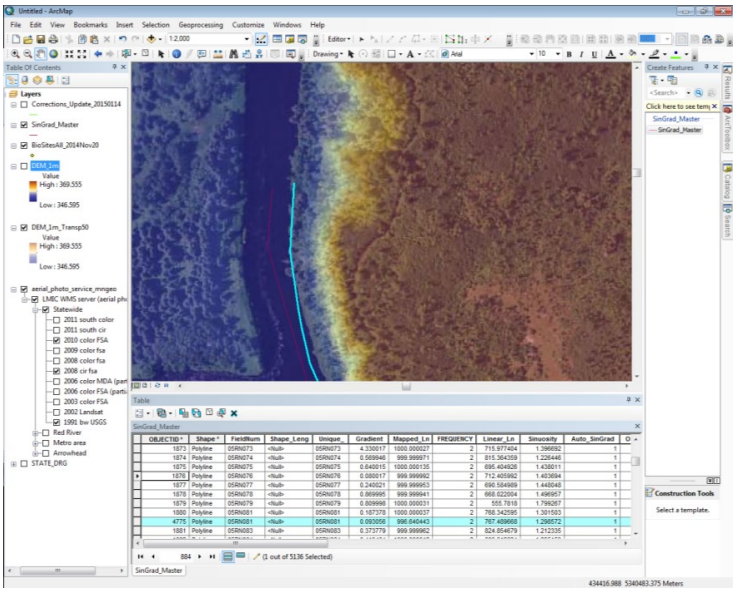
Exceptions and Tips

- Sometimes you won't be able to draw a full 500 meter line upstream or downstream of X, because of a lake, reservoir, larger river (2 stream orders or larger), bridge, state line, etc. If so, draw your line to this feature and stop. If the arc length is less than 500 meters, add that missing distance to the other arc to obtain a total reach length of 1000 m.
    - -For instance, if the SinUp arc runs into a lake 350m from the X point, 150 m would be added to the SinDown arc. SinUp would be 350m, and SinDown would be 650 m for a total reach length of 1000 m.
    - -If the river you are tracing is of a comparable size (less than 2 stream orders) to the one it flows into, continue drawing your gradient line through to 500m in length. If not the line should be ended and the missing length added to the other arc.
    - It is important to note that in rare situations it may not be possible to complete a combined length of 1000m for the arcs. If this occurs make note in the comments. This could occur in short stream segments close to a larger river/lake or where the DEM does not have coverage.

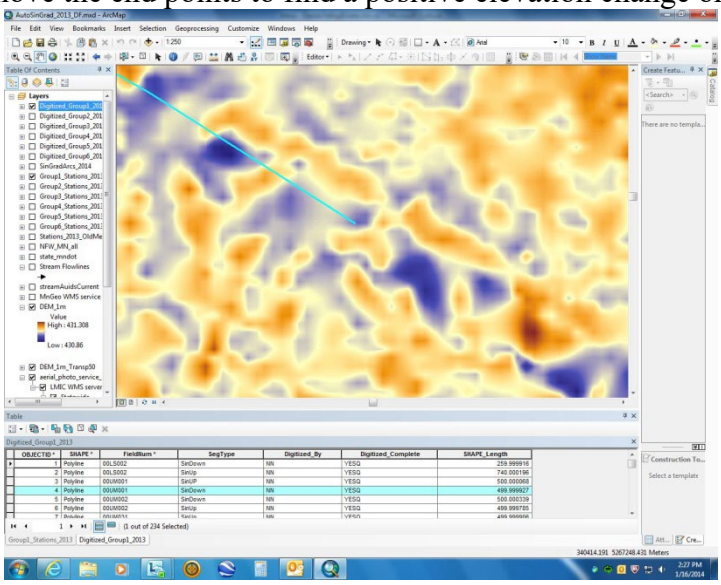
Remember to avoid placing the end point on a bridge or close to a road crossing as a bridge or a culvert can cause a faulty reading. If a segment ends on one of these slide the reach to avoid it by either going past it or stopping before it. Adjust the other arc accordingly.

Do not draw lines over dams or large waterfalls. Slide the reach in order to avoid them as you would for a lake or larger stream.

