

1. Why do it?

The Dipstick[®] will enable you to collect elevation data that is much more precise than that available from a Rod and Level. If you need to know exactly how a surface looks in 3-D, or if you need very precise elevations of points on the surface, you can make a 3-D elevation study on your own. Some examples of reasons for doing an elevation study include:

- checking drainage patterns, such as checking for "birdbaths" where water might collect on a nominally flat surface;
- determining exact elevations of critical locations such as mounting pads for a machine that must be mounted exactly level;
- determining exact elevations for a system that interfaces with the surface;
- checking the results of corrective grinding, and other reasons.

2. What is the Difference between an Elevation Study and a 3-D Map?

A 3-D Map requires much more data than an Elevation Study. That's the fundamental difference. For an Elevation Study, you can collect a limited amount of data, and you can collect it where you need the data. To make a 3-D Map, you need to collect the data at regular intervals over the entire surface of interest.

3. What Do You Need?

- To make an **Elevation Study of a surface**, all you will need for a basic study is your Dipstick[®]. This will allow you to graph lines (one at a time or many at once) and calculate elevations of each of the points on any of the lines.
- To make a **3-D plot of a surface**, you will also need a 3-D plotting or graphing software program such as Microsoft Excel[®] or Perspective Jr.[®] or a specialized graphing program like Harvard Graphics[®]. These programs take the data and present it as a 3-D plot. What you need to do to make this work will be explained below. We'll demonstrate how to do it in MS Excel[®], which most people have access to.

Whichever method you want to use, you need to decide the data location and spacing before you start collecting data.

4. Dirt or Grit on the Surface

If the surface is excessively dirty, have it swept to remove the dirt/grit that you would otherwise walk over. (A light coat of dust is OK, but not piles of dirt or grit.) This can be important, depending on the desired accuracy of the result, because the Dipstick[®] can measure to .001 inch, or 1/10 mm. The cleaner the floor, the better your data will be. When you compute the Surface Roughness Bias from the data you collect, check to ensure that it is less than .002"/step. Anything more indicates a problem.

3. Marking the surface

You need to collect the data in lines that are precisely located. You should mark straight lines so you won't wander around while collecting data. There isn't any point in collecting very accurate data that isn't in a regular grid, because the graphing program will place it in a regular grid. Starting at a convenient point near one corner of the surface to be measured, mark this starting point with chalk, crayon, or a dot of paint. Lay out the lines where you will collect data, spacing the lines evenly if you are doing a 3-D Map.

Paint is much better than chalk or crayon, if you need a permanent reference, because when you get the results calculated and graphed, you will be able to go right to the key spots on the surface. As a minimum, mark the 4 corners of the area to be measured. It's best to also mark the measurement lines with a chalk line or similar method. We like to spray paint clear lacquer over the chalk line so it will last for a while, but a temporary method is OK, so long as you can find these lines later from the paint spots at the corners.

5. Three Ways to Collect Data

You should collect the data in closed loops, in any of these three methods:

- "Out-and-back" lines
- A "Comb" pattern, or
- A series of "boxes," either overlapping, or tied together by one or more "base" lines.

