Read.me to Visualize Data points on a Lake's Surface and Calculate Bathymetry

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Overview

This guide explains to users how to load XY data into ArcGIS to calculate bathymetry of lakes.

This read.me contains three general areas
1. Load / Plot lake data into ArcGIS
2. Interpolate
3. Calculate Volume of Lake

Before using this guide:

1. Load in the raster of the Study Area (helps determine if XY data for your lake is in the correct location)

2. On Coordinate Conversions:
Coordinate conversions are necessary as it is useful to display data in UTM coordinates in ArcGIS, and data is often gathered in Decimal Degrees (DD) or Degrees Minutes, Seconds (DMS).
This code details how to convert coordinates in ArcMap. However, you can convert coordinates before loading data into ArcGIS.

If users coordinate data is not in UTM and users want to convert this coordinate system to UTM, it is recommended to use the document named "UTMConversion1":

"UTMConversion1" currently located in
"N:\geo4\HGF_Boike\SAMoilov\GIS_Database\Coordinates\Conversion"

1. Loading / Plotting data into ArcGIS

In order to calculate the volume of your lake, it is first necessary to load in the XY data of your lake. It is also necessary to have data points that map the shore of the lake, which provide a boundary to the lake and points where depth = 0 meters.

1.1 Shore Points in ArcGIS
There are 3 ways of dealing with shore points in ArcGIS.

1. You have a file that contains "Shore" Data

2. Data does not contain shore points → Use Lake boundaries from an existing shapefile to convert to points

3. Manually Create Shore Points (data does not contain shore points)

1. You have a file that contains "Shore" Data

Users have "shore" coordinates in a .txt file. It is recommended that the file has clearly marked "Northing", "Easting", and "Depth" columns. An example of this format is in sheet 1 of "Banya_Coordinates" located at
N:\petacarb3\Elevation_data\Russia\Samoylov_lakes_bathymetry\Samoylov_Lake_Points\Banya

1.1 Import "shore" data into ArcGIS:

In ArcGIS, click on the File Tab → Add Data → Add XY Data. Select the appropriate data you wish to add, with the correct x (Latitude or "Northing"), y (Longitude or "Easting") and z (Depth) information.

1.2 Exporting Data / Add as Layer

Right Click on the Table (data.file) you've loaded into ArcGIS, drag your mouse to 'Data', and Export the Table. This will add the Exported Layer to the map and creates an 'Object ID' or OID, which is useful when dealing with data tables

1.3 Use the „Convert Coordinate Notation" Tool:

(Located under "Data Management Tools" -> "Projections and Transformations" --> "Raster" -->" Convert Coordinate Notation").

Using the Convert Coordinate Notation Tool:
"Input Table": The XY data added as a map layer (from step 1.2)
"Output": Specify the Location and Name of the output table
"Input Coordinate Format": Specify the coordinate format the data is in.
"Output Coordinate Format": For example UTM52North for the Lena Area
"Spatial Reference": For example WGS_1984_UTM_zone_52N

2. Use Lake boundaries from an existing file to convert to points

2.1. Using lake boundaries from an existing file:

Users must load a shapefile that contains polygons of lake boundaries. An example file is "Lakes.shp" (for the Samoylov study area) located at
N:\petacarb3\Elevation_data\Russia\Samoylov_lakes_bathymetry\Samoylov_Lake_Points

2.2. Use the "Feature Vertices to Points" Tool

Located under "Data Management Tools" → "Features" → "Feature Vertices to Points", select the "Input Feature" as the Lake layer.

2.3. Use the "Add XY Coordinates" Tool

The "Feature Vertices to Points" Tool converts the lake.shp (polygon), to a series of points. However, these points do not have XY coordinate information, and users must use the "Add XY Coordinates" Tool.

3. Manually Create Shore Points

An example where users must manually create shore points is for Lucky Lake. No shore points originally existed, so users must load in the image of the study area and manually create shore points.

3.1. Use the Editor Toolbar to create points
Located under the "Customize" Tab → "Toolbars" → "Editor"

3.2 Click on the "Editor" drop down window and "Start Editing" on the appropriate layer.
 Users create shore points by clicking around the perimeter of the Lake as viewed on the raster image. When users are finished creating points save the edits and select the "stop editing" option.

3.3 Assign spatial information to the points
This can be accomplished by using the "Add XY Coordinates" in the "Data Management Toolbar."