When tracing large rivers, do not draw the line along the bank. This can also give a false gradient reading. See below:

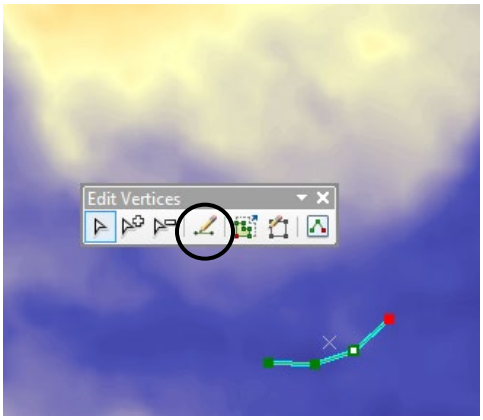


In low gradient areas it might help to zoom in farther on the stream in order to find the stream trace. Make sure to zoom out on occasion and reference other layers to ensure an accurate stream trace. When drawing the lines try to finish them without having searched for the lowest area. Check the elevation change and make sure it is not negative. If necessary move the end points to find a positive elevation change or 0.



Zoomed in in low gradient areas can give a better idea where the stream is.

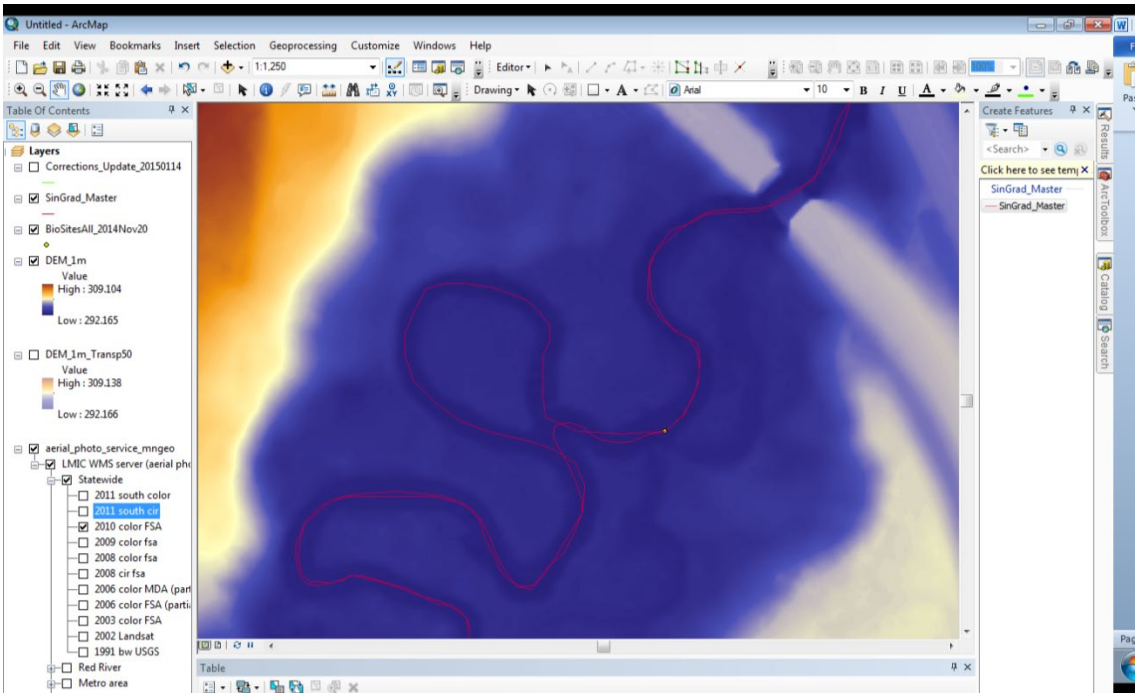
Remember that the “C” key on the keyboard can be used to turn the curser into a hand tool without having to stop the drawing session. Also, if you end a sinarc prematurely, you can click the pencil icon (after you double click on the sinarc) on the Edit Vertices toolbar to continue the feature instead of having to redraw the arc or making two arcs and trying to combine them.



