Marmion Lake Mapping Project Update
December 19, 2007

In addition to the survey work completed over the month of October, 2007, the following work has been completed on the mapping portion of the project:

Cleaning the survey data

The data collected during the field survey contained some errors and anomalies that needed to be corrected. For example, if the boat was travelling too fast, or if cavitation occurred, the unit would typically record zero values for the depth. In some instances, abnormal deep depths were also erroneously reported. Frequently, where the depth was less than 0.4 metres, the depths would also be recorded as zeros. It was necessary to correct these values in the data to avoid confounding the computer software during the creation of lake contours. A simple solution would have been to simply sort the data, select all zero values and delete those records. However, instead each zero value recorded in the data was examined in turn to verify the error. Rather than discarding the records where the zero values were due to extremely shallow conditions, as opposed to high speeds for example, these were not deleted, but assigned an arbitrary value of -0.2 metres. This was done to preserve the configuration of the feature represented to assist the software in the eventual drawing of contours. The absolute accuracy of these assigned values was largely irrelevant, since the shallowest contour is at 1 metre in any event, and this simply tells the software that the depth is less than 1 metre in that location. **Figure 1** illustrates a section of the lake with survey data points shown: the highlighted yellow locations show points where zero depths were recorded erroneously in deep water where no shallow structure exists.

In examining the zero value records in detail, it was also discovered that some depths of -0.2 metres had been erroneously recorded by the depth sounder along with the zero values in deep water for the reasons previously mentioned. Consequently, all recorded depths of -0.2 metres were also examined to confirm their validity, and deleted if found to be in error.

Re-digitizing the lake boundaries, including the islands

The original survey data, that included contouring the shorelines of the lake and islands, did not conform well to the boundaries of the lake used by MNR in their GIS system. If the MNR boundaries were used to create the required depth contours, this resulted in much of the data along the shorelines being clipped out, as the depth data overlapped the shoreline in many locations. This discrepancy was due to differences in tolerances between the MNR digitized lake boundary data and the GPS data recorded by the survey. The differences were not large geographically, but sufficient to make the two data sets incompatible for our purposes. **Figure 2** illustrates the discrepancies and overlap between the data points in red and the MNR lake coverage. Additionally, since the MNR lake boundary data is proprietary and copyrighted, the use of this data may be legally problematic for the Atikokan Bass Classic in any event. Therefore, the lake shoreline has been completely re-digitized based upon the 1995/96 aerial photography. This involved digitizing some 26,000 vertices or points to form a new lake polygon. The new boundary encompasses and conforms to all the data collected in the lake survey. When the original MNR lake shapefile and the new lake shapefile are displayed overlapping on screen for the lake in its entirety, they appear virtually indistinguishable. This is to be expected, since they both represent the same lake and its' configuration. **Figure 3** displays the revised lake coverage with the original MNR coverage overlaid and shown as a red outline. However, when one zooms in on smaller sections of the lake, the differences become evident, although not large. **Figure 4** shows a detail of a section of the lake illustrating differences between the new lake coverage and the original MNR coverage shown as a red outline.

In addition to adjusting the shoreline, several small islands in various locations were discovered that were clearly evident on the aerial photographs, but which did not show on the MNR coverage. These were digitized and added to the new lake and island layer. A new shoreline for what is known as Moose Lake, lying south of Highway 622, was created as well, as previously it had consisted of a shoreline that represented that basin when it had been drained during construction of the Atikokan Generating Station. **Figure 5** illustrates the difference between the former Moose Lake mapping (in red), and the revised mapping. Finally, many rocks which rise above the surface of the water during normal water levels were not originally digitized, and these are now digitized and included as part of the islands layer.

Pinning the data

In order to ensure that the software correctly identified the shoreline (where the depth was obviously zero) a set of "placeholder" depths was created at a distance of 1 metre from the shoreline for the entirety of the lake. These placeholder depths were assigned an arbitrary value of -0.2 metres. Although there may be locations where the lake may be deeper than this one metre from the shoreline, the effect would be marginal when it came to constructing contours. A test of the methodology using only the data for Sawbill Bay confirmed this.

Additionally, all reefs and other shallow areas identifiable on the aerial photographs were digitized using a perimeter of points. These shallow features were verified using older 1982 and 1965 photography where available. Generally, shallow features were readily discernable on the 1995/96 photography at depths down to -2.0 to -2.5 metres. This was confirmed by examining multiple features where actual depths over these features had been recorded by the field survey. The perimeter points were then assigned depth values based upon their visibility on the photos and the adjacent data and field notes recorded during the field survey. Once again, the effect of including this data was tested by producing contours both with and without it. The resulting contours were essentially the same for the deeper contours, as one would expect, but tended to conform better (but not perfectly) to the size and configuration of shallow areas when the manually created data was included.

For the final production of contours, a merged data set was therefore used that included the near-shoreline points at -0.2 metres, the shallow features points at -1.0 to -2.0 metres and the cleaned survey depth points. The added records not collected during fieldwork were identified in the attribute tables for the merged file as “placeholder” and “assigned”, respectively under the Comment field, to distinguish them from the original field data. Overall, there are 382,581 depth records (points) in the merged data file, of which 302,691 are field records. **Figure 6** displays a detailed section of the lake illustrating the field data (red), the “placeholder” data (purple) and the “assigned” data (blue).

Deriving depth contours

Some time was spent examining various ways of generating depth contours from the depth data using computer software. One method involves creating a TIN, which is a surface covering the extent of the lake comprised of triangles joining the depth points in groups of three. Each triangle thus created represents a sloping surface based upon the depths recorded for each of the three points forming its vertices. **Figure 7** shows a section of the TIN created for the lake. Contours can then be generated from the TIN by drawing lines through the appropriate positions on each sloping triangle’s surface. The resulting contours, although relatively accurately reflecting the original data, tend to appear very “jagged”. **Figure 8** illustrates an example of the contours produced from the TIN for a small section of the lake, using a 5 metre grid and a 1 metre contour interval.

An alternative method for creating the contours involves creating a grid from the original data points. The grid divides the surface up into regular cells or squares, each of which is assigned a depth value based on the surrounding point depths. The contours are then derived by drawing the appropriate depth lines through the appropriate grid cells. The resulting contours are much “smoother” than those produced from the TIN, although the depths represented by grid cells, being derived rather than actual depths, are less accurate. It is possible to set the grid cell size used and therefore hypothetically increase the resolution or potential accuracy by using smaller cells. **Figure 9** illustrates contour produced from a grid for the same section of lake shown in Figure 8, also using a 5 metre grid and a 1 metre contour interval.

