Bathymetric Mapping of a small lake using canoes, GPS units, and ArcMap

A high school field and classroom project involving a small lake, GIS, and a certain amount of adventure.

Lesson Overview:

A bathymetric map shows the shapes and depths of the bottom of a lake, pond, reservoir and other underwater area. Making a bathymetric map can be an exciting and rewarding project for high school students. The project can also be linked to other studies and develop real-world skills in technologies such as GIS. This lesson describes field data collection and classroom GIS methods that can be used by high students to create a bathymetric map of a small lake.

Estimated Time:

A class of 12 students working in four teams, each equipped with a Garmin GPS unit, marked/weighted rope, and a canoe, could take enough field measurements to make a bathymetric map of a lake with a surface area of 100 acres and a maximum depth of less than 50 feet, in one 6 to 8 hour day. An additional field day might be needed to correct errors or fill-in large areas with poor coverage. Once field data is collected it will take five to ten class periods to enter data and create a final map. Class time to complete lesson will vary depending on student skill.

Materials and Equipment:

- 1 GPS unit per student group (Garmin preferable)
- 1 Clipboard (per group) for data collection if Garmin or similar GPS units are used
- A 60 foot-long nylon rope marked in feet or half meters (one per group).
- A weight of 2 to 5 lbs (one per group)
- ArcMap with 3D Analyst Extension
- Field Data collection sheets if Garmin or similar GPS units are used (one per group, with extras to be left on shore)

- A laminated map of the lake, which has been marked into survey lines(one per group).
- Gallon Ziploc bags (2 per group)
- Red permanent marker (one per group)
- Black permanent marker (one per group)
- A stout board or stick that can be used as a spindle (one per group)

Note: This lesson was written for class groups recording depth measurement positions with Garmin, or similar GPS units. The lesson could be conducted using Trimble Junos, which would greatly reduce data entry time. Also, electronic sounding devices could be used to measure depths. These would improve accuracy and reduce data collection time. However, Trimble Junos and electronic sounding devices are quite a bit more expensive than Garmin GPS units and weighted ropes.

Objectives:
The students will be able to:

- Collect depth measurements using a Garmin or similar GPS unit
- Input field collected depth measurements into ArcMap.
- Use ArcMap to create both shaded-depth and depth-contour bathymetric map.

Teacher Notes and Prep

Introduction:
Prior to conducting the lesson the teacher will need to locate a suitable lake and enough canoes, life jackets, and paddles for each student group. A lake with a surface area of 50 to 200 acres and a maximum depth less than 50 feet would probably be suitable for most classes. Summer camps are often near a small lake and have canoes, which they might rent or loan to a school group. Including the students in the planning process will increase the students' understanding, appreciation, and motivation for the project. Furthermore, some students in your class may have contacts to make accessing a lake and acquiring equipment much easier.

Once a lake is selected it will be necessary to divide the lake into separate parts that can be mapped by each student group. This can be done in many ways. Only one method is outlined below. This method requires field maps that are created and printed using ArcMap. The teacher can make field maps, or have the students make them as part of the lesson. Before creating field maps it will be necessary to create base map layers.

Creating Base Map Layers
The teacher should create a base map layer for the project. Layers can be acquired though online sources. Layers that work nicely are georeferenced 1:24000 topographic maps, or 10M resolution air photos, or both. The teacher should create a project folder to hold the base maps.

Creating a Geodatabase:

In the folder that contains the base maps the teacher may also want to create a geodatabase for the field data. The teacher may want to have the students do this step depending on how much time is available and whether or not the teacher wants the students to develop skills creating geodatabases and feature classes. This procedure is outlined below for teacher or students to use:

Open ArcCatalog and navigate to the folder that was created to hold the base maps.
Right click on the folder > New > Personal Geodatabase
Give the geodatabase an appropriate name

Creating a Field Map:

