Volumes by Section (Average End Area) vs Volumes by TIN MODEL

by Pat Sanders

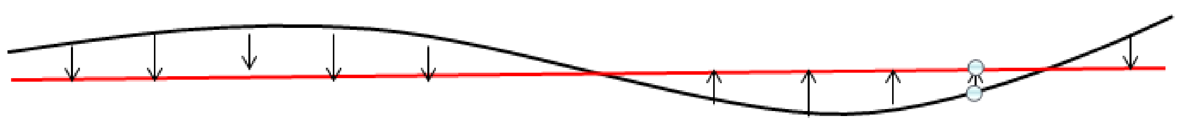
More and more, the dredging industry is moving towards the calculation of volume quantities by TIN MODEL or other surface model techniques. When an agency first makes the transition, they usually run comparisons to see how the TIN MODEL volume compares to the volume by sections. Those comparisons are sometimes very close (<1% difference) and sometimes not so close!

Here are a few of the reasons why the volumes can differ when comparing TIN MODEL (TIN) results to CROSS SECTIONS AND VOLUMES (CSV) results in HYPACK®.

1. **Average End Area (AEA) techniques in CSV treat every sounding across a profile section as if it was exactly on the planned line. TIN keeps the exact location of the sounding.**

   When running sections across a channel with a single beam echosounder, it's difficult to stay exactly on-line.

   FIGURE 1. Map View of Track Line (black) vs Planned Survey Line (red)

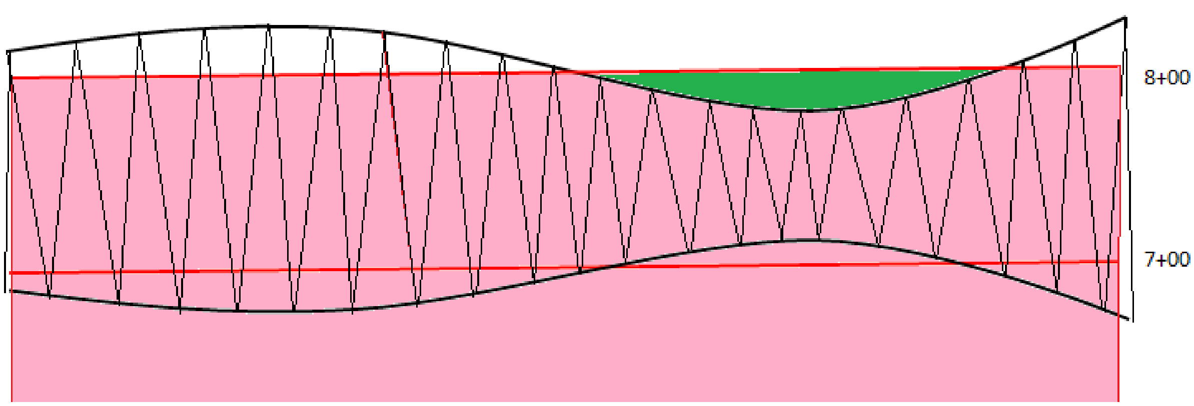
   

   When computing the area above a profile, **AEA makes the assumption that the bottom is uniform close to the line and a sounding**. A sounding 5m from the planned line is moved perpendicular to the planned line. If the bottom is flat or the section is uniform, this usually results in negligible difference.

   The TIN MODEL keeps the exact location of every sounding, combines them into logical triangles and then computes the volume between each triangle surface and the channel design surface. No soundings are moved.

   Where you have to be careful with TIN volumes is on the end sections!