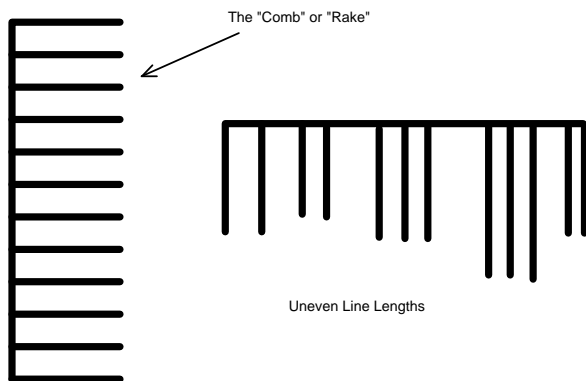
a. "Out-and-Back" lines

This is the simplest method, and is often very satisfactory to achieve the desired result, if all you need is data for certain specific locations. (Why measure the whole surface if you don't need to?) Here's an example showing how this technique might be used: One major aircraft manufacturer measures the deflection of runway and taxiway pavement by starting from a point that is sufficiently remote from the aircraft that it is assumed to be unaffected by the presence or absence of the aircraft. Using a starting point elevation of 0.000, they walk a line from that point to a point right next to one of the wheels, and reverse direction on the same line, returning back to the starting point. Then they remove the aircraft and collect another set of data in the identical location. The only difference is that in the second Run, the aircraft has been removed. After computing the Bias for each of the two Runs, the runs are segmented to retain the first half of each run. These profiles then represent the elevations of the profile between the starting point and the aircraft's wheel location, both before and after removing the aircraft. The two segmented Runs are then selected and the menu item CALCULATE/DIFFERENCE is used. This creates a profile that represents the precise deflection of the pavement due to the weight of the aircraft.

b. The "Rake" or "Comb" pattern

We call it the "Rake" or "Comb" method because the layout pattern looks like the tines of a garden rake, or the teeth of a comb. There is a "Base" line, which is typically the longest line, and there are the "tines" or "Teeth" lines, which all start from the base line. If the tines are short, you won't have to measure the tines "out and back". The base line should *always* be measured "out and back."

Although the teeth or tine lines do not have to be parallel or the same length, we recommend that you make the pattern symmetric, even, and parallel, unless you have a reason for not doing so. Collecting the data in even, regular patterns will make it *much* easier to make 3-D graphs.



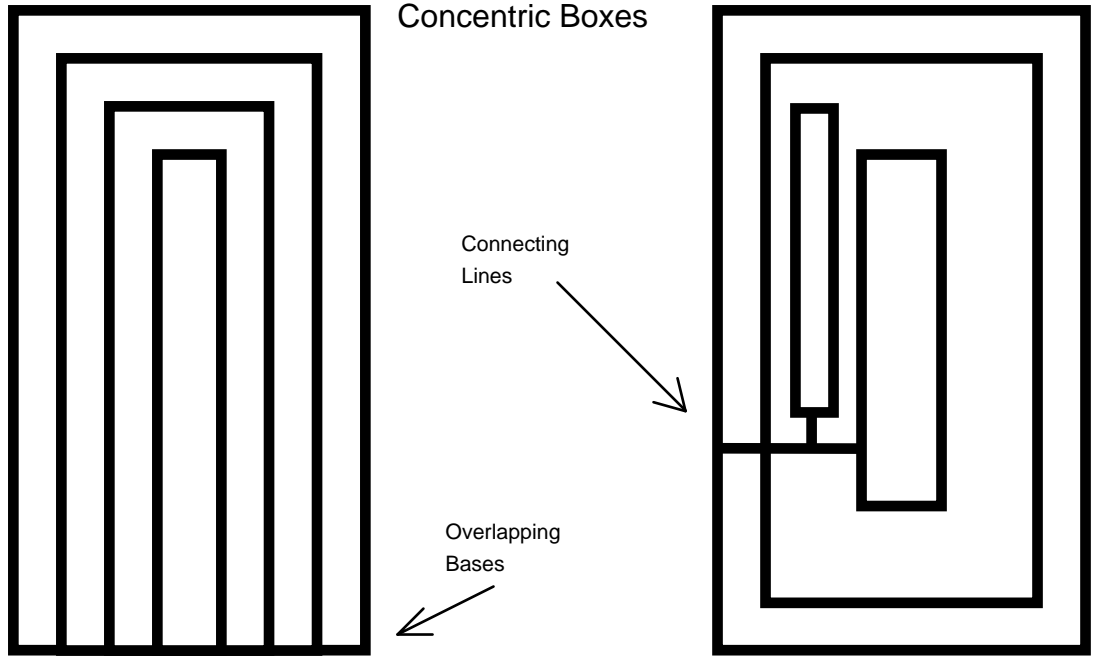
c. The "Box" method

Boxes are quite a bit more efficient than the "Rake" or "Comb" in terms of data collection and analysis time, particularly if you need to cover a large area without collecting data at every point.