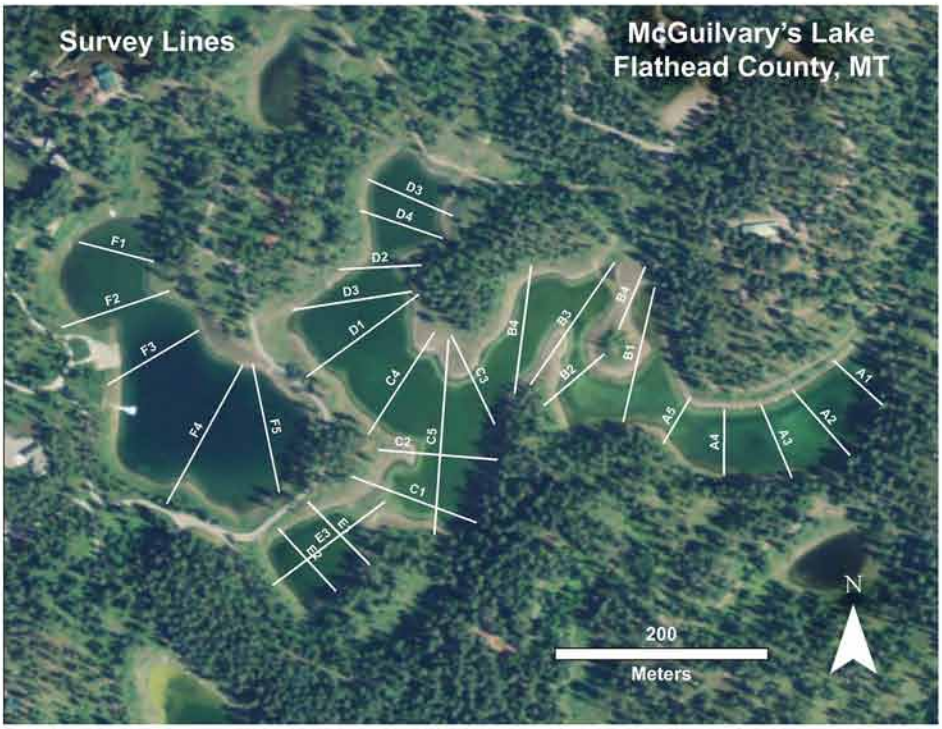
Still in ArcCatalog, right click on the geodatabase you just created
> New > Feature Class
On the pop-up menu name the feature class "Survey_Lines"
You can leave "Alias" blank
For "Type of features stored in this feature class" > Polyline Features
Select next at the bottom
Choose "Import" from the buttons on the right side of the next menu.
Navigate to one of the base maps in the folder containing the geodatabase

Next close ArcCatalog and open ArcMap.
On the start menu select "New Map" > My Template>Blank Map>OK
Next click on the "Add Data" icon
On the popup menu navigate to the project folder and select your base maps
After the base maps have loaded click on the "Add Data" icon again
Click on your geodatabase and add your "Survey_Lines" feature class
Your base maps and "Survey-Lines" feature class should appear in your table of contents. (If your table of contents doesn't show click on the "Windows" tab. Then click on "Table of Contents" in the drop down menu.

Navigate to the lake the class will be mapping
Zoom in so that it fills the screen.

Next decide how you will divide the lake so that each group will have a roughly equal part to map. You are going to draw lines that traverse the lake within each part. To give you a feel for how you might divide the lake in areas an example showing a finished field map is included in Figure 1. The lake in this example is only 35 acres in surface area. It was mapped by 5 student groups in about 3 hours. Each group measured depths along five lines, which were numbered A1 to A5, B1 to B5, and so on.

Figure 1: Example of survey lines drawn on a field map.



Drawing and Labeling Survey Lines

Before you begin drawing survey lines you will need to add a field to the survey line feature class.
Right click on the "Survey_Line" feature class in the Table of Contents.
Select "Open Attribute Table" from the drop down menu.
Once the attribute table is open click on the "Table Options" icon in the upper left-hand corner.
Click on "Add Field"
In the pop up menu name the field "Line_Name"
For "Type" select "Text" from the drop down menu.
Then click ok at the bottom.

To draw survey lines click on "Editor" and select start editing in the drop down menu. OK>
(If "Editor" is not showing right click in any gray space at the top of ArcMap. A dropdown menu will display additional tool sets. From the menu select "Editor")
Click on the "Survey_Lines" and the "line" icon under "Construction Tools" will be highlighted.
When you move the cursor back to your map it will be displayed as a small cross.
Move the cross to where you want the start part of your first line and click.
Next move the cursor across the lake to where you want the first line to end and click.
A line will now appear on your map. Right click and select finish sketch from the drop down menu.

If you don't like how the line came out, right click and select delete sketch from the drop down menu.

After you have a line drawn open the attribute table and name the line by clicking on and filling in the appropriate cell.

Repeat the procedure in this section to draw additional lines until you have an equal number of lines for each group. In the example in Figure 1 there are 5 sets of lines (one set for each group). Each set is about 150 feet apart and is from 150 to 250 feet long.

Note: Some of the lines on the imagery (or base map layer) for the example are on dry ground. The mapping activity for the example was conducted when the water level was higher and all lines where on water.

Inserting a Title, North Arrow and Scale Bar, and Exporting the Field Map
Now that you have survey lines drawn onto the lake you should label, export, and print your map.

First click on "View" on your main menu.
Next, select "Layout View"
You may need to turn on the "Layout Tools". Do this by right clicking somewhere in the blank, light-gray space above your map.

You may wish to study the layout tools in ArcGIS Desktop Help if you are unfamiliar with them. In the search window type in "displaying maps in data view and layout view"

Click on the "Change Layout" icon
From the dropdown menu that appears select "Layout" and select and appropriate template. This should match the size and orientation of the finished field map you plan to print.
(For the example "Letter (ANSI A) Landscape mxd" was used.)
You can insert a title, north arrow, and scale bar by clicking on "Insert" on the main menu.
Experiment with the options in the drop down menus for text, north arrow, and scale bar to make the map the way you would like it.

Once you have the map ready in "Layout View" click on "File" in the main menu
Select "Export Map"
At the top of the popup menu navigate to where you want to save the map.
For "File Name" type in "Field Map"
For "Save as Type" select JPEG.
For "Resolution" type in 300.
Click "Save"

Once your map has been exported you can open it with a picture viewer (such as Windows Photo Viewer) and print a copy for each group. It will work well to laminate the printed field map so they will be water proof when in the canoe.