   FIGURE 2. TIN Modeled Data vs Planned Survey Lines

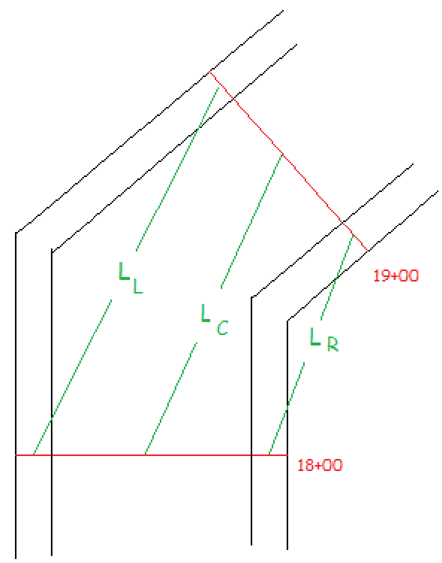
In Figure 2, line 8+00 is the last section. We have single beam data and have made a TIN MODEL. When you compute volumes in the TIN MODEL, for each pair of planned lines, the TIN MODEL first clips the surface model to just the area between the two planned lines. It then computes the volume quantity. In this case, it would report the Volume between 7+00 and 8+00. TIN will not compute any volume where the model does not cover the pairs of planned lines. In our example in Figure 2, the green area would not generate any volumes.

If you are doing volumes in TIN MODEL, make sure your survey data extends beyond the ends of your channel! This applies mainly to single beam data. Failure to extend your TIN model beyond the end sections can result in a volume total that is less than the truth!

2. **Handling Channel Geometry**

AEA doesn't know anything about what happens to the channel between lines.

FIGURE 3. *AEA Volume Calculations in a Curved Channel*



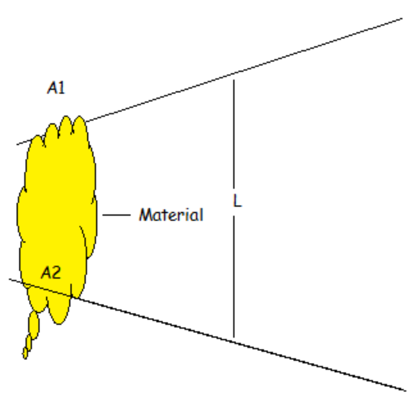
In the extreme example shown in Figure 3, we have a sharp corner in our channel. For the center channel, an AEA method computes the area in the center above section 18+00, and the area in the center above section 19+00, then takes the average of those areas and multiplies it by a distance between lines (L_C in our drawing).

TIN MODEL can use a CHN file (Advanced Channel Design) to know exactly what is happening to the channel when you have turns or transitions between the sections. Using the TIN MODEL with a CHN is much more accurate than using AEA!

You can improve your AEA results by adding additional lines. At a minimum, try to get a line through the bisector of the center line.

3. **Material piled up around the inside or outside of a turn.**

FIGURE 4. *Material Piled up at the Inside of a Turn*



AEA doesn't look to see where the area occurs in a section. When your planned lines are non-parallel, this can result in overstating the volumes if the material is piled on the inside of a turn or understating the volumes when the material is piled on the outside of a turn.

In Figure 4, AEA will compute the area above line 1 (A1) and the area above line 2 (A2) and multiply the average by the distance L. L is determined based on the geometry of the planned lines and not on the location of the material.

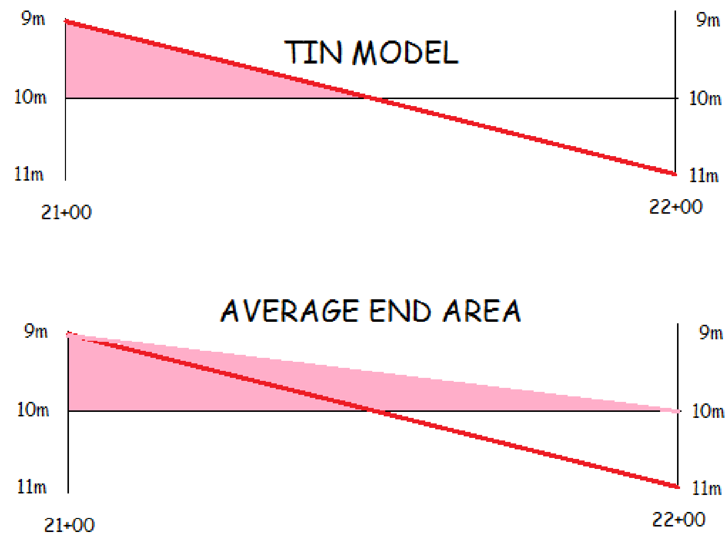
Meanwhile, **TIN MODEL** would be creating triangles using the exact data points and would "know" exactly where the material was and come much closer to the actual volumes.