For covering a large area, you can collect the data in overlapping boxes. The boxes may be touching each other or may be any convenient distance from each other, but you will need to link each of the boxes with a line, in order to get the relative elevations of the several boxes right.

Multiple Linked Boxes



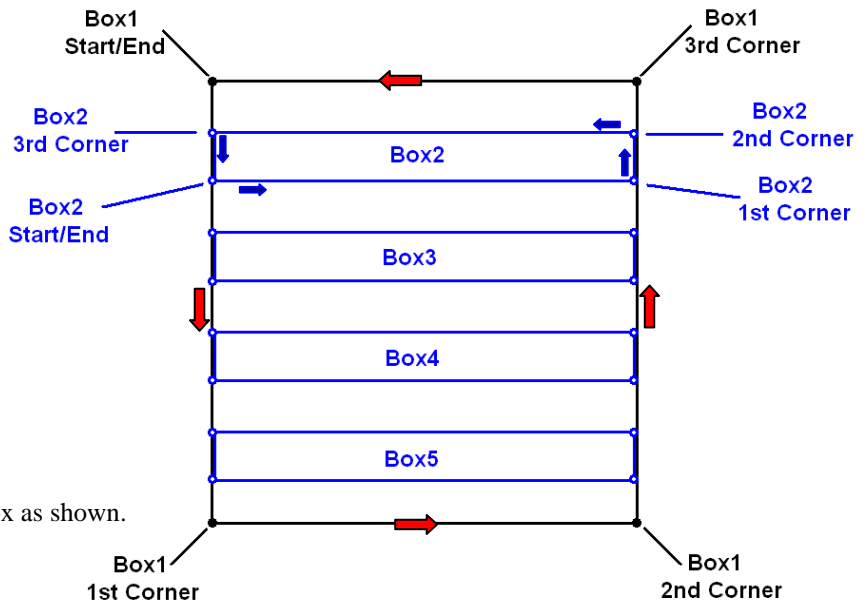


This is a sample of a "ladder" type of Box arrangement. →

The first box goes all the way around the perimeter, and the secondary boxes fill the inside like ladder rungs. Arrows show the direction of data Collection – black for the outer box and Blue for the interior boxes.

The interior boxes do not need to overlap each other, but the narrow ends of the interior boxes should overlap the outer box as shown.

This is the box layout pattern that we use most often.



Decide whether you will use the "Rake/Comb" method, or the "Box" method before laying out the measurement lines. We prefer the "box" method for complex elevation studies and 3-D graphs, and the "comb" method for more simple requirements.

6. Designating Run Names

Designate the runs with names that you can remember, that will mean something to you later. There is nothing worse than labeling all runs numerically from 1 to whatever, with no correlation to the run location on the surface.

Name the area covered by each comb and use the same name for the comb. You might have a comb in bay 18, so call the base line 18B. (B for "base") You could number the teeth from N to S, so you have runs labeled 18B, 18-1, 18-2, 18-3, etc. If some of the combs are aligned N-S and some are E-W, designate the base line 18BNS, or 18BEW. You don't have to carry the NS or EW designations on to the teeth, because you know they are perpendicular to the base line. The important thing is to give each line a meaningful name that will help you remember where it was taken from. If you use boxes, name each box in a way you'll be able to remember later. Each box will be broken into its 4 constituent lines later. The Dipstick[®] software will automatically name each of these 4 lines with the name of the box and a suffix.

7. Collecting Data

a. Combs

Start the Dipstick[®] with the rear foot on the paint mark and collect data along the base line. Using a keel or chalk, mark a circle around the foot when you get to any point from which you want to run a "tooth" later. Do not move the Dipstick[®] off the base line or turn it off; simply draw a circle where you want to start a "tooth". Mark the step number on the surface next to the circle. You will come back to this location later to start your "tooth" runs. When you get to the end of the base line, collect the last reading, then rotate the Dipstick[®] in a complete circle, setting it back where it was so it can collect another reading. Now continue back along the base line until you get back to the start point. (The details of how to do this are covered in the Hardware Manual under "Bias Run".) Assign a start point elevation of 0 (zero) to the Base Line.