In determining the best approach to be used for the Marmion project, both methodologies, as well as some variations, were employed and the results compared to determine the most suitable in terms of accuracy and ease of interpretation by the end user. Grids were created directly from the depth data as well as from the TIN, using 5 and 10 metre grid cells. Contours were produced from the TIN, as well as from the various grids, at both 1 and 2 metre contour intervals. Several observations were made:

- Contours produced from the TIN were generally too “jagged” in many locations for practical use, as the end user would find the results too difficult to interpret. It also made for a rather messy-looking map. The TIN-derived contours did, however, tend to capture fine variations in the depths more accurately.
- Contours produced from the grids were smoother and more easily interpreted,

although they did tend to lose some fine details in some locations.

- No significant differences existed between contours produced at 1 metre intervals versus 2 metre intervals, apart from the obvious fact that twice as many contour lines were produced when using a 1 metre contour interval. The even-numbered contour lines produced using the 1 metre contour interval were identical to the contours produced using the 2 metre interval, which is to be expected. However, using a 1 metre contour interval produced a very "busy" map, with the number of contour lines potentially obscuring other features and making the map more difficult to read.
- Some small differences did exist between contours produced using a 5 metre versus a 10 metre grid, with the contours derived from the finer grid tending to capture some depth variations marginally better. This was not consistent, however, probably due to the irregular and variable spacing of depth points in the original data.
- No significant differences existed between contours produced from the grid created directly from the survey data versus those created from the TIN at the same grid cell spacing (apart from the fact that the processing time to create the grid from the original data was about four times as long as the time to create a corresponding TIN, and creating a grid from the TIN took a fraction of the time!).

As a consequence of the foregoing, it was decided that the best approach was to produce the contours using a 5 metre grid and use contours produced directly from the TIN as a guide to make any necessary adjustments or corrections. Additionally, a 2 metre contour interval worked best, but with a contour at the 1 metre depth included to provide additional detail in shallower areas. This was accomplished by creating contours at a 1 metre contour interval, then deleting all the odd-numbered contour records except the 1 metre depth. **Figure 10** shows the same section of the lake shown in Figures 8 and 9 produced using the above approach.

Cleaning the contours

The computer software that produces the contours does so by following a set of instructions (an algorithm) that tells it how to deal with predetermined scenarios that it might encounter in the data. Essentially, the algorithm tells the software "if you encounter this, then do this". If the software encounters a situation that is not covered in the instructions, it basically has been told to "skip it". When this happens, a gap is left in the contour line. Such gaps can be short, or quite long, depending on the difficulty that the software has encountered. **Figure 11** shows an example of gaps left in the contours by the software. In other instances, especially where the depth data is quite complex and variable, the software may produce rather odd contours that may not accurately reflect the actual structure of the bottom, since the software can only follow the algorithm and cannot assess the appropriateness of the results. The contours produced for Marmion Lake contained anomalies of both types that required correction. Further, some refinement of contours surrounding shallow features such as reefs was required to more accurately reflect actual size and configuration as evident on the aerial photographs.

Gaps in the contour lines produced by the software were most evident in the 1 and 2 metre contours where they occurred near shore. To close these gaps reference was made to the contours produced from the TIN, which often either did not contain the gaps, or gave some clue as to where the contours should go. **Figure 12** shows the TIN-generated contours lacking gaps for the same area shown in Figure 11, for comparison. The process involved filling in these gaps with appropriately configured line segments and then joining the lines to make them continuous. The process is very tedious and time-consuming as there are many hundreds of such gaps to be closed. There is no automated way of doing this.

In reference to somewhat odd contour lines created on occasion where the depth data is extremely variable, it was observed that this tended to happen most consistently associated with the 2 metre contour. At first it was not intuitively obvious why this was problematic at this depth more than others, but the depths fluctuating up and down from somewhat below to somewhat above 2 metres repeatedly over relatively short distances was a common factor. Assuming the depths were correct, they suggested an undulating bottom that rarely was in evidence at other depths. It was very difficult to visualize the structure that was producing these results, which explains why the software had so much difficulty. In examining the aerial photographs, which should have provided some insight as anything 2 metres in depth or shallower usually showed clearly, no evidence of such repetitive ridge-like structure could be seen. The problem was finally resolved when looking at the 1965 aerial photograph of one such area. The 1965 photography tends to show the flooded timber somewhat better than later photography. It is known from observation on the lake during the survey work that the residual standing timber that remains today, both as snags above the surface and as deadheads at or just below the water’s surface, occur consistently in water between 2.5 and 8 metres in depth. In areas shallower and deeper than this range they are much less common. The reason why they don’t tend to occur in deeper water is simply because these areas were probably flooded to begin with and never had any standing timber. In the shallower areas, where the standing timber died but lacked the support offered by the surrounding water in deeper locations, the trees tended to succumb to windthrow and simply blow over. They would then either become waterlogged and sink, or drift off to come to rest elsewhere. The latter was often the case, with timber eventually finding its’ way to windward bays or the lee side of islands and points where it would eventually sink. Some of these sunken trees may rest right on bottom, but others may be propped up by remnants of their root systems, or piled on top of one another like pick-up sticks. A depth sounder passing over such an area might show these logs on its’ display for what they are, much as it is possible for them to display weeds and stumps. But that depends upon continuous readings that allow the sounder to differentiate between these things and hard bottom. The BASS software, on the other hand, is designed to receive data at timed intervals, and simply accepts the data as having been received from a bottom signal. Therefore passing over an area with timber piled this way and at various depths above bottom, the software on the laptop is going to record depths that go up and down, up and down sporadically over short distances. And these situations are most likely to occur in areas less than three metres in depth where the 2 metre contour would lie. The only solution is to modify the computer-generated contours as required so that they reflect more reasonably the bottom conditions that are evident from the aerial photographs and surrounding structure above water.

Figure 13 shows a small section of the lake with a small island and bay. The yellow highlighted depth records shown are all recorded as being above the 2 metre depth (for the area of the small bay only). **Figure 14** shows the 1965 photography for the same area. **Figure 15** shows the same area using the 1982 photography. Note that in neither photograph do any shallow areas show up in the small leeward bay of the island, such as those clearly evident and above 2 metres surrounding the tiny island off the northeastern point. **Figure 16** shows the TIN-generated contours for this area and **Figure 17** the corresponding grid-generated contours, Finally, **Figure 18** shows the adjusted 2 metre contour line in this location.