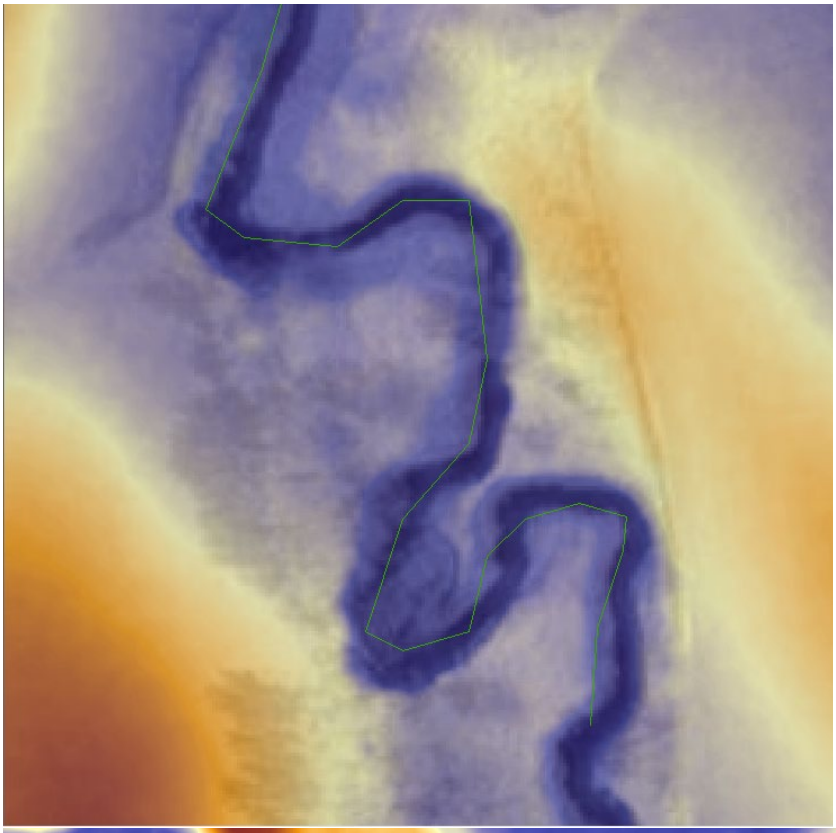
Along the MN border the DEM coverage ends. If you have a site on the border try to get the arcs completed in the DEM coverage that is present on the MN side, even if that means the arcs will not be down the center of the stream. If there is not enough coverage to trace 1000m, try sliding the reach in either direction if DEM coverage is better. Do not slide the reach more than 500m from its original location. If it is not possible to complete 1000m, trace as far as is possible and make a note about the length.

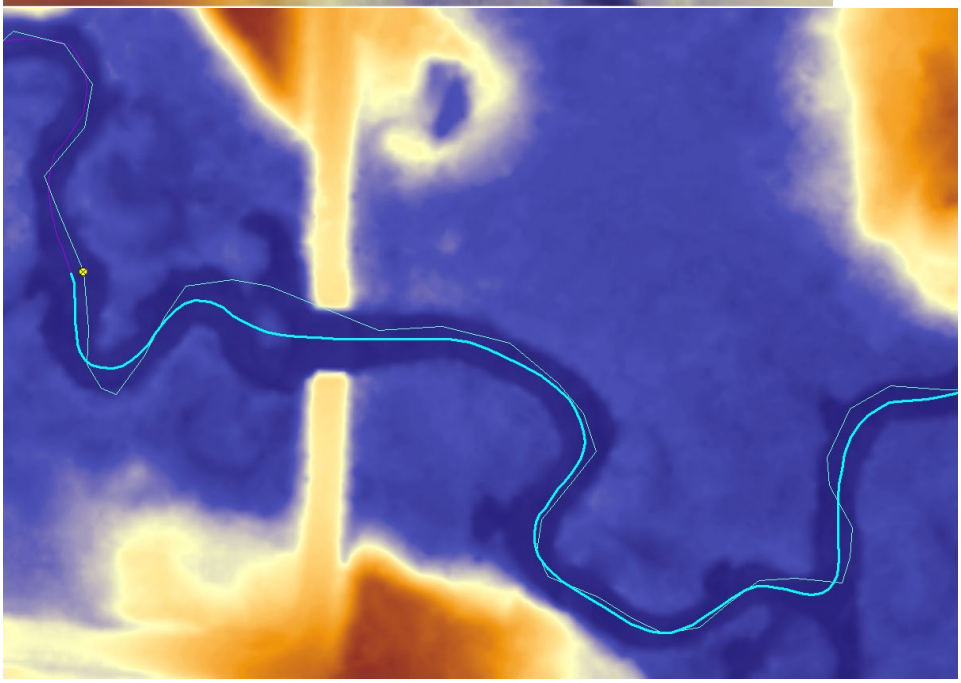
As long as a line does not end on an island/dry spot it is should be traced through. The line should continue down the middle of the stream, and that can include tracing over the island. If the line will end on the island, shift the line as previously described.

Reference other layers or site pictures when there is a question as to which direction the stream flows. Or to check if the line ends on a road/culvert. Oxbows can also be identified in aerials and should not be included in the arc.



Remember that the lines should be smooth and mirror the stream channel. They should not be angled or "boxy." This requires that multiple vertices be used to accurately trace the stream channel. See the image below for examples of lines needing more vertices (the second image has the corrected line highlighted):





Reference UpdatingsinGradMaster.docx for more tips and information.

If you are unsure about how to trace a stream or have questions, contact the project lead.