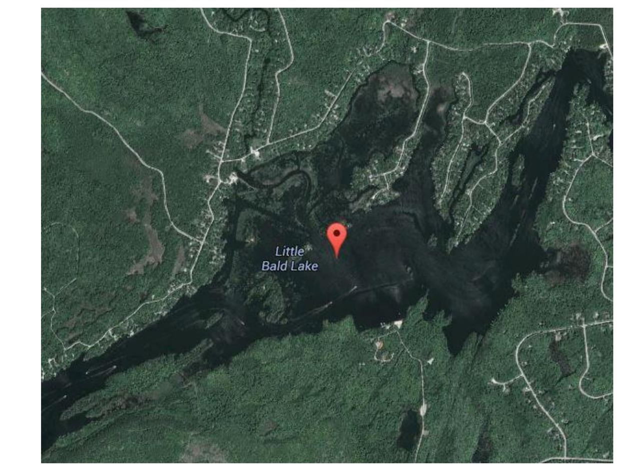
UNCOVERING THE ANCIENT CHANNEL OF LITTLE BALD LAKE

Trent Severn Waterway



Introduction:

The study area under investigation is Little Bald Lake, which is a sub-basin of Lake Kawartha (refer to Figure 1). Little Bald Lake is slightly larger than it's adjacent neighbor, Big Bald Lake. The size and name discrepancies between these two lakes is from the size of Little Bald Lake prior to the construction of a dam at Buckhorn. Flooding that resulted from this construction caused marshlands in the northeastern corner of Little Bald Lake to become much more recognizable as part of the lake, resulting in a larger surface area of Little Bald Lake by definition than when the naming was put into place (Kawartha Lake Stewards Association, 2009).

Before this change in the lake, the lakes had a different morphology and appearance. It is suspected that an ancient channel stretched through beneath what is now Little Bald Lake. This interesting geomorphology within the lake, one that appears to have pre-existed the lake itself, is thought to have been flooded by the Trent Severn series of locks, creating what we know now as Little Bald Lake.

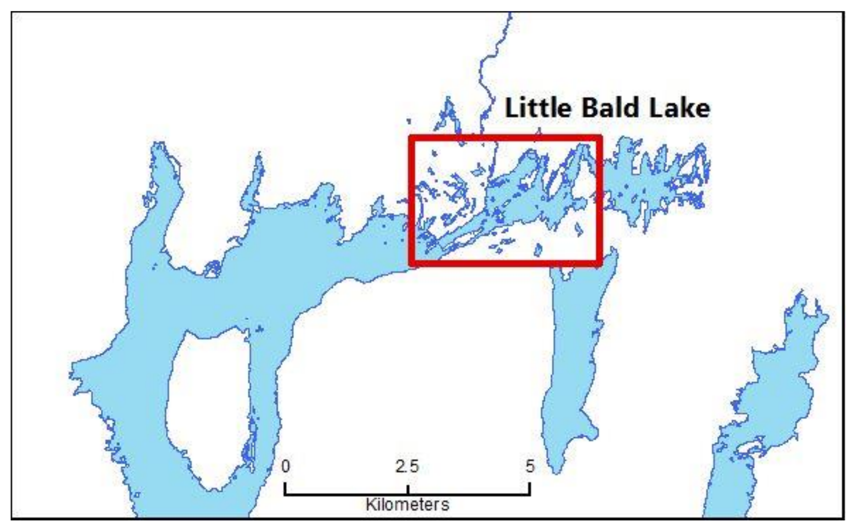


Figure 1: Study Area

Objectives:

This investigation's primary objective is to uncover this ancient channel from a package of raw data, including a shape file of the entire system of the Kawartha Lakes, rivers, and data depicting the depths taken at various points on a vigorous trek across and around Little Bald Lake. From this data, the points of depth will be narrowed to those in the lake of interest alone and the depths will be manipulated to reflect the depth in reference to Mean Sea Level (MSL). From these new depth measurements, the data will be interpolated and contours will be created. After refining the contours and modelling the files in ArcScene, the ancient channel can be discovered and seen a much clearer view.