The process of examining all the contours a section of lake at a time and correcting or adjusting them as required is a very time-consuming operation, but unfortunately unavoidable. This work is ongoing.

Other feature data

In addition to the coverages for the lake, the islands and the contours as previously described, coverages representing the following features are also being produced for the project:

- Roads and trails for the area surrounding the lake, including the landing area
- point features representing known rocks representing potential navigation hazards (largely to simply highlight these locations as they will be reflected in the depth contours as well)
- areas with concentrations of snags and deadheads, often referred to as “stump fields”.
- floating islands representing remnant peat bog that moves about in accordance with wind and water levels and often becomes lodged on deadheads.

- thick, unnavigable marsh, such as reeds or cattails
- navigation routes

FIGURES

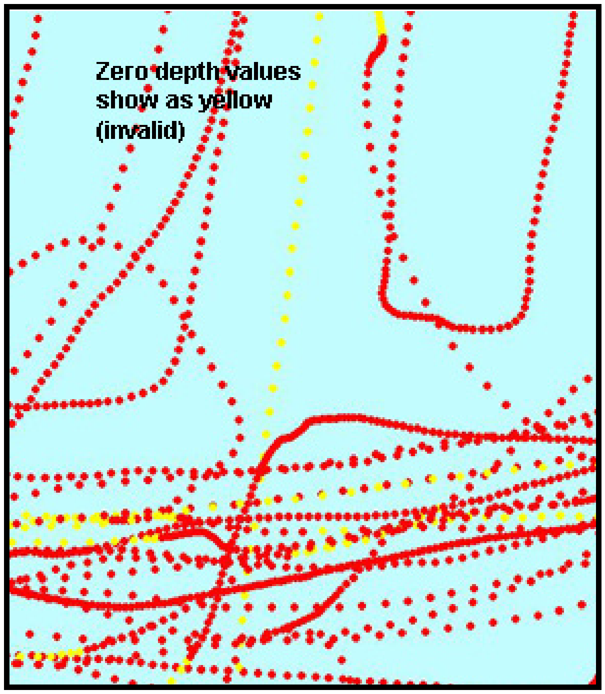

Figure 1: Erroneous Data

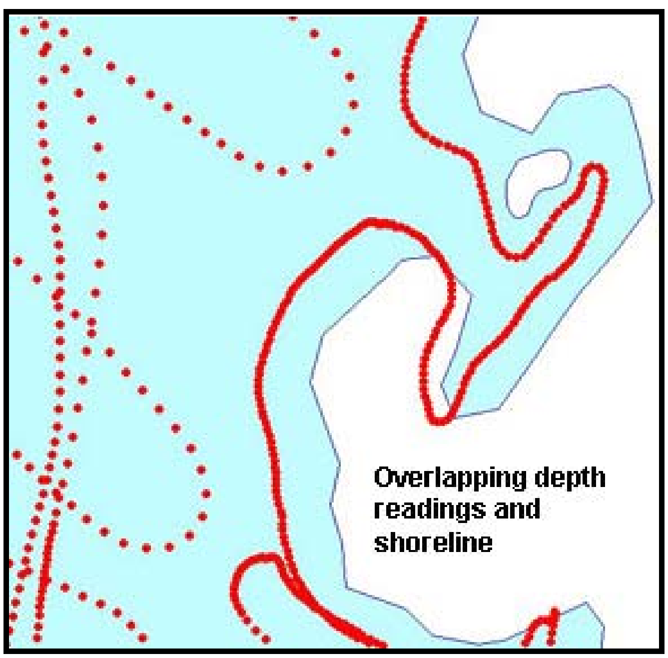

Figure 2: Overlapping survey data points

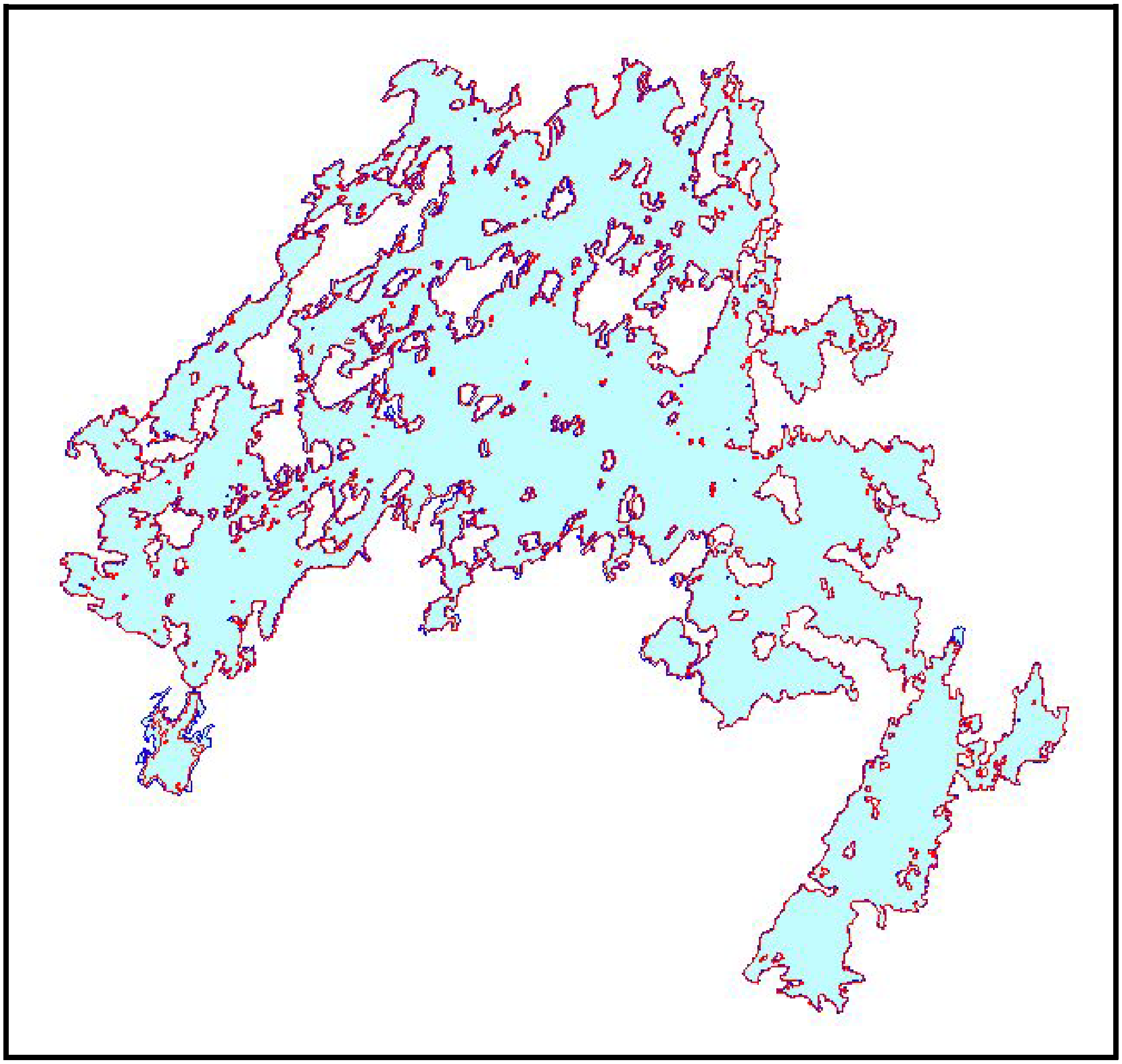

Figure 3: Original MNR coverage (red) overlaying new coverage

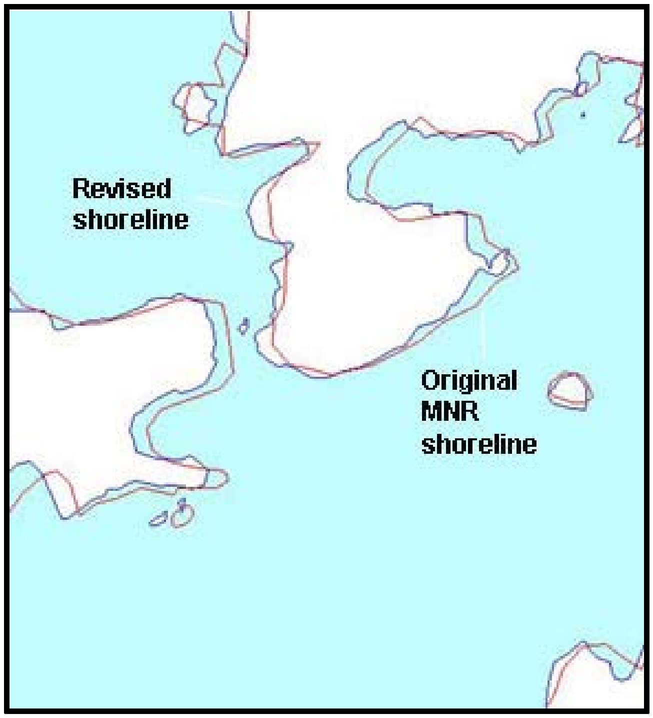

Figure 4: Detail of MNR vs. new lake boundary