Now collect all the "tooth" runs, starting at the locations where you circled the foot.

b. Boxes

Start the Dipstick[®] with the rear foot on the paint mark at one corner of the end box, and collect data along a line. For example, if your lines run from West to East as shown in the example above, start at the lower left (Southwest) corner of the Western box, and measure along the South (right) line, going from West to East. (Whichever way you do it is OK, but always start at the outside corner of the outside box, collecting data in the same direction, i.e., going East.)

After you have gone as far as you want to, say 50 ft, stop and mark a circle around the front foot. Don't stop the run on the pocket computer, just stop rotating the Dipstick[®] for a moment while you mark the surface. Now turn the Dipstick[®] so you march *across* to the opposite line, stopping when the front foot is on the left (North) line at a point just opposite where you stopped a moment ago. It is important that this point be exactly across from the 50th step, because these are the two points you are going to compare. Mark a circle on the floor around your front foot again. It doesn't matter if the front foot is the switch end or the battery end, so long as it's the front foot. Then turn West and march back on the North line until you are at the end of the line opposite where you started at the beginning. Stop and mark this point by circling around the front foot. Finally, turn South and march back across to where you started from.

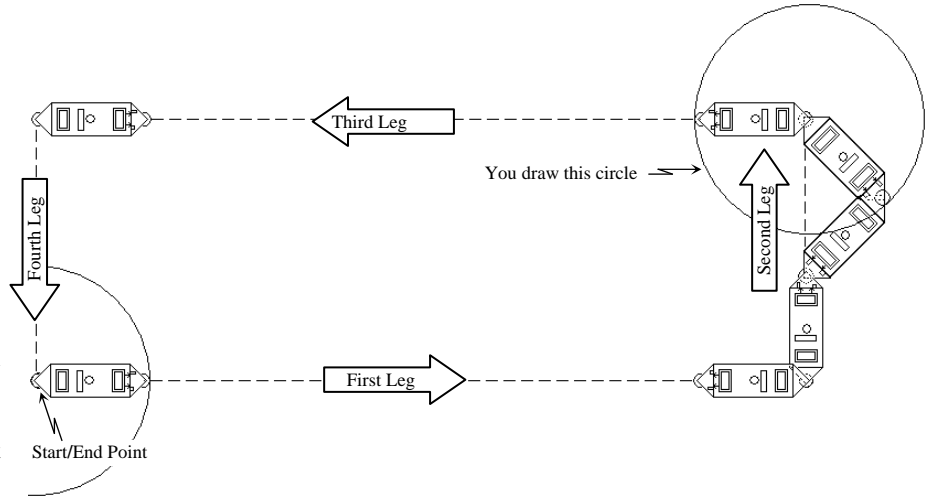
It is imperative that you end up with one end of the Dipstick[®] exactly on top of the paint spot where you started. Terminate the collection of data at this point.

Record the locations of the turning points and the end point on the run **Notes** by step number, i.e.: 50, 56, 106, 112. In this example, let's assume the box is 6 steps wide. You start at the paint mark, and the 50th reading is taken with the battery end of the Dipstick[®] over the first turning point. The second turning point is 6 steps later, at 56, and the last turning point is at 106, across from the starting point. The run is ended with the battery end of the Dipstick[®] forward, with the foot right over the paint mark, at step # 112. You will need these turning points for the analysis later.

Go to the spot on the South line where the circle is on the floor at the 50th step. (The first turning point from the first box) Start a second box here, again going East along the South line for 50 steps. Mark the turning location, turn North, and march to the North line. Finish this box just like the first box. Point # 106 of the second box should be right on top of point # 56 from the first box, and point # 112 (the end point) from the second box should be right on top of point # 50 from the first box, which is at the same point as the start point of the second box. Record the locations of the turning points and the end point on the run **Notes** by step number, i.e.: 50, 56, 106, 112.