1.2 "Lake" Points in ArcGIS
Before loading in data with depth information into ArcGIS, users must have a .txt file that has three data columns: "Northing", "Easting", and "Depth." An example of Lake data in a useful format can be viewed in "Banya_Coordinates" (sheet 2) located at
N:\petacarb3\Elevation_data\Russia\Samoylov_lakes_bathymetry\Samoylov_Lake_Points\Banya

1.2.1 Add XY Data and Export Table and Layer
Add the data in this .txt files using "Add XY Data" and "Export Table" / "Add as a Layer" to your map

1.2.2 Use the „Convert Coordinate Notation" Tool:
(Located under "Data Management Tools" -> "Projections and Transformations" --> "Raster" -->" Convert Coordinate Notation").
Convert Coordinates to appropriate coordinate system, e.g. UTM52N (if necessary)

1.3 Merging "shore" data with "lake" data
Before doing Interpolation, it may be necessary to use the "Merge" Tool (Located under "Data Management" --> "General" --> "Merge")to combine "shore" data with "lake" data into one layer

2) Interpolation

To view the Interpolation Methods available: Click on Spatial Analyst Tools --> Interpolation

Problems with producing an interpolation surface that covers the correct area:

Users encounter difficulty in producing a raster interpolated layer that covers JUST the area of the lake and not any other surface

Solution:
1. Complete the interpolation (any method)

2. Use the boundary of the lake, either "shore points" or a polygon of the lake, to limit the extent of the interpolated surface using the "Clip" Tool (for rasters), located under "Data Management"→ "Raster" → "Clip".

Alternatively: Users can instead complete the interpolation and in the "environments" tab, select the "Processing Extent" to be the same as the "shore points" layer.

2.1. Users have shore data in a layer

If you already have shore points, users must convert these points to a polygon, so that this polygon layer can be used in the Clip tool (for rasters). To convert shore points to a polygon, use the "Points to Line" tool, located under "Data Management Tools" → "Features" →"Points to Line". The resulting polygon can be used as the "Output Extent" in the Clip Tool. **N.B.** While using the "Clip" tool and using the polygon as the output extent, it is imperative to check the "Using Input Features for Clipping Geometry" and the "Maintain Clipping Extent" boxes.

2.2. Use Lake boundaries from an existing shapefile to convert to points (data does not contain shore points in a layer)

If lake boundaries already exist as polygons, users can use these polygons directly in the clip tool (for rasters). If the lake boundaries shapefile contains multiple lakes, users can open the attribute table of the lake shapefile and highlight the row in the attribute table that corresponds to the correct lake. Keeping this row selected, users can use the lake boundary shapefile as the output extent in the "Clip" tool, again checking the boxes for "Using Input Features for Clipping Geometry" and "Maintain Clipping Extent."

2.3. Manually Create Shore Points (data does not contain shore points in a layer)

If users manually created shore points, users must convert these points to a polygon, so that this polygon layer can be used in the Clip tool (for rasters). To convert shore points to a polygon, use the "Points to Line" tool, located under "Data Management Tools" → "Features" →"Points to Line". The resulting polygon can be used as the "Output Extent" in the Clip Tool. **N.B.**While using the "Clip" tool and using the polygon as the output extent, it is imperative to check the "Using Input Features for Clipping Geometry" and the "Maintain Clipping Extent" boxes.

3) Calculating Volume

After creating a raster surface that has depth information, you can calculate volume using the "Surface Volume" Tool.

Surface Volume Tool:
"Input surface" = the interpolated raster layer you calculated in Step 4.
"Output Text File": It is recommended to specify a .txt file name that contains the volume you calculate
"Reference Plane" : Either ABOVE or BELOW
"Plane Height" = 0.
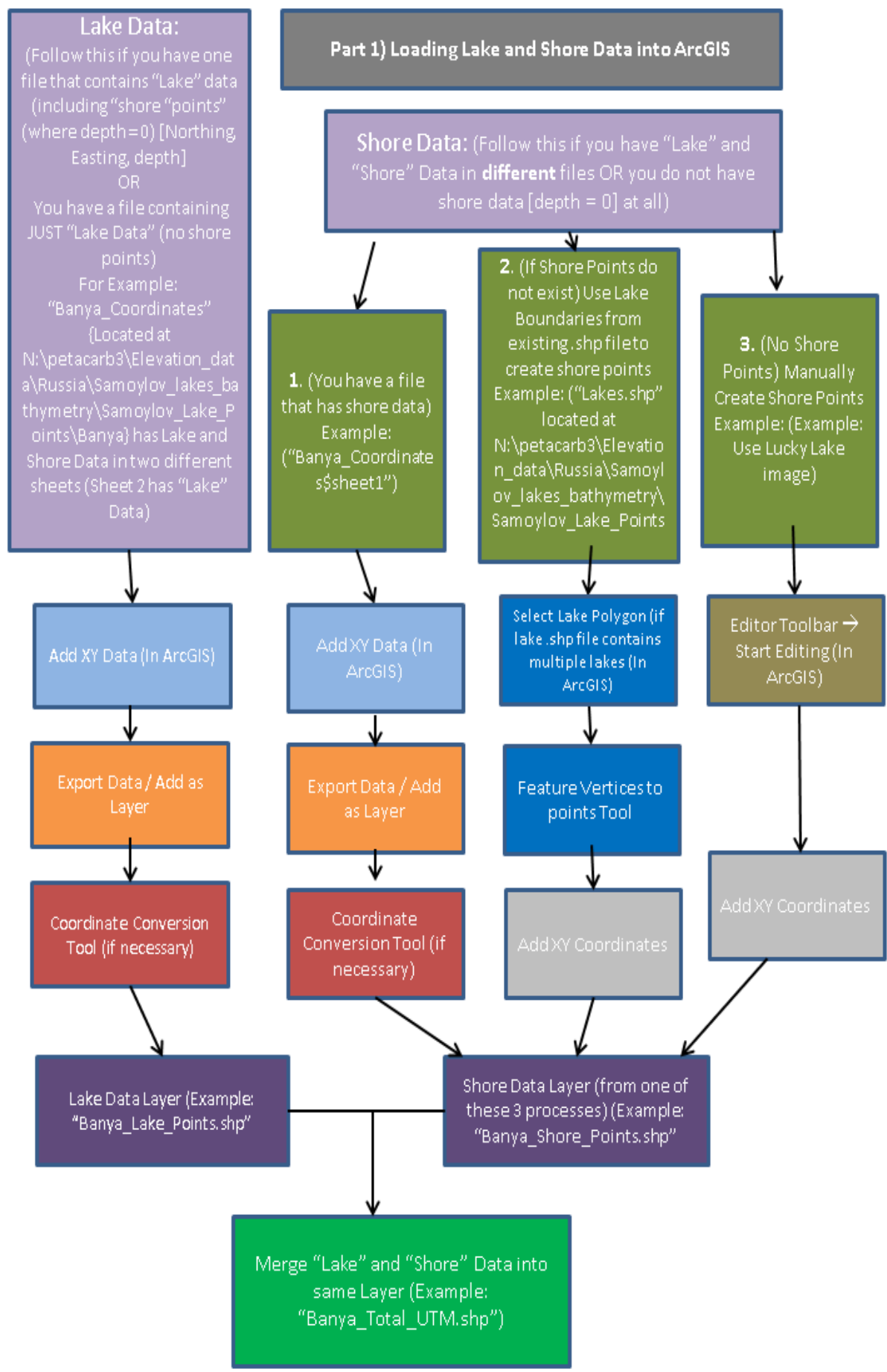"Z factor": Used to convert the units depth values (z values) are in