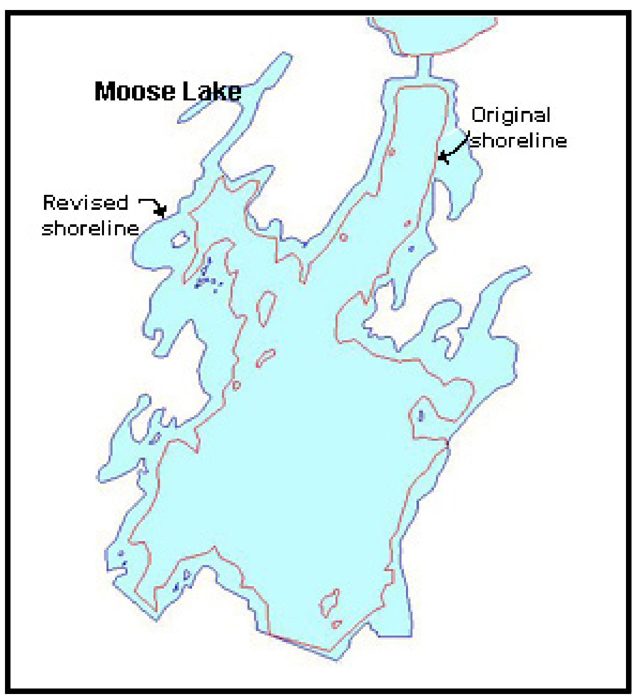

Figure 5: Revised Moose Lake shoreline

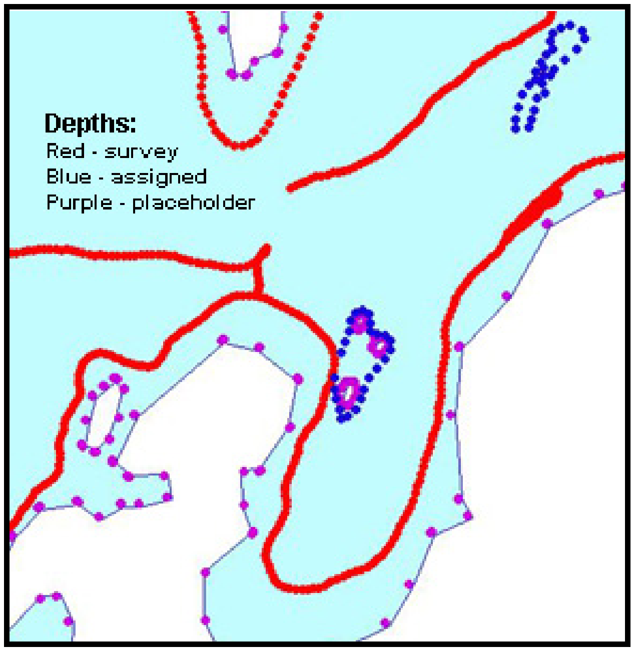

Figure 6: Merged depth data

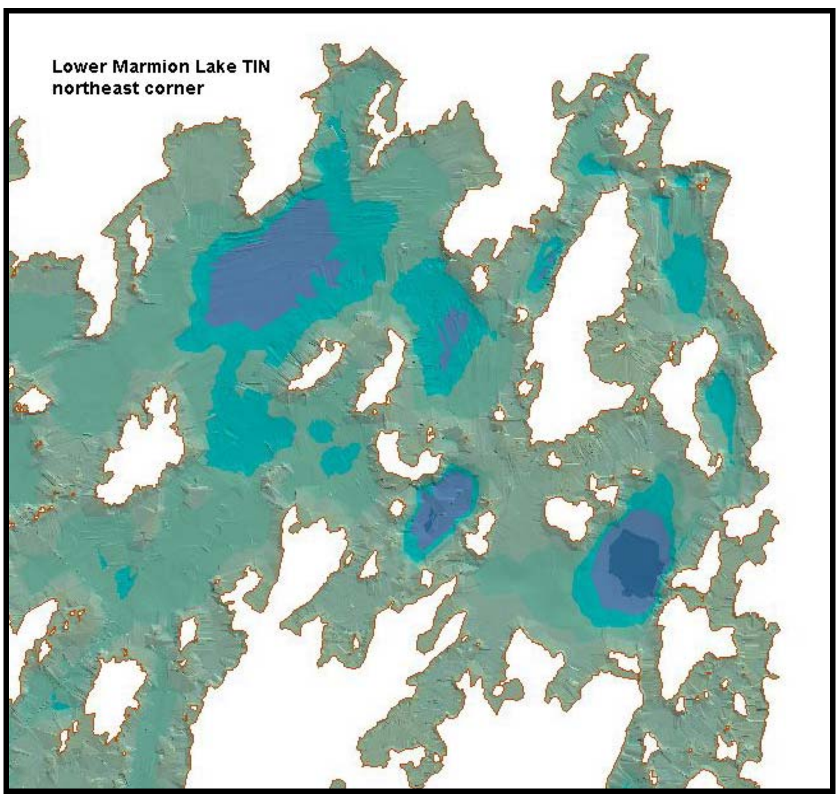

Figure 7: TIN

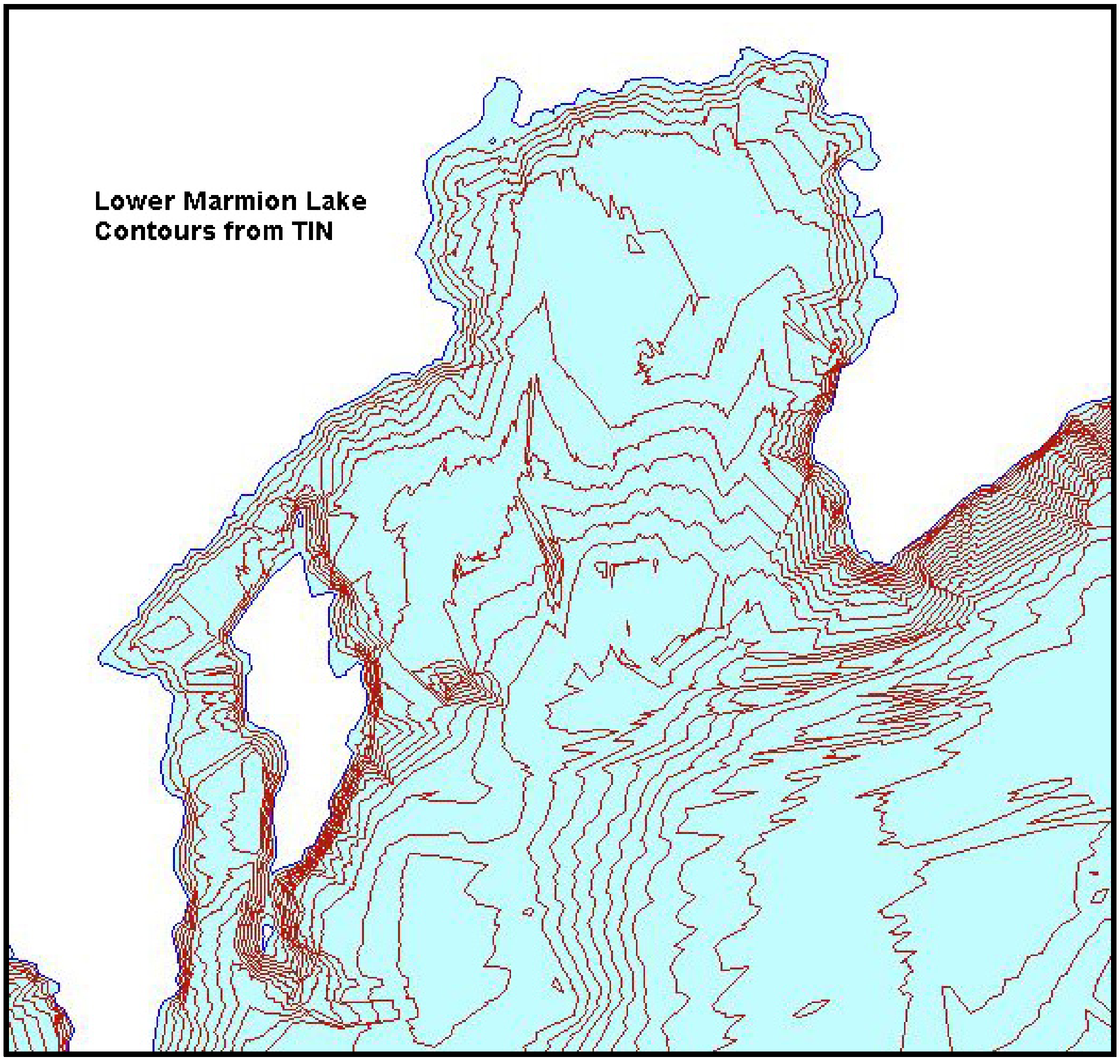

Figure 8: Contours produced from the TIN

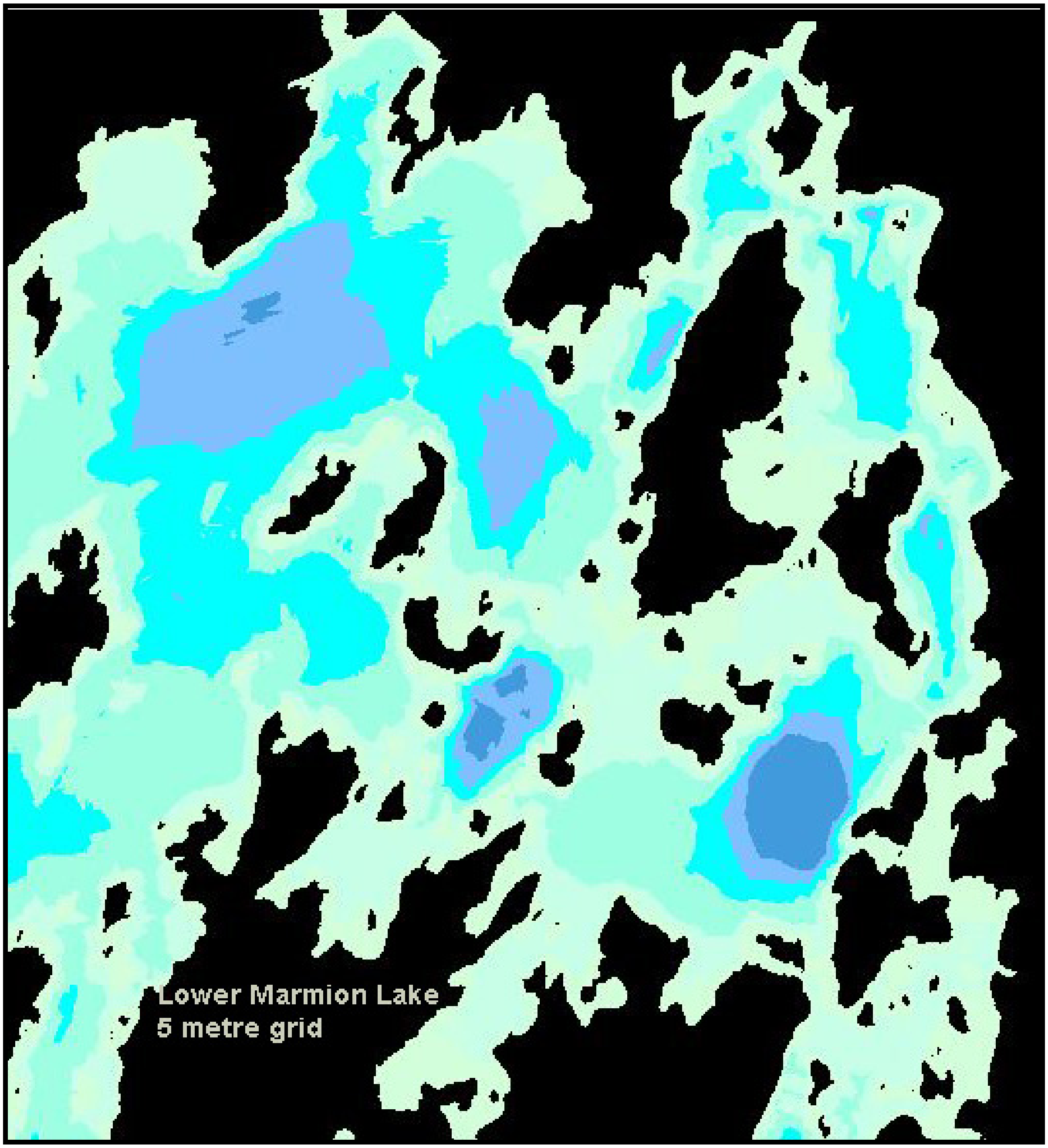

Figure 9: Grid (same area as Fig. 7)

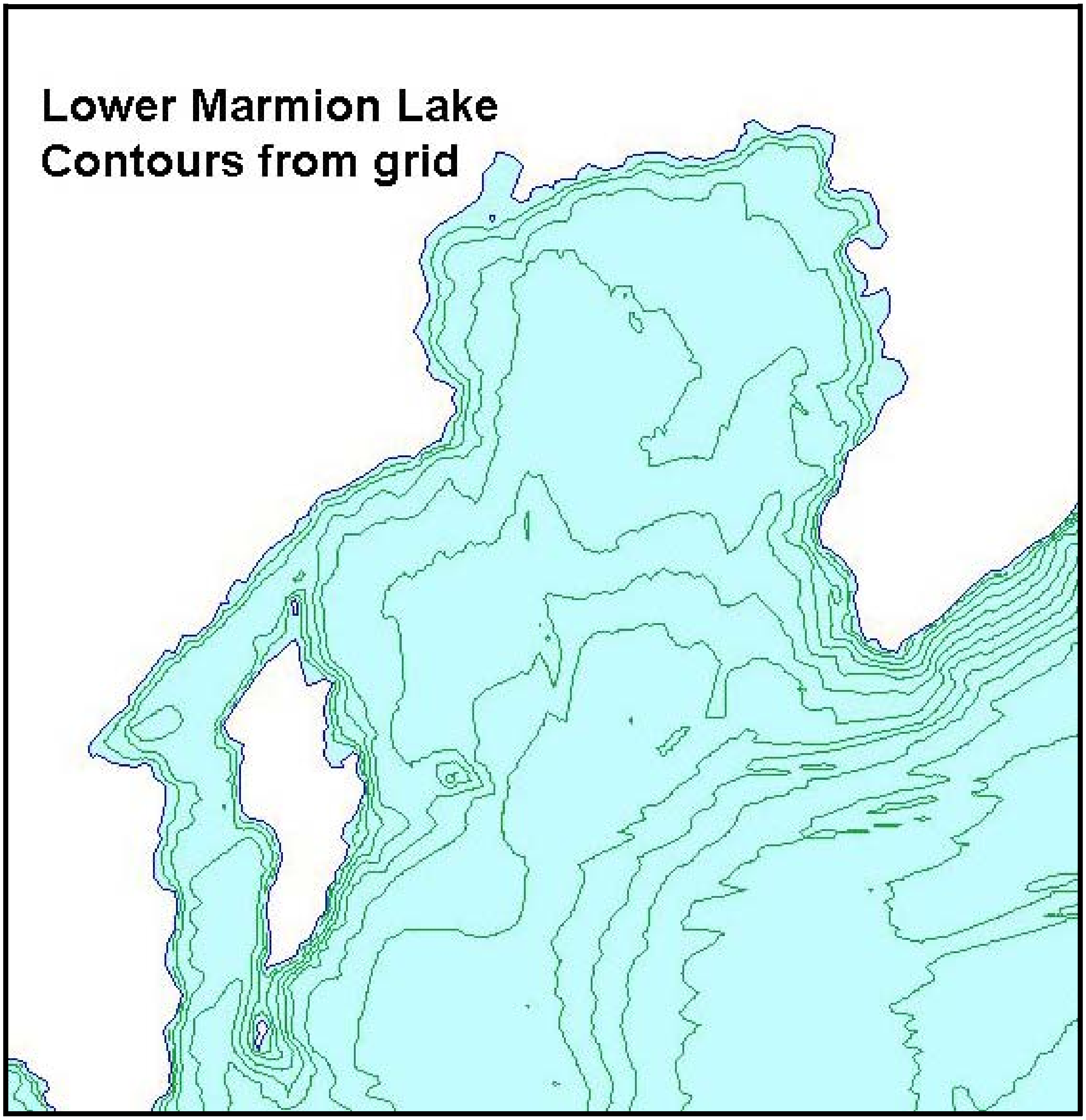

Figure 10: Contours from grid (same area as Fig. 8)