This can result in significant differences between the AEA and TIN volumes. *Additional survey lines **will not** solve the problem.* With AEA, you're stuck.

4. **AEA doesn't care if the bottom drops below the channel design.**

   Figure 5 shows a cross sectional profile taken along a centerline. The bottom is 1m above the design depth at 21+00 and 1m below the design depth at 22+00.

FIGURE 5. *Volumes Where the Bottom Drops Below the Design Level*



TIN MODEL knows exactly where the bottom passes through the design surface and computes the volume as shown in the top of the figure.

Average End Area computes the area above section 22+00 as $0m^2$. The resulting volume between the two sections will wind up being the shaded pink region in the bottom of the figure.

In almost every case we have shown so far, TIN MODEL results in more accurate volume computations than AEA. There is one case I want to mention where TIN MODEL results can be problematic

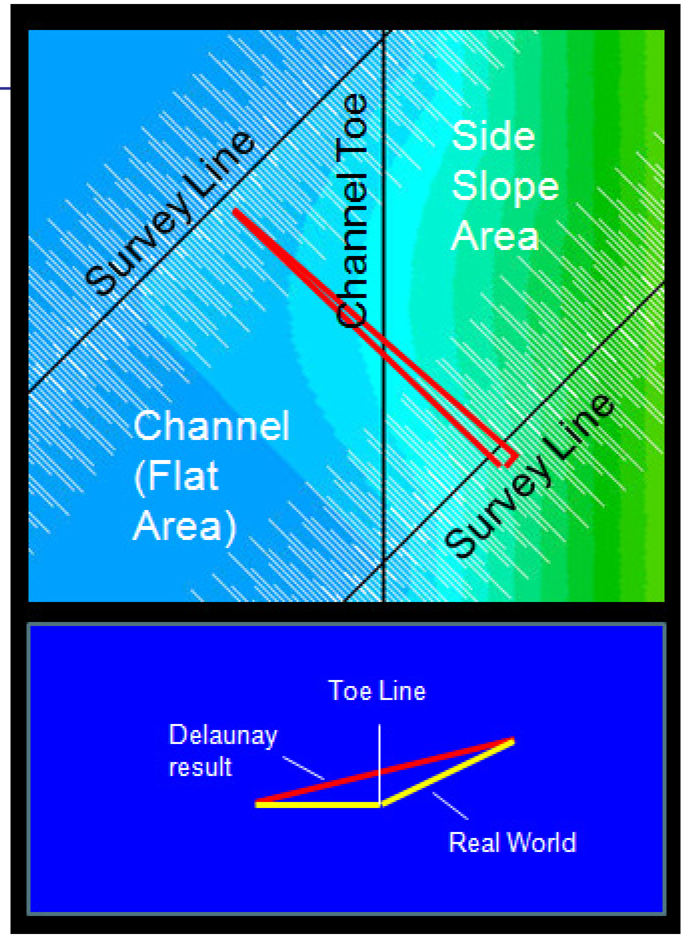
5. **Single Beam data on non-perpendicular lines up the side slope.**

   Artificial scalloping can occur when making Delaunay triangles in TIN MODEL where you have single beam data run non-perpendicular up the side slope.

   The HYPACK® TIN MODEL defaults to make Delaunay triangles. In Figure 6 (left-top), a triangle is created between a point in the center channel (top of triangle) with two points up the side slope.

   If you look at the resulting triangle surface (shown in section at the bottom of the figure), the Delaunay triangle surface (in red) doesn't reflect the actual real world profile. We have pushed the bottom upwards, created a "scalloping" affect that is apparent if you examine the contours.

FIGURE 6. Delaunay Triangles Cause Scalloping Where Survey Lines are not Perpendicular to the Side Slope



This only happens with single beam data run non-perpendicular up the side slopes!

In most cases, this effect can be eliminated by creating triangles that are proportional to the distance along line and not Delaunay triangles. To do this in the HYPACK® TIN MODEL, just provide the planned line file and check the “Align TIN to LNW” option in the opening window.