Prepping the Garmin GPS Units

Before using the Garmin in the field it is necessary to set the Datum to match that used in the base map layers. This can be accomplished in the preferences menu for most units. Also, it will work best for uploading data into ArcMap if the Garmin records Latitude and Longitude in degrees decimal. Most GPS units will let you set how latitude and longitude are collected in the preference menu. Lastly, if the students haven't used the Garmin GPS units it is best to have them practice taking waypoints on the school grounds before they use them at the lake.

Student Activity:

In-class Equipment Preparation

If this is the first time your class is making a bathymetric map it will save you time to have the class help prepare the equipment for the field day. Each group will need about 50 feet of rope (1/4 inch nylon rope with a braded sheath works well), a weight of 2 to 5 pounds, a stout stick or board (a 2 ½ foot long 2x4 works nicely), a black permanent marker, and a red permanent marker. Appropriate weights can be scavenged from the school maintenance folks, a local wrecking yard, or welding shop. Most anything that is heavy enough can be used, but it needs to be something to which the students can firmly tie the rope. As part of the lesson it may be appropriate to teach the students to tie strong non-loosening knots (such as a bowline or figure 8).

Tie the weight on the end of the rope and let the weight just barely touch the floor. Hold the rope straight up above the rope. Measure on the rope the point, which is 0.5 meters above the floor, and mark this point with the black permanent marker. The mark should go all around the rope and be about ¼ inch wide. While still holding the rope and weight so that the weight is just barely touching the floor, measure the point, which is 1 meter above the floor, and mark this point with the red marker. Now lay the rope on a table and measure and mark every meter (in red) and half meter (in black), up from the two marks made while holding the rope and weight up. When the other end of the rope is reached tie it on to the board or stick you are using as a spindle and roll the rope around the spindle.

Field Data Collection, Part 1:

Before Leaving Shore

Students will need to work in small groups for data collection in canoes. Groups of 3 students work well. A group of two is possible, but requires each student to complete several tasks and presents some coordination challenges because both students are facing in the same direction. A group of 4 also works, but can overload a small canoe. Each student should wear a life jacket at all times and students unfamiliar with canoes should be given appropriate safety instruction.

Before leaving shore each group should be oriented on the field map so they know where they will be working. Also it would be best to go over the procedure with the students so they understand what they will be doing and work efficiently. Orientation could be accomplished in class and reviewed before leaving shore. Each group should have in their canoe:

- The weighted, marked rope on the spindle
- A clip board
- A Garmin GPS unit
- A field data form and extra copies (A blank form is included with this lesson.)
- Pencils (a few per group)
- The field map
- Ziploc bags

Notes:
(1) One Ziploc bag can be used to keep the Garmin in. The Garmin is water resistant, but if there is a great deal of splashing (from paddling or hauling the rope and weight in and out of the canoe) or there is water in the bottom of the canoe, it would be prudent to keep the Garmin in the plastic bag. It can still be operated and the display will still be legible while it is in the bag. The other Ziploc can be used to offer some protection to the field data form. It will fit over most clipboards and the form when students are not recording data.

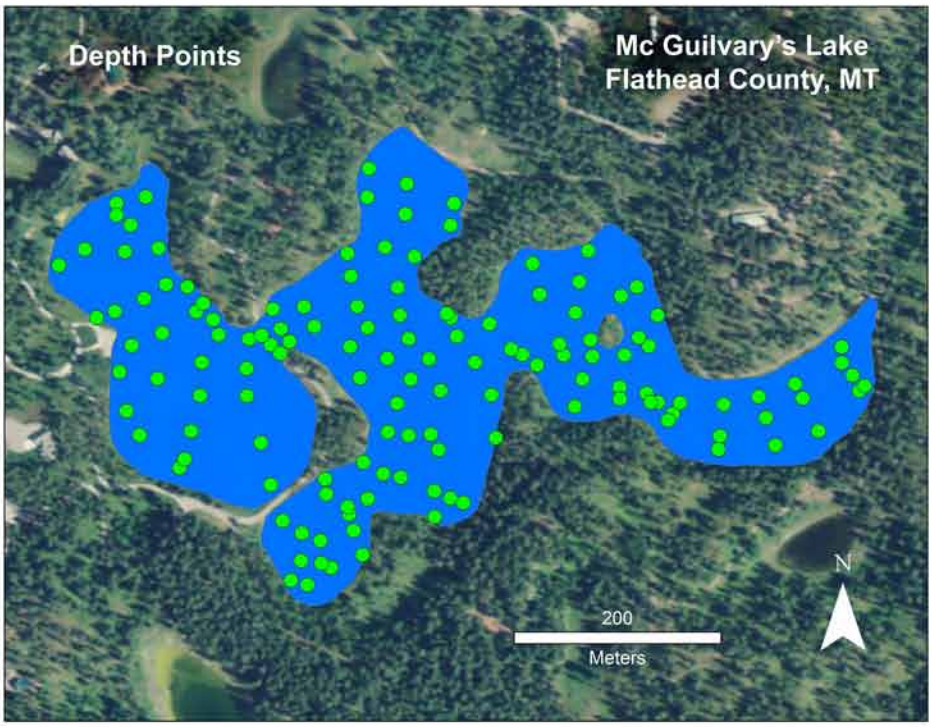
(2) Wooden pencils are highly recommended over mechanical pencils or pens. Wooden pencils float if dropped over board or in a puddle in the boat; whereas, mechanical pencils sink and can malfunction when soaked in water. Pencil lead remains legible on a soaked data form: whereas pen ink bleeds and become impossible to read.