8. General Info on Collecting Data

If you need the two long legs of the box to be parallel at an arbitrary distance apart, (not an even number of steps apart) say for measuring in wheelpaths, here's how to make the short transverse legs land exactly on top of the opposite wheelpath: When you reach the end point on the first wheelpath, press <Enter> to stop the run, and mark a circle around the Moon foot at that location. Now pick up your Dipstick® and go across and mark the desired location directly opposite. Use the Dipstick® to draw a circle around this point on the floor. Draw the circle so it is tangent to the outer edge of the Moon foot as shown in the drawing. Then go back to where you stopped collecting data and carefully put the Dipstick® down exactly on the Moon foot circle at the end of the first leg.



Now you can "Append" or extend your run from this point. Select the box run you have already started, then use <Collect> <Append> to re-start this run. The computer will tell you which foot should be forward. (In this case, "forward" is to the left, or "up" in the drawing)

Press <Enter> to continue taking data towards the circle across the aisle. At the point where you would step across the circle, *don't step over the circle*, but *put the foot down exactly tangent to the circle. (Anywhere on the circle)* This will require that you "step off" at a slight angle as shown in the picture above. Your next step will always put you exactly on the desired spot at the center of the circle. You will also have to use this procedure to get exactly back on to the starting point of the run.

9. Processing the Data

a. Combs

Download the data to a PC. Calculate the Data Collection Bias from the Base Line, and apply this Bias to all runs. If your "Teeth" runs are long, you may want to calculate the Bias on each run independently and apply that Bias to the run it was collected on. If the "Teeth" runs are short, You won't need to calculate the Bias on anything other than the Base line.

After processing the data, you will need to find the elevations of each of the points where you started the "teeth" from the Base Line, then edit the "teeth" runs to include the correct start point elevation for each of the runs.

You have referred the start point elevations of each "tooth" run to the corresponding elevation at the same point on the "Base" line. The elevations of this Base line are all referred to its start point, which you set at 0 (zero). Therefore, the elevations of any and all points on any of the lines are referenced to each other, and are measured relative to the zero elevation of the start point of the Base line. If you now want to know what the difference in elevation is between any pair of points on any line, all you need to do is subtract the elevation of one from the other. It is just as if you now have a great many bench marks located 12 inches (300 mm) apart.

b. Boxes

After collecting the data, download it to a PC, and unbox the boxes following the procedure described in the hardware manual. (EDIT/UNBOX)

The start point elevation of the second box should not be zero, but should be whatever is computed for the end point elevation of the first leg of the first box. (The elevation of the 50th point in the example) Similarly, the start point elevation of the third box will be the elevation of the end point of the first leg of the second box, and so on.

You have referred the start point elevations of each leg of each box to the corresponding elevation at the same point on the previous box. The elevations of this Base line are all referred to its start point, which you set at 0 (zero). Therefore, the elevations of any and all points on any of the lines are referenced to each other, and are measured relative to the zero elevation of the start point of the first leg of the first box. If you now want to know what the difference in elevation is between any pair of points on any line, all you need to do is subtract the elevation of one from the other. Once again, it is just as if you now have a great many bench marks located 12 inches (300 mm) apart.