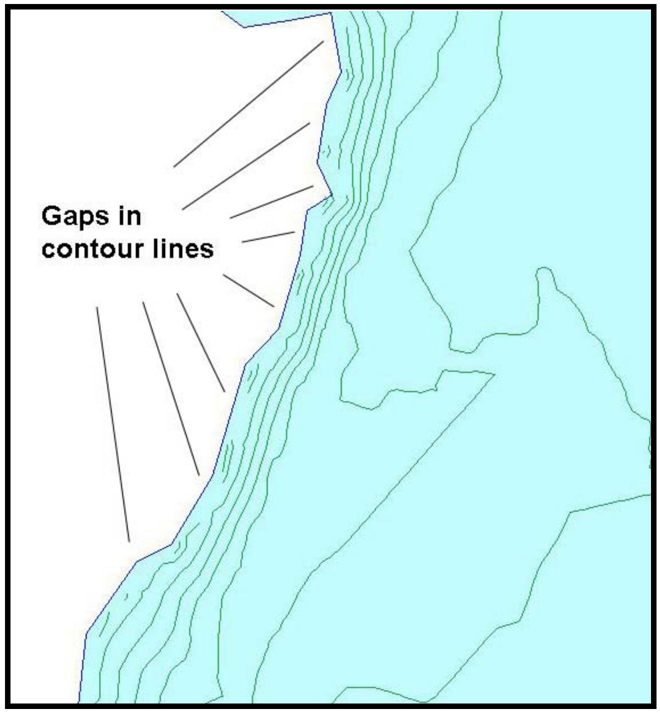

Figure 11: Gaps left in grid contour lines by software

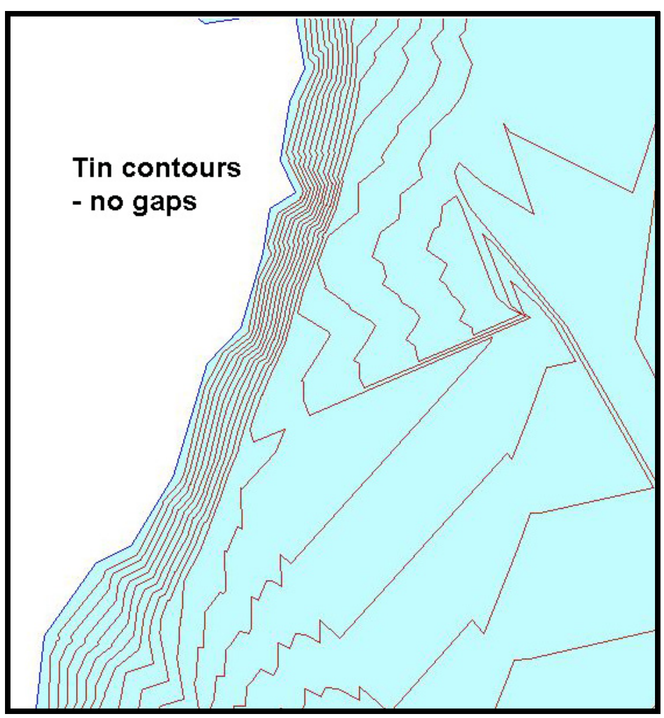

Figure 12: No gaps in contours from TIN

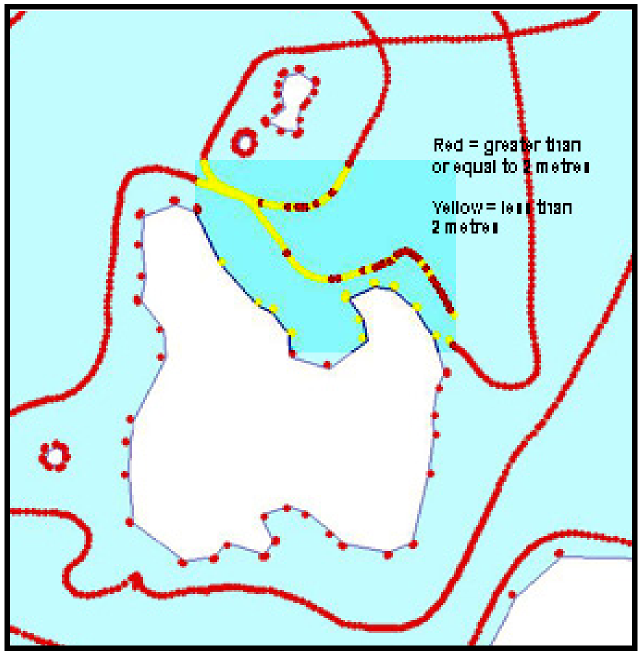

Figure 13: Distribution of depths recorded less than and greater than 2 metres in selected location