Field Data Collection, Part 2:
On the Lake
Each group should paddle to their part of the lake. Using the field map as a guide they should then paddle to their first line and paddle along the line stopping at regular intervals to measure and record the depth. An interval of about 50 feet works well. Students should be given some practice in estimating the length of appropriate distance before they are in the canoes. Alternately, the students could be required to measure and record a certain number of "spaced out" points along each line. For most lines 5 points would be adequate. Figure 2 shows a nice distribution of depth points on a lake of about 35 acres.

Notes:
(1) Some Garmin, Trimble Junos, and other GPS units will let you input the survey lines and display them along with your position. This can make it easier for the students to follow survey lines and select points to measure depths. However, having the students locate themselves on the field maps will develop field skills and probably result in good enough data.

(2) It isn't necessary that each point is precisely on the line or equal spaced out. One to two meters plus or minus will work great. Several other factors will affect precision and accuracy. Your map will at best be accurate to 0.5 meters, which all things considered is pretty good. Having enough points and good coverage will be more important than fretting too much about accuracy.

Figure 2: Example of depth point distribution.



To take a depth measurement students should try to get the canoe as still as possible. They then should lower the weight to the bottom counting off meters as it is lowered. Coordinating this activity in the canoe will be challenging at first. The students will need to develop a team effort that will keep track of the count, not tangle the rope, and not drop the spindle over board, while also working safely in the confines of the canoe. As the weight reaches the bottom the group needs to mark and record a waypoint on the Garmin. A different prefix should be used by each group for naming their waypoints, and each waypoint should have unique name. For example, one group could record all of their points with the prefix "A", another "B", and so on. After a waypoint is marked, and before the next measurement is taken, the waypoint name, latitude, longitude, and depth should be recorded on the data form. A blank field form is included with this lesson plan and an example map showing depth points measured on a lake is presented in Figure 2. A polygon has been traced to the lake surface in Figure 2 to make the depth points easier to see.

Note: Some Garmin, Junos, and other GPS units will let you record your data electronically. This is a great time saver and improves accuracy by eliminating

transcription errors, but the group may want to record data on a paper form as a back up, and some GPS units will only let you mark the point.

Field Data Collection, Part 3:
Before Leaving the Lake
It would be prudent to look over each group's data before you leave the lake, especially for groups that finish way before others. Make sure all data has been recorded and the point coverage seems sufficient. If there is time you might need to send some groups back out to redo some of their data or collect more. Once all groups are finished separate the data forms and set them out where they can dry.

Back in the Classroom

Teacher Prep

Downloading GPS data
GPS data can be downloaded into ArcMap using the DNR Garmin program for Garmin users. Others GPS users may need to type latitude and longitude data into an excel spreadsheet that can be added using the add XY data tool.

It will be easiest and save much class time for the teacher to download all of the data to one computer. Each Garmin GPS unit will create a layer with the waypoint name, and latitude and longitude. These layers can then be merged into one layer using the geoprocessing tools. The Merge menu allows all of the layers to be added in a drop down menu. After all layers have been added use the folder icon in the "Output Dataset" and navigate to the project geodatabase. Name the merged layer an "All_Depth_Points" > Save. This will take you back to the merge menu. Push the OK button at the button.

Note: For some Garmin, and Trimble Juno GPS units the student collected depth measurements will be included in the merged table. If this is the case, skip ahead to "Inputting Data into ArcMap".

Before the students begin field data forms should be photocopied and organized. Depending on whether you want students to work individually inputting data or with a partner will depend on how many copies of the field form will be needed. Also before data entry the project folder will need to be copied onto each student computer.

Student Activity

Inputting Data into ArcMap
Students can start by opening a blank map in ArcMap. They can then add the base map layers by using the add data icon in the "Standard Tool" bar. Using the drop down menu they can navigate to the project folder. Next they can add the "All_Depth_Points" layer from the geodatabase in the project folder.

Once this layer is added students should see all of their depth points appear on the base map.

To make the depth points easier to see, they can right click on the "All_Depth_Points" layer name in the table of contents
Select "Properties" from the drop down menu.
Next select the "Symbology" tab at the top of the popup menu.
Double click on the symbol shown and change the color and symbol size to something that is easy to see; Circles rather than elaborate symbols will work best for up coming analysis and displays.
Once an appropriate symbol size and color have been selected, click ok at the bottom

Notes:
(1)The students will likely notice some points that are obviously in the wrong place. Hopefully, there aren't too many. If they are mostly in the right place tell the students to ignore the "off" ones for now.