The ABOVE or BELOW option depends on if the raster layer contains positive or negative values for depth. For example, if the raster layer has positive values for depth, select ABOVE, as you want to calculate all the depth values above 0. If the raster layer has negative values for depth, use BELOW, to calculate all the depth values below 0.

Final Notes:
It may be useful to calculate the surface volume using multiple interpolation methods to formulate an idea of how your surface volume changes among methods and create a loose approximation of what your surface volume is.

Flowcharts:

Flowchart 1: Depiction to load and process Lake Data and Shore Data into ArcGIS. Users should first look to the top left "Lake Data" and follow that option if "Lake" and "Shore" Data are in the same file, OR the user just has "Lake Data". Since it is imperative to have shore data (where depth = 0) as well, users can then follow the "Shore Data Box" if Shore data is in a separate file then "Lake Data". Note there are three options for working with shore data; including if you already have a file containing XY shore data (option 1), using lake polygons to create shore points (option 2), and if users must manually create shore points (option 3).

Lake Data:
(Follow this if you have one file that contains "Lake" data (including "shore "points" (where depth=0) [Northing, Easting, depth]
OR
You have a file containing JUST "Lake Data" (no shore points)
For Example:
"Banya_Coordinates"
{Located at N:\petacarb3\Elevation_data\Russia\Samoylov_lakes_bathymetry\Samoylov_Lake_Points\Banya} has Lake and Shore Data in two different sheets (Sheet 2 has "Lake" Data)

Part 1) Loading Lake and Shore Data into ArcGIS

Shore Data: (Follow this if you have "Lake" and "Shore" Data in **different** files OR you do not have shore data [depth = 0] at all)

1. (You have a file that has shore data) Example: ("Banya_Coordinates$sheet1")

2. (If Shore Points do not exist) Use Lake Boundaries from existing .shp file to create shore points Example: ("Lakes.shp" located at N:\petacarb3\Elevation_data\Russia\Samoylov_lakes_bathymetry\Samoylov_Lake_Points

3. (No Shore Points) Manually Create Shore Points Example: (Example: Use Lucky Lake image)

Add XY Data (In ArcGIS)

Add XY Data (In ArcGIS)

Select Lake Polygon (if lake .shp file contains multiple lakes (In ArcGIS)

Editor Toolbar → Start Editing (In ArcGIS)

Export Data / Add as Layer

Export Data / Add as Layer

Feature Vertices to points Tool

Coordinate Conversion Tool (if necessary)

Coordinate Conversion Tool (if necessary)

Add XY Coordinates

Add XY Coordinates

Lake Data Layer (Example: "Banya_Lake_Points.shp"

Shore Data Layer (from one of these 3 processes) (Example: "Banya_Shore_Points.shp"

Merge "Lake" and "Shore" Data into same Layer (Example: "Banya_Total_UTM.shp")

Flowchart 2: With "lake" and "shore" data in the same layer, users can perform interpolations. If the interpolated rasters do not cover the correct area (just spanning the lake), users must use the Clip tool (for rasters) to clip the interpolated surface to the extent of the lake (the "shore points). Users can either convert "shore" points to a polygon to be used in the Clip (options 1 and 3), or use the existing polygon of lakes boundaries in the Clip (option 2). After clipping the interpolated layer to the correct extent, users can use the surface volume tool to calculate the volume of their lake.