Data quality and meticulous handling of the data and data processing is important to compute accurate and successful results. The field of GIS and geographical research depends on high quality results to maintain integrity and continue to support further research. For these reasons among others, this investigation has been carried out with the objective of maintaining accuracy throughout the methodology and producing high quality and highly usable results.

Methodology:

Step 1: Initial Lake Data Acquisition

The raw data used for this investigation was acquired using a Garmin GPSMap 188 Sonar device. With the GPS, a trek was taken across Little Bald Lake, taking coordinate information and depth measurements. The GPS was set to record locations in the NAD 83 coordinate system in UTM Zone 17. A total of two trips were taken, and the same device was used to record the data and the data for each trip was stored in separate comma delimited text files. Along with the location and depth information, the GPS time and the temperature of the lake were recorded. Shown below depicts the trips taken across Little Bald Lake to collect the GPS coordinates and depths at various points in the lake. (refer to Figure 2)

Preprocessing was an important step in this investigation to refine the data to be the most useful to achieve our objectives. As a brief overview of the following content in this investigation, preprocessing first began with eliminating the points that were outside of the lake boundary. Values that were recorded with a depth of 0m that were not along the shoreline were also eliminated. Furthermore, the shoreline was converted into a series of points and a buffer was set around the shoreline to capture points that were most accurately depicting the elevation of the shoreline itself. After averaging these depths, we were able to manipulate the depths of the measurements within the lake to obtain depth values in reference to MSL. At this point, we merged the layers and preprocessing is complete.

Figure 2: A lakes layer depicting the points collected on the two trips across Little Bald Lake

Step 2: Eliminating Data Beyond Lake Boundary

The first step in preprocessing was to eliminate the data that fell outside of our area of interest. In ArcMap 10.2.2, the lakes layer was clipped to only include Little Bald Lake using the 'clip' function and selecting an area to clip the layer to. However, there were still points that were located outside of the lake with a depth measurement of 0m. To have an attribute table that only included points useful to us, we had to eliminate these points that strayed far from the lake itself . The refined contents of the attribute table later became very useful, so this step was quite important. A second clip was done on the points layer to only include those that fell within the boundary of the Little Bald Lake layer. The result of this was a new lakes layer only containing Little Bald Lake, a new layer containing only points within the Little Bald Lake layer boundary, and refined attribute tables that will be much easier to deal with without excessive data that was not applicable to achieving our objectives.

Step 3: Creating Points for the Shoreline

In order to calculate the depth of the lake, the Bald Lake polygon needed to be converted into a polyline layer. This was done by using the Feature to Point tool, where the Little Bald Lake boundary was converted into points.

Converting the Bald Lake polygon into a polyline created the boundary of the lake, this would allow for accurate depth estimations because it allowed for the shoreline to be visible in order to correctly observe the pattern of data collection.