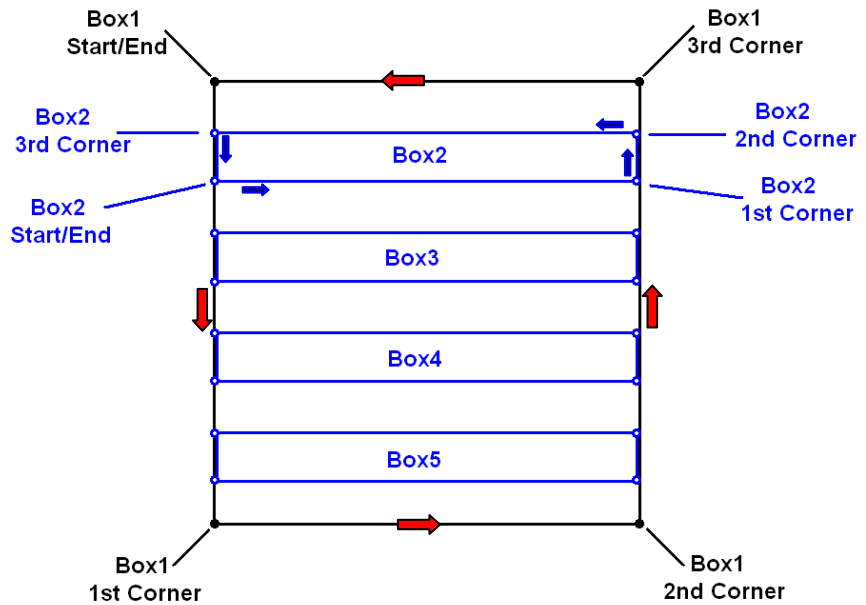
10. Making a 3-D Graph

We strongly recommend using the “box” technique for all 3-D graphs. You’ll want to snap lines to make an outer box that defines the perimeter of the area being measured, and a number of inner boxes to fill in the data inside the outer box. For most purposes, it is not necessary to have all the boxes at 1-ft intervals. A very satisfactory result can be obtained by collecting boxes that are 4 ft apart. To get good results, you need to snap a line or

As an example, let’s say that the area you want to measure is 36 x 36 ft.

Step 1 – Collecting the Outer Box

You’ll collect the first box that bounds the exterior perimeter, 36 ft on a side. Start at the northwest corner in the drawing to the right (marked Box1 Start/End) and walk the Dipstick south until you reach the end of the area to be measured. As you do this, stop every 4 ft and mark a circle around the Dipstick foot that is 4 ft away from the last marked location. This will make the first Box go slow, but you’ll need these locations later. When you reach the first corner of Box1, wait for the beep, then press the letter “C” on the keyboard of the Dipstick computer. The Dipstick will “beep” at you to let you know it marked this corner. This is not a new reading. (The Dipstick can only make one sound, “beep” so don’t worry, this is not another step.) Do not stop the data collection program. Now turn the Dipstick and walk towards the east as shown above, until you reach the 2nd corner of Box1. Do not mark every 4 ft on this leg. After you hear the beep when you reach the end, press the letter “C” again to mark this corner. Then turn north and walk all the way to the 3rd corner of Box1, again marking a circle around the Moon feet every 4 ft., and press the letter “C” again after you reach the corner. Finally, walk the Dipstick back to the west until you reach the start/end point of Box1. Press <Enter> to stop collecting data. The end of this leg is exactly the same point where you started from. Do not mark every 4 ft on this leg. This completes the first box – the outer black box – in the picture above. You will have walked a big “box” and you will have marked the line every 4 ft on the west and east sides as shown in the picture above.



Step 2 – Collecting the Inner Boxes

Go 8 ft down (south) from the start point of the outer box, and set the back end of the Dipstick on the circle you marked there, with the start end of the Dipstick facing east across the outside Box. Note: this is 8 ft down, not 4 ft down from the start point. You will be at the start/end point of Box2. Start a new run, and collect data from here all the way across to the other side of the large outer box. When you reach the 1st corner of Box2, press the letter “C” on the keyboard, then turn north and walk 4 steps to the 2nd corner of Box2. Again, press the letter “C” here. Then turn the Dipstick

toward the west and collect data all the way back across until you reach the 3rd corner of Box2, and press “C” once more, then turn the Dipstick south and collect 4 more steps. You will be at exactly the same point where you started Box2. Press <Enter> to stop collecting data in Box2. Pick up the Dipstick and walk 8 ft farther south (8 ft, not 4) then collect Box3 the same way. Continue collecting data in boxes this way until your inner boxes fill the space inside the outer box as shown above.