(2) If data was collected with some Garmin or Trimble Juno GPS units depth measurements may already be included in the "All_Depth_Points" layer. If this is the case, skip ahead to "Symbolizing and Editing Depth Points".

Now the students can start adding the depth measurements.
First open the attribute table for the "All_Depth_Points" layer.
Right click on the layer and on the drop down menu select, "Open Attribute Table"
Next, add a field to the attribute table.
Click on the "Table Options" icon in the upper left.
From the drop down menu select "Add Field".
Name the field "Depth"
For "Type" select "Double" from the drop down menu.
Click "OK" at the bottom
Now, in your editor tool bar select "Start Editing" from the drop down menu.
Click on "All_Depth_Points" in the popup menu. Then "OK" at the bottom.
You should now be able to enter the depth measurements into the attribute table.
Click on the appropriate cell and type in the depth.

IMPORTANT - All Depths should be recorded as a negative number.

After you have entered a few depth measurements into the attribute table return to the Editor tool bar and save your edits by opening the dropdown menu and selecting save edits.
Do this every so often as you enter data.
Also, it is a really good idea to frequently save your map.
Do this by clicking on the "File" tab at the top and save.

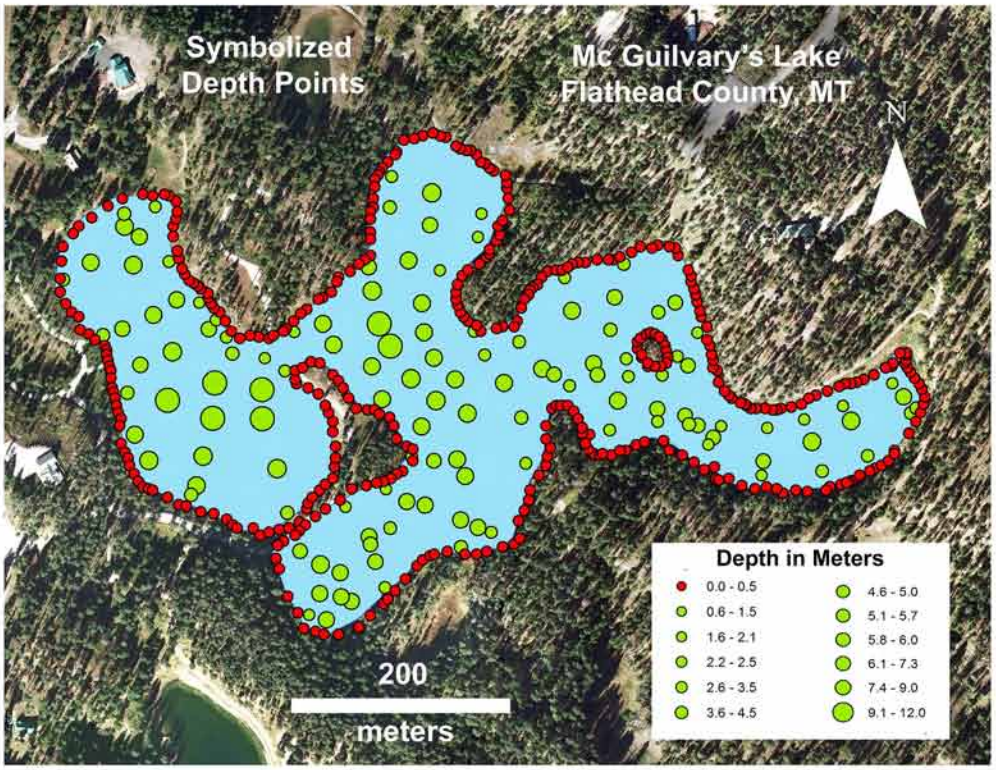
Note: The first time you save your map it will ask you where you want to save the map and what you want to name it. It is probably best to save the map in the project folder. You should also name it appropriately. It should be easy to recognize.

WARNING – Do not save your map using the default, "Untitled". It is likely to be over written by another user and you will lose your work.

After you finish inputting all depths into the attribute table, go to the "Editor" tool bar.
From the drop down menu select, "Stop Editing"
When asked if you want to save your edits click, "Yes".

Symbolizing and Editing Depth Points
Now that all depth measurements are entered it is time to take a look for errors and to see if coverage is adequate to make the bathymetric map. This can be done visually using symbology. An example map with symbolized depth points is presented in Figure 3.

Figure 3: An example of a map with symbolized depth points.



To symbolize depth points, first right click on the "All_Depth_Points".
From the dropdown menu select "Properties"
Select the "Symbology" tab from the popup menu
On the right side, under "Show" select "Quantities" > "Graduated Symbols"
For "Value" select "Depth"
For "Normalization" select "None"
For "Classes" either select the total range of your depth measurements (for example 12, if your deepest point is 12 meters) or a leave the automatically generated class numbers as is.