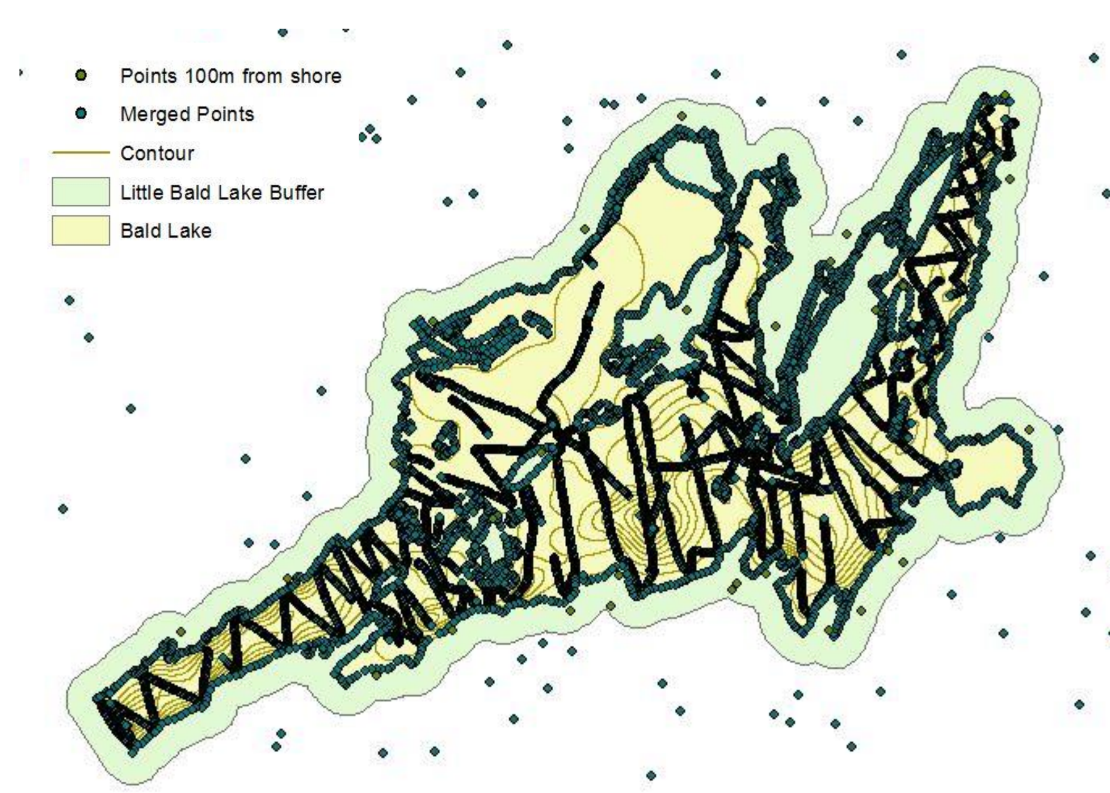


Figure 3: Depth Sounding Points

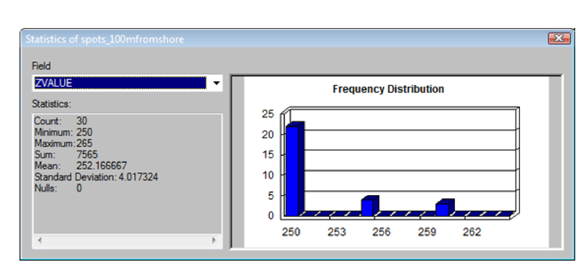


Table 1:Frequency Distribution of Z values

Step 4: Examination of Shoreline Elevation Values and Data Adjustment

Due to the depths of the shoreline points being referenced from a MSL of zero, a more accurate depth needed to be calculated. This was achieved using the average of the spots layer depths and adding it to the lake depths (refer to Figure 3). In order to attain this, the Little Bald Lake polygon layer was buffered to 100m to create a boundary for the spots layer to be clipped to.

Clipping the spots layer to the Little Bald Lake layer returned the spots that were within the 100m boundary of the lake.

This allowed for an average of the depths of the spots that were 100m within the lake boundary to be calculated and applied to the depth of the lake boundary using excel. The average was determined by using the statistics of the spots 100m from the lake boundary, and then this average of 252.17 was added to each of the lake boundary points using the field calculator in the attribute table. This created a depth for the lake that was relative to the true MSL.

Step 5: Merge All Points into One Layer

All of the spots, points, and bald lake boundary points were merged together into one layer. The new layer contained all of these points with depths that were relative to MSL (refer to Figure 4 for a graphic illustration of the Merge tool).