Step 3 - Editing the Data

You can do this on the Dipstick computer or on your desktop or laptop computer. Select the first (large, outer) box and use EDIT/UNBOX. If you have pressed the letter “C” each time you reached a corner, the computer will fill in the corner locations for you. If you forgot to type the letter “C” in the corners, you can fill it in now. When you press <Enter>, the computer will calculate and adjust for the bias on this box, and it will break the box into 4 legs. What’s more, the 3rd and 4th legs will be reversed, so they will look as if they had been collected in the same direction as legs # 1 and #2. Now select Box1/A and use REPORT/DATA POINT LISTING to get the elevations of the points that are 4 ft apart on the first leg of the outer box. Write down or print and circle the elevations of the start point, point number 4, point number 8, point number 12, point # 16, and so on. You want the elevations of every 4th point on leg Box1/A.

Now open the Run Header for Box2, and type in the start point elevation for Box2. The elevation of the start point of Box2 is the same as the elevation of point 8 on Box1/A. Now use EDIT/UNBOX for Box2.

Now open the Run Header for Box3, and type in the start point elevation for Box3. The elevation of the start point of Box3 is the same as the elevation of point 16 on Box1/A. Now use EDIT/UNBOX for Box3.

Repeat this process for all the other Boxes.

Step 4 - Making ASCII Elevation files

At the Run level, highlight Box1/A and use REPORT/ELEVATIONS (fle) and it will make an ASCII Elevation file from the Run you have highlighted, and it will store the new ASCII file inside the Job folder. You can do this over and over for each of the runs in the project.

Speed Tip: Instead of making the ASCII files one-by-one, go to the Run level and ensure that all the long runs are marked with the Run Flag “A”, and that no other Runs are marked with a Run Flag “A”. You can mark or unmark Runs by highlighting them in the DipFloor program and using EDIT/RUN HEADER, and checking (or unchecking) the ASTM E-1155 box. After doing this, go up to the Surface Level and choose

REPORT / MULTIPLE REPORTS (BATCH) / ASCII ELEVATIONS (File).

This will *instantly* create and save ASCII Elevation files for all the Runs that were marked with the Run Flag “A”. You will still need to make ASCII files manually for all the short 4-ft runs, since they cannot be marked with the checkmark for ASTM E-1155. This completes the 4th step.

Step 5 – Entering the data into a spreadsheet

Open the ASCII files with a spreadsheet program like MS Excel[®]. If your computer says it cannot open the ELV files, tell it to use MS Excel[®], and tell it to always use this program for these kind of files. The ASCII files will always be formed in a vertical column of numbers. Select the column of numbers and use EDIT/COPY. Open the spreadsheet where you will make the graph and paste the ASCII elevation data files you just produced. Copy each long ASCII file to the same spreadsheet, and align the data in the same pattern as it was in on the surface when you collected it. In our example, the elevations along the west side of the outer box (Box1/A) are aligned in a vertical column, so it will be easy to put these in. Likewise, the ASCII file for the data in Box1/C is aligned the same way. But all the other long ASCII files are in vertical columns too, while the spreadsheet needs them in a horizontal alignment. When you paste them in, use “PASTE SPECIAL”, then select “TRANSPOSE.” This will paste the numbers in a horizontal row from left to right. Note that the first elevation point in each of the horizontal points will be the same as the elevation of the points every 4 ft on Box1/A, so you can overlap these points. The top horizontal data set is Box1/D, and the bottom one is Box1/B. Do not paste the short 4-step ASCII files yet, just do the long ones. Paste Box1/C in last, in the column just to the right of the last horizontal entry. Now you should have a spreadsheet with a box of data around the perimeter and many rows of data separated by 4 ft vertically.