You can also select a color for all symbols if the automatically generated colr is difficult to see.
Right click on "Symbols".
Select "Properties for All Symbols.
From the color palette select a color that will be easy to see
Do not change the size or symbol or they will not show as graduated symbols
Click "OK"
Because the depths are negative you will need to flip the values.
Right click on "Symbols"
Click on "Flip Symbols"
Click "OK"

You will now see the size of the depth points drawn relative to their depth value. Larger circles will be represent deeper points and shallower points will be represented by small dots. Study the depth points to make sure they all make sense. If there are points that are out of the lake, or within the lake, but clearly in the wrong place, you will need to edit these before you can make a bathymetric map.

Before you start editing it will be helpful to turn on the survey lines and label the points.
Click on the survey lines in the Table of contents.
If they are above the depth points move the survey line layer so that it is below the depth points layer.
To label the survey points, right click on the "All_Depth_Points" layer
Click on "Properties"
Select the "Labels" tab.
On the popup menu for "Label Field" select "Way_Point" name (or the name of the field that gives the names for each point).
You can change the text symbol and color so that it will be easy to see on the map.
Click "OK" at the bottom of the menu.
If the labels don't show, right click on the "All_Depth_Points" layer and click on the labels in the dropdown menu.

To edit your depth points select "Start Editing" drop down menu on the editor tool box.
Select "All_Depth_Points" from the next popup menu.
The "All_Depth_Points" should appear o the "Create Features" popup menu.
If it doesn't click on the "Organize Templates" icon at the top of the menu.
In the next popup menu, Select "All_Depth_Points".
Then click on the "New Templates" icon.
Make sure the box in front of "All_Depth_Points" is checked in the next popup menu.
Click "Finish" and close the "Organize Templates" menu.
The "All_Depth_Points" layer should now be showing in the "Create Feature" menu.
You can close the create feature menu.

Use the edit tool in the "Editor Menu" to edit depth points that are wrong.
Click on the tool and move it to a point that is wrong and click
The point will be highlighted.

By clicking and holding you can move the point to another location. This is helpful if the point is labeled and you know about where it should be moved. For example if the point that is in the wrong place is labeled A7 it could logically be moved to a place on an "A" line that is between A6 and A8. There may be other clues that would allow you to move points that are off into approximately the right location.

If points are off and you can't figure out where they should go, it will be best to delete them. This can be accomplished by left clicking on the point and selecting delete from the drop down menu.

Once you have finished editing your depth points, stop editing and save your edits. At this time you will want to study your map. To make a good bathymetric map you will need good coverage. You may be able to add a few points as estimates in small area with poor coverage. This can be done in Editor using the create feature menu. (This procedure is outlined in the next step for creating "Zero Points".) If coverage is poor in a large part of the lake it will be best to return to the lake and gather more data.

Making the Bathymetric Map, Part 1
Marking the Lake's Edge
Before making a bathymetric map using the depth points you gathered it will be necessary to define the edge of the lake with zero-depth points. You can see this in Figure 3 as red dots.

Select "Start Editing" drop down menu on the editor tool box.
Select "All_Depth_Points" from the next popup menu.
The "All_Depth_Points" should appear on the "Create Features" popup menu.
Click on the "All_Depth_Points" layer.
The point tool should be highlighted at the bottom of the menu and when you move the cursor back to the map it will be shaped like an arrow and carrying a point.
Move the cursor to the edge of the lake (or where the water depth is zero.)
Right click and a point will be dropped at this location.
Move the cursor to another zero point and click again.
Repeat this procedure until you have a zero points all around the edge of the lake.
It will work best if the points are about 2 feet apart.
Also, you will need to surround islands with zero points.
Occasionally save your edits as you create zero points.

Once you have finished creating zero points open the attribute table for the "All_Depth_Points" layer. All of the points you just created will show a <Null> value for depth
Click on the each empty cell and type in a "0"
Once all "0" are typed in stop editing and save your edits

Making the Bathymetric Map, Part 2
Creating a TIN (or shaded depth map)
A TIN (or triangulated irregular network) represents land surface by connecting irregularly distributed elevation (or depth points) with a network of nonoverlapping triangles. A TIN is used to generate shaded relief and contour maps.