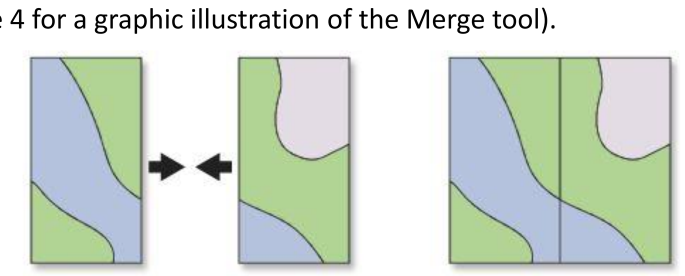


Figure 4: Illustration of Merge Tool

Step 6: Natural Neighbor Interpolation Method

Also known as Sibson or "area-stealing" interpolation.

Strengths
- advantages over simpler methods of interpolation such as nearest-neighbour interpolation
- provides a more smooth approximation of the underlying "true" function
- the weights are calculated by finding how much of each of the surrounding areas is "stolen" when inserting into the tessellation
- will not produce peaks, pits, ridges, or valleys that are not already represented by the input samples

Weaknesses
- implementation is relatively difficult
- some simple implementations are numerically unstable

Natural Neighbour Interpolation is preferred over others due to its simplicity and because it interpolates a raster surface from points. The input point feature in this case will be the Little Bald Lake surveyed points that contain Z values calculated in an earlier step. The default cell resolution was then changed from 2.03095899954889E-04m to 2m, this value determines the cell size at which the output raster will be created.

The output of the Natural Neighbour Interpolation tool created the following Digital Elevation Model in Figure 5.