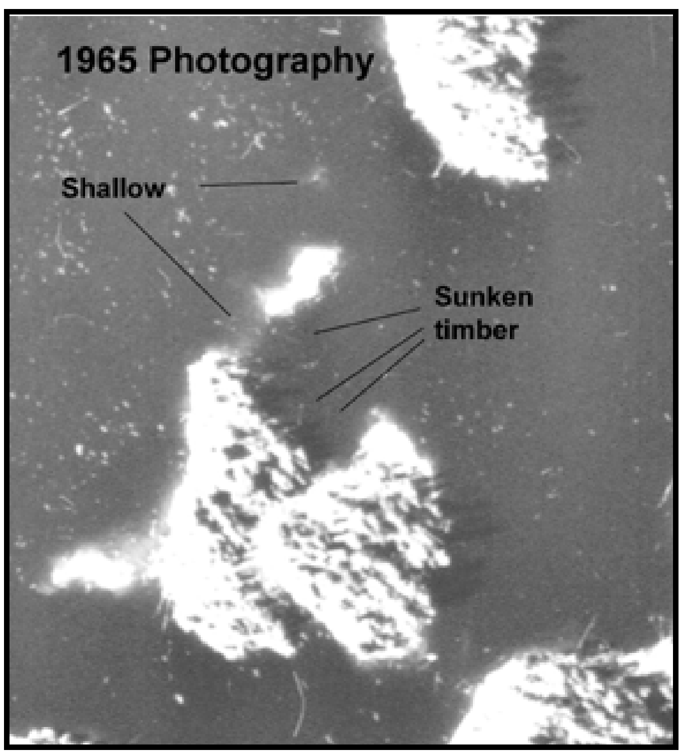

Figure 14: 1965 aerial photography for area in Fig. 13

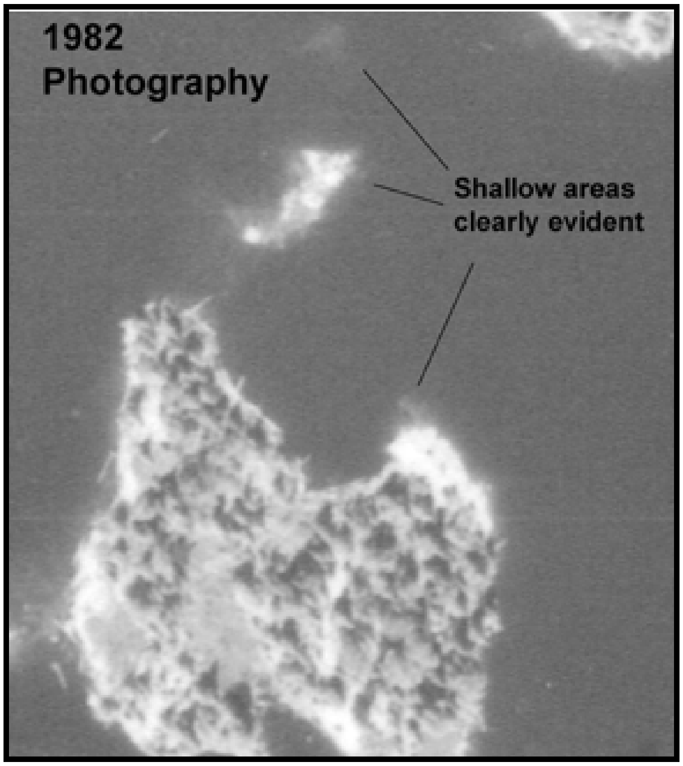

Figure 15: 1982 aerial photo of area of Fig. 13 & 14

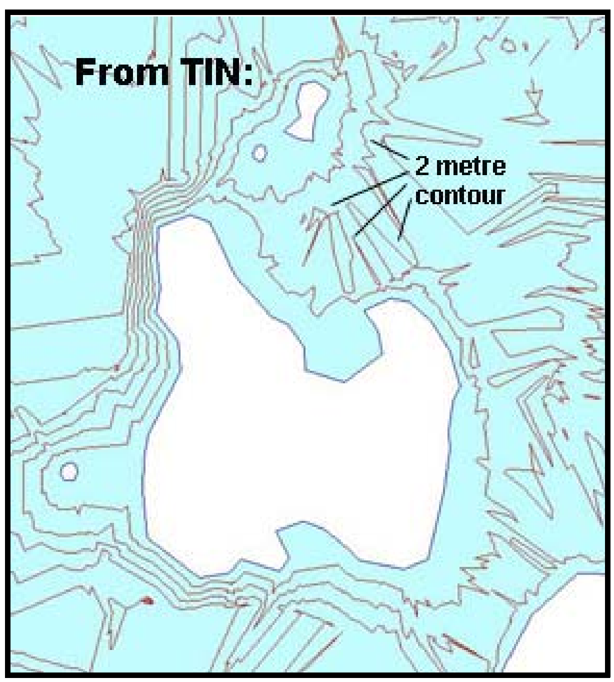

Figure 16: Contours of selected area drawn from TIN

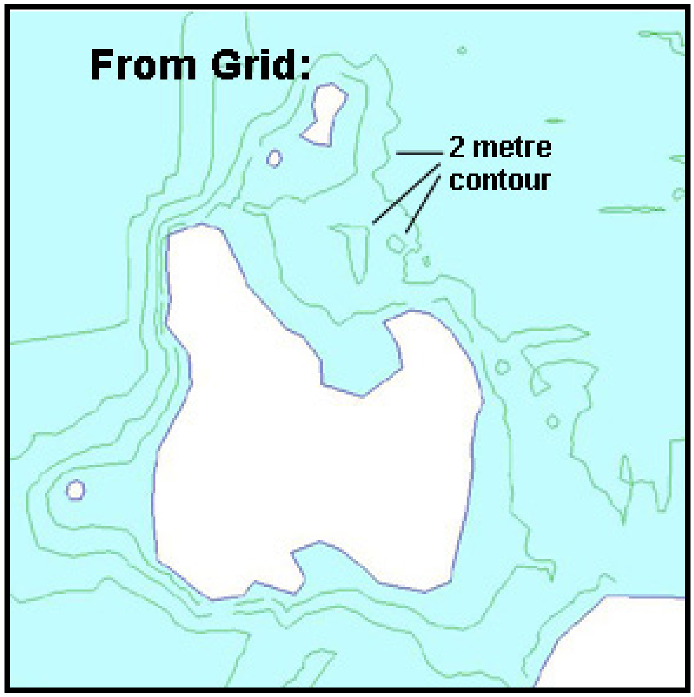

Figure 17: Contours of selected area drawn from grid

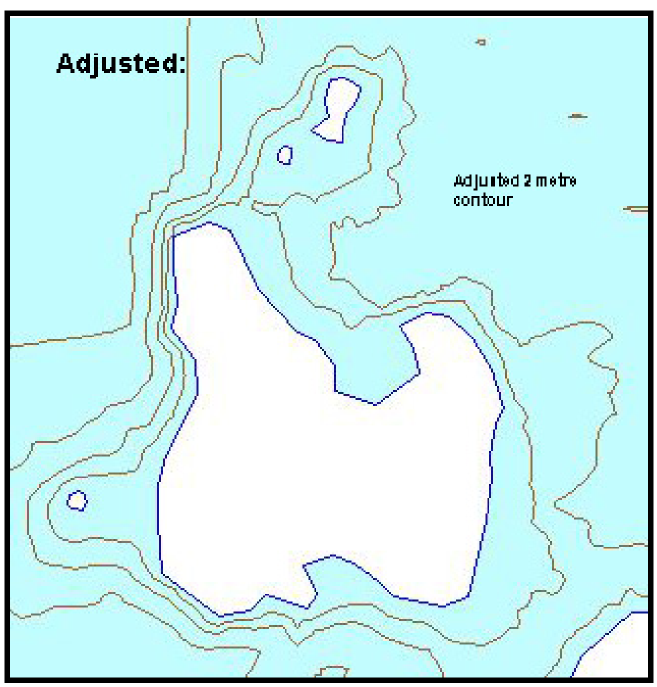

Figure 18: Contours adjusted to account for anomalies