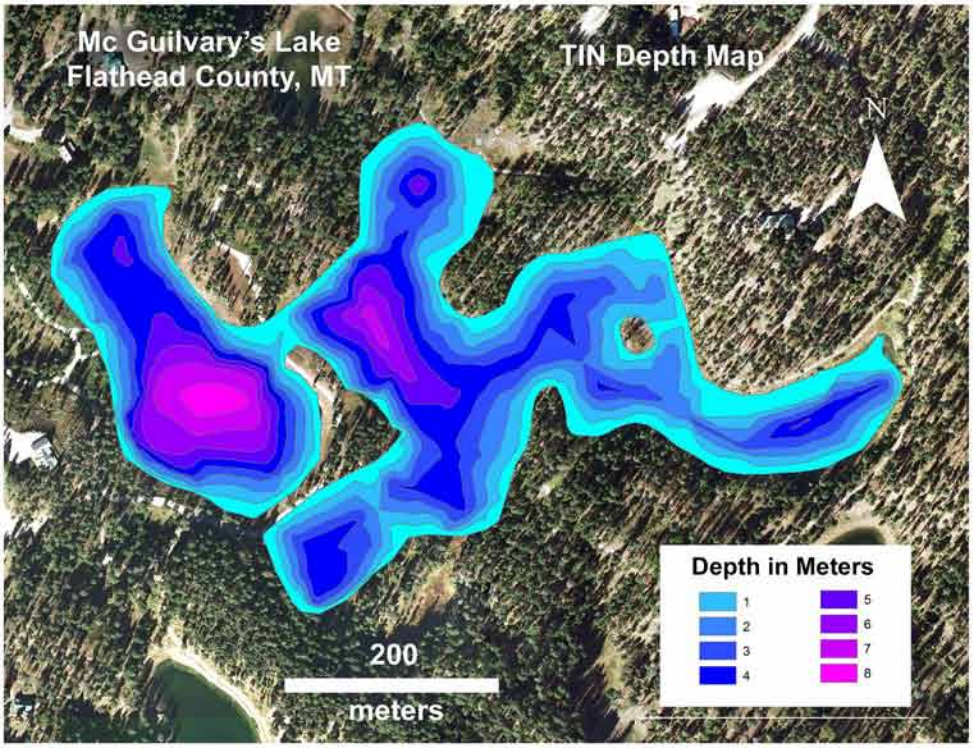
Open ArcToolbox, expand 3D Analyst Tools > TIN Management> Create TIN
On the Create TIN popup menu, select the folder icon to the left of "Output TIN"
Navigate to the project folder for "Look In:"
Name the TIN, "Lake_Depth_Shades"
Click on the "Spatial Reference" icon to the right of the next box.
Click on "Import"
Navigate to "All_Depth_Points" and click "OK" at the bottom
For "Input Feature Class" select "All_Depth_Points" from the drop down menu
Make sure the "height field" is "Depth"
Click on "OK"

If all went well you should have a shaded depth map of the lake.
The outside of the area outside of your lake should be a solid color (probably light blue).
If this is not the case you may need to return to editor and edit a few more of your points.

Once your TIN looks reasonable, you can adjust the symbology to improve appearance.
Right click on the "Lake_Depth_Shades" layer.
Select "Properties"
Lick on the "Symbology" tab at the top of the menu
Choose a color ramp with shades of blue to represent the lakes depth
Select the number of classes to represent each meter of depth
Turn off "Show hillshade illumination effect in 2D"
(This effect doesn't seem to work well for bathymetric maps)
Click on the color for the shallowest depth range.
In the "Symbol Selector" menu choose "No Color"
Click "OK" > "OK"

An example of a shaded depth map is presented in Figure 4.

Figure 4: An example of a shade depth map.



Making the Bathymetric Map, Part 3

Creating a Contour Map

A contour map uses lines of equal elevation (or contours) to show depth. The TIN (or shaded depth map) created in Part 2 can be used to create a contour map of the lake bottom. Figure 5 presents a poster which includes contour lines.

Open ArcToolbox, expand "3D Analyst Tools". Expand "Terrain and Tin Surface".
Double click on "Surface Contour"
For "Input Surface" use the drop down menu and select the "Lake_Depth_Shades" layer
For "Output Feature Class" use the folder icon to the left to navigate to the project geodatabase

For "Contour Interval" for a shallow lake with not much relief type in "1", for a deeper lake with moderate relief type in 2, for a deeper lake with steep relief type in 3.
Click "OK"

You can right click on the newly created contour layer and go to symbology to adjust the color and line width for the contour lines. You can also click on labels tab and label the contours.

Making the Bathymetric Map, Part 4 (optional)
Fine tuning your bathymetric map
The shaded lake depth and contour lines on your bathymetric map no doubt look angular and your map probably has a few other non-natural oddities, such as contour two contour loops connected at a single point. If you have the time your students can fine-tune the map. The process is tedious and may not be in the bet interest of the weak of spirit. Here are some tips and general procedure to improve the appearance of your map:

Smoothing contours – Because the TIN surface relies on straight line between points depth changes it creates sharp angels where contours bend. Most likely the contours are rounded. Students can use the editing tool in "Editor" to reshape contours.

First select "Start Editing" in the Editor dropdown menu.
Choose the contour layer from the popup menu. > "OK"
Right click on a light gray space above your map and select "Edit Vertices"
The "Edit Vertices" tool will appear somewhere on your map.
The first tool to the left, or "Modify Sketch Vertices Tool", lets you display and move vertices.
Double click on one of the contours using the first tool.
All of the contours for that line should be showing as green dots.

You can hover the tool over a vertex until small arrows pointing in all directions surround it. Now click on the vertex and you will be able to move it to another location.

You can also add and move vertices using the next tool to the right, or "Add Vertex" tool
Click on this tool.
Move the cursor to any location that is on the line and between two existing vertices.
Click and a new vertex will be added. Once the new vertex has been added it ca be moved.

You can also remove vertices using the second tool from the right, or the "Delete Vertex" tool.
Click on this tool
Hover over an existing vertex and click.
The vertex will be deleted.

There are other tools in the "Edit Vertex" tool set that you can experiment with and learn about. Use the "Edit Vertex" tool set to reshape contours to a more natural appearance. As you reshape them keep them close to where they were plotted, but realize that they were created from a few points that you took and some may be off.