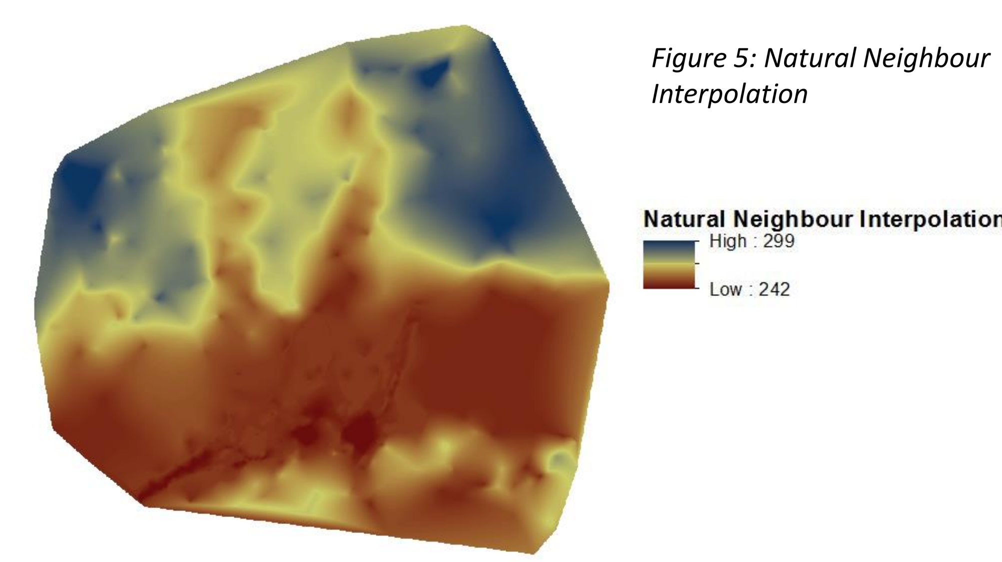


Figure 5: Natural Neighbour Interpolation

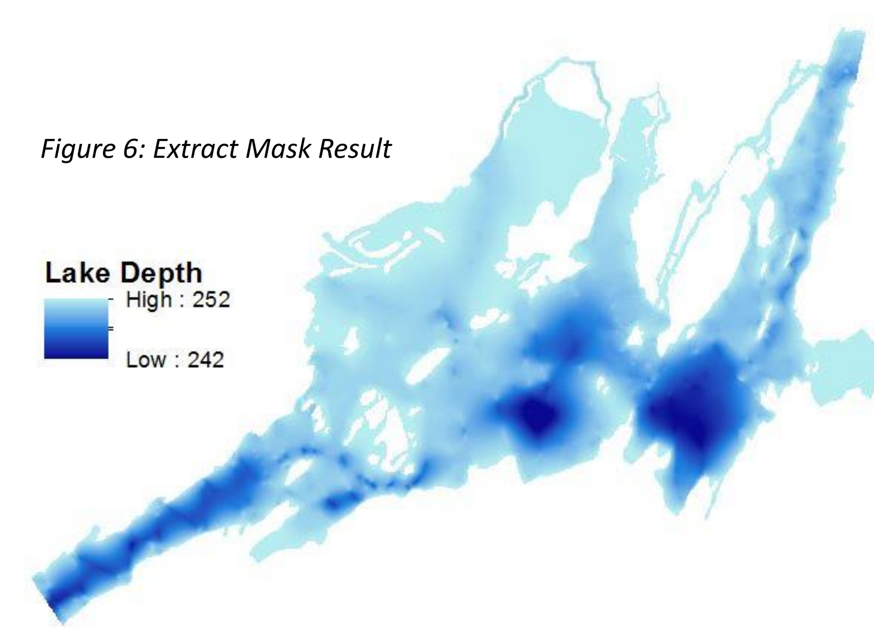


Figure 6: Extract Mask Result

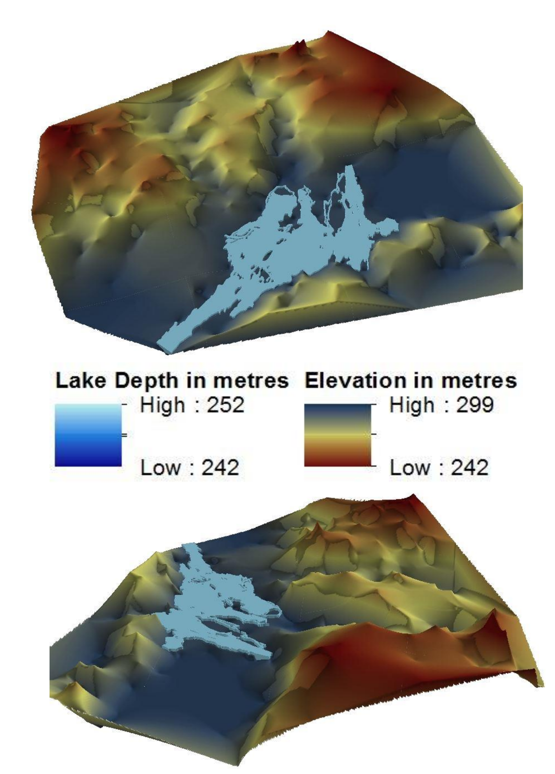
The Extract by Mask tool under the Data Analyst Tools in ArcToolbox was then used to clip the DEM to the Little Bald Lake study area (refer to Figure 6). This tool extracts the cells of a raster that correspond to the areas defined by the mask. The cubic convolution resampling method was then implemented after the Nearest Neighbour Interpolation technique was used in order to store the different raster datasets using the same cell resolution. This resampling technique is necessary because the centres of the input cells rarely align with the transformed cell centres of the desired resolution. The cubic convolution method uses the weighted average, which is calculated from the 16 nearest input cell centres and their values.

ArcScene

ArcScene is a program that allows you to overlay many layers of data in a 3D environment. This provides height information and displays the projected topography in a 3D format. This program also allows one to view the landscape from multiple viewpoints, controlled by the user.

The extracted layer was then imported into ArcScene, along with the DEM, which was then rendered to exaggerate the vertical from the original 12.8m to 20m in order to create a greater definition in the elevation model. Little Bald Lake used an offset base height of 1m to elevate the layer on top of the DEM (refer to Figures 7 and 8).

The Hillshade tool is used to create a shaded relief raster and illuminates the topography that includes shadows on the relief, depending on the angle at which it is viewed.