Step 6 – QC Checks on your Data

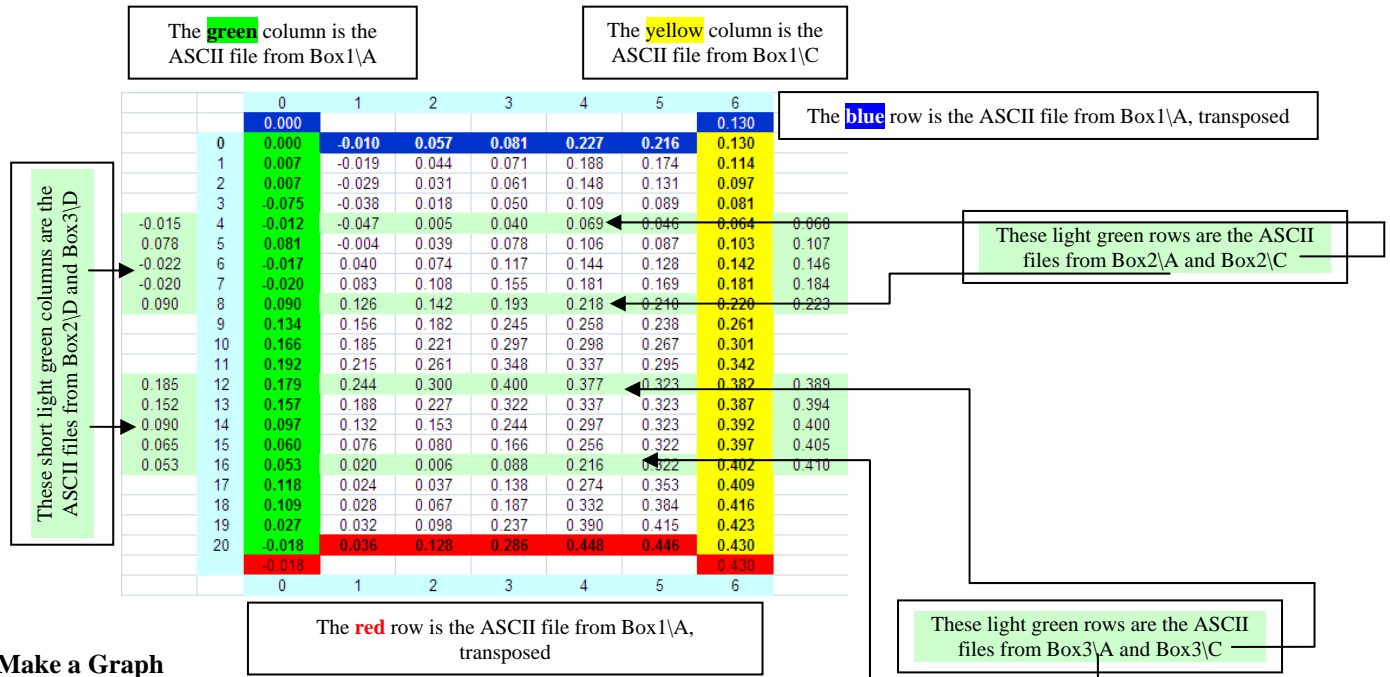
Now go get those little 4-step ASCII files and paste them into the spreadsheet. Theoretically, they should match the data from Box1/A and Box1/C, but they won’t match exactly. Paste these files at the corresponding locations, but one column to the left or right of the data you already have. The purpose of doing this is to see how well you collected the data. Compare the 4 elevations in these little 4-step runs with the elevations on Box1/A and Box1/C. If the elevations match within 0.030”, you will be OK. If the elevations do not match, then you have made a mistake somewhere, either in the outer box (Box1/A & C) or in the smaller inside boxes. If the elevations don’t match, redo the box that doesn’t

Appendix IV

Elevation Studies & 3-D Dipstick Topo Maps

match up until they do match. If you have collected the data properly and have followed these instructions, they will match up. After you are finished checking the elevations and are satisfied that the data is correct, you can delete the many small 4-ft data sets.

Depending upon the spreadsheet you use, you may have to input data into all the blank fields. There must not be any text in the data. For a better-looking plot, you may wish to average the data between columns to fill blank spaces. While this is not strictly correct, in many cases it may be approximately correct, and it may produce a more viewable picture that still represents the surface quite well. (Sometimes the 3-D picture is difficult to discern if there are many empty cells in the data that produce the picture.)



Make a Graph

Finally, make the graph or 3-D plot following the instructions for the spreadsheet or graphing software.