Recreating the TIN – Your Contours will no longer match your TIN once you have reshaped them. You can recreate the TIN by replacing depth points along each contour.
Start by creating a new depth point layer.
In ArcToolbox expand "Data Management Tools"
Click on "Feature Class"
Double click on "Create Feature Class"
For "Feature Class Location" use the folder icon to navigate to the geodatabase in the project folder
Name the feature class "Adjusted_Depth_Points"
For "Geometry Type" select "POINT"
For "Template Feature Class" use the dropdown menu to select "All_Depth_Points"
For coordinate system use the icon to navigate to "All_Depth_Points"
Click "OK" at the bottom

Next in the same manner that you created zero depth points around the edge of the lake, create points along each contour for the appropriate depth.
You will also need to recreate the zero depth points.
Save your edits as you go and when you finish stop and save your edits

Last recreate the TIN using the "Adjusted_Depth_Points" and the same procedure you used to create the original TIN.

Making a lake poly for the bottom of your TIN – Your TIN probably doesn't go to the edge of the lake. You can create a poly of the lake surface, which you can place below the TIN.

Click on "Feature Class"
Double click on "Create Feature Class"
For "Feature Class Location" use the folder icon to navigate to the geodatabase in the project folder
Name the feature class "Lake_Poly"
For "Geometry Type" select "POLYGON"
For coordinate system use the icon to navigate to "All_Depth_Points"
Click "OK" at the bottom

To draw the lake poly click "Start Editing" on thr drop down menu on the editor toolbox.
Select "Lake_Poly" from the next popup menu.
Click on the "Organize Templates" icon at the top of the menu.
In the next popup menu, Select "All_Depth_Points".
Then click on the "New Templates" icon.
Make sure the box in front of "Lake_Poly" is checked in the next popup menu.
Click "Finish" and close the "Organize Templates" menu.
The "Lake_Poly" layer should now be showing in the "Create Feature" menu.
You can close the create feature menu.

Click on "Lake_Poly" in the "Create Feature" Menu

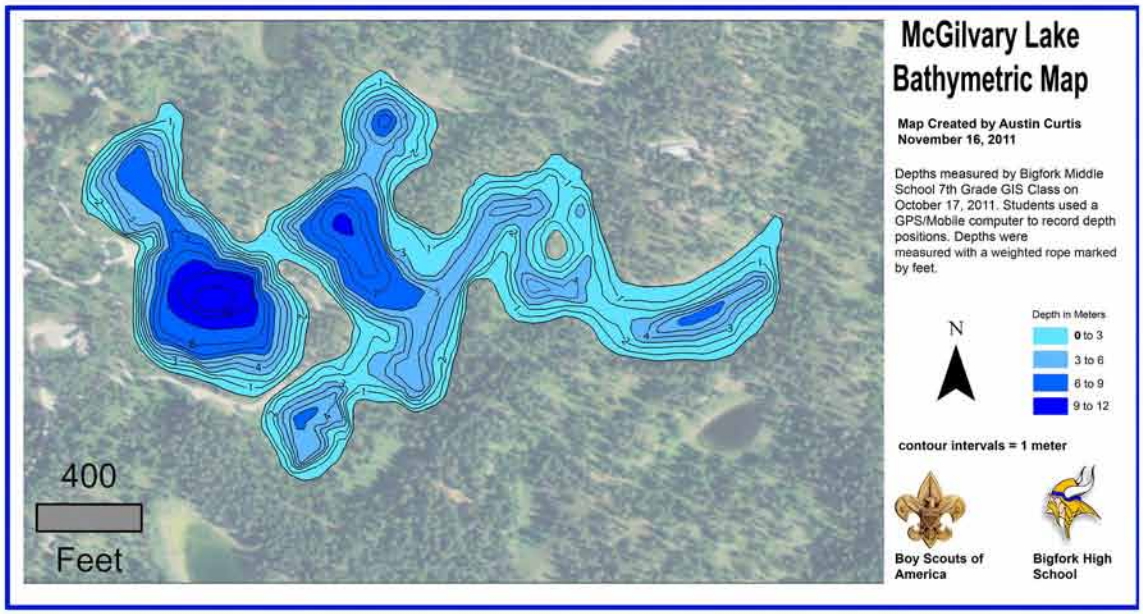
When you move the cursor to the map it be displayed as a small cross
Move the cross to the edge of the lake and click
Next move the cursor to another point on the lakes edge about 20 feet away.
Repeat the process until you have surrounded the lake.

Click on "Stop Editing" in the "Editor Toolbox" and save your edits
Move the finished poly below the TIN in the Table of Contents
Using symbology select a color that goes well with those you selected for your TIN.

Creating a Poster

A nice way to finish up the lesson is to have the students create posters of their data. There are many ways a project poster could be created and the author would be willing to share ideas. A sample student poster is presented in Figure 5 for guidance and inspiration.

Figure 5: Example of a student created poster.



Questions or comments? Contact hansb@bigfork.k12.mt.us

Bathymetric Mapping Data Form

Lake Name:	Group Members:
Date:	
Survey Lines:	

Waypoint Name	Latitude	Longitude	Depth (meters)