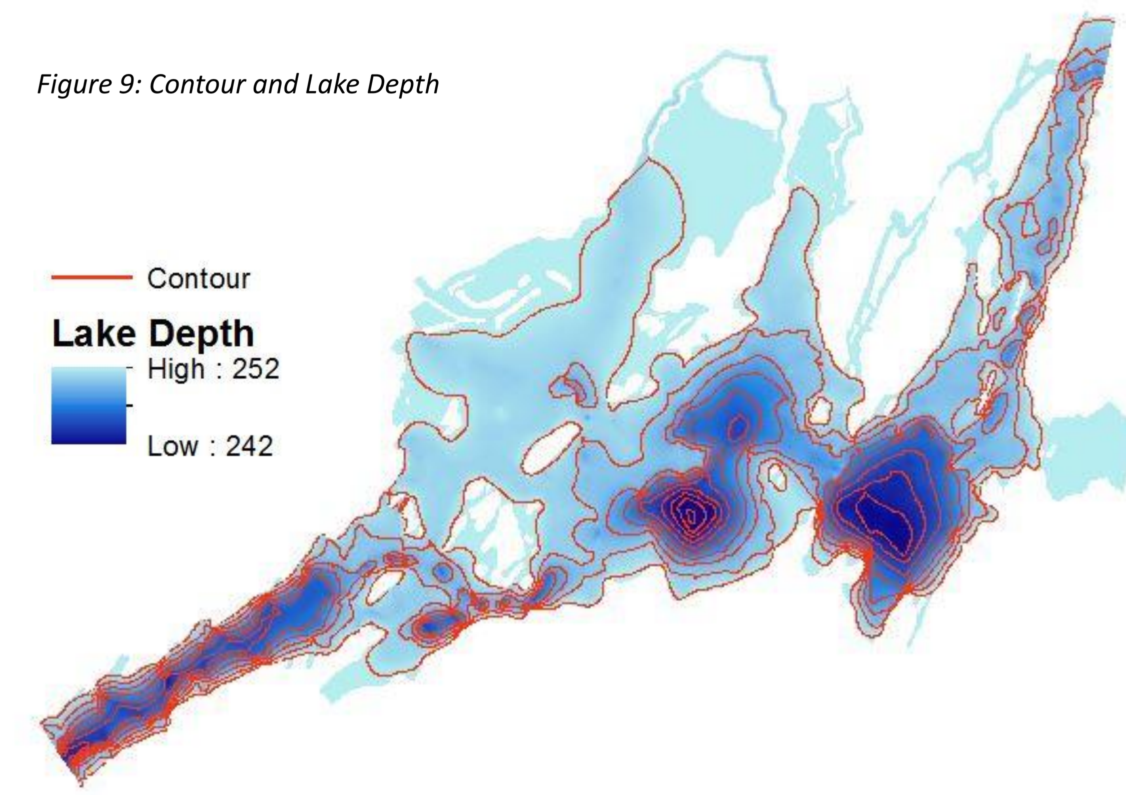


Figures 7 and 8: ArcScene DEMs

Contour Creation

The contour lines were generated using the Contour tool in the Spatial Analyst toolbox. This tool creates a line feature class of contours from the z-value of a raster surface. The result reflects the change in elevation of the specific input raster layer. The contour interval was set to 1 meter, which means each contour line has 1 meter difference in elevation compared to the lines right beside it. In this project, the lower elevation contours are located in the western channel and the south eastern part of the lake. The close contour lines in these areas indicates a steep incline in lake bathymetry (refer to Figure 9).

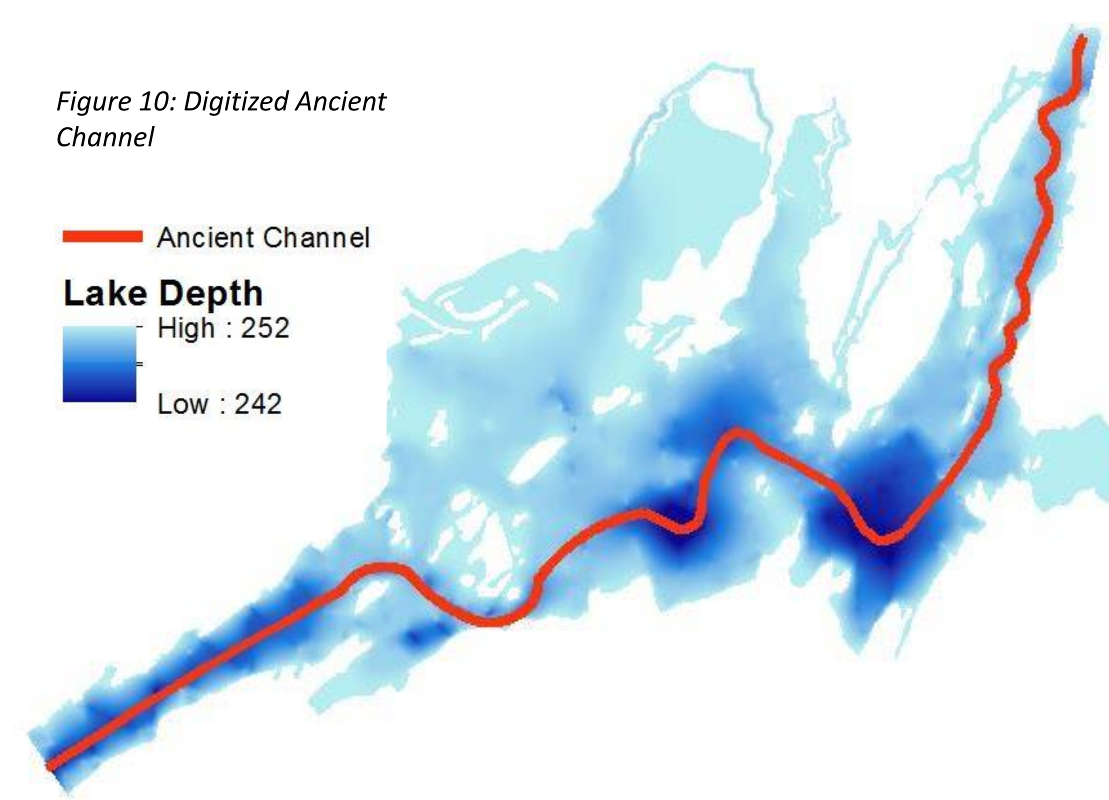
Figure 9: Contour and Lake Depth



Digitizing the Channel

The ancient channel was identified by digitizing the deepest elevation, depicted by the dark blue colour on the contour bathymetry map. The darkest regions would represent the likely area of the ancient channel as they represent the deepest sections of the lake that have not been affected by the damming and flooding of the Trent Severn Waterway (refer to Figure 10).

Figure 10: Digitized Ancient Channel



Conclusion:

GIS are widely used in detecting area and landscape changes. Through the application of various GIS functions, we were able to identify the ancient channel that was flooded by the Trent Severn Waterway. Preprocessing was found to be crucial in this discovery, supporting the value of accurate data and ensuring the quality of the data throughout the entire process. The tools used are important to collect accurate data and the methods of management of the data after acquisition maintains the integrity of the data. This investigation of discovering the ancient waterway supports that the methodology of an investigation is just as crucial as the results.

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Data Sources: National Topographic Data Base (NTDB – 31D09); Government of Canada, Natural Resources Canada; Earth Sciences Sector; Mapping Information Branch; Centre for Topographic Information – Sherbrooke, current as of 2012. All other data are collected by Noreen Goodliff. All other information current as of 2013.

Projection: Transverse Mercator Projection: North American Datum 1983
Universal Transverse Mercator (UTM) Grid Zone 17 North

Produced by: Rachel Schaus, Xiaochen Xing, Courtney Dunn, and Sarah Lavoie using ArcMap 10.2.2 and Powerpoint